ON VALUE-LADEN SCIENCE

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Philosophical work on values in science is held back by widespread ambiguity about how values bear on scientific choices. Here, I disambiguate several ways in which a choice can be value-laden and show that this disambiguation has the potential to solve and dissolve philosophical problems about values in science. First, I characterize four ways in which values relate to choices: values can motivate, justify, cause, or be impacted by the choices we make. Next, I put my proposed taxonomy to work, using it to clarify one version of the argument from inductive risk. The claim that non-epistemic values *must* play a role in scientific choices that run inductive risk makes most sense as a claim about values being needed to *justify* such choices. The argument from inductive risk is not unique: many philosophical arguments about values in science can be more clearly understood and assessed by paying close attention to how values and choices are related.

KEYWORDS: values; values in science; argument from inductive risk; motivating reasons; justifying reasons

1. Introduction

Understanding the role of values in scientists' choices is a central aim of contemporary philosophy of science. There is consensus that values play an important role in choices about experimental design and project selection. Ethical restrictions on how human and animal subjects are treated are widely accepted, and social values rightfully shape decisions about what research is pursued. Other kinds of value influence are broadly condemned. Wishful thinking, for example, is usually taken to be objectionable: scientists should not choose to accept a hypothesis simply because it would be good if it were true. Despite these areas of agreement, there is disagreement

about the role of values in more "internal" stages of science, including in choices about the characterization of data, acceptance of hypotheses, and presentation of results.[1]

In debates about these disputed areas, what it means for a particular kind of scientific choice to "involve" values or to be "value-laden" is taken to be self-evident. Yet this apparent agreement belies diverse understandings of what values contribute to choice: they "lead" scientists in particular directions; are "embedded" or "encoded" in scientific choices; "contribute to" or "factor into" choices; or can be "invoked" in choice, either "explicitly or implicitly."[2] In my view, the diversity of this terminology is revealing: there are in fact several distinct ways in which values relate to choices, giving rise to different conceptions of what it means for a choice to be value-laden. My aim here is to show that pulling apart these senses of value-ladenness has the potential to reshape discussions about values in science.

In the first half of the paper, I distinguish four ways in which values bear on choices (scientific or otherwise). These fall into two categories: values can provide reasons for choices, or they can stand in causal relationships with choices. In Section 2, I discuss how values can serve as either motivating or justifying reasons. Section 3 characterizes the ways in which values can be causally linked to a choice, roughly as causes or effects. This taxonomy, summarized in Section 4, can be used to advance debates about values in science in at least two ways: by helping identify crosstalk between authors, and by facilitating clearheaded evaluation of philosophical claims. The second half of the paper illustrates this potential. In Sections 5–7, I deploy the taxonomy to advance

[1] In discussing these debates, I'll follow previous work in using "values" to refer to non-epistemic values unless otherwise noted. Many doubt that the distinction between epistemic and non-epistemic values is defensible (Rooney 1992), but for the sake of argument, I assume that some distinction in the vicinity exists.
[2] In order of citation: Schroeder (2017), Elliott (2011), Rolin (1998), Carrier (2013), McKaughan and Elliott (2015), Lacey (2010), Biddle and Kukla (2017).

discussion about one version of the argument from inductive risk. This is just one of the many philosophical problems that the taxonomy has the potential to solve or dissolve.

2. Values Act as Reasons for Choice

Let us now begin to distinguish the several different ways in which values bear on choices. First, it is common for values to provide reasons for choices. In this section, I'll characterize two ways in which values can serve as reasons: they can motivate or justify a choice. Using two brief examples, I'll show that the literature on values in science contains discussion of both relationships between values and choices.

2.1 Values and Reasons

We often think of epistemic and non-epistemic values as giving scientists reasons to choose one option over another. For example, in deciding which theory to accept, a value for explanatory power provides a reason to select the theory that explains the most. When choosing a research project to pursue, a value for social welfare provides a reason to study tuberculosis rather than hair loss. A value for profit, however, provides a reason to study hair loss rather than TB. There is considerable philosophical disagreement about the precise nature of the relationship between values and reasons. Some argue that reasons and values are identical or at least necessarily connected (Bond 1983, Raz 1975/1990). Others believe that reasons are derived from values or that both are derived from natural properties of objects (Dancy 2000, Scanlon 1998). These subtleties do not matter here; all that is required for our purposes is the widely accepted idea that reasons are often rooted in or connected to values. To be non-committal about the exact nature of

this relationship, I will speak of values "providing," "serving as" or "acting as" reasons for choices.[3]

A distinction is commonly drawn by philosophers of action between motivating reasons and justifying reasons for action (Baier 1958, Bond 1974). Reasons seem to play two different roles in practical reasoning: they motivate and they justify. Motivating reasons are "reasons for which a person does something," and as such are tied to the person's "desires, beliefs, and emotions" (Bond 1983, 30). Justifying reasons are "reasons for or against doing a thing" and so are "tied to the world beyond" (*ibid*., 30).[4] For example, consider a politician who votes to expand healthcare benefits for elderly people. His motivating reason is that the expansion will benefit him financially, because he owns a nursing home company. Although his motivations are entirely selfish, there may nevertheless be a justifying reason for his action. We may imagine that his vote is justified by healthcare inequalities and deficiencies in elder care. The motivating and justifying reasons for the politician's action are different (though they may be the same in other cases).

An extension of the distinction between motivating and justifying reasons now suggests itself: values (acting as reasons) may motivate or justify choices. That is, a value can serve as a motivating reason or as a justifying reason for a choice. Discussion of both types of relationships between values and choices can be found in the literature on values in science. I'll now take a closer look at each.

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[3] The idea that values can serve as reasons bears a superficial similarity to Douglas's (2009) distinction between indirect and direct roles for values in science. When values play the direct role, they "act as reasons in themselves to accept a claim," while in the indirect role, they "act to weigh the importance of uncertainty about the claim" (Douglas 2009, 96). Note that Douglas's "direct role" for values is indexed to a particular kind of choice: values can only play a direct role in decisions about hypothesis acceptance. By contrast, the characterization here recognizes that values provide reasons for many different kinds of choices.

