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DISAGREEMENT AND VALUES IN SCIENCE

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1. Introduction

Disputes about the mental capacities of non-human animals are widespread in comparative psychology. Some researchers believe that we should be cautious in ascribing complex mental states to, say, non-human primates. They endorse a methodological tenet known as "Morgan's canon," proposed by ethologist Conwy Lloyd Morgan: "In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale" (Morgan 1894, 53). For example, imagine you see a rhesus macaque hide a piece of food outside another monkey's line of sight. One possible explanation of this behavior is that the first monkey has attributed beliefs and desires to the second, and is trying to prevent him from finding the food. Another is that the monkey has learned through reinforcement that he is rewarded when he stashes food in this particular spot, since it's usually there when he goes back for it. In the absence of further information, Morgan's canon sanctions the latter explanation: we shouldn't appeal to sophisticated cognitive capacities if a simple explanation featuring more basic capacities will account for the behavior.

Other researchers, favoring more liberal mental ascriptions to non-human animals, reject Morgan's canon. They argue that it's extremely *un*parsimonious to deny that non-human primates have complex mental states, since that would imply that there is a large cognitive gap between humans and our closest evolutionary ancestors, making a mystery of the origins of human mental capacities. The simplest explanation of primate behavior may instead be one that reveals continuity between the mental lives of humans and primates. Of course, comparative psychologists have devised increasingly sophisticated paradigms designed to discriminate between possible explanations of animal behavior. To rule out the reinforcement learning explanation above, for instance, they might ensure that different hiding spots are out of sight of the competitor monkey in different trials. At the end of the day, though, researchers are usually left with several possible ways of explaining animal behavior. The explanation they prefer sometimes depends on conflicting judgments about which explanation is simplest.[1]

Simplicity is one of the "epistemic values," a list of criteria taken to be desirable in scientific hypotheses, which also includes things like fruitfulness, explanatory power, and scope. Although most scientists endorse at least some of the epistemic values, they often interpret or weigh them differently. Comparative psychologists, as we've seen, disagree about how to assess the simplicity of competing hypotheses. Some philosophers of science believe that such conflicting epistemic value judgments implicate *non*-epistemic values in science. They might argue, for instance, that comparative psychologists' competing understandings of simplicity are connected to conflicting views about the moral status of animals. Others resist the idea that non-epistemic values are needed to explain or adjudicate epistemic value conflicts. This debate will be my focus in the present chapter. Does the presence of disagreement about epistemic values imply that science is laden with non-epistemic values?

[1] This is an opinionated take on comparative psychology debates. For more on Morgan's canon, see (Karin-D'Arcy 2005, Sober 2015, Fitzpatrick 2017).

I will attempt to answer this question in Sections 6–8, after surveying epistemic values and the disagreements surrounding them in Sections 2–5.

2. Epistemic Values in Science

Thomas Kuhn's (1977) essay, "Objectivity, Value Judgment, and Theory Choice," tries to blunt certain criticisms of his landmark book, *The Structure of Scientific Revolutions*. Kuhn had argued there that scientific theories are incommensurable: there is no common yardstick by which to measure them. Empirical evidence and logic do not compel agreement with one scientific theory or another. Critics contended that this made theory choice irrational. Kuhn's (1977) essay argues that epistemic values (also sometimes called "theoretical virtues") play an important role in scientists' evaluation of competing theories. These values, though not determinative of theory choice, constrain the options and serve as common ground for the scientific community.

Kuhn's discussion of epistemic values focuses on five examples. First, scientists value accuracy (or "empirical adequacy"): a theory should accord with experimental and observational data. Second, a theory ought to contain no contradictions and be compatible with other accepted theories. That is, it ought to be both internally and externally consistent. Third, a theory should have broad scope: it should apply to a range of phenomena, including phenomena it wasn't initially meant to explain. Fourth, it is best if a theory is simple. And finally, we want theories that are fruitful, in that they "disclose new phenomena or previously unnoted relationships among those already known" (*ibid.*, 103). Because scientists seek theories which satisfy these criteria, Kuhn argues, their choices are not arbitrary or unprincipled.

