Must Understanding Be Coherent?

Abstract: Several authors suggest that understanding and epistemic coherence are tightly connected. Using an account of understanding that makes no appeal to coherence, I explain away the intuitions that motivate this position. I then show that the leading coherentist epistemologies only place plausible constraints on understanding insofar as they replicate my own account's requirements. I conclude that understanding is only superficially coherent.

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A necessary feature of understanding—or so it would seem—is that one grasps how various propositions within a common domain hang together. Newton provided us with a unified understanding of the motion of the planets, the ebb and flow of the tides, and the antics of cannonballs, apples, and other terrestrial objects. A good sleuth spins together disparate clues about a suspect's motives, means, and opportunity to understand how a crime unfolded. A doctor triangulates between a battery of tests and a variety of symptoms to understand her patient's maladies.

But what epistemological traction can we get from figurative talk that things "hang together" when we understand? A natural idea is that understanding bears a deep connection with coherence theories of justification—as several epistemologists have suggested (Carter and Gordon 2014; Elgin 2004, 2006, 2007; Kvanvig 2003, 2009; Riggs 2009). Elgin and Kvanvig provide two of the clearest statements:

> [An individual] proposition derives its epistemological status from a suitably unified, integrated, coherent body of information. This is *the core conception of understanding* […] And it is the conception of understanding that is closely connected to explanation. (Elgin 2007, 34; emphasis added)

> The *central feature of understanding*, it seems to me, is in the *neighborhood* of what internalist coherence theories say about justification. Understanding requires the grasping of explanatory and other coherence-making relationships in a large and comprehensive body of information. (Kvanvig 2003, 192; emphasis added)[1]

Against these views, I will argue that understanding's connection with coherence is shallow, floating innocuously atop sturdier depths. In other words, coherence is not part of the "core conception of understanding." Similarly, while the "central feature of understanding" is in the *neighborhood* of coherence, it isn't at *home* there. On my view, understanding is *quasi-coherent*: it walks like coherence and talks like coherence, but does not require a coherentist epistemology.

Specifically, I will first present the defining features of coherentism about understanding (§1). Then I will offer my alternative account of understanding that makes no appeal to coherence (§2). After that, I argue that my own view undercuts the best arguments for coherentism about understanding (§3), and conclude by showing that attempts to saddle understanding with robust coherence requirements deliver implausible results (§4).

1. Coherentism about understanding

I will be critiquing the following coherentist thesis about understanding:

> (CU) *Ceteris paribus*, if both S_1 and S_2 have the true belief that *q explains p* but S_1's belief that *q explains p* plays a more central role in a more coherent belief system than S_2's, then S_1 better understands why *p* than S_2.

CU is modest on two fronts. First, it's a claim about how understanding *improves*. By contrast, a categorical statement that all understanding requires coherence might be refuted by relatively unimpressive instances of understanding. Second, it doesn't claim that understanding improves *only* via coherence. Hence, I'm not demanding too much of coherentists. Despite CU's modesty, I will argue that it is dispensable.

In another sense, however, CU is slightly immodest—or at least unorthodox. Often, coherentism about understanding is driven not by understanding *why* something is the case, but by so-called *objectual* understanding, i.e. the understanding we have of a subject matter. For reasons I rehearse elsewhere (Khalifa 2013), I will be assuming objectual understanding is reducible to understanding-why. Even if this assumption were relaxed, I suspect that many of my arguments would, with slight modification, still pose problems for "objectualist" variations of CU.

More of CU—specifically, what's meant by "a more coherent system"—will be discussed below. For now, I'll rest on general intuitions. A belief plays a more central role in a belief system when it plays important inferential and explanatory roles in that system. One belief system B_1 is more coherent than another belief system B_2 when B_1 scores better with respect to its theoretical virtues and the quantity and quality of its members' inferential relations. More metaphorically: the denser one's web of beliefs, the more coherent one's belief system.

I haven't found an explicit argument for CU, nor any other coherentist accounts of understanding. Nevertheless, the following strikes me as capturing the spirit of Elgin and Kvanvig's remarks:

(1) *Ceteris paribus*, if S_1 grasps more connections between *p* and other relevant propositions than S_2, then S_1 better understands why *p* than S_2.
(2) Coherentism about understanding (i.e. CU) best explains this fact. [probably]
(3) Coherentism about understanding is true.

Call this the *Connection Argument*. I'll grant the first premise. The coherentist then asserts that no other epistemology could account for this platitude about understanding better than coherentism. Roughly, the thought is that any other epistemology will have to "write in" *ad hoc* the dense web of connections that falls out of coherentism without artifice.

2. Understanding as scientific knowledge

I'll challenge the second premise of the Connection Argument, arguing that coherentists err by having too narrow a view of the alternative epistemologies that could explain the intimate link between understanding and grasping sundry connections. Specifically, I'll suggest that the following "scientific knowledge" approach to understanding provides a better explanation of the relevant features of understanding:

> (SKU) *Ceteris paribus*, if both S_1 and S_2 have the true belief that *q explains p* but S_1's belief that *q explains p* more closely resembles scientific knowledge than S_2's, then S_1 better understands why *p* than S_2.

In this section, I clarify SKU (§2.1) and then motivate it with an example (§2.2). In the next, I compare it with CU.