[4] Philosophers disagree about whether there are two distinct types of reasons or simply two different things reasons can do (Bond 1974, Dancy 2000, Alvarez 2010). I am sidestepping this debate by adopting the weaker idea that reasons (at least) play different roles in choice (see Section 4).

2.2 Motivating Reasons

Values that serve as motivating reasons for a choice motivate the agent who is making the choice. E.J. Bond (1974) notes that motivating reasons need not be conscious or arrived at through deliberation. We can likewise say that values that serve as motivating reasons need not be explicitly endorsed by the person who holds them. The first way in which a choice may be value-laden, then, is if it is motivated, consciously or unconsciously, by values.

Margaret Morrison is one author who seems to think of values as providing motivating reasons for scientific choices (for other examples, see Section 6.1). In her (2014) "Values and Uncertainty in Simulation Models," she argues that although computational modeling is inevitably shaped by subjective elements, it can and should be insulated from values. Morrison associates subjectivity with between-researcher disagreement and a lack of algorithmic decision-making (Morrison 2014, 941, 948). She insists on the distinction between "the subjective features of…judgements and possible socio-economic or political *motivations*" (*ibid*., 950; my italics). The latter she calls "values." This suggests that Morrison is thinking of values as motivating scientific choices. Further evidence comes from her discussion of the Sleipner accident, which occurred when the gravity base structure of an offshore platform sunk in the North Sea because its walls were too thin. Morrison argues that, although those who designed the platform made poor "subjective" decisions, they did not do so because they were trying to cut costs or minimize construction time. Since there were no values in their "underlying motivation," the design process did not involve values (*ibid*., 949). Morrison's general claim is that even though modeling requires

judgment calls, values need not (and should not) serve as motivating reasons for the choices modelers make.[5]

2.3 Justifying Reasons

A second way in which values can bear on choices is by serving as justifying reasons for those choices, that is, reasons for or against doing something. I take justifying reasons to be *pro tanto* or "contributory" reasons rather than "all-things-considered" reasons, following Dancy (2000) and others. This means that there can be justifying reasons favoring alternative courses of action. For example, a reason to model climate change in one way might be that it is computationally inexpensive. A reason to model it in a different, incompatible way might be that bugs could be easily detected. These are both justifying reasons even though they speak in favor of different choices, one of which may be less justified overall. The same can be said of values that provide justifying reasons for a choice. A value for computational efficiency favors the first climate modeling option even if it is ultimately outweighed by a value for error detection which favors the second. The idea that values can act as justifying reasons gives rise to a second sense of value-ladenness: a choice is value-laden if it is justified by appeal to values.

Several philosophers of science seem to be interested in how values can serve as reasons that justify choices. Eric Winsberg is one example. In part of his (2012) "Values and Uncertainties in the Predictions of Global Climate Models," Winsberg argues that climate modelers have to make "literally thousands" of what he calls "unforced" methodological choices (130). These are modeling choices in which one option is not "objectively better" than the alternatives, so the

[5] Note that this conception of the relationship between values and choices is dissociable from the content of Morrison's claims. Being interested in a particular way that values bear on choices does not commit one to any particular view of values in science.

researcher must exercise her discretion in selecting one (*ibid*., 130). Winsberg argues that unforced choices in climate modeling reflect non-epistemic values:

> [S]uch choices can only be defended against some set of predictive preferences and some balance of inductive risks. In other words, any rational reconstruction of the history of climate science would have to make mention of predictive preferences and inductive risks at pain of making most of these choices seem arbitrary…I do not mean to attribute to the relevant actors these psychological motives, nor any particular specifiable or recoverable set of interests. I am not in the business of making historical, sociological, or psychological claims. (*ibid*., 131)

Winsberg is arguing that the full justification of climate scientists' choices would have to appeal to values. His disavowal of any interest in scientists' motivations, plus his reference to "rational reconstruction," reveal that he is thinking about values in their capacity as justifying reasons. Values must be appealed to, he argues, to tell a story about climate modeling that rationalizes its trajectory. Hence, when Winsberg claims that there is "value-ladenness…in all the nooks and crannies" of climate modeling, he means that a thorough justification of the choices made by modelers would require frequent appeal to values (*ibid*., 132).[6] (I'll return to this argument in Section 6.2.)

Thus far, we have seen two different ways in which values relate to choices, both of which involve values acting as reasons. Although the foregoing characterizations suffice for our purposes, there are open philosophical questions about these relationships. Must values be good values to serve as justifying reasons for a choice? Does a value need to be accessible to the agent in order to provide a justifying reason for her choice? Are motivating reasons just a subset of

[6] Winsberg's mention of "predictive preferences" might seem to indicate that he is thinking of values as motivating scientists' choices, but the rest of the passage makes clear that he doesn't mean scientists' *actual* preferences. He is referencing an earlier argument that modelers often have to choose which variables they want their complex models to predict most accurately (*ibid*., 124). When Winsberg references "predictive preferences," then, he only means that scientists' methodological choices must be defended by appeal to claims about which prediction task is most important.

justifying reasons, or are there values that motivate but do not justify a choice? As these questions touch on deep disagreements about the nature of reasons themselves, I leave them open here.

3. Values are Causally Implicated in Choice

In addition to providing reasons, values may enter into *causal* relationships with choices. Crudely put, values can be causes or effects. More carefully, values can act as causal effectors, bringing about particular choices, or as affected goods, being impacted by choices that are made. In this section, I'll characterize these two causal relationships (and their corresponding notions of value-ladenness) and again illustrate each with an example.

3.1 Causal Effectors

Values are often thought to have causal efficacy: they can bring about certain outcomes. This is shorthand for the idea that the *possession* of values makes a difference to the choices people make. To make such claims is to be interested in values in their capacity as causal effectors. A third way in which a choice can be claimed to be value-laden, then, is if it is causally influenced by someone's possession of a value.

