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COMMENT

# Bounded Understanding Is Still Understanding

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## Abstract

Shiffrin et al. (2026) argue that scientists' understanding is frequently illusory. We agree that genuine metacognitive errors exist: scientists do confuse correlation with causation, mistake predictive success for explanatory insight, and overestimate their explanatory depth. However, the target article extends the label well beyond such errors, conflating genuine mistakes with two distinct phenomena: structural understanding misclassified as shallow causal explanation, and scope-dependent effects mistaken for absent ones. We argue that recognizing bounded understanding as bounded, rather than labeling it illusory, better equips scientists to specify what question they are asking—and whether their analysis answers it.


Shiffrin et al. (2026) argue convincingly that scientists' understanding is rarely complete and that overconfidence is real. But a diagnosis is useful only if it specifies what went wrong. The target article's central concept, illusion of understanding, is applied so broadly that it groups genuine cognitive errors together with legitimate but bounded forms of scientific knowledge. This breadth costs the framework its corrective power. We trace the problem to two conflations.

**Different Types of Understanding** Structural and mechanistic understanding are distinct; lacking one does not imply a deficiency in the other (De Regt, 2017; Potochnik, 2017). The target article, however, defines understanding as "an individual's account of the causes of some phenomenon" (p. 2), thereby equating understanding with causal understanding. The authors' own monarch butterfly example (p. 5) illustrates the consequence. To explain how monarchs navigate thousands of miles across four generations, four scientists pursue different approaches: bioenergetic necessity, navigational cues, cross-generational information transfer, and molecular mechanisms. Each is said to offer an "incomplete account". But these are different questions, not shallow versions of one question. More generally, structural understanding (grasping what something *is*, the organization or pattern that makes it the kind of thing it is) answers a different type of question than mechanistic understanding. Kepler described planetary orbits as ellipses decades before Newton explained why they are elliptical; the structural insight was not a deficiency but a precondition—it defined the very explanandum that Newton's mechanics later addressed. Structural understanding is not a failed attempt at mechanistic explanation; it is often a necessary stepping stone toward it.

Of course, some researchers do mistake structural descriptions for causal explanations, a genuine error corrected by recognizing what type of question one's analysis answers. But the target article goes further, treating any shortfall from complete causal understanding as potentially illusory. The authors acknowledge that understanding is "rarely or possibly never complete" (p. 1). If the measure of understanding is causality, and causal knowledge is inherently provisional (cf. Hume, 1985), then treating any shortfall from conclusive causal knowledge as illusion renders all science perpetually illusory, including the provisional understanding on which further progress depends. Yet "illusion" implies that the knower is unaware of a deficit. Scientists who recognize their understanding as incomplete are not deceived; they are doing science. If our goal is to track cognitive error (Shiffrin et al., 2026), "illusion" should be reserved for cases where scientists overestimate their grasp or misidentify the type of question their results address.

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**Question and Scope Specification Dissolve Paradox** Even when considering causal understanding itself, the statistical paradoxes the authors discuss do not demonstrate its absence. Instead, they demonstrate that causal claims have scope conditions and that different analyses can legitimately target different estimands. In Simpson's paradox, $\theta_1 = \mathbb{E}[Y|X]$ and $\theta_2 = \mathbb{E}[Y|X, Z]$ differ because $\theta_1$ averages over $Z$ while $\theta_2$ conditions on it. Under appropriate identification assumptions, a treatment may benefit patients within each subgroup while appearing harmful in the aggregate: a scope-dependent effect, not an absent one (Hernán et al., 2011). Lord's paradox has the same structure: $\mathbb{E}[Y|\text{Group}]$ and $\mathbb{E}[Y|\text{Group}, X_0]$ answer different questions: whether groups differ overall versus whether they differ given the same initial value (Lord, 1967). The apparent contradiction reflects two analysts targeting different estimands. Each presupposes a different underlying causal system, and each is correct within that system (Pearl, 2016; Pearl & Mackenzie, 2018). More to the point, though, once the intended estimand is specified, the paradox dissolves. That scientists often neglect this specification is a genuine methodological shortcoming, but a correctable one, amenable to training in causal reasoning, not evidence of a deep cognitive illusion.

Scope-dependent effects that reverse across contexts are compatible with causation (Cartwright, 1999); mistaking them for unconditional ones is a misidentification of *where* an effect holds, not *whether* it holds. These paradoxes appear troubling only under the presupposition of a single question-independent causal truth, where contradictory conclusions signal failure. Relaxing this presupposition transforms many of these paradoxes into pedagogical resources rather than evidence of cognitive failure. Simpson's paradox, for instance, teaches that effects can be subpopulation-specific, refining rather than undermining causal reasoning. The authors' own door-opening example (pp. 21–22) lists neurochemical, biomechanical, and other causal levels as each valid but incomplete. We agree that multiple levels coexist, but once a research question targets one level, incompleteness at the others is scope limitation, not illusion. Properly delineated research questions do not eliminate metacognitive error (a researcher can still overestimate their explanatory depth), but they dissolve the paradox and reduce the territory that "illusion" must cover.

These distinctions are not merely taxonomic; each requires a different response. The two conflations we identify call for methodological corrections: recognizing what type of question an analysis answers, and specifying under which conditions and for which populations an effect holds. The genuine metacognitive error that Rozenblit and Keil (2002) originally defined, overestimating one's own explanatory depth, calls for something different: metacognitive calibration. Collapsing all three under a single diagnosis obscures which correction is needed.

If these distinctions hold, much of what the authors call illusion requires reclassification. Confusing correlation with causation, and prediction with explanation, remain genuine metacognitive errors. But Newtonian mechanics was not illusory; it delivered valid causal understanding within its domain, and its later refinement by relativity marked a scope expansion, not a retroactive exposure of illusion. Bounded understanding, recognized as such, is not cognitive failure but epistemic maturity (cf. Simon, 1956). When scientists fail to recognize their bounds, as they sometimes will, the corrective is better calibration, not the retroactive judgment that bounded knowledge was illusory all along. Labeling it so risks discouraging the critical stance scientific progress requires. As Keil (2003) has argued, human understanding of complex phenomena is inevitably coarse-grained; the question is whether that coarseness is recognized and managed, or mistaken for depth. When "illusion" covers both "I overestimate how well I can explain a toilet" and "quantum field theory remains philosophically incomplete," the concept has lost diagnostic precision. The problem (Shiffrin et al., 2026) raise is important. The solution is not to diagnose ever more illusions, but to equip scientists to specify what question they are asking—and whether their analysis answers it.

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## Declarations

**Competing Interests** The authors declare no competing interests.

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