The idea that epistemic values play an important role in science has been discussed by a number of authors since Kuhn (McMullin 1982, 1996; Laudan 1984, 2004; Douglas 2013; Schindler 2018; Mizrahi 2021). To Kuhn's list of empirical adequacy, consistency, scope, simplicity, and fruitfulness, others have added values such as unifying power, predictive ability, reproducibility, internal and external validity, explanatory depth, and precision. Some proposed epistemic values, particularly simplicity, have been challenged (Sober 2015, Baker 2016): should scientists really favor simple theories, or does such a preference boil down to groundless faith that the world is simple? Disputes about which values deserve consideration are also connected to discussion of what makes a value epistemic (Steel 2010). Some have favored a narrow construal of epistemic values, encompassing only those values which are directly truth-conducive or act as minimal requirements on a theory. These authors conceive of cognitive values as a broader class of values that bring more indirect epistemic benefits (Laudan 2004, Douglas 2013).

While early treatments of epistemic values focused on theory appraisal, there is increasing recognition that epistemic values bear on a wide array of scientific choices. For instance, considerations related to simplicity or explanatory power might prompt a modeler to build a model with a particular mathematical form. A researcher's choice of subject population in a randomized clinical trial might reflect a judgment about the relative importance of internal versus external validity. And an experimentalist might decide to test a particular hypothesis out of a suspicion that it could prove fruitful or unifying. As Ernan McMullin (1982) recognized, epistemic value judgment "permeates the work of science as a whole" (18).

3. Sources of Disagreement about Epistemic Values

Kuhn's decision to call the desirable characteristics of scientific theories "values" was a deliberate one. He denied that there is an algorithmic decision procedure for comparing theories. On Kuhn's view, theory choice depends on criteria that "function not as rules, which determine choice, but as values, which influence it" (Kuhn 1977, 111). Epistemic values cannot serve as rules because "individuals may legitimately differ about their application to concrete cases," and because "they repeatedly prove to conflict with one another" (*ibid.,* 103). Adding one further category to Kuhn's analysis, we can attribute endemic disagreement about the application of epistemic values to three sources (Rooney 1992):

(1) *Inclusion*: Which values qualify as genuinely epistemic?
(2) *Weighting*: How should epistemic values be traded off against one another?
(3) *Interpretation*: How should each epistemic value be operationalized?[2]

There can be (and are) reasonable disagreements between scientists about the inclusion, weighting, and interpretation of epistemic values. Take *inclusion:* As mentioned in Section 2, there is a large literature on whether simplicity is an epistemic value. Some think simplicity is valuable for its own sake, others that it is an instrumental good, and still others that it is a red herring. Other values whose status as epistemic is contentious are the feminist values proposed by Helen Longino (1995, 1996). Longino claims that criteria like novelty and ontological heterogeneity have just as much claim to being epistemic as the complementary values of external consistency and simplicity.[3]

Second, there are disagreements about the relative *weighting* of different epistemic values and how they ought to be balanced when they come into conflict. For instance, while some think empirical adequacy is lexically prior to all other epistemic values, others are willing to accept a hypothesis that doesn't accommodate all of the relevant data if it has impressive scope or unifying power. Similarly, modelers often face trade-offs between explanatory power and predictive ability. One modeler might try to maximize predictive accuracy, while another might seek a model that provides an intelligible explanation of the target phenomenon.

Finally, there is often more than one *interpretation* of an epistemic value in a concrete situation. Our comparative psychology case provides a textbook illustration: researchers disagree about which psychological hypotheses are simplest. Some take the attribution of basic mental capacities to be simple, while others see simplicity in the positing of mental continuities between humans and primates. There is a similar flexibility in many other epistemic values, as can be seen in their division into subtypes. In applying the value of empirical adequacy, one may prioritize either qualitative or quantitative agreement with existing data (Kuhn 1977). The fruitfulness of a theory can be understood as its proven fertility, which reflects past successes, or untested fertility, which concerns future potential (Ivani 2019). And one might measure simplicity by how many types of entities a theory posits (ontological parsimony) or the number and complexity of its basic principles (syntactic parsimony; Baker 2016). This multiplicity of ways of operationalizing epistemic values gives rise to disagreement between scientists about which choices best instantiate them.