Some authors argue that when values play a role in project selection or experimental design, value influence filters through the rest of the research process, making downstream decisions like hypothesis appraisal value-laden (Elliott and McKaughan 2009, Biddle and Winsberg 2010). These kinds of arguments concern values in their role as causal effector. One example is Robyn Bluhm's (2017) "Inductive Risk and the Role of Values in Clinical Trials." Bluhm discusses three controversies about the design of randomized controlled trials (RCTs): whether studies should be randomized, whether RCTs should be explanatory or pragmatic, and

whether placebo controls should be used. She argues that these three debates have "implications for the relationship between values and evidence" (Bluhm 2017, 208). Bluhm aims to refute Heather Douglas's (2000) claim that values are irrelevant to whether a piece of evidence confirms a hypothesis. She argues,

> [Douglas's] sharp separation between evidence and values does not work. This is because ethical (as well as epistemological) values influence the methods chosen by clinical researchers. In turn, methodological choices shape the data collected and thus the evidence available to confirm (or fail to confirm) the hypotheses being considered…[T]he relationship between evidence and hypothesis is [therefore] influenced by values because the data themselves depend on methodological decisions that are defended on both ethical and epistemological grounds. (*ibid*., 208-9)

On Bluhm's view, decisions about hypothesis acceptance are value-laden because they are based on evidence collected from studies whose design was shaped by values. This argument concerns the causal link between values and scientific choices. Bluhm is pointing out that value-laden scientific choices early on have a causal impact down the road. Since she takes this to undermine Douglas's claim that evidential relevance is value-free, she is interested in a distinctly causal conception of value-ladenness.

One might wonder whether there is a difference between values causally influencing a choice and values motivating a choice. On some accounts of reasons, motivating reasons have causal power and therefore serve as causal effectors as well (Davidson 1963). If this view is correct, any value that serves as a motivating reason for a choice also serves as a causal effector of that choice. However, the converse is not true. A value can causally influence a choice without motivating it, as Bluhm's examples show. Consider a clinical researcher who is motivated by a value for patient welfare to conduct an RCT with an active control rather than a placebo. Her results are affected by this choice: she is less likely to gather evidence of the new treatment's relative effectiveness than if she had used a placebo. Consequently, she is less likely to reject the null hypothesis. Her decision to accept or reject the null is therefore causally influenced by her

possession of a value for patient welfare, even though patient welfare doesn't directly motivate her acceptance or rejection.

It may also be possible for values to exert a causal influence on a choice without playing a motivational role at all. One might argue that this is the best characterization of some of the problematic episodes in twentieth-century science analyzed by feminist philosophers of science. In primatology, for example, the sexist values of primatologists affected how they interpreted primate behaviors, leading them to ignore alternative explanations and not search for evidence contrary to prevailing narratives about sexuality and social organization (Longino 1990, Lloyd 2005). One could argue that primatologists' sexist values exerted this causal influence without directly motivating their individual actions. Consider the fact that researchers observing female primates interpreted the females' sexual behavior through an entirely reproductive lens, and did not entertain alternative frames. They simply *saw* the behavior as playing a role in reproduction. One might think this wasn't a matter of motivation at all. Sexist values may have affected the researchers' observations, but they didn't motivate them to see things in a certain way, consciously or unconsciously. Even though the primatologists would have acted differently had they not possessed sexist values, the values did not serve as motivating reasons for their actions. Whether this reconstruction is plausible depends on how one thinks about motivation (I suspect it may ultimately be untenable). But given that it is an open question whether values can act as causal effectors without serving as motivating reasons, our taxonomy should include both relationships between values and choices.

3.2 Affected Goods

In addition to exerting a causal influence, values may themselves be impacted by choices. This is the second causal relationship between values and choices: values are affected by what we choose. Because of the social authority of science, scientific choices influence a wide range of values, including public health, environmental preservation, and individual and corporate wealth. For some, talking about values in science is a way of talking about these profound impacts. When these authors say that parts of science involve values, they highlight how those parts affect the things we deem important. When they claim that scientific choices promote values, they mean that those choices facilitate the flourishing of certain goods in the world.

This conception of the relationship between values and choices is pervasive but often hidden, appearing mostly in the background of work on values in science. It is visible, however, in Kevin Elliott's (2017) *A Tapestry of Values: An Introduction to Values in Science*. Elliott argues that, in many parts of science, "regardless of the motivations of the scientists, their choices support some social values while weakening others" (Elliott 2017, 13; see also Kitcher 2001, 2011). As an illustration, he discusses the work of Theo Colborn, who pioneered the study of endocrine-disrupting chemicals in her book *Our Stolen Future*. Elliott claims that even if Colborn didn't decide to write *Our Stolen Future* "with the goal of supporting a particular set of values, her choice served the value of promoting public health over alternative values, such as promoting the short-term economic growth of the chemical industry" (Elliott 2017, 12). More generally, Elliott argues that "it is virtually inevitable that [scientists'] standards of evidence will be value-laden, in the sense that they will serve some social values rather than others" (*ibid*., 99). On this fourth (somewhat unorthodox) definition of value-ladenness, then, any action that affects things that are

valued is value-laden. Whenever a scientist's choice promotes some goods over others, even indirectly or unintentionally, values are said to be involved.

One might think that conceiving of value-ladenness in this way is not particularly useful. Michael Scriven (1972) makes the point in a colorful passage: "'Science is not value free,' the radical is fond of saying… True enough, true of scientists, and of science as a social phenomenon. But never denied by the value-free supporter, who was only arguing that the *content* of science is value free, not that its *effect* has no social significance" (246-7). Scriven is right that some polemical claims about values in science turn out to be mundane once we realize that they are about values in their capacity as affected goods. But he is wrong to suggest that all claims about values as affected goods are trivial. Pointing out that specific scientific choices advance specific values can be surprising and consequential. For instance, consider a social scientist who is conducting educational research, the results of which will have an influence on policy. Imagine that if he uses stratified sampling, he is more likely to reach a conclusion that favors school choice; whereas if he uses random sampling, his findings will likely strengthen the case for public education. Since his choice of sampling technique impacts educational equity and child well-being, it is value-laden in Elliott's (2017) sense. There are many other examples of apparently innocent methodological choices that turn out to have significant consequences. Calling attention to these choices is philosophically and practically important.