2.1. A 'Science-First' Epistemology of Understanding

Let me offer two meta-epistemological scruples that inform my approach to understanding. First, I don't think that a full-blown conceptual analysis of knowledge is required to answer the pressing philosophical questions about understanding. The only traditional epistemological theses that my view requires are that: (a) scientific knowledge requires true belief that could not easily have been false and (b) scientific knowledge is compatible with foundationalism. Second, I hold that descriptions of scientific practice are rich enough to give us anything else we could want from the epistemology of understanding.[2]

Specifically, by *scientific* knowledge, I mean knowledge gained through the best methods and evidence characteristic of the natural and social sciences as we currently find them. I am a scientific pluralist, and am thus skeptical that a single kind of explanation, methodology, evidence, or inference applies to every instance of scientific knowledge. Nevertheless, I will now present some very general methods that apply to many scientific inquiries involving explanations. As I see it, scientific knowledge of an explanation typically has three features: consideration, comparison, and belief-formation.[3] First, scientists typically can *consider* many of the plausible potential explanations of the phenomenon of interest. Sometimes, consideration requires generating new hypotheses from scratch, or (more commonly) it only involves countenancing explanations that have been generated by others. Second, scientists typically can *compare* the potential explanations that they have considered. Here, they cite scientific evidence (and perhaps other, non-evidential scientific factors) that favors some explanations over others. In paradigmatic cases, one explanation is the "winner" of these comparisons, though

sometimes multiple explanations are good along different dimensions. Finally scientists *form doxastic attitudes* based on the comparisons just discussed. Scientists believe that clear winners in the prior stage of comparison are true, disbelieve clear losers, and assign appropriate degrees of belief about the middle of the pack. For ease of reference, I'll call this tripartite structure *scientific explanatory evaluation*.[4]

Earlier, I mentioned that I take scientific knowledge to require true belief that could not easily have been false. In other words, scientific knowledge requires safe belief. Following Pritchard, I define safety thusly:

> *S*'s belief is safe *iff* in most near-by possible worlds in which *S* continues to form her belief about the target proposition in the same way as in the actual world, and in all very close near-by possible worlds in which *S* continues to form her belief about the target proposition in the same way as the actual world, her belief continues to be true. (Pritchard 2009, 34)

Our description of scientific explanatory evaluation clarifies how *S* "continues to form her belief about the target proposition in the same way as in the actual world." In the present context, this means that in the relevant possible worlds, *S* continues to believe that *q explains p* by:

- considering the same class of potential explanations of *p* as she did in the actual world, and
- ranking those explanations in the same way and on the basis of the same evidence as she does in the actual world.

Finally, a good deal more should be said about how SKU parses degrees of understanding. However, these complications won't figure in what follows, so I'll save that for another day.

2.2. The Case of Peptic Ulcers

Let's now see how SKU works with a real scientific example: our current understanding of peptic ulcers. The example suggests itself for two reasons. First, it's an example replete with many details that could constrain any analysis of understanding. Second, it has been given a thorough coherentist rendering by Thagard (1999). Consequently, while it should be favorable to coherentist accounts of understanding, I'll argue below that it evinces nothing stronger than the *appearance* of coherence.

Peptic ulcers are sores that develop in the stomach (gastric ulcers) or in the duodenum (duodenal ulcers). Through the 1970s, biomedical scientists held that excess acidity in the stomach causes these ulcers. Starting in the 1970s, antacids were used as effective relief from peptic ulcers, although they did not cure ulcers. Furthermore, it was assumed that bacteria could not survive in the stomach's acidic environment. However, as first conjectured in 1983 by Australian physicians Robin Warren and Barry Marshall, biomedical scientists now hold that bacteria cause peptic ulcers. Consequently, antibiotics are often used to treat them.

Focusing just on one of Warren and Marshall's (1984) earliest publications of these ideas, we can already see the process of scientific explanatory evaluation at work. In that study, they discovered the bacteria that would later be called *Helicobacter pylori* in the stomach biopsies of several people with gastritis, and inferred that the bacteria explains the gastritis. Consonant with the first and second features of explanatory evaluation, they used techniques and evidence designed to eliminate several alternative explanations of why the patients have gastritis, or how the bacteria entered the patients' systems, e.g.

> Where possible patients completed a clinical questionnaire designed to detect a source of infection or show any relationship with "known" causes of gastritis or Campylobacter infection, rather than give a detailed account of each patient's history. The emphasis was on animal contact, travel, diet, dental hygiene, and drugs, rather than symptoms. (1984, 1311)

Similarly, they required patients to fast at least four hours before the endoscopy, used certain stains (e.g. haematoxylin and eosin (H&E), Warthrin-Starry silver, Gram), cultured the samples, and had their results independently coded, all done to rule out certain results as mere artifacts. Here, if an auxiliary hypothesis better explains an experimental result than a hypothesis of interest, that result is merely an artifact.

Moreover, our safety requirement on understanding provides a plausible *raison d'être* for why scientists undertake these measures: to make sure that their explanations could not easily have been false. In modalease, they are setting up an experimental situation such that in all nearby possible worlds, the presence of bacteria explains why the patients have gastritis.

Marshall and Warren found evidence that only the bacteria explanation explained. For instance, with the aforementioned questionnaires, they discovered the following:

> The only symptom which correlated with gastritis or bacteria was "burping" which was more common in patients with bacteria ($p = 0.03$) or gastritis ($p = 0.007$). This association remained when patients with peptic ulcer were excluded. None of the other questionnaire responses showed any relationship to the presence of gastric bacteria or gastritis. (Marshall and Warren 1984, 1312)

Here, the use of significance testing illustrates how the aforementioned kind of scientific explanatory evaluation affords us understanding, for a low p-value indicates that the correlation between explanans and explanandum could not easily have been a fluke. Similarly, the endoscopy results indicated a very close correlation between ulcers and bacteria ($p = 0.0002$).

We see more evidence of safety guiding Marshall and Warren's study when we turn to the histopathological tests for their explanation:

> Gastritis could usually be graded with confidence at low magnification. There was some difficulty with about 25 cases where the changes were mild or the specimens were small, superficial, or distorted. To ensure that gradings were reliable, single H & E sections from the last 40 cases were examined "blind" by another pathologist who agreed with the presence or absence of gastritis in 36 cases (90%), and gave an identical grading in 32. (Marshall and Warren 1984, 1312)

Thus, once again, the scientists achieved understanding only when they created a "safe space" for their explanations.

Importantly, Marshall and Warren also provided an explanation that challenged the widely held belief that the stomach was inhospitable to bacteria. The bacteria were discovered to be able to survive stomach acid by burrowing beneath the mucous layer in the stomach, and producing enzymes that neutralize acid. This helps them to account for evidence that would otherwise render their account implausible.