4. Do Scientists Actually Disagree?

Thus far we have seen three potential sources of disagreement about the application of epistemic values. But I have not yet provided much evidence that such disagreements actually exist in science. Samuel Schindler (forthcoming) has recently suggested that, in fact, there is not as much disagreement as philosophers often assume. Schindler surveyed natural scientists, social scientists, and scholars in history and philosophy of science (HPS) about the relative importance of different

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[2] I distinguish these three sources of disagreement for convenience, not because they are irreducible to one another. For instance, Okasha (2011) suggests that different interpretations of an epistemic value can be treated as independent criteria with separate weights. Moreover, one might exclude a value by assigning it a weight of zero.

[3] Kuhn did not recognize much disagreement about *Inclusion*, as he held that epistemic values are largely shared among scientists at any given time.

epistemic values and about whether possessing those values indicates that a theory is correct. The values he focused on were internal consistency, accuracy, predictive ability, unifying power, simplicity, and external consistency. Among Schindler's many findings was that, in a Condorcet winner analysis, all three groups ranked the epistemic values in a similar way – in roughly the order just listed, although the HPS group ranked simplicity lowest. Schindler claims that his results undermine the Kuhnian view that "theory choice is a very subjective matter and scientists tend to have diverse theory-choice preferences" (*ibid.*, 19). Kuhn's account is "too pessimistic," he argues, because there is broad agreement about the overall ranking of epistemic values (*ibid.*, 19).[4]

Despite these strong claims, Schindler's analyses do not directly bear on Kuhn's claim about epistemic value diversity. Since the statistical tests he performs – mostly T-tests and one-way ANOVAs – are for comparing group means, his analyses only justify claims about agreement *across* the three groups (natural scientists, social scientists, and HPS scholars). But the individual differences *within* each group are what are most relevant to the claim that scientists disagree about the relative weighting of epistemic values. Moreover, there is evidence of substantial individual differences in the figures which convey within-group response information (see Schindler's Figures 2, 4, and 5). For instance, Schindler asked his subjects to rate their agreement with the following statements on a 5-point Likert scale:

"It's acceptable for a theory to be in conflict with some of the relevant data…

(a) ... when a theory unifies phenomena previously thought to be unrelated.
(b) ... when a theory is simple.
(c) It's not acceptable for a theory to be in conflict with any of the relevant data."

The agreement ratings for (c) followed a bimodal distribution: among natural scientists, 48% agreed with the statement, and 44% disagreed; among social scientists, it was 29% and 60%. There was also considerable variability in responses to (a): 50% of natural scientists agreed and 35% disagreed, while 59% of social scientists agreed and 24% disagreed. (Only group means were reported for (b).) These numbers suggest that there is substantial disagreement among scientists about whether empirical adequacy can be traded off against epistemic values like simplicity and unifying power. Schindler's data bear out Kuhn's claim of value diversity rather than undermining it.[5]

A number of historical and contemporary case studies, including the comparative psychology example, also support the claim that scientists frequently disagree about the application of epistemic values. Kuhn (1977) suggests that epistemic values fueled the clash between heliocentrism and geocentrism. External consistency had favored geocentrism, since it fit better with then-current physical theory. But heliocentrism was simpler, in the sense that it required less mathematical apparatus. Kuhn claims that simplicity was important to Kepler and Galileo, implying that their heterodox theoretical views were in part the product of epistemic value commitments. McMullin (1982) offers the debate between Bohr and Einstein about the quantum theory of matter as another example. Einstein saw quantum theory as lacking in simplicity, internal coherence, and external consistency. Bohr conceded that the new theory did not fit with classical physics, but he was impressed by its successful predictions. Predictive success mattered more to Bohr than Einstein; external consistency mattered more to Einstein than Bohr. If McMullin's reconstruction is accurate, disagreement about epistemic values was largely responsible for their heated dispute. As McMullin argues, "[T]here can be no doubt from the abundant testimony of the two physicists themselves that they had very different views as to what constituted a 'good' theory" (1982, 17).