4. Four Relationships Between Values and Choices

Our taxonomy of the ways in which values bear on choices is summarized in Table 1. Although my focus has been on non-epistemic values in science, note that this taxonomy is fully general: it characterizes four different ways that values (of any kind, epistemic or non-epistemic)

bear on choices (in any domain, even outside of science). I do not claim to have described all of the possible relationships between values and choices. Nevertheless, within the two broad categories, the subdivisions appear to be exhaustive. When values serve as reasons, they either motivate or justify choices. (That is an implication of the dominant view among philosophers of action, anyway.[7]) When values play a causal role, they either influence or are impacted by choices.

One might claim that there are not only several different relationships between values and choices, but several distinct kinds of things we call values. The latter, more metaphysically ambitious view would hold that values are not one sort of entity, but four. This position mirrors a view about the nature of reasons mentioned briefly in Section 2.1. Some authors believe motivating and justifying reasons are metaphysically distinct: they are two "quite different sorts of thing" (Bond 1974, 333). Others argue that there are just two "senses" of reason or two "roles" that reasons play (Baier 1958, Dancy 2000, Alvarez 2010). I have offered a taxonomy that is neutral about the ontology of values because my arguments below only require greater attention to what values *do*, not what they *are*.[8]

Values serve as reasons for making choices.		Values stand in causal relations with choices.	
Motivating Reasons	**Justifying Reasons**	**Causal Effectors**	**Affected Goods**
Values motivate an agent to make a choice.	Values justify a choice.	Values causally impact a choice.	Values are promoted or undermined by a choice.

Table 1. Four ways in which values relate to choices.[9]

[7] One exception is Alvarez (2010), who suggests that there is a third category of explanatory reasons alongside motivating and justifying reasons. She argues that some reasons that explain an action may not motivate it, as in: the reason the tulips died is that the temperature dropped. Such examples strike me as straightforward causal explanations in which talk of reasons shouldn't be taken literally. A value that Alvarez would count as providing an explanatory reason is one that serves as a causal effector on my account.

[8] I thank an anonymous reviewer for encouraging me to pursue the ontologically neutral approach.

[9] The major division in this taxonomy between reasons and causes may call to mind Intemann's (2008) distinction between "treating values as a-rational causal forces that merely influence scientific reasoning" and thinking of values as "operating as reasons themselves" (1071; see also Melo-Martín and Intemann 2016).

This four-fold distinction gives rise to four different senses of value-ladenness: a choice may be said to be value-laden if it (1) is motivated by values; (2) is justified by values; (3) is causally affected by the possession of values; or (4) advances or undermines values. (In discussions of values in science, 'values' here refers to non-epistemic values.) There are open questions about how different senses of value-ladenness are themselves related (see Sections 2.3 and 3.1). If a choice is value-laden in the first sense, for example, it is arguably also value-laden in the third sense (Davidson 1963). Thus, although these understandings of value-ladenness are conceptually distinct, many choices are value-laden in multiple respects.

Equivocation about the relationship between values and choices has led to rampant confusion and misunderstanding in the literature on values in science. Different philosophers implicitly adopt competing conceptions of value-ladenness, and even within a single paper, authors frequently slide between different senses. Crosstalk is the inevitable result. For instance, someone who is thinking of values in their capacity as causal effectors might (correctly) argue that values influenced the decision to accept or reject a particular hypothesis on the grounds that acceptance was made more or less likely by a prior methodological decision shaped by values. Someone thinking about values as motivating reasons might (correctly) deny that values played a role in that very same decision because the scientist was not motivated by values in accepting or rejecting the hypothesis.

Although there are clear similarities between my taxonomy and Intemann's distinction, her narrow concern with underdetermination arguments contrasts with my more general aim of characterizing the different ways values and choices are related. Moreover, I am doubtful that our distinctions overlap exactly given that Intemann also glosses hers in terms of the instrumental versus intrinsic use of values. In addition, Intemann does not subdivide the two categories as I have done here. Hence, even if Intemann is gesturing at the same overarching distinction, the taxonomy in Table 1 provides a more thorough disambiguation.

In what follows, I will zoom in on one discussion that has been significantly clouded by lack of clarity about the role of values in choices: the debate over the argument from inductive risk (AIR). Section 5 introduces what I call the "must" version of AIR, which I abbreviate AIR_m. In Section 6, I show that advocates and opponents of AIR_m frequently think about the relationship between values and choices in different ways. I assess the different possible interpretations of AIR_m in Section 7, suggesting that the argument is really about which scientific choices must be justified and what that justification involves. As such, however, the argument depends on a notion of scientific justification that has yet to be clearly articulated or defended. By reframing the discussion of AIR_m, these remaining sections illustrate the philosophical payoff of using the taxonomy above to clarify and assess claims about values in science.

5. The Argument from Inductive Risk

The phrase "inductive risk," coined by Carl Hempel (1954, 1965), refers to the potential consequences of mistakenly accepting a false claim or rejecting a true one. Richard Rudner (1953) provides the canonical formulation of AIR:

> [S]ince no scientific hypothesis is ever completely verified, in accepting a hypothesis the scientist must make the decision that the evidence is *sufficiently* strong or that the probability is *sufficiently* high to warrant the acceptance of the hypothesis. Obviously our decision regarding the evidence and respecting how strong is 'strong enough', is going to be a function of the *importance*, in the typically ethical sense, of making a mistake in accepting or rejecting the hypothesis.[10] (2)

Adopting a high evidential threshold for acceptance of hypotheses increases the chance of mistakenly rejecting a true hypothesis, while adopting a lower threshold increases the chance of