Regarding the third feature of explanatory evaluation, belief-formation, Marshall and Warren first discuss the failure of other explanations of gastritis and ulcers, and then assert the following:

> We know of no other disease state where, in the absence of complicating factors such as ulceration […], bacteria and PMNs [polymorphonuclear leucocytes, a telltale sign of gastritis] are so intimately related without the bacteria being pathogenic. (Marshall and Warren 1984, 1314)

This is not quite an assertion that the presence of bacteria explains gastritis, but that is consonant with my idea that a doxastic state should be based on the explanatory comparisons. Since Marshall and Warren were offering a brand new explanation of gastritis, they might reasonably have thought that more explanatory evaluation was in order. Hence, their qualifier about this explanation is in line with SKU.

Importantly, this was just the beginning of this explanation's career; several subsequent observations and experiments precipitated this advance in our understanding of peptic ulcers. Marshall and Warren discovered that antibiotics cure peptic ulcers. Later, the previous consensus that the stomach was too acidic to host bacteria was flatly refuted, as *H. pylori* was microscopically observed, and was grown in laboratory cultures (Marshall et al. 1990). Also, several studies indicated higher rates of ulcer healing and lower rates of recurrence among ulcer sufferers in whom *H. pylori* was eradicated (e.g., Marshall et al. 1988). Parallel points about safety and the three features of explanatory evaluation apply to these studies.

Thus, we see that several scientific practices accord with SKU, as described above. In particular, various experimental controls and statistical tests are consonant with the idea that we achieve understanding if our explanatory commitments are based on considering and comparing competing explanations, and if these commitments could not easily have been false. Understanding why some people have ulcers amounts to emulating (to some degree) the kind of knowledge that Marshall, Warren, and their successors had of *H. pylori*.

3. Debunking the Connection Argument

With CU and SKU in hand, I'll now argue that coherentists' monopoly on grasping myriad connections is illusory: SKU explains why understanding involves grasping connections better than CU. Consequently, the Connection Argument is unsound.

Specifically, I'll argue in two steps. First, scientific explanatory evaluation entails something that *resembles* coherence, in the sense that understanding involves grasping several "coherence-making" relationships—namely, explanation, conditional probability, and inference (§3.1). Then, I'll show that this web-like simulacrum is compatible with a denial of coherentism (§3.2). Combined, I take these points to show that the balance of arguments suggests that understanding is only quasi-coherent.

3.1. SKU and the Connection Argument

Recall the contentious premise in the Connection Argument:

> Coherentism about understanding (i.e. CU) best explains why, *ceteris paribus*, if S_1 grasps more connections between p and other relevant propositions than S_2, then S_1 better understands why p than S_2.

I'll now argue against this claim. Specifically, I will show that SKU explains why understanding involves grasping connections better than CU. To see this, suppose that S's true belief that q_1 *explains* p is the result of scientific explanatory evaluation, as described in §2.1. Then S has considered and compared other explanations of p and found them wanting. Furthermore, let two propositions a and b stand in a *positive* relationship if a explains b, a can be inferred from b, or $P(a|b)$ is relatively high.[5] Finally, assume that a and b stand in a *negative* relationship if a and b are competing explanations of some third proposition c, $\sim a$ can be inferred from b, or $P(\sim a|b)$ is relatively high.

In the stage of comparison, any potential explanation of p will stand in a positive explanatory relation with p, but in order for q_1 to supersede q_2 as an explanation of p, the former must either stand in a positive relationship with some further evidence e, or the latter stands in a negative relationship with e. Pictorially, we can represent a simple instance of this thusly:

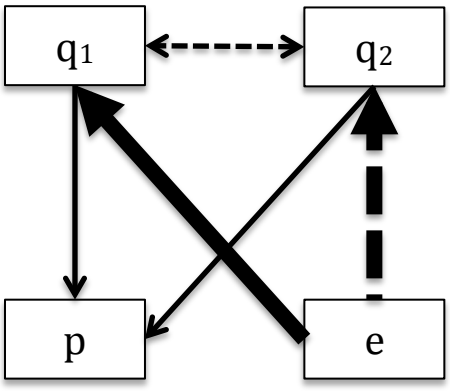

Figure 1: Simple case of explanatory evaluation. Thin lines indicate explanatory relationships; thick lines, inferential relations; solid lines, positive relations; dotted lines, negative relations.

This structure will simply repeat itself if *S* considers more explanations of *p*, and still finds q_1 to be the best of them, thereby looking more web-like. Thus, q_1 will always stand in at least as many positive relationships as its competition. However, we should also require that q_1 does not stand in any negative relationship (modulo its competition with other explanations).[6] The reason for this rider is that if q_1 stands in one of these negative relationships, q_1 may be the best of the bad lot of explanations that *S* has considered. In such a case, *S's* belief that q_1 *explains p* could easily have been false.

To render this more concrete, let's consider Thagard's coherentist representation of scientists' understanding of peptic ulcers:

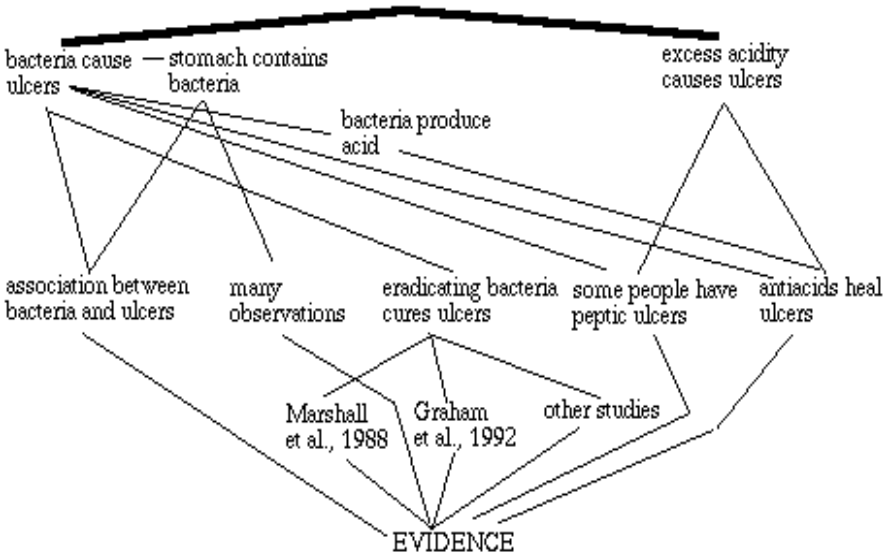

Figure 2. Coherence relations in assessing the acceptability of the hypothesis that bacteria cause ulcers (circa 1995). Thin lines indicate explanatory relationships (explanantia are above explananda; horizontal lines indicate "co-explanations"), and thick lines indicate contradictions or explanatory competition (Thagard 1999).