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[4] I should note that, despite this disavowal of Kuhn, earlier in the paper Schindler says, "Kuhn is probably right that there is a lot of diversity of theory-choice preferences in the scientific community" (3).

[5] There is additional evidence of significant intra-group variation in the article's supplementary materials, which can be found online.

Case studies like these show that scientists do indeed disagree about the inclusion, weighting, and interpretation of epistemic values. Nor are such disagreements merely idle disputes: scientists who countenance different values, or who weigh or interpret those values differently, often make different choices in theory acceptance, model building, experimental design, and more (cf. Laudan 1984, Douglas 2013). Although these disagreements were reasonably explicit in the examples discussed, they may not always be so. It is fairly common for scientists not to realize when they are disagreeing or what they are disagreeing about (Weinberger and Bradley 2020). Even a thorough canvassing of overt disputes surrounding epistemic values is therefore likely to underestimate the true extent of epistemic value diversity among scientists.

5. Implications of Epistemic Value Disagreement

Philosophers have historically been interested in what conflicting epistemic value judgments mean for the rationality of science. It is tempting to think that two rational agents with the same evidence must end up in the same epistemic state. When paired with the claim that scientists sometimes accept different theories because of different epistemic value commitments, this view of rationality suggests that science is not rational. Philosophers have rushed to defend the rationality of science from this challenge (Kuhn 1977, Laudan 1984). Bojana Mladenović (2017) argues that Kuhn's strategy is to relocate scientific rationality from the individual to the social level by claiming that "scientific rationality consists in part in the use of scientific values as *reasons* in discussions and deliberations" (110). Disagreement about epistemic values does not threaten scientific rationality so understood.

In a less defensive mode, Kuhn also argues that value diversity enables scientific progress. Determining the true potential of a new theory, he claims, requires researchers to work with it, test it, and fine-tune it. But this initial investigative work will not be undertaken if scientists always agree about the theory that is most promising. Luckily, disagreement about epistemic values prompts some scientists to jump ship and try out new theories, readying them for mass adoption. As Kuhn explains, "what from one point of view may seem the looseness and imperfection of choice criteria conceived as rules may, when the same criteria be seen as values, appear an indispensable means of spreading the risk which the introduction or support of novelty always entails" (Kuhn 1977, 112).

Although scientific rationality and progress were central preoccupations of Kuhn and his contemporaries, my interest is in the connection between epistemic value diversity and recent discussions of *non*-epistemic values in science. It has been suggested that disagreement among scientists about how to apply epistemic values implicates non-epistemic factors in science. The flexibility of epistemic values means that science is value-laden, that is, infused with non-epistemic values including social, political, and moral values. There are at least two versions of this "gap argument" (Intemann 2005), the first weaker than the second. We can call the first "the descriptive gap argument" and the second "the logical gap argument." Let's now take a closer look at each.[6]

6. The Descriptive Gap Argument

The descriptive gap argument holds that, as a matter of psychological or sociological fact, non-epistemic values often lead scientists to apply epistemic values in divergent ways. Disagreement about epistemic values belies non-epistemic influences on the weighting, interpretation, and inclusion of epistemic values. This means that scientific choices are often value-laden, in the sense that they are

[6] There are other arguments in the vicinity of the descriptive and logical gap arguments that I will not address here. See footnotes 8 and 11 for brief discussion of several other related arguments.

causally influenced by the possession of non-epistemic values by scientists or the broader community (Ward 2021). McMullin (1982) endorses the descriptive gap argument, explaining that since epistemic values underdetermine theory choice, "other values *can* and *do* enter in, the sorts of value that sociologists of science have so successfully been drawing to our attention of late… I am thinking of such values as the personal ambition of the scientist, the welfare of the social class to which he or she belongs, and so on" (22). Non-epistemic values shape the application of epistemic ones.

