The Determinants of Knowability

Samuel G. B. Johnson[1], Kristen J. Kim[2], & Frank C. Keil[1]
(samuel.johnson@yale.edu, kjkim@princeton.edu, frank.keil@yale.edu)
[1]Department of Psychology, Yale University, New Haven, CT 06520 USA
[2]Department of Psychology, Princeton University, Princeton, NJ 08544 USA

Abstract

Many propositions are not known to be true or false, and many phenomena are not understood. What determines what propositions and phenomena are perceived as *knowable* or *unknowable*? We tested whether factors related to scientific methodology (a proposition's *reducibility* and *falsifiability*), its intrinsic metaphysics (the *materiality* of the phenomena and its *scope* of applicability), and its relation to other knowledge (its *centrality* to one's other *beliefs* and *values*) influence knowability. Across a wide range of naturalistic scientific and pseudoscientific phenomena (Studies 1 and 2), as well as artificial stimuli (Study 3), we found that reducibility and falsifiability have strong direct effects on knowability, that materiality and scope have strong indirect effects (via reducibility and falsifiability), and that belief and value centrality have inconsistent and weak effects on knowability. We conclude that people evaluate the knowability of propositions consistently with principles proposed by epistemologists and practicing scientists.

Keywords: Lay epistemology; folk science; experimental philosophy; psychology of religion.

Introduction

Facts and falsehoods abound in both lay and scientific discourse. There are facts about the relationship between electricity and magnetism, and the possibility of multiple universes; about the mechanisms of cell division, and the origins of life; about the relationship between supply and demand, and the causes of crime. Beyond science, ordinary humans debate, both with one another and with themselves, questions about the existence of God, the afterlife, and the beginning of the universe.

Science aims to separate the true from the false, as does everyday cognition. Yet, sometimes it is unclear how to determine what is true: Cognitive science, for example, is much closer to understanding early vision than the nature of conscious experience. Indeed, some view the latter question as essentially *unknowable* (e.g., Chalmers, 1996; cf. Dennett, 1991).

The question of what is knowable and what is unknowable has important implications for individuals and for society. Humans have a strong drive to understand the world and explain their lives (e.g., Gopnik, 1998; McAdams, 1993), filling in gaps in their understanding using whatever means are available (Johnson, Rajeev-Kumar, & Keil, 2015). Even though much is unknown, we have developed various strategies for resolving this ignorance. We allocate science funding not only on the basis of what discoveries would be important, but also what discoveries are feasible. And when a topic is not amenable to empirical inquiry, it is seen as a more appropriate domain for faith (Preston & Epley, 2009). We spend our days pursuing the knowable, even as the unknowable keeps us up at night.

Here, we ask what leads people to perceive a phenomenon as knowable. Our strategy is to examine those factors that practicing scientists and philosophers have considered relevant to assessing knowability, anticipating that laypeople may use similar reasoning.

Much evidence has accumulated that adults, and even children, come to understand the world much as scientists do (e.g., Carey, 1985; Gopnik, Meltzoff, & Kuhl, 1999; Keil, 2003). This is not necessarily surprising: To the extent that evolution has endowed us with reasoning mechanisms that track reality, and to the extent that culture has invented scientific methods that track reality, one would expect those methods to converge. Thus, laypeople and scientists potentially share idealized methods for generating and assessing knowledge claims.

This approach led us to consider six factors, divisible into *methodological*, *intrinsic*, and *relational* factors.

Methodological factors. The first two factors concern the applicability of the (scientific or folk-scientific) methods by which propositions are assessed:

Reducibility. According to classic definitions (e.g., Putnam, 1973), a higher-level proposition is *reducible* to lower-level propositions (such as the facts of fundamental physics) if the higher-level can be deduced from the lower-level or, especially, if the higher-level can be *explained* in terms of the lower level. If all phenomena can be reduced to fundamental physics, this reduces the burden of science to understanding the physics and its implications. Arguably, then, to the extent that a proposition is reducible to propositions about fundamental physics, it should be more knowable.