While Thagard explicates this episode using explanatory coherence, we can deliver the same verdict using SKU. There are two explanations of why some people have ulcers: the bacterial explanation and the acid explanation, and the former stands in far more positive relationships than the latter; neither explanation stands in negative relationships in Thagard's diagram. Thus, SKU explains why understanding involves grasping connections at least as well as CU. Below, I discuss Thagard's view in greater detail. However, my current point—that we can get exactly the same explanatory connections using either CU or SKU—doesn't hinge on those details.

So far, I've played for the tie: SKU is *at least as good* as CU in explaining the relevant intuitions. This suffices to unseat the Connection Argument, but just for fun, I'll now go for the win—SKU *better explains* our intuitions about understanding than CU. Consider a case in which someone has a belief in an explanation that fares well with respect CU but not SKU, and contrast him with a person whose fortunes are reversed:

- Andy consults an arbitrarily large number *n* of independent experts, all of whom tell him that *the presence of bacteria explains why some people have peptic ulcers*, but none of these experts provide any further details about the evidence by which they arrived at this belief, and Andy doesn't have the slightest clue as to what this evidence would be.

- Betty consults no experts, but carefully considers all of the viable explanations, and learns many details about *m* different experiments, which are sufficient for her to adjudicate between these different explanations and for her true belief that *the presence of bacteria explains why some people have peptic ulcers* to be safe.

Finally, let us add that *m* is much smaller than *n*, such that Andy's belief system is far more coherent than Betty's. Yet, Betty's understanding of peptic ulcers is intuitively superior to Andy's. SKU explains this intuition: Betty better approximates scientific knowledge than Andy. A coherentist account, such as CU, delivers precisely the opposite verdict. Thus, not only does SKU capture the intuition that we achieve understanding by grasping inter-propositional connections, it also accounts for why certain connections don't provide as much understanding as others. On this latter front, it outperforms a purely coherentist approach.

Perhaps a coherentist would reply that coherentist considerations are sliding in through the back door, for Betty must use a sizeable amount of background knowledge to achieve her understanding. However, since *n* can be arbitrarily large, this reply won't guarantee that Betty's understanding is *more* coherent than Andy's. Furthermore, any such response must consider cases in which Andy's background knowledge about his various testimonial sources offsets any gains that Betty would gain from her background knowledge.

Note that we have done this while effectively assuming that Andy's consulting of the various experts is safe. However, most coherentists don't have a safety condition built into their account, so things are even worse for the coherentist when we relax this assumption.[7] For instance, consider the following:

- Charlie consults the same number *n* of independent *pseudo*-experts that still explain peptic ulcers with bacteria. In addition to telling him that bacteria explains peptic ulcers, each pseudo-expert tells Charlie that the exact same experimental result *e* is the best scientific evidence for believing this explanation, and Charlie accepts this testimony. From Charlie's perspective, *e* coheres with the bacterial explanation of ulcers. However, the experiment that produced *e* was never performed; it is a complete fabrication that each of these pseudo-experts (through dumb luck) concocted independently of the other. No real scientist would assent to *e*.

Clearly, like Andy, Charlie understands worse than Betty, and there's no reason to think that Charlie's belief system is any less coherent than Andy's. Indeed, the presence of *e* might make Charlie's beliefs more coherent than Andy's. Thus,

scientific explanatory evaluation seems far more central to understanding than coherence.

Finally, for the sake of completeness, consider the following:

- Doug consults no experts, but considers all of the viable explanations, and learns many details about *m* different experiments, which are sufficient for him to adjudicate between these different explanations, but his true belief that *the presence of bacteria explains why some people have peptic ulcers* is unsafe.

For instance, suppose that Doug makes a systematic and far-reaching mistake about experimental design, but this confusion fortuitously cancels itself out given that he has looked at precisely these experiments. Had he looked at either *m*+1 or *m*-1 experiments, he would have formed a false belief about the causes of peptic ulcers. Once again, the intuition is that Doug does not understand peptic ulcers as well as Betty. SKU delivers this verdict, but there is no reason to think that Betty and Doug differ with respect to the coherence of their beliefs.

3.2. Compatibility with Foundationalism

Thus far, I have argued that SKU is at least as good as CU in accounting for our intuitions about understanding, and might well surpass it. But one may worry that because SKU doesn't offer an analysis of knowledge, there is an implicit coherentism in my view. To eliminate this possibility, I'll now argue that SKU is compatible with foundationalism. Importantly, the only claim being made here is that SKU is *consistent* with foundationalism. I make no stronger claim about whether understanding *entails* foundationalism, for only the weaker claim is needed to show that the preceding doesn't impose any significant coherentist requirement on understanding.

To do this, we'll need to clarify what foundationalism entails:

(FJ) *S*'s justification *j* for the explanation of *p* by *q* is foundational if and only if *j* itself is justified, and one of the following holds:
(a) *j* is not part of *S's* belief system; or
(b) if *j* did not stand in any explanatory, probabilistic, or inferential relationships with members of *S*'s belief system, then *j* would still be justified; or
(c) there is some other member of *S's* belief system, *b*, that justifies *j*, and, had *b* not stood in any explanatory, probabilistic, or inferential relationships with members of *S*'s belief system, then *b* would still be justified.

The first of these conditions rejects the coherentist's credo that only a belief can justify a belief; the second treats *j* as a self-justifying or basic belief; and the third treats *j*'s justification as derivative of some other basic belief *b*. This captures the core ideas of epistemic foundationalism. Thus, a genuine coherence constraint would deny all three of these conditions. Note that FJ is not *Cartesian*

foundationalism. In particular, I assume that fallibilism and foundationalism are consistent.