[10] Rudner is presupposing a certain picture of scientific inference which I'll grant for the sake of argument. There has been considerable discussion, however, about whether Bayesians can escape the argument from inductive risk (Jeffrey 1956, Steel 2015). I will also follow Rudner in treating the acceptance and rejection of a hypothesis as exhaustive options, ignoring the possibility of suspension of judgment (even though, to use the language of hypothesis testing, failing to reject a null hypothesis is not the same as accepting it).

mistakenly accepting a false hypothesis. Scientists must strike a balance between these false negatives and false positives. Rudner's claim is that the tradeoff is shaped by value-laden assessments of the consequences of each type of error. As an example, he compares the hypothesis that a drug is non-toxic with the hypothesis that a batch of belt buckles is not defective. He argues that "we would require a relatively high degree of confirmation" before accepting the former hypothesis because "the consequences of making a mistake here are exceedingly grave by our moral standards" (*ibid*., 2). We need not be as cautious with the latter hypothesis because the consequences of mistaken acceptance are not as serious. Decisions to accept or reject hypotheses like these are said to "run" inductive risk, meaning that potential errors have practical consequences outside of science. Although Rudner does not use the language of epistemic values, recent authors have taken AIR to establish that choices about the acceptance and rejection of scientific hypotheses that run inductive risk involve non-epistemic values.[11]

Rudner's simple formulation belies considerable complexity in AIR, particularly regarding the strength of its conclusion. There are at least four versions of the argument that make different claims.[12] First, there is a version of AIR that is normative: it asserts that values *should* be considered when scientists make decisions about hypothesis acceptance that run inductive risk. Authors who discuss this "should" version of AIR include Heather Douglas (2009) and Daniel Steel (2010). A second, "can" version of AIR claims that values *can* permissibly enter into such choices: scientists have the moral discretion to make use of values or not. This position is not currently represented in the literature. The third version asserts that values *must* (in a non-moral

[11] The Rudnerian argument from inductive risk focuses on hypothesis acceptance. Many philosophers now argue that AIR applies more widely because there is inductive risk throughout the research process (Douglas 2000, 2009). Recent years have seen a backlash to this expanded definition of inductive risk (Biddle 2016, Biddle and Kukla 2017). I will sidestep this debate by focusing on hypothesis acceptance.

[12] Betz (2013), Steel (2016), and others distinguish some but not all of these versions of AIR.

sense) play a role in choices about hypothesis acceptance that run inductive risk. The "must" version of AIR is arguably defended by Richard Rudner (1953) and Justin Biddle and Quill Kukla, writing as Rebecca Kukla (2017). Finally, there is a descriptive, "do" reading of AIR. It says that scientists *do* navigate (or have navigated) inductive risk tradeoffs using values. Kent Staley (2017) develops this kind of argument, presenting evidence that values played a role in physicists' decision to accept the discovery of the Higgs boson.

These four versions of AIR are frequently conflated. Here I am interested in the strongest: the "must" version, which I abbreviate AIR_m. Recent debates about AIR_m have been held back by lack of clarity about what it means for choices that run inductive risk to "involve values." It is only by distinguishing between different ways in which values bear on such choices that we can get a handle on what philosophers mean when they say that values *must* (or conversely, *need not*) enter into science.

6. Advocates and Opponents of AIR_m

Much discussion of AIR_m concerns an objection first raised in Isaac Levi's (1960) response to Rudner (1953). Opponents of AIR_m argue that epistemic values alone suffice to trade off inductive risks, while proponents insist that non-epistemic values need to supplement the epistemic ones. I will now show that the objection to AIR_m focuses on what is required to motivate scientific choices, while the reply is concerned with what it takes to justify them. In this section, I'll present these two interpretations of AIR_m. In the next section, I'll evaluate them.

6.1 Opponents of AIR_m

In Levi's (1960) response to Rudner, he grants that scientists must set "minimum probabilities" for accepting or rejecting hypotheses but argues that these thresholds need not reflect non-epistemic values (347). If they are instead dictated by "'scientific' standards of inference," the value-neutrality of science can be preserved (*ibid*., 356). Several contemporary authors, including Sandra Mitchell (2004), have taken up this objection to AIR_m, arguing that epistemic values alone can be used to trade off potential errors. Mitchell criticizes Douglas' (2000, 2003) claim that policy-relevant science is necessarily shot through with non-epistemic values. She argues that scientists can decide whether to accept causal claims by appeal to a broad set of epistemic values, which includes "variety of evidence, accuracy of measurement, and replication of experimental results… accuracy of prediction, problem-solving ability, simplicity, and scope" (Mitchell 2004, 248-9). Mitchell recognizes that epistemic values might not "*uniquely* determine" whether a scientific claim should be accepted but argues that "nevertheless, if the scientists…make judgments employing only…broadly epistemic or cognitive values, then there is no necessity for values outside this set to enter the process" (*ibid*., 249). Scientists can manage inductive risk in policy-relevant science using only epistemic values.

Stephen John (2015) makes a similar argument in his discussion of the role of values in the work of the Intergovernmental Panel on Climate Change (IPCC). The IPCC has to make decisions about whether or not to include particular pieces of evidence in its periodic Assessment Reports. These decisions are subject to false positives and false negatives, John claims, in the sense that false evidence might be wrongly included or true evidence wrongly excluded. He argues that the IPCC's errors have significant practical consequences, so its decisions about evidence inclusion run inductive risk (cf. Betz 2013). However, John suggests that the IPCC navigates such inductive

risk trade-offs using epistemic values alone. John takes epistemic values to be values about the importance of knowledge. He argues that the IPCC's decisions about evidence inclusion are shaped by a concern for safety in Pritchard's (2005) sense: the IPCC wants to employ a method that ensures that it only makes claims when those claims are true in nearby possible worlds. Safety is an important aspect of knowledge, so the IPCC's decisions about evidence inclusion reflect epistemic values. John's argument entails a rejection of AIR_m even though he does not frame it as such. His claim that the IPCC's error balancing reflects epistemic values amounts to a denial that non-epistemic values are needed to trade off inductive risks.[13]