Although the doctrine that all sciences can be reduced to fundamental physics is controversial among philosophers of science (e.g., Putnam, 1973; Strevens, 2009), it is plausible that laypeople see phenomena as knowable to the degree they are reducible. This is in part because laypeople are themselves reductionists: They prefer lower-level explanations of higher-level phenomena, within limits (Burke, Johnson, & Keil, 2016).

Falsifiability. The most well-known doctrine of scientific knowability is certainly Popper's theory of *falsificationism* (Popper, 1959/1934). The idea is that a proposition counts as scientific only if it can be proven false by an empirical test. This proposal has likely received such widespread influence among scientists because it resonates with intuitive notions of how evidence relates to hypothesis (in philosophy, see Mill, 1967/1843; in psychology, see White, 1990).

Intrinsic factors. The next two factors concern the intrinsic nature or content of the phenomenon itself:

Materiality. Some (alleged) phenomena manifest in the realm of material things; that is, they affect entities composed of physical particles. For instance, electricity is a material phenomenon because it concerns the motions of electrons, whereas the soul (if it existed) would be immaterial by definition. Debates over the knowability of how conscious experiences arise, for example, revolve largely around the question of whether the mind is material or immaterial (Chalmers, 1996).

Scope. Whereas phenomena in physics seem highly knowable because they are highly material and reducible, they also seem *unknowable* because they have an extremely wide scope of application. For example, consider the gravitational force. On the one hand, a phenomenon such as gravity that impinges on everything in the universe will present no difficulty to scientists in terms of finding material to test. But on the other hand, the scientific method is intrinsically *comparative* (e.g., Mill, 1967/1843). One cannot, for example, compare those bits of matter that are subject to gravity from those that are not. Perhaps in part for this reason, gravity is still poorly understood among physicists.

Relational factors. Finally, we consider two factors that concern the ways that propositions relate to each other in one's broader system of beliefs:

Belief Centrality. Some propositions are central to our conceptions of the world; if we no longer believed that 2+3=5, for instance, the world would have to be constituted in a wholly different way (if this is even conceivable). To the extent that a proposition is foundational to our other knowledge, that other knowledge can act as evidence in favor of that proposition. To some degree, this mirrors the approach to epistemology taken by rationalist philosophers such as Descartes. In the *Meditations*, Descartes is able to justify knowledge of the external world only on the basis of God's existence (Descartes, 2013/1641).

Although laypeople probably would not endorse rationalist approaches to knowledge justification, they may nonetheless see epistemically central propositions as more certain than less central propositions. For this reason, such propositions may be seen as less falsifiable and, perhaps counterintuitively, as *less* knowable. Put differently, some beliefs are axiomatic or *basic*: They are not susceptible to contradiction from other knowledge sources because those other sources are themselves dependent on that knowledge (a view known as *foundationalism*; e.g., Plantinga, 1981). Yet, if people are both foundationalists *and* falsificationists, then basic beliefs may actually be seen as fundamentally unknowable because they are unfalsifiable.

Value Centrality. Finally, some propositions are not central to one's other *beliefs*, but instead to one's *values*. For some (e.g., Kant, 2002/1785; Lewis, 1952), our moral sense is the most compelling evidence for God's existence. In addition to reasons of epistemic justification, people may also have motivational reasons to believe in propositions that justify their values: "If there is no God," said Jean-Paul Sartre, "then everything is permitted." Whereas Sartre was an atheist, and hence accepted the nihilist conclusion of this conditional, many people who accept the conditional are more likely to infer the contrapositive: Since some things are *not* permitted, God must exist. Such motivated reasoning may relegate highly value-laden beliefs to the realm of unknowability.