Quick inspection of SKU and FJ reveals no contradiction. To see this more clearly, suppose that the edges of the coherentist's web—the deliverances of perception—are banished to the foundationalist's basement. Then *S* can still believe an explanation and grasp its many relationships to her other beliefs through scientific explanatory evaluation. Hence, foundationalists can accept SKU.

Indeed, here it's worth noting that Thagard—who has provided one of the most descriptively adequate accounts of coherence to date, including how scientists came to accept the bacterial theory of ulcers—relies on epistemic principles that are consistent with FJ. Specifically, one of Thagard's (1992, 66) principles of (so-called) explanatory coherence, "Data Priority," holds that "Propositions that describe the results of observation have a degree of acceptability on their own." However, Data Priority is basically a restatement of FJ's condition (b), save that it specifies that basic beliefs are restricted to "the results of observation."

At this point, it's tempting to rebut this by re-litigating epistemic coherentism within the framework of its decades-old conflict with foundationalism.[8] In other words, after demythologizing the given, defusing various isolation objections, disproving various impossibility results, etc. one might think that understanding is coherent, simply because one also holds that *all* justification is coherentist. But this is problematic in two ways. First, it is arguable whether coherentism emerges triumphant from this battery of considerations (Olsson 2005, 2012). Second, even if this could be shown, it's not clear that the outcome of this debate—which was originally situated within an analysis of *knowledge*—is relevant to an analysis of *understanding*. After all, whether FJ is true or false, agents will "grasp" exactly the same relationships within their cognitive systems, and that seems to be all that matters for the Connection Argument.

To summarize, we've seen that SKU explains away the intuition that motivates coherence requirements on understanding—namely that we must grasp how things hang together—without any real commitment to coherentism. As a result, there is no strong motivation for coherence requirements on understanding. Moreover, we've told a broadly diagnostic story: understanding involves grasping connections, and this gives the *appearance* of coherence. Hence, understanding is quasi-coherent.

4. A Dilemma for Robust Coherence Requirements

However, the preceding does not yet seal coherence's coffin. In particular, one may grant that SKU captures many important features of understanding, but then insist on a further coherence requirement to boost understanding even further. To extinguish this last coherentist ember, I'll argue that any coherence requirements stronger than the quasi-coherence entailed by SKU do not enhance understanding.

In broad outlines, the reasoning for this is as follows: either a coherence requirement figures in scientific explanatory evaluation or it doesn't. If such a requirement figures in scientific explanatory evaluation, then it fails to be stronger

than SKU. In other words, it's *redundant* given my "science-first" account of understanding. Alternatively, if a coherence requirement does *not* figure in scientific explanatory evaluation, then it can be argued that it's unnecessary for understanding—an *extravagance*. Thus, ambitious coherentism seems on a collision course with either redundancy or extravagance. If this is correct, we have even further reason to suspect that understanding is only quasi-coherent. To add some flesh to these bones, I'll now interpret three popular coherence theories through the lens of this general argument.[9]

4.1. Thagard

Let's first consider Thagard's (1992, 65-66; 2000, 43) explanatory coherence theory:

> **Principle E1 (Symmetry)**: Explanatory coherence is a symmetric relation, unlike, say, conditional probability. That is, two propositions *A* and *B* cohere with each other equally.
> **Principle E2 (Explanation)**:
> a. A hypothesis coheres with what it explains, which can either be evidence or another hypothesis.
> b. Hypotheses that together explain some other proposition cohere with each other.
> c. The more hypotheses it takes to explain something, the lower the degree of coherence.
> **Principle E3 (Analogy):** Similar hypotheses that explain similar pieces of evidence cohere.
> **Principle E4 (Data Priority):** Propositions that describe the results of observation have a degree of acceptability on their own.
> **Principle E5 (Contradiction):** Contradictory propositions are incoherent with each other.
> **Principle E6 (Competition)** If *A* and *B* both explain a proposition, and if *A* and *B* are not explanatorily connected, then *A* and *B* are incoherent with each other (*A* and *B* are explanatorily connected if one explains the other or if together they explain something).
> **Principle E7 (Acceptance):** The acceptability of a proposition in a system of propositions depends on its coherence with them.

As we've already seen, Principle E4 undermines Thagard's claim to being a proper coherentist, since it entails foundationalism.

However, even if we bracket this point, Thagard's position falls prey to the dilemma of redundancy and extravagance sketched above. Note that Thagard's view overlaps substantially with our own. In particular, E2a is consistent with the idea that explanations yield positive relationships; E4, with the idea that evidence matters to explanatory evaluation; E5 and E6, with some of our negative relationships. Consequently, these principles appear redundant. Hence, if Thagard offers stronger coherence requirements than SKU, then it is because of the remaining principles.

If Principle E2b offers distinctive contributions to understanding, they are unclear. Obviously, understanding is sometimes achieved only by grasping how complementary hypotheses contribute to an explanation. However, in that case one simply has a more complex explanans, which SKU can readily assimilate. Consequently, E2b is, at best, redundant.

Some of the remaining principles only appear relevant if coherence has already been shown to figure in understanding. For instance, although Principle E1 stipulates that *coherence* is a symmetric relationship, all of the coherence-making relationships are asymmetric. Thagard explicitly acknowledges this with respect to conditional probability above, and also accepts that explanation is asymmetric.[10] Hence, E1 only becomes relevant if a stronger coherence requirement on understanding can be established. Since that's precisely what's at stake, E1 puts the cart before the horse. Similar points apply to E7.

The remaining principles are E2c, which prizes simpler explanations, and E3, which prizes explanatory analogies. Note that insofar as these virtues assist in scientific explanatory evaluation, the redundancy objection stands. Thus, they must sidestep the extravagance objection by contributing to understanding in other ways. Such contributions may be in the offing, but I wish to point out that there are strong reasons to think that simplicity and analogy sometimes are idle with respect to understanding. Indeed, I will now argue that there's little evidence that they play any role in our understanding of peptic ulcers.