The argument is developed in more detail by Phyllis Rooney (1992), who observes that philosophers of science do not agree about which values are epistemic. She also points out differences in what she calls the "evaluation" and "valuing" of epistemic criteria: disagreements about how epistemic values should be interpreted and weighted. These "openings," according to Rooney, "leave a lot of room for the operation of what are termed 'non-epistemic values'" (*ibid.*, 15). As such, "non-epistemic factors are encoded within the *when* and the *how*" epistemic values are invoked (*ibid.*, 15). For instance, different applications of simplicity and fruitfulness often "embed" non-epistemic features of the social context (*ibid.*, 18). Rooney is particularly interested in how patriarchal and androcentric values shape scientists' deployment of simplicity. Ultimately she argues that this intertwining undermines the very distinction between the epistemic and non-epistemic. However, one need not go that far to grant that science is causally value-laden because social and cultural factors often influence scientists' application of epistemic criteria.[7]

The descriptive gap argument is difficult to deny. It is likely that (at least) some disagreements about epistemic values can be traced back to differences in non-epistemic values. Perhaps the possession of certain non-epistemic values by Bohr or his community contributed to his emphasis on predictive ability in his dispute with Einstein. Perhaps non-epistemic considerations related to institutional affiliation help explain why some comparative psychologists prefer one operationalization of simplicity to another. These particular claims would need to be historically substantiated. But Rooney points out that detailed analyses of such dependencies have been conducted by feminist scholars such as Anne Fausto-Sterling, Donna Haraway, and Evelyn Fox Keller, whose work highlights how sexist values enter in to science via purportedly epistemic routes. Another excellent example of historical scholarship supporting the descriptive gap argument is Daston and Galison's (2007) study of how scientists' understandings of the epistemic value of objectivity have evolved in response to changing moral ideals, social organization, and visualization technologies. Such research establishes that, indeed, non-epistemic values sometimes shape the application of epistemic values in science.[8]

7. The Logical Gap Argument

Occasionally Rooney seems to suggest something stronger than the descriptive gap argument. She argues that "the 'application' of a 'constitutive' criterion in a scientific context *requires* a complex background of languages, practices, and skills, within which all sorts of constitutive-contextual features are already encoded" (Rooney 1992, 19; my italics). Epistemic values must be mediated by

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[7] Rooney declares that she is not making a claim about "some cognitive gap that is left over after accepted epistemic criteria and rules of inference are applied" (Rooney 1992, 15). Non-epistemic factors play a role *in the very application* of epistemic criteria, not afterward. I still call this a "gap" argument because it concerns the lack of precise rules of application for epistemic values.

[8] Daniel Steel (2010) endorses the descriptive gap argument while also explicitly *condoning* the non-epistemic channeling of epistemic values. He claims that if one is deciding between different possible applications of epistemic values, "nonepistemic values can legitimately play a role in deciding which one to select" (Steel 2010, 32). Here, then, is a normative extension of the descriptive gap argument: it is *permissible* for non-epistemic values to shape the application of epistemic ones.

"constitutive-contextual features," which we may call non-epistemic factors. According to this second, "logical gap argument," it is not just that some uses of epistemic values are contingently influenced by non-epistemic ones. Instead, value-ladenness is a logical inevitability.

Paul Hoyningen-Huene (1992) claims that Kuhn intended something like the logical gap argument. Kuhn held that "every individual choice between competing theories depends on a mixture of objective and subjective factors, or of shared and individual criteria" (Kuhn 1977, 106). Hoyningen-Huene takes the objective factors to be cognitive or epistemic values. The subjective factors are what bring a scientist to apply the epistemic values the way he does. Although Kuhn did not call these subjective factors "values," this is what Hoyningen-Huene takes him to mean:

> [I]f the cognitive values do not determine the decision of the scientist, how can he or she ever reach a decision in the situation of theory choice? The answer is that theory choice becomes possible through the influence of *additional* values contributed by the individual scientist which may vary strongly from one member of the community to the next…[A]nalysis of the theory choice of an individual scientist thus results in two kinds of active values: cognitive values to which the whole community is committed, and individual values varying within the community. (Hoyningen-Huene 1992, 493)

According to Hoyningen-Huene, Kuhn claims that non-epistemic values have to fill the gap left by the flexibility of epistemic values. There is no other way for scientists to reach a decision.