The Current Work. On the basis of the idea that laypeople and scientists may share idealized standards for generating and assessing knowledge, we predicted that reducibility and falsifiability would be especially important, as these criteria govern the methodological basis on which knowledge is achieved. The psychology literature makes less clear predictions about the intrinsic or relational factors. One possibility we explore is that the intrinsic factors are relevant insofar as they are relevant to the methodological factors (e.g., material things lend themselves more to reduction and falsification.)

We test these six potential factors in three studies. First, we measure judgments of each factor for various scientific items (e.g., consciousness, economic cycles) in Study 1, and various pseudoscience items (e.g., clairvoyance, karma) in Study 2. Then, Study 3 adopts an experimental approach, attempting to replicate the patterns from Studies 1 and 2 using controlled stimuli.

Studies 1 and 2

In our initial studies, we tested the relationships among the six methodological, intrinsic, and relational factors for a set of 40 scientific and 30 pseudoscientific phenomena.

Method

Participants. We recruited 350 participants from Amazon Mechanical Turk, who were randomly assigned to complete the science items of Study 1 ($N = 176$) or the pseudoscience items of Study 2 ($N = 174$).

Items. We developed 40 science items for Study 1 and 30 pseudoscience items for Study 2. For each item, participants were asked to "consider the topic below." The topic was presented in a box, together with a brief parenthetical description. For example, one of the items in Study 1 read "Determinism (i.e., the idea that all events are the results of prior conditions, such as the movement of atoms or previous physical events)" and another read "The determinants of economic cycles (i.e., the causes behind economic recessions, depressions, etc.)." In Study 2, one item read "Clairvoyance (i.e., being able to know things about objects, people, or events without using the senses)" and another read "Karma (i.e., the moral sum of a person's actions that determines his or her future fate)."

Measures. Between-subjects, participants completed a measure of either *knowability*, *reducibility*, *falsifiability*, *materiality*, *scope*, *belief centrality*, or *value centrality* (N = 50 per condition) for either the 40 science or the 30 pseudoscience items. The scales were phrased as follows:

Knowability. "To what extent do you think it would be possible for scientists to attain a complete understanding of this topic?" from 0 ("Not at all") to 10 ("Completely").

Reducibility. "To what extent do you think a complete understanding of this phenomenon would invoke only facts about the movement of particles and purely physical components?" from 0 ("Not at all material") to 10 ("Very material").

Falsifiability. "Suppose one scientist made a claim about the above topic, and another scientist wanted to design an experiment to find out whether the claim is true or false. To what extent do you think it is possible to design such an experiment?" from 0 ("Not at all possible") to 10 ("Completely possible").

Materiality. "How much do you think the above topic is within the material realm?" from 0 ("Not at all material") to 10 ("Very material").

Scope. "Consider everything in the universe. How many of these things does the above topic apply to?" from 0 ("Very few") to 10 ("Very many").

Belief Centrality. "Consider all the things you could know about the topic above. If all of this knowledge turned out to be wrong, how many other things that you know would also turn out to be wrong?" from 0 ("Very few") to 10 ("Very many").

Value Centrality. After reading each topic description, participants were asked: "How important is the above topic to your moral beliefs or values?" from 0 ("Not at all important") to 10 ("Very important").

	K	R	F	M	S	BC
R	.44***	—				
F	.84***	.10	—			
M	.75***	.47***	.61***	—		
S	–.07	.63***	–.34**	.01	—	
BC	.22º	.22º	–.02	.19	.52***	—
VC	.39***	.27*	.12	.38**	.47***	.79***
C	.33**	.26*	.06	.31**	.52***	—

º < .10 * < .05 ** < .01 *** < .001

Note. Entries correspond to knowability (K), reducibility (R), falsifiability (F), materiality (M), scope (S), belief centrality (BC), value centrality (VC), and a composite measure averaging belief and value centrality (C).

Table 1: First-order correlations (combined dataset).

Results

For each item, we calculated the mean score on each judgment, across all participants making that judgment for the item. Analyses are all at the item level. (However, Study 3 will rely on a subject-level analysis.)