Thagard (1999, Ch.4) claims that the bacterial theory of ulcers was accepted on the basis of its explanatory coherence. If this were true, then we would expect that the scientific articles that Thagard cites in his discussion of this historical episode to use many keywords associated with explanatory coherence. I decided to test this hypothesis. To assess this, I compiled the 27 publications written by biomedical scientists researching ulcers and cited by Thagard.[11]

The next step was to find distinctively explanationist terms. These were determined using Thagard's remaining two principles of explanatory coherence:

1. *Simplicity:* The more hypotheses it takes to explain something, the lower the degree of coherence; and
2. *Analogy:* Similar hypotheses that explain similar pieces of evidence cohere.

To give explanatory coherentism a fair hearing, I also included Lycan's (2002) account of the theoretical virtues:

3. *Scope:* Other things being equal, prefer T_1 to T_2 if T_1 explains more than T_2;
4. *Testability:* Other things being equal, prefer T_1 to T_2 if T_1 is more readily testable than T_2;
5. *Neatness:* Other things being equal, prefer T_1 to T_2 if T_1 leaves fewer messy unanswered questions behind;
6. *Fecundity:* Other things being equal, prefer T_1 to T_2 if T_1 is more fruitful in suggesting further related hypotheses, or parallel hypotheses in other areas; and

7. *Conservatism:* Other things being equal, prefer T_1 to T_2 if T_1 squares better with what you already believe.

I then performed searches over the aforementioned directory for various words from these seven criteria, as well as their cognates.[12] The results of these searches are summarized here:

Search string	Number of instances	Number of articles	Instances/ total # articles (27)
simpl	14	7	0.52
analog	4	3	0.15
similar	64	24	2.37
scope, consilien, explains more, power	1	1	0.04
test	217	25	8.04
neat, mess, unanswered	0	0	0
fecund, fruitful	1	1	0.04
conserv, already, consistent with	22	11	0.81
cohere	0	0	0
explain, explanat	27	17	1
differ	154	22	5.70
p < or p = [13]	96	12	3.56
statistic	56	14	2.07

Table 1: Word counts for key articles in the discovery of bacterial theory of ulcers. Gray rows reflect words that are not part of the explanatory coherentist framework.

The results suggest that the scientists did not explicitly use simplicity and analogy. Rather, it appears that citing various pieces of statistical and experimental evidence and being well versed in the methodology that licenses inferences from evidence to explanation can be achieved with nary a reference to simplicity or analogy. Such a person seems to have achieved significant understanding, and does not even appear to be converging towards explanatory coherence.

Let's first look at simplicity. Of the fourteen references to simplicity, there appear to be four chief senses of "simplicity":

- The scientists referred to simple therapies or protocols (not explanations) that are easy for patients to comply with, e.g. "We have observed that triple therapy is often not effective in patients who have previously received metronidazole, and compliance with the complicated treatment protocols remains a major problem. *Simpler* protocols and improved therapies are needed" (Graham et al. 1992, 708; emphasis added).

- The scientists also referred to simple therapies or protocols (not explanations) that have fewer side effects, e.g. "Side effects from our regimen resulted in 10 patients failing to take all the treatment and a further 8 reported mild side effects but finished treatment. Previous attempts to find a more *simple* and effective regimen that eliminates *H. pylori* have invariably resulted in lower eradication rates" (Hosking et al. 1994, 510; emphasis added). However, if *X* is a side effect of *Y*, then *Y* explains *X*. Hence, more side effects would actually increase explanatory coherence, so simplicity in this sense is antithetical to the simplicity of an explanation.

- The scientists also mention simple methods and tests (not explanations), which seems to mean nothing more than tests that are easy to use, e.g.

> At endoscopy, the *simplest* method of diagnosis is mucosal biopsy […] C_{14} test is less expensive and *simpler* […] *Simple* biopsy test done at endoscopy […] Available to all gastroenterologists. *Simple* and very accurate… Serology is the *simplest* and most widely available diagnostic test […] Although less accurate than the best serum ELISA methods, these tests may be equal to rapid office tests, are *simpler*, and may be particularly appropriate for children […] The European "standard" ^{13}C-urea breath test uses a *simplified* method with only one or two samples taken […] The ^{14}C-urea test exposes the patient to radiation equivalent to one thousandth of an upper GI series and is *simpler* than the $_{13}$C test. (Marshall 1994, S121-S122; emphasis added)[14]

- "Simply" also is used as a synonym for "merely," e.g. "Considering the tens of millions of dollars that have been spent on *H. pylori* research and treatment it is amazing that not one researcher has yet published the clinical results in ulcer patients of *simply* eradicating *H. pylori* with antibiotics alone" (Graham 1995, 1096; emphasis added).[15]

Similarly, analogy shows up in a scant three articles, and only four times total. However, a search for the synonym "similar" does much better, showing up in 24 of 27 articles, and is used an average of twice per article. However, since "similar" is a fairly common word, it is questionable just how many of these are being used as explanatory analogies, as is required by Thagard's principle of analogy. This gains further plausibility when it's noted that "differ" shows up twice as much as "similar," but there is no theoretical virtue of "disanalogy." Furthermore, Thagard does not include any analogies in his discussion of the bacterial theory of peptic ulcers.

Might other theoretical virtues, e.g. Lycan's, fare better? The results suggest otherwise. There is little textual evidence that scientists evaluate explanations in terms of scope, neatness, or fecundity. While testability seems to fare better than the other virtues, scientists frequently used the word "test" as a synonym for "evidence,"

and any account of scientific reasoning—explanatory coherentist or otherwise—will discuss evidence.

While a search for "conservatism" and its cognates returned no results, "already" and "consistent with" did return some results. Examples of the former include:

> The appearance of microvilli as distinct from the more bulbous surface projections in eases of chronic gastritis has *already* been noted (Fung, Papadimitriou, and Matz 1979, 278; emphasis added).

Examples of the latter include:

> …persons who immigrate to the United States from regions with a high incidence of gastric carcinoma retain a high risk for development of this malignancy, whereas subsequent generations are at lower risk. This trend is *consistent with* the persistence of *H. pylori* infection in untreated persons (Cover and Blaser 1992, 138; emphasis added).

Each of these passages refers to a previous study. Indeed, scientists' practice of citing prior studies that are consistent with their hypotheses and results is evidence that conservatism plays some role in scientific practice.