The logical gap argument is less persuasive than the descriptive gap argument. Why, a skeptic might ask, *must* it be non-epistemic values that determine how epistemic values are applied? To flesh out this objection, we need to distinguish several ways in which values bear on choices (Ward 2021). I suggested above that the descriptive gap argument deploys a *causal* conception on which a scientific choice is value-laden if it is causally influenced by the possession of values. A second, *motivational* understanding takes values to serve as motivating reasons for which a scientist makes a choice. Value-laden choices in this sense are motivated by non-epistemic values. On a third, *rational* conception, values serve as justifying reasons, making a choice value-laden if it is justified by non-epistemic values.

Are non-epistemic values necessary for the application of epistemic ones, as the logical gap argument claims? It seems to me that the answer is "no" for the causal and motivational conceptions of the relationship between values and choices. Scientists' deployment of epistemic values need not be motivated or caused by non-epistemic values. Consider a researcher who is operationalizing predictive accuracy in order to build a new model. She uses the accuracy metric that is standard in her field, and that all comparable models use. It is not obvious that this modeler *must* have been motivated to interpret predictive accuracy as she did by non-epistemic considerations. Someone might insist that she must have at least been motivated by a value for, say, conformity with her professional community. But even this is not strictly necessary, particularly because the researcher might not have regarded the selection of an accuracy metric as a choice at all. If she did not even consider other possible metrics, it seems like a stretch to say she must have been motivated by a desire to conform. Such scenarios undermine the idea that non-epistemic values always motivate or causally influence an individual's application of epistemic values. Even the fixing of disciplinary conventions surrounding accuracy metrics need not have been caused by something non-epistemic. The standard metric may have been selected accidentally or arbitrarily, or because it served another epistemic goal (see Section 8). Hence, the logical gap argument fails to show that science is necessarily value-laden in either a causal or a motivational sense.

But what of the rational understanding of value-ladenness? A proponent of the logical gap argument might claim that non-epistemic values are nonetheless required to *justify* how one deploys epistemic values. I am again skeptical. Imagine that a comparative psychologist who favors Morgan's canon is asked to justify his understanding of simplicity: why hold that a simple hypothesis is one that ascribes minimal mental capacities to non-human animals? The psychologist might say that this understanding of simplicity has led to predictively successful theories in the past, justifying his interpretation of simplicity by appeal to another epistemic value, predictive accuracy. Alternatively, he might say that he believes humans are cognitively more advanced than non-human species, so it is reasonable to adopt the working assumption that animals have basic cognitive capacities. In this case, his understanding of simplicity is justified by a belief about the world (false though it may be). The researcher could appeal to non-epistemic values to justify his operationalization of simplicity, but he need not: justification can also be found in epistemic values and empirical claims.

8. Scientific Justification and Epistemic Values

This rejection of the logical gap argument finds common cause with Larry Laudan's (1984) "reticulated model" of scientific justification. Laudan's proposal is offered as an alternative to what he calls the received "hierarchical model." The hierarchical model of scientific justification involves three levels. The lowest level is comprised of matters of fact. Disagreements about matters of fact are resolved by appeal to the middle level, which contains methodological rules. When scientists disagree about methodological rules, they justify their preferred rules by appeal to cognitive aims and values, which make up the highest level of the hierarchy.[9] According to the hierarchical model, there is a "unidirectional justificatory ladder…from aims to methods to factual claims" (*ibid.*, 62). This means that scientists who disagree about cognitive aims or values have nowhere to turn: such "axiological disagreements," as Laudan calls them, are irresolvable. Deciding between competing cognitive values is simply a matter of taste. Something like the hierarchical model is implicit in the logical gap argument, which assumes that epistemic values lack justification from within the epistemic realm.[10]