Correlations. The first-order correlations among the measures are given in Table 1.

Both methodological factors were associated with knowability. There was a moderately strong relationship between knowability and reducibility, r = .44, such that phenomena were seen as more knowable when reducible to fundamental physics. There was also a very strong relationship between knowability and falsifiability, r = .84, such that phenomena were seen as more knowable to the extent that disagreements could be resolved in terms of empirical tests. These correlations are both consistent with popular views among scientists and philosophers of science. Interestingly, falsifiability and reducibility were almost completely uncorrelated, r = .10, suggesting that people conceptualize these as independent dimensions.

The intrinsic factors also seem to have a relationship with knowability and with the methodological factors. Materiality was a consistent predictor not only of knowability, r = .75, but also of reducibility, r = .47, and of falsifiability, r = .61. One possible interpretation of this pattern is that more material things are seen as more knowable *because* they are more reducible and more subject to empirical falsification. We test this possibility using regression analyses below.

Although scope was not associated with knowability, r = –.07, it *was* associated with both falsifiability and reducibility: Phenomena that applied to very many things were seen as *more* reducible, r = .63 (perhaps because the most general phenomena tend to be lower on the reductionist hierarchy), but as *less* falsifiable, r = –.34 (perhaps because there are few opportunities to observe the absence of something that is ubiquitous). Thus, scope may have an *indirect* relationship with knowability, via these two opposite pathways (see regressions below).

The results for the relational factors are somewhat less clear. Because these measures were highly correlated with each other, r = .79, we averaged them to form a composite *Centrality* measure. This measure was a significant predictor of knowability, r = .33, although the reason is less clear from the data. We had hypothesized that highly central beliefs might be seen as less falsifiable (and hence *less* knowable), but this was not borne out by the data. We further analyze and discuss this effect below.

Regression Models. Table 2 shows regression coefficients for a model predicting knowability judgments from just the methodological factors (reducibility and falsifiability) in Step 1, and from all factors in Step 2. (The composite centrality measure was used to avoid multicollinearity.) This reveals that the methodological factors (reducibility and falsifiability) were strong predictors of knowability (b = 0.58 and 0.66, respectively, in Step 2), even after adjusting for the other predictors. Although reducibility and falsifiability seem to completely screen off materiality (b = 0.09, *ns*), there does seem to be a residual effect of scope (b = –0.27), such that wider scope phenomena were seen as less knowable, even after accounting for the other factors.

Finally, centrality seems to be associated with knowability, such that more phenomena more central to beliefs and values are seen as more knowable (*b* = 0.45).

	DV: Knowability	
	Step 1	**Step 2**
R	.45 (.06)***	.58 (.09)***
F	.83 (.05)***	.66 (.06)***
M		.09 (.10)
S		–.27 (.07)***
C		.45 (.08)***
R^2	.827	.898

Table 2: Unstandardized *b*s and SEs (combined dataset)

One concern about these analyses, however, is that they collapse across the science and pseudoscience items, which may differ in a variety of ways. Indeed, even at a gross level, the means significantly differed between these item sets on all measures (Table 3).

	Study 1 (Science)	**Study 2 (Pseudoscience)**
K* **	5.90 (1.16)	2.91 (1.16)
R* **	5.10 (1.50)	3.41 (0.82)
F* **	5.97 (1.70)	4.22 (1.46)
M* **	5.22 (1.01)	3.59 (0.73)
S*	4.95 (2.39)	3.95 (1.43)
BC* **	5.54 (1.19)	4.43 (0.86)
VC* **	5.51 (1.21)	3.44 (1.19)

Table 3: Descriptive statistics (Studies 1 and 2)

Thus, correlations between knowability and the other measures could potentially be driven by gross differences between item sets rather than meaningful differences among items. To address this concern, we repeated the regression of knowability judgments on the predictors, separately for Studies 1 and 2 (Table 4).