Thus, we have seen that searching for keywords characteristic of explanatory coherentism only produces the rather unremarkable claim that scientists perform tests and attempt to be consistent with (some) earlier studies. This does not amount to a vindication of explanatory coherence. Furthermore, searches for "cohere" yielded no results. Thus, even if it could be shown that some of the theoretical virtues played a more prominent role, it is not clear that the structure of scientific justification is coherentist.

By contrast, we see that statistical reasoning plays a far more pronounced role than the theoretical virtues. If we take "explain" as our baseline—which shows up on average about once per article—we see that the only "explanationist-friendly" words that show up with greater frequency are "similar" and "test". However, as mentioned above, "similar" shows up half as much as "differ", and "test" does not single out explanatory coherentism. Indeed, three of the five phrases that show up more than twice per article are decidedly not part of the explanatory coherentist framework (in gray above).

The preceding suggests that the most distinctive aspects of explanatory coherentism are largely idle in the advancement of understanding. Explanatory coherentists have two responses. First, they might claim that while scientists don't *explicitly* use simplicity and analogy, they do so *implicitly.* I fully grant that this is a possibility, but if it is to be more than idle speculation, an argument is needed. Moreover, it's not enough to show that explanatory virtues *could* be implicit in scientific practice. Rather, it must be shown that these virtues *are* (and perhaps *must* be) presupposed by scientific practice. Otherwise, worries about quasi-coherence linger: we might just as well make do with statistical reasoning with nary

a concern about simplicity and the other virtues. To my knowledge, no arguments navigating these difficulties have been offered.

Second, explanatory coherentists might grant that one can achieve *some* understanding without these explanatory virtues, while still requiring *full* understanding to be virtuous. However, this is another promissory note that must be redeemed. For instance, several authors deny that the best explanations in the special sciences ought to exhibit simplicity or unification—even in the long run (Dupré 1993, 2002; Kellert, Longino, and Waters 2006; Mitchell 2002; Wylie 1999). Indeed, they argue that disunity is often a virtue. If these authors are correct, then, at best, simplicity only improves our understanding of some phenomena. Thus, if coherentists wish to defend the idea that understanding must pass through simplicity, analogy, and other theoretical virtues, they must engage these sorts of arguments. To my knowledge, these dialectical burdens have not been undertaken.

Furthermore, a very plausible justification for why these virtues improve our understanding of only some phenomena, but not of others, appeals to scientific practice. For example, our best evidence for this "local" explanatory coherentism might be that theoretical physicists have successfully deployed simplicity as a virtue, but archaeologists have successfully deployed complexity as a virtue. However, this largely concedes that explanatory coherence enhances our understanding only when it promotes scientific knowledge of an explanation (in which case it is redundant), and should otherwise be abandoned (for it would then be extravagant). Hence, this "local" explanatory coherentism simply presupposes the very dilemma it is supposed to avoid.

To summarize, principles of explanatory coherence fall into four categories. First, some are redundant given that SKU is already in place (Explanation, Data Priority, Contradiction, Competition). Second, some would only be relevant if it were already established that understanding has strong coherence requirements (Symmetry, Acceptance). Third, some do not obviously improve our understanding (Simplicity, Analogy, Scope, Neatness, Fecundity). Fourth, some are not distinctive of explanatory coherence (Conservatism, Testability). Thus, once we embrace SKU, explanatory coherentism adds nothing further to understanding.

4.2. BonJour

Thagard's coherentism is not the only way of characterizing understanding. Using the following criteria of coherence, BonJour (1985, 95-99) offers an alternative account of coherence:

(B1) A system of beliefs is coherent only if it is logically consistent.
(B2) A system of beliefs is coherent in proportion to its degree of probabilistic consistency.
(B3) The coherence of a system of beliefs is increased by the presence of inferential connections between its component beliefs and increased in proportion to the number and strength of such connections.
(B4) The coherence of a system of beliefs is diminished to the extent to which it is divided into subsystems of beliefs which are relatively unconnected to each other by inferential connections.

(B5) The coherence of a system of beliefs is decreased in proportion to the presence of unexplained anomalies in the belief content of the system.

In principle, these five criteria could be plugged into CU to give it some kind of bonus not captured by SKU. However, we've seen that explanatory, inferential, and probabilistic relationships can figure in scientific explanatory evaluation, so redundancy looms large.

But could some of these relations not figure in scientific practice in this way? Extravagance also threatens this Bonjourian account of understanding. Consider Eberhard, who has precisely the same scientific knowledge of ulcers as Betty. However, whereas both are fluent in English, Eberhard also knows German. Then only he will be able to draw inferences from English statements about ulcers to German statements about ulcers. Hence, by (B3), Eberhard's belief system is more coherent. But since these inferential relations clearly play no role in scientific explanations of ulcers, Eberhard does not have a better understanding of *ulcers* simply by being bilingual. Similarly, one could tease out trivial inferences, e.g. by using disjunction-introduction (B3) or explain things completely unrelated to ulcers (B5) to increase coherence, but these surely will be extravagances when it comes to understanding ulcers. Hence, Bonjour's coherence requirements offer no obvious way to steer clear of the dilemma between redundancy and extravagance.

4.3. Lehrer

Finally, consider Lehrer's account of coherence, which we can derive from his account of justification:

> *S* is justified in accepting that *p* if and only if *p* coheres with system system *X* of *S*. (Lehrer 2000, 126)[16]

> *S* is justified in accepting that *p* if and only if everything that is an objection to *p* for *S* on *X* is either answered or neutralized for *S* on *X*. (Lehrer 2000, 137)

From these two claims, we get an account of coherence:

> *p* coheres with system *X* of *S* if and only if everything that is an objection to *p* for *S* on *X* is either answered or neutralized for *S* on *X*.

Once again, let's consider if this can be substituted into CU to give coherentism a distinctive role in understanding that isn't already captured by SKU.

For Lehrer, the system *X* can assume one of two values, which correspond to two grades of justification. *S's evaluation system* consists of *S*'s accepted propositions, *S's* preferences to accept certain propositions, and *S's* inferences. *S's ultrasystem* (roughly stated) is the subset of *S's* evaluation system that is true. The two systems correspond to subjective or "personal" justification and a more demanding kind of "undefeated" justification, respectively. As it turns out, the problems with applying Lehrer's coherentism to an analysis of understanding don't hinge on this difference.

