Values in Science
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Abstract: After describing the origins and nature of the value-free ideal for science, this chapter details three challenges to the ideal: the descriptive challenge (arising from feminist critiques of science, which led to deeper examinations of social structures in science), the boundary challenge (which questioned whether epistemic values can be distinguished from non-epistemic values), and the normative challenge (which questioned the ideal *qua* ideal on the basis of inductive risk and scientific responsibility). The chapter then discusses alternative ideals for values in science, including recent arguments regarding epistemic values, arguments distinguishing direct from indirect roles for values, and arguments calling for more attention to getting the values right. Finally, the chapter turns to the many ways in which values influence science and the importance of getting a richer understanding of the place of science within society in order to address the questions about the place of values in science.

Keywords:
Value-free ideal, epistemic values, cognitive values, inductive risk, direct vs. indirect roles, responsible science, science in society

Introduction

Science takes place in society. Although this might seem obvious, incorporating an understanding of this into philosophy of science has driven dramatic changes in the understanding of values in science in recent years. Seeing science as fully embedded in, and responsible to, the broader society that supports it, the scientific endeavor becomes fully value-laden. This change is not just for the description of science, performed by all-too-human actors who inevitably bring their values with them into their science. The change also applies to science in the ideal. However, the distinctive nature of science must also be described, and protected from abuse or the misuse of values in science. The issues for philosophers thus become: 1) What are the implications of the embedding of science in society? 2) When and how are values legitimate? 3) Which values are legitimate? And 4) What is the ideal for science embedded in society?

The changes which this conceptual shift have wrought take place against the backdrop of the value-free ideal. This chapter will first describe the value-free ideal before moving on to the challenges philosophers have leveled against it. It will then describe the terrain of how to conceive of the role of values in science once the value-free ideal is rejected *qua* ideal. As we will see, challenging questions of the place and role of science in society come to the fore, with important implications for the philosophy of science.

The Value-Free Ideal

The value-free ideal has historical roots stretching back centuries (Proctor 1991), but the contemporary formulation dates from the Cold War era. (Douglas 2009, chap. 3) Precursors to the contemporary value-free ideal, including Max Weber, did not articulate the full-fledged value-free ideal, suggesting instead that values served to helped focus scientists on what was significant, and that science could not proceed without values. (Douglas 2011) That values shape what scientists chose to explore was, and remains, an uncontroversial way in which values influence science. That scientists' interests and concerns help direct scientists' attention in some directions and not others seemed unproblematic, and was never contested by philosophers of science. But by 1950, this was thought to be part of the "logic of discovery" in science rather than the "logic of justification." If values played a role in the logic of justification, the worry was (and remains) that science could be corrupted.

It was not until a debate over the role of values in science erupted in the 1950s that the value-free ideal emerged in its full articulated form. The debate began with the work of C. West Churchman (1948) and Richard Rudner (1953), and their acknowledgement that, in addition to values shaping the direction of research, values were required to set what was thought to be sufficient evidence. Rudner pointedly argued that because science was not a deductive process, and there was always an inductive gap between the evidence and the scientific claims being made ("no scientific hypothesis is ever completely verified"), one had to decide "that the evidence is sufficiently strong or that the probability is sufficiently high to warrant the acceptance of the hypothesis." (Rudner 1953, 2) Making this decision involved considering "the importance, in the typically ethical sense, of making a mistake in accepting or rejecting the hypothesis." (ibid.) This meant that social and ethical values had a legitimate role in deciding whether a scientific claim is sufficiently justified—the determination of sufficient justification can include social and ethical values weighing the importance of a mistake, and whether we have enough evidence to consider such a risk worth worrying about. For example, if we think a false positive type of error is more worrisome, we might demand more evidence. If we think a false negative type of error is more worrisome, we might demand less before finding a claim "sufficiently warranted." Whether one or the other is more worrisome is a value judgment, one that often depends on social and ethical valuations of the consequences of error. What counts as sufficient warrant thus depends on the claim and the context in which it is made, and whether there are serious implications of error in that context.

Such a view brought values, however, into the heart of doing science. And as such, there was substantial resistance to it. Philosophers like Richard Jeffrey and Isaac Levi resisted this line of argument, albeit in different ways. Jeffrey argued that scientists did not need to accept and reject hypotheses; instead he thought they should just assign probabilities to them. (Jeffrey 1956) Rudner had anticipated this approach, however, and had argued that even in assigning probabilities, one needed to decide that the probability was sufficiently warranted. The problem of assessing sufficiency might be mitigated, but it was not eliminated.

Levi took a different tack, arguing that, as a normative matter, scientists should not consider the broader societal implications or the context of their work when assessing scientific claims. Levi suggested that certain "canons of inference" should be used when examining evidence and its relationship to hypotheses, and that such canons were entirely sufficient for addressing the inferential gap that confronted scientists. (Levi 1960) For Levi, such canons demanded a uniform response from scientists when confronting judgments about the strength of evidence.

It was this line of argument that helped to formulate the value-free ideal for science. The canons of inference were to include such considerations as simplicity, scope, and explanatory power, aspects which were soon to be called "epistemic" or "cognitive" values. The value-free ideal was the idea that social and ethical values should influence only the external aspects of science—like which projects were undertaken and which methodologies were thought to be ethically acceptable—but that in the heart of science, at the moment of inference, no social and ethical values were to have any role whatsoever. Rather, only the canons of inference