	DV: Knowability	
	Study 1 (Science)	**Study 2 (Pseudoscience)**
R	.45 (.13)**	.47 (.18)*
F	.68 (.07)***	.35 (.10)**
M	–.23 (.14)^o	.46 (.27)
S	–.25 (.09)**	–.03 (.16)
C	.16 (.10)	–.34 (.26)
R^2	.823	.848

Table 4: Unstandardized *b*s and SEs (Studies 1 and 2)

This analysis revealed that even *within* each item set, the relationship between reducibility and falsifiability was robust. There was again no consistent relationship with materiality once the other factors are accounted for, and the relationship with scope held up only for the science items. The most substantial divergence between the combined and more fine-grained analyses was for centrality: Whereas centrality was a significant positive predictor on the combined dataset, it does not have any consistent relationship with knowability within either dataset. This suggests that this effect was spurious, caused by differences across (rather than within) datasets.

We can also use these data to look at what predicts the methodological factors themselves, using regressions to predict reducibility (Table 5) and falsifiability (Table 6).

	DV: Reducibility	
	Step 1	**Step 2**
F		.07 (.08)
M	.57 (.10)***	.63 (.12)***
S	.45 (.06)***	.59 (.07)***
C		–.38 (.10)***
R^2	.606	.678

Table 5: Model predicting *reducibility* (Studies 1 and 2).

	DV: Falsifiability	
	Step 1	**Step 2**
R		.16 (.18)
M	.92 (.13)***	.78 (.19)***
S	–.30 (.08)***	–.43 (.14)**
C		.16 (.17)
R^2	.496	.505

Table 6: Model predicting *falsifiability* (Studies 1 and 2).

The intrinsic factors both had large and consistent influences on the methodological factors. Materiality had a strong, positive effect on both reducibility and falsifiability judgments (*b* = 0.63 and 0.78, respectively). This indicates that the strong correlation between materiality and knowability is due to the effects of materiality on reducibility and falsifiability, rather than any direct effect on knowability.

Consistent with the first-order correlations, scope had a strongly positive effect on reducibility but a strongly negative effect on falsifiability (*b* = 0.59 and –0.43, respectively), indicating *opposite* indirect effects on knowability. That is, to the extent that a phenomenon applies to many things in the universe, it is seen as more reducible to physics but *less* falsifiable. These two pathways seem to largely cancel out, leading to a weak relationship between scope and knowability overall.

Centrality appears to have a negative association with reducibility (b = –0.38), after adjusting for the other factors, such that phenomena more central to one's beliefs and values tend to be less reducible to physics. However, centrality seems more likely to be an *effect* of reducibility than a *cause*, particularly because centrality has no clear relationship with knowability, whereas reducibility does. Centrality also has no relationship with falsifiability (b = 0.16, *ns*), consistent with the idea that centrality is not a key driver of knowability.

Discussion

Overall, these results paint a consistent picture of what determines knowability. Across many ways of looking at the data, the methodological factors of reducibility and falsifiability play a large role, accounting for the majority of the variance in knowability. The intrinsic factors (scope and materiality) appear to have indirect effects on knowability via reducibility and falsifiability, but little or no direct effect. Finally, centrality appears to be associated with reducibility, but is more likely an effect than a cause. These folk-scientific methods appear to closely mirror the way that professional scientists and philosophers think about what is knowable.

Despite these consistent findings across very different sets of items, and despite the good model fits (accounting for 80–90% of the variance in knowability, and 50–70% of the variance in reducibility and falsifiability), these results are correlational. Thus, conjectures about the direct and indirect causal relationships are difficult to assess. We therefore adopted an experimental approach for converging evidence.

Study 3

In Study 3, we used artificial stimuli to look more directly at the relationships of the six factors with knowability. We would predict that the methodological factors should have strong relationships with knowability, consistent Studies 1 and 2. We would also expect a relationship with at least materiality (given its positive effects on both reducibility and falsifiability) and perhaps scope (given its positive effect on reducibility and negative effect on falsifiability). We would not predict a relationship with belief or value centrality, since these factors did not seem to play a causal role in Studies 1 and 2.