First, it is natural to think that answering and neutralizing objections to an explanation are relevant to scientific explanatory evaluation. However, §2.1 already provides a more detailed account of the kinds of objections, answers, and neutralizers characteristic of understanding. In particular, alternative explanations of *p*, the disconfirmations thereof, etc. provide a clearer picture of the kinds of objections one must overcome in order to achieve understanding. Thus, SKU renders much of Lehrer's coherentism redundant.

Furthermore, where Lehrer diverges from SKU, he runs into trouble. Consider how Lehrer defines objections, and the answers and neutralizers thereof:

> *o* is an objection to *p* for *S* on system *X* if and only if it is less reasonable for *S* to accept that *p* on the assumption that *o* is true than on the assumption that *o* is false based on *X.* (Lehrer 2000, 131)

> An objection *o* to *p* is answered for *S* on *X* if and only if *o* is an objection to *p* for *S* and it is more reasonable for *S* to accept that *p* than to accept that *o* on *X*. (Lehrer 2000, 131)

> *n* neutralizes *o* as an objection to *p* for *S* if and only if *o* is an objection to *p* for *S* on *X*, but the conjunction of *o* and *n* is not an objection to *p* for *S* on *X*, and it is as reasonable for *S* to accept the conjunction of *o* and *n* as to accept *o* alone on *X*. (Lehrer 2000, 136)

Clearly, all of these notions hinge on the reasonableness of accepting a proposition *p*, r(*p*), which Lehrer (2000, 146) defines as follows:

$$r(p) = P(p)Ut(p) + P(\sim p)\, Uf(p)$$

Here P(*p*) and P(~*p*) are probabilities, Ut(*p*) is the positive utility of accepting *p* if *p* is true, and Uf(*p*) is the negative utility of accepting *p* if *p* is false. Consequently, one's preferences for seeking truth and avoiding error also figure in whether or not a belief coheres.

However, this added twist of epistemic utilities is irrelevant to understanding. Specifically, we can always imagine someone who fully understands why something is the case and then imagine someone who is otherwise identical save for a more demanding standard of reasonableness owing to "perverse" epistemic utilities. This has untoward consequences for a theory of understanding.

For instance, consider our heroine Betty, save that this time, she is contrasted with Fred, such that the only difference is that Fred assigns a pathologically higher negative utility to accepting a false explanation about the causes of ulcers. According to the preceding definitions, it is possible that there is at least one objection to Fred's explanation that will not be an objection to that same explanation on Betty's system. Let us further assume that Fred cannot answer or neutralize this objection. However, given that her belief system is the same, Betty could not answer or neutralize these objections, either; the only difference is that this objection does not arise for her in the first place because of her more tempered

epistemic utilities. However, if we were to construe CU à la Lehrer, only Betty is a candidate to fully understand why some people have peptic ulcers. However, this is counterintuitive, for Betty's understanding of peptic ulcers appears no different than Fred's. Consequently, one's epistemic utilities appear irrelevant to one's understanding.

Conclusion

To summarize, we began with the intuition that understanding involves grasping how things hang together. At first blush, coherentism seemed to provide the best explanation of that intuition. However, I've argued that a 'science-first' epistemology accounts for that intuition just as well as coherentism, if not better. In the process, I've shown that this approach to understanding is compatible with foundationalism, and that stronger brands of coherentism face many problems, by counseling us to seek theoretical virtues where none are to be had, to forge empty connections between disparate beliefs, to calculate utilities that don't affect the quality of our understanding. Thus, the connection between understanding and coherence is superficial—understanding is only quasi-coherent.

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[1] Here is additional textual evidence: "A tenable theory is a tapestry of interconnected sentences that together constitute an understanding of a domain… Understanding involves a network of commitments" (Elgin 2004, 114);
[2] Scientific knowledge *may* be analyzable. My point is that such an analysis is unnecessary for the tasks at hand.
[3] I would be unsurprised if some scientific methodologies furnish scientific knowledge of an explanation, but depart from this script. In these cases, I tend to defer to scientific practice, though with an eye towards indicating its broader epistemological import. Most importantly, it suffices for present purposes to show that *some* understanding doesn't require coherence, since that means that SKU is still more fundamental than CU.
[4] While this bears some resemblance to inference to the best explanation, my arguments in §4.1 imply that the similarities are superficial.
[5] I stipulate that if *b* confirms or is evidence for *a,* then they stand in one of these positive relationships. Parallel points apply to disconfirmation/evidence against and negative relationships.

[6] If one weights these relationships (e.g. by using probabilities), then we can massage this point: q_1 should not stand in any negative relationships that render it very improbable. This would allow the best explanation to tolerate, e.g. small anomalies.
[7] Lehrer (2000) might be an exception; see 4.3.
[8] For a recent version of this debate, see the exchange between Elgin and Van Cleve in Steup, Turri, and Sosa (2013).
[9] I don't discuss probabilistic accounts of coherence, though Gijsbers (2015) poses some nice challenges to those who would use probabilistic coherence measures in the context of understanding.
[10] In order to discriminate explanantia from explananda, Thagard (1992) implements explanatory coherence in a computer program that represents explanatory information as an ordered pair.
[11] Thagard claims that some epidemiologists not working on ulcers invoke coherence as a criterion of explanatory evaluation (e.g., Susser 1973). However, there is no citation evidence that these epidemiologists influenced the ulcer researchers whom Thagard studied.
[12] I did not restrict any of my searches to whole words only; nor were my searches case-sensitive. I examined each hit in the search to check for spuriousness. For example, while a search for "test" should not be limited to a whole word search, since that would omit "tests," "testing," etc. I had to omit words such as "intestine."
[13] I also did searches where there was no space between 'p' and the equality/inequality sign.
[14] See also Olbe et al. (1996, 1394).
[15] See also Graham and Go (1993, 281).
[16] This account of coherence is entailed by Lehrer's definition of justification in terms of coherence Lehrer adds a time variable *t* that I omit throughout this discussion.