Mitchell and John's objections to AIR_m are best understood as claims about what it takes to *motivate* scientific choices. This can be seen in Mitchell's assertion that, "it is crucial to keep [epistemic and non-epistemic] values distinct although they may be *embodied in a single individual*," which suggests that values are serving as part of an individual's motivational structure (2004, 251; my italics). Motivating reasons are properly said to belong to an agent whereas justifying reasons can only be acted on or responded to by him. The passage also expresses the worry that different types of values might be confused for one another, a concern that makes most sense in the context of motivation: it can be difficult to tell which of her values motivated a scientist to endorse a certain hypothesis. Furthermore, Mitchell disputes Douglas's (2000, 2003) claim that non-epistemic values were the source of specific historical disagreements among scientists, arguing instead that epistemic values were likely responsible. To think of divergent values as a "source of disagreement" is to think of different values as motivating different people (Mitchell 2004, 248). On the most natural reconstruction of her arguments, then, Mitchell is thinking of

[13] John suggests that he is deploying AIR rather than challenging it. This is because he takes the argument to establish that values *of some kind* must enter into certain scientific choices. Most authors, however, take it to support the involvement of non-epistemic values in particular.

values in their capacity as motivating reasons. John claims that IPCC authors' decisions about evidence inclusion are "guided by" epistemic values, emphasizing that the organization's "inner workings are not themselves based on ethical or political values" (2015, 11). One can read these passages as claiming that the scientists preparing IPCC Assessment Reports have epistemic motivating reasons to include the evidence that they do. John's frequent use of "preference" as a synonym for "value" reinforces this interpretation, since our preferences motivate our decisions. Hence, John too seems most concerned with which values *motivate* the choices of scientists.[14]

On an interpretation that focuses on values' role in motivating scientific choices, AIR_m asserts that non-epistemic values must (in a non-moral sense) motivate scientists who face decisions that run inductive risk. Mitchell and John reject this, arguing that it is possible for scientists' choices to be motivated by epistemic considerations alone.[15]

6.2 Advocates of AIR_m

Advocates of AIR_m deny that epistemic values are sufficient for balancing inductive risks. Their response to Levi-inspired objections is typically that epistemic values do not uniquely determine where to set evidential thresholds. Epistemic values require interpretation and active application (Kuhn 1977, McMullin 1982). Hypotheses do not wear their degree of scope or simplicity on their sleeve, in part because there are different ways of operationalizing them.

[14] As noted in Section 4, authors often switch between different conceptions of the relationship between values and choices within a single paper, so it can be difficult to find one consistent interpretation of a given argument. In arguing that Mitchell and John should be interpreted as making a claim about values in their capacity as motivating reasons, I am merely suggesting that such an interpretation makes sense of the majority of what they say and contributes to the most plausible reading of their arguments.

[15] One can read Mitchell and John as rejecting AIR_m in service of a normative argument: their ultimate aim is to show that researchers *shouldn't* use non-epistemic values to manage inductive risk in policy-relevant science or IPCC Report preparation, respectively. I leave this normative extension to one side, since I am only discussing the "must" version of AIR here, not the "should" version.

Moreover, epistemic values can pull in different directions. For instance, prioritizing fruitfulness sometimes detracts from explanatory power. Scientists using epistemic values therefore have to weigh them against one another. According to some authors (e.g. Rooney 1992), interpreting and trading off epistemic values requires non-epistemic judgment. Because epistemic values do not function as algorithms, they cannot be deployed without non-epistemic values. The same situation arises if, following John (2015), we take epistemic values to be values for knowledge. There are different ways that one can prioritize knowledge and different aspects of knowledge that are in tension with one another (James 1896, Kelly 2013). To put the point in the language John uses, to have knowledge we must seek safety, which requires us to be cautious in believing things. And yet, we must also have true beliefs. But valuing the acquisition of safe beliefs and valuing the acquisition of true beliefs pull in different directions, the latter recommending that we believe claims liberally and the former recommending the opposite.

No matter how we think about epistemic values, then, they often fail to uniquely dictate choices about hypothesis acceptance. Authors who ground their defense of AIR_m in this failure tend to focus on values acting as justifying reasons for such choices. Winsberg (2012), discussed in Section 2.3, is one example. He advances a similar argument with Huebner and Kukla in a (2014) paper on values in collaborative research. Winsberg et al. (2014) discuss "justificatory stories," "rational reconstruction," and "defending" methodological decisions, language that shows the authors' focus on justification rather than motivation (19-20). They argue that "no unforced methodological choices can be defended in a value vacuum. There is no set of shared standards that dictates them" (*ibid*., 20). Unforced choices, which "shared" epistemic criteria cannot justify, "seem completely arbitrary" unless non-epistemic values are invoked to defend them (*ibid*., 20). This emphasis on *defending* scientific choices indicates that Winsberg and

colleagues take AIR_m to establish a necessary role for values in their capacity as justifying reasons in science.

The same can be said of other proponents of the argument. Rudner (1953) claims that "any adequate analysis or (if I may use the term) *rational reconstruction* of the method of science" must involve value judgments (4; my italics). Douglas (2017a) likewise argues that scientists' choices about whether there is sufficient evidence to accept a claim need to involve non-epistemic values to be "nonarbitrary." Instead of appealing to conflict between epistemic values, she claims that epistemic values simply do not speak to the issue of whether "the evidence you have is *strong enough* to make a claim at a particular point in time" (Douglas 2017a, 83). Since epistemic values are not "designed" to address questions about evidential sufficiency, non-epistemic values must be invoked to justify the adoption of a given threshold (*ibid*., 83). Hence, advocates take AIR_m to assert that non-epistemic values must be invoked to justify scientific decisions about the acceptance or rejection of hypotheses that run inductive risk when (or given that) those decisions are not dictated by epistemic values alone.

Opponents and advocates of AIR_m, who seem to be in dialogue with one another, are in fact talking about entirely different arguments. Opponents are rejecting a claim about scientists' motivations, while proponents are endorsing a claim about what it takes to justify scientific choices. This lack of contact is the result of emphasizing different ways in which values bear on choices. By paying closer attention to the relationship between values and choices, we have identified two competing interpretations of AIR_m concerning motivating and justifying reasons. Bond (1974) argues that conflation of motivating and justifying reasons "has led to serious error in ethics and philosophy of action" (333). In light of this ongoing crosstalk about AIR_m, philosophy of science can be added to Bond's list.