As Laudan persuasively argues, however, the hierarchical model of justification is oversimplified and too pessimistic about the insolubility of axiological disagreements. On his alternative reticulated model, there are a variety of ways to justify cognitive values. Instead of a unidirectional "flow" of justification between the levels of the hierarchy, there is a "complex process of mutual adjustment and mutual justification" among matters of fact, methodological rules, and cognitive values (*ibid.*, 63). His discussion suggests several ways in which particular applications of epistemic values can be justified. For instance, one can justify a certain interpretation of an epistemic value by showing that other interpretations are incoherent or not realizable. Alternatively, if there is agreement among scientists that a particular theory is exemplary, demonstrating that the theory instantiates a certain epistemic value lends support to the prioritization of that value. Yet another approach would be to show that widely endorsed methodological rules conduce to a particular epistemic value. Each of these justificatory strategies is not always available, but the lesson is simply this: it is not the case that epistemic values, sitting at the top of the hierarchy, can only be justified by something extra-scientific. Instead, there is a complicated interplay between levels, such that different

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9 Laudan prefers the term "cognitive values" to "epistemic values" (Laudan 2004), but I use them interchangeably. There is some ambiguity about whether he locates cognitive values at the highest level of the hierarchy only, or whether they also serve as methodological rules in the middle level. As we will see, this question doesn't much matter once we embrace the reticulated model of justification.

10 Laudan (1984) takes Kuhn to be a proponent of the hierarchical model (30-33, 49-50). He reads Kuhn as arguing that there is no way to rationally evaluate a scientist's cognitive aims or values (see Mladenović [2017] for a more sympathetic interpretation). Laudan also argues, contra Kuhn, that most scientific choices are not practically underdetermined. The cases in which "shared [epistemic] criteria are too ambiguous to yield a definitive preference" between theories are "idiosyncratic" (Laudan 1984, 32). This is one respect in which I disagree with Laudan: as argued in Section 4, I think it is not unusual for scientists' epistemic value commitments to lead them to different choices.

ways of deploying epistemic values can be justified by appeal to methods, facts, or other epistemic values.

This reticulated model of justification undercuts the claim that flexibility in epistemic values introduces a justificatory gap that can only be filled by non-epistemic values. It turns out there are a variety of ways to justify the application of epistemic values. Proponents of the logical gap argument have yet to establish that such justifications always bottom out in something non-epistemic. A rational understanding of value-ladenness therefore does not vindicate the logical gap argument as currently proposed. Just as on the motivational and causal conceptions of value-ladenness, the argument fails to show that non-epistemic values are a logically necessary part of science.[11]

9. Conclusion

Kuhn's characterization of epistemic values has proven to be an enduring element of his account of scientific change. This chapter has argued that scientists do indeed apply epistemic values in different ways, shaping their practical choices and theoretical conclusions. Historical case studies and recent survey results reveal that such disagreements encompass the inclusion, weighting, and interpretation of epistemic values. Moreover, these disagreements sometimes stem from divergent non-epistemic values. The descriptive gap argument, in conjunction with detailed historical work, has shown that non-epistemic values often shape the deployment of epistemic ones. However, it is implausible to further suggest, as the logical gap argument does, that epistemic values' flexibility necessitates the involvement of non-epistemic values. The value-laden character of science is not to be established in one fell swoop by pointing to a logical gap which only non-epistemic values can fill, but rather by examining, case-by-case, the factors that influence how scientists apply epistemic criteria.

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[11] Helen Longino is noticeably absent from the argumentative landscape surveyed here. In some of her work, Longino seems to advocate the descriptive gap argument, as when she claims that "the particular weighting and interpretation assigned [epistemic] standards will vary in different social and historical contexts as a function of cognitive and social needs" (1990, 77). Elsewhere she claims that applying epistemic values in different ways *serves* different non-epistemic values. For instance, to support the claim that "certain interpretations of the simplicity criterion are laden with socio-political values," she argues that prioritizing ontological simplicity in economics "props up" oppressive family structures (Longino 1995, 393). Here, Longino seems to adopt yet another conception of value-ladenness: a "value-laden" choice is one that promotes a particular non-epistemic value (Ward 2021). We may call this a fourth, *objectual* conception of how values bear on choices, in recognition of its treatment of values as things in the world that can be promoted. Thus I read Longino (1995, 1996) as making a slightly different argument than those discussed here: science is value-laden in the sense that the application of epistemic values often advances non-epistemic ends.

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