Method

Participants. We recruited 100 participants from Amazon Mechanical Turk; 1 was excluded from analysis due to missing data.

Items. Participants completed 12 novel items (4 concerning physical phenomena [e.g., nerium force], 4 concerning biological phenomena [e.g., zenilan synthesis], and 4 concerning psychological phenomena [e.g., perception cavelation]). For each item, participants were told that "There are many unknown phenomena in our universe that scientists are trying to understand" and that (for example) "Currently, the biological phenomenon of *zenilan synthesis* is not understood." After a brief description of the item (varying across conditions; see below), participants were asked to rate "To what extent do you agree with the claim that someday in the future, scientists will understand everything there is to know about zenilan synthesis?" on a scale from 0 ("Strongly Disagree") to 10 ("Strongly Agree").

Manipulations. There were 12 within-subjects conditions in a 6 (factor: Reducibility, Falsifiability, Materiality, Scope, Belief Centrality, Value Centrality) x 2 (High, Low) design. (We refer to these conditions by the initial letter of the factor, with a '+' or '–' sign; e.g., high materiality is denoted 'M+'.) Only the target factor was described for each item. Each description began with "Although zenilan synthesis is not understood, it is widely believed that…" followed by phrasing varying across conditions. In the R+/R– conditions:

> …a complete understanding would invoke [only facts about / facts that cannot be reduced to] the movement of particles and purely physical components.

In the F+ and F– conditions:

> …if a scientist wanted to make a claim about it, it would [*not*] be possible for another scientist to design an experiment to find out whether the claim is true or false.

In the M+ and M– conditions:

> …it is [*not*] within the material realm.

In the S+ and S– conditions:

> …it [applies to many / does not apply to most] things in the universe.

In the BC+ and BC– conditions:

> …if everything you could know about zenilan synthesis was wrong, very [many / few] other things that you know would also be wrong.

In the VC+ and VC– conditions:

> …it is [very / not at all] important to many moral beliefs and values.

The 12 conditions were balanced with the 12 items for each participant. The '+' and '–' versions of each factor were always adjacent in the presentation order and matched for domain (physical, biological, or psychological). The order of the 6 factor conditions was randomized, as was the order of the '+' and '–' versions.

Results and Discussion

The results were consistent with the patterns of influence uncovered in Studies 1 and 2 (see Table 7). Propositions high in reducibility and falsifiability were rated more knowable than propositions low on these factors [$t(98)$ = 4.42, $p < .001$ and $t(98)$ = 7.34, $p < .001$], consistent with the direct effects of these factors in Studies 1 and 2. In addition, propositions corresponding to phenomena that were highly material and wide in scope were rated more knowable than propositions low on these factors [$t(98)$ = 8.01, $p < .001$ and $t(98)$ = 5.58, $p < .001$], consistent with the indirect effects of these factors uncovered in Studies 1 and 2, via reducibility and falsifiability. However, centrality to beliefs and values did not influence knowability judgments [$t(98) = -0.52$, $p = .61$ and $t(98) = 1.32$, $p = .19$], again consistent with Studies 1 and 2, where these factors appeared to be correlated with, but not causally antecedent to, knowability.

	DV: Knowability	
	+	–
R ***	6.05 (2.45)	5.19 (2.53)
F ***	6.54 (2.52)	4.30 (2.94)
M ***	6.45 (2.20)	4.16 (2.81)
S ***	6.30 (2.48)	4.88 (2.69)
BC	5.28 (2.94)	5.37 (2.56)
VC	5.82 (2.68)	5.50 (2.67)

Table 7: Means (SDs) in Study 3.

These results are consistent with the picture that knowability is determined directly by methodological factors, and indirectly by intrinsic factors. One concern is that we cannot fully rule out the possibility that relational factors (belief or value centrality) also have an influence on perceived knowability, because merely *describing* a proposition as central would not manipulate that proposition's *actual* centrality relative to one's other beliefs (especially given that these stimuli were artificial). That said, our manipulations *were* strong enough to produce effects of the other factors. In conjunction with the naturalistic (but correlational) results of Experiments 1 and 2, we think it unlikely that centrality plays a key role in perceived knowability for most phenomena.

General Discussion

When is a proposition knowable (even if unknown), or a phenomenon understandable (even if not understood)? Consistent with the idea that people act as intuitive scientists, people adopt some of the same epistemological principles as philosophers and practitioners of science: Propositions are knowable to the extent that they can be reduced to more fundamental facts and to the extent that they are subject to empirical falsification. These methodological factors depend in turn on facts about the intrinsic physics or metaphysics of the underlying phenomena: They are seen as more reducible to the extent that they are material and wider in scope, and as more falsifiable to the extent that they are material and narrower in scope. Although relational factors (centrality to one's beliefs and values) were sometimes associated with knowability (and also with some of the other factors), these associations do not appear to be causal. We nonetheless regard the issue of belief and value centrality (both their causes and their consequences) as an intriguing direction for future work.

We are currently building on these findings in several ways. First, we are expanding on Studies 1 and 2 to test other factors, such as domain (an intrinsic factor), that might be associated with knowability and might also help to explain some of the variance in the other intrinsic and methodological factors. Second, we are expanding on Study 3 to further test the relationships among factors (e.g., the indirect effects via falsifiability and reducibility). Third, we are looking at individual differences that might predict perceptions of knowability (e.g., religiosity, trust in science, and need for cognitive closure). Finally, we are testing real-world applications of these findings, such as ways to frame real phenomena so as to influence their perceived knowability and potential downstream consequences.

References

Burke, N., Johnson, S.G.B., & Keil, F.C. (2016). *Folk reductionism*. Manuscript in preparation.
Carey, S. (1985). *Conceptual change in childhood*. MIT Press.
Chalmers, D. (1996). *The conscious mind*. Oxford University Press.
Dennett, D.C. (1991). *Consciousness explained*. Boston, MA: Little Brown.
Descartes, R. (2013/1641). *Meditations on First Philosophy*. Cambridge University Press.
Gopnik, A. (1998). Explanation as orgasm. *Minds & Machines*, *8*, 101–118.
Gopnik, A., Meltzoff, A.N., & Kuhl, P. (1999). *The scientist in the crib.* New York, NY: HarperCollins.
Johnson, S.G.B., Rajeev-Kumar, G., & Keil, F.C. (2015). *Sense-making under ignorance*. Manuscript under review.
Kant, I. (2002/1785). *Groundwork for the metaphysics of morals*. Yale University Press.
Keil, F.C. (2003). Folkscience: Coarse interpretations of a complex reality. *Trends in Cognitive Sciences*, *7*, 368–373.
Lewis, C.S. (1952). *Mere Christianity*. New York, NY: HarperCollins.
McAdams, D.P. (1993). *The stories we live by*. New York, NY: Guildford Press.
Mill, J.S. (1967/1843). *A system of logic ratiocinative and inductive*. London, UK: Longmans.
Plantinga, A. (1981). Is belief in God properly basic? *Noûs*, *15*, 41–51.
Preston, J., & Epley, N. (2009). Science and God: An automatic opposition between ultimate explanations. *Journal of Experimental Social Psychology*, *45*, 238–241.
Popper, K. (1959/1934). *The logic of scientific discovery*. London, UK: Routledge.
Putnam, H. (1973). Reductionism and the nature of psychology. *Cognition*, *2*, 131–146.
Strevens, M. (2008). *Depth*. Harvard University Press.
White, P.A. (2009). Ideas about causation in philosophy and psychology. *Psychological Bulletin*, *108*, 3–18.