7. An Assessment of AIR_m

We have now seen that the taxonomy proposed in Sections 2–4 can help diagnose misunderstandings and communication failures in the literature on values in science. What's more, it can also facilitate more careful evaluation of philosophical claims. Putting aside exegetical issues, we can ask: is AIR_m substantive and persuasive given any of the conceptions of value-ladenness characterized above? I'll argue in this section that the most plausible version of the argument is underdeveloped. The success of AIR_m depends on when and where justification is required in science, a topic that has not yet been directly addressed by either party to the debate.

Both interpretations of AIR_m discussed in the previous section appeal to values in their capacity as reasons. Before assessing these interpretations, it is worth considering why there has been little discussion about AIR_m rooted in either of the two causal relationships between values and choices. In my view, the problem with both causal interpretations is that they trivialize AIR_m. If values are taken to be acting as *causal effectors*, AIR_m asserts that non-epistemic values must causally influence all choices about hypothesis acceptance that run inductive risk. This claim is hard to deny. As we saw in Section 3.1, values causally influence every decision about hypothesis acceptance that is based on evidence from studies whose design was shaped by non-epistemic concerns. Since the design of virtually all research is affected by considerations relating to feasibility, cost, convenience, ethics, and so on, the causal influence of values is felt throughout science. Indeed, assuming the decision to pursue *any* research project is influenced by the possession of values, *every* part of science is causally downstream of values. This understanding of AIR_m is therefore undeniable and hence uninteresting. (This is not to deny that showing *how* the acceptance of a certain hypothesis was causally influenced by specific values can be interesting, a

point made briefly in Section 3.2. The triviality only lies in the general claim that such influences must occur.) An interpretation of AIR_m in terms of values serving as *affected goods* has a similar problem. It claims that hypothesis acceptance decisions that run inductive risk must have consequences for values. This version of AIR_m is basically tautological. Recall that a choice is said to run inductive risk when potential errors have practical consequences outside of science. Any choice that runs inductive risk in this sense necessarily affects goods in the world.

Having dismissed both causal interpretations of AIR_m, let's now return to the two interpretations present in the existing literature. The reading of AIR_m favored by Mitchell and John concerns the *motivating reasons* for scientists' choices. On this interpretation, AIR_m asserts that choices about the acceptance and rejection of hypotheses that run inductive risk must involve non-epistemic values as motivating reasons. Opponents of AIR_m are quite right to reject this claim. Non-epistemic values do not *have to* enter a scientist's motivations no matter what kind of choice she faces. It is possible for a scientist to be entirely motivated by epistemic considerations even if potential errors carry tremendous practical consequences. A scientist can ignore the social and political dimensions of a choice and act on the basis of (her understanding of) epistemic values alone. One could try to deny this possibility by offering something akin to Colombo et al.'s (2016) empirical argument that scientists' moral values are likely to bias their hypothesis appraisal. This does not seem like a promising strategy, however, since one would need to provide empirical evidence that non-epistemic values *must* motivate scientists' choices, not that they usually do.

Hence, the only interpretation of AIR_m that is both substantive and reasonably plausible is (unsurprisingly) the one favored by its proponents, which takes values to be acting as *justifying reasons*. On this reading, AIR_m asserts that decisions about the acceptance and rejection of hypotheses that run inductive risk cannot be justified without non-epistemic values. This

interpretation of the argument is intriguing but currently underdeveloped. Even if we grant that epistemic values must be operationalized and traded off, proponents have not yet established that epistemic values' failure to uniquely justify scientific choices necessitates the involvement of non-epistemic values. First, one might reject the idea that justification of a choice requires that one show that the chosen option is superior to all others. A choice can arguably be justified merely by citing reasons in its favor; one need not establish that the selected option is better than all the alternatives. If this is right, the fact that epistemic values underdetermine choices about hypothesis acceptance does not detract from the justification they provide.

Second, the proposed defense of AIR_m only works if we think about epistemic values as a set. Even when epistemic values taken together do not uniquely determine a scientific choice because they conflict, one interpretation of a single epistemic value might pick out a single option. For example, imagine that a scientist is deciding which of two competing hypotheses to accept. One hypothesis is the simplest and the other is the most fruitful (on some interpretation of simplicity and fruitfulness). Epistemic values as a set do not favor one option over the other, since simplicity and fruitfulness pull in different directions. Single epistemic values, however, do discriminate between the options. Simplicity justifies acceptance of the first hypothesis and fruitfulness justifies acceptance of the second. Since individual epistemic values suffice to justify such choices, non-epistemic values are not needed.

A proponent of AIR_m would likely respond that this only pushes back the need for non-epistemic values, since the prioritization of simplicity over fruitfulness (or vice versa) itself requires justification. But one need not grant this regress. An opponent of AIR_m can argue that interpreting or trading off epistemic values in a particular way does not require justification. Justification of choices arguably has to stop somewhere; why not here? Alternatively, the opponent

could accept that justification is needed but deny that non-epistemic values are the only justifiers. Perhaps other epistemic values, or something besides values entirely, can justify the application and weighing of epistemic values.

These questions reveal that the debate over AIR_m has been taking place on the wrong ground. Advocates and opponents of AIR_m have both failed to recognize that the argument is essentially about when justification is needed in science and what it requires. To resist the replies suggested above, advocates of AIR_m need to provide an independently motivated account of scientific justification. The account must explain which scientific choices have to be justified, and which requests for justification are unreasonable; what sorts of things are potential justifiers for any given choice; and why justifying some decisions requires an appeal to non-epistemic considerations. Opponents of AIR_m, meanwhile, need an account of scientific justification on which epistemic values (or something besides values) can justify choices about hypothesis acceptance even when those choices have practical consequences.

The need for explicit discussion of the nature of scientific justification can be illustrated by returning to Douglas' (2017a) defense of AIR_m. Recall that Douglas argues that epistemic values are not the kinds of things that can justify a judgment that the evidence is sufficient to accept a scientific claim. To believe otherwise is a kind of category mistake, she argues. Scientists' justification of evidential sufficiency judgments therefore requires non-epistemic values. Even granting Douglas' claim about the limits of epistemic values, her argument depends on contentious commitments about justification. First, she assumes that only *values* that can justify judgments of evidential sufficiency. Moving from the in-principle irrelevance of epistemic values to the need for non-epistemic values, as she does, only makes sense if justification requires values. Second, Douglas seems to assume that individual scientists judge whether the evidence is sufficient to

accept a claim. But an objector could deny that scientists themselves make such judgments, perhaps because they only assess whether the evidence meets a conventional threshold for hypothesis acceptance (e.g. $p \leq 0.05$). Douglas briefly considers this objection, citing evidence that different fields employ different statistical significance thresholds. The fact that such diversity exists does not, however, establish that scientists "need" to justify the thresholds they use, nor that the justification must appeal to "external concerns" (Douglas 2017a, 85).

Understanding that AIR_m is about the justification of scientific choices clarifies the terms of debate. It also helpfully recasts the discussion about a different objection to AIR_m raised by Betz (2013, 2017) and Parker (2014). These authors argue that value influence in science can be avoided, or at least minimized, by changing the sorts of hypotheses that scientists accept. By "hedging" hypotheses and making them more coarse-grained, scientists can minimize their exposure to inductive risk, Betz and Parker claim. For instance, although deciding whether to accept a claim such as, "The earth's temperature will rise by 3°C in the next 50 years" requires value-laden error trade-offs, accepting a claim like, "Given assumptions XYZ, it is likely that the earth's temperature will rise between 0.5°C and 7°C in the next 100 years" does not. If scientists weaken their hypotheses such that they become "virtually certain," values need not be involved in hypothesis acceptance, refuting AIR_m (Betz 2013, 218). The understanding of AIR_m proposed here suggests that this objection should be assessed by considering how hedging changes what is needed to justify a claim. Does adding qualifiers and coarse-graining scientific hypotheses shift the bar for justification? If a hedged hypothesis is "virtually certain," can its acceptance be justified by epistemic considerations alone? The success of Betz and Parker's objection hinges on the answers to such questions.

8. A Speculative Diagnosis

The preceding sections sought to make sense of the claim that non-epistemic values *must* (or conversely, *need not*) enter into decisions about hypothesis acceptance that run inductive risk. I argued that the debate over AIR_m has been misdirected: since the most plausible interpretation of the argument concerns values in their capacity as justifying reasons, its fate depends on which scientific choices require justification and what is needed to justify them. Only by turning our attention to these broader issues can we determine whether non-epistemic values are required to justify decisions that run inductive risk. I hope that this discussion has shown the payoff of attending to the distinctions introduced earlier. We can use the taxonomy presented in Sections 2–4 to pinpoint crosstalk between authors (Section 6) and evaluate philosophical arguments (Section 7). The literature on AIR_m is not unique in this respect. For example, I suspect that different conceptions of value-ladenness are partly responsible for the disagreements between Stéphanie Ruphy (2006) and Helen Longino (1990, 2002) about the role of feminist values in science, and between Bluhm (2017) and Douglas (2000) about values' relevance to confirmation relations (see Section 3.1). Almost all work on values in science would benefit enormously from greater clarity about the different ways in which values bear on scientific choices.

I am not the first to discuss ambiguities surrounding the notion of "value-ladenness" in philosophy of science. Scriven (1972) was an early and harsh critic: "If there is one set of arguments worse than those put forward for 'value-free science', it is those put forward against it. Both have one common characteristic, besides a high frequency of invalidity, and that is the failure to make any serious effort at a plausible analysis of the *concept* of 'value judgment'" (219). Ernan McMullin (1982) also acknowledged the polysemy of "value," arguing that it would be unwise to try to find a single notion applicable in all contexts. More recently, Biddle (2013) has argued that

"the terminology of values is, at best, misleading," suggesting that we adopt "contextual factor" instead (125). I disagree with Biddle's recommendation but agree with his diagnosis.[16] The terminology of values should not be abandoned, but we need to be clearer about what values are and how they relate to scientific choices.

How did we end up with so much confusion about value-ladenness in the first place? I suspect the tendency to include an ever-greater variety of topics under the banner of "values in science" is partly to blame. Recent remarks by two prominent contributors to the literature support this speculative diagnosis. Douglas (2017b) argues that before the recent rediscovery of mid-century work on inductive risk, "the role of science in society was not a central topic for philosophers of science" (x). But raising questions about "the saturation of science with values" has "enabled the philosophy of science to address the role of science in society more robustly" (*ibid*., x). Longino (2004) similarly claims that "[m]uch philosophical discussion about the relationship of science to its social contexts is pursued under the rubric of values in science. This functions as a kind of catch-all for the messy and complex world of social relationships as it might bear on the practice of science" (128).

There is a whiff of criticism in Longino's observation, and rightly so. Much philosophical work on science and society has been framed in terms of values, perhaps because we lack the conceptual resources to do otherwise, or perhaps because "values in science" is a well-established topic in the field. This trend has had unfortunate consequences. Shoehorning everything related to science and the social into the literature on values in science has distorted the targets of

[16] Biddle argues that "in many situations, contextual factors that are not accurately described as values will invariably influence theory choice" (*ibid*., 131). For example, having a hangover is a contextual factor that could influence a scientist's appraisal of a theory but is not a value. I agree that contextual factors are a more inclusive category than values but think we should preserve the latter. It is of little doubt that having a hangover is not a legitimate influence on theory choice, but the proper place of non-epistemic values in science is contested.

investigation and hidden the multiplicity of ways in which choices involve values. If this is right, more room needs to be made in philosophy of science for other topics. Discussion about the role of values in science will improve when other work on science, society, and the social can flourish on (and in) its own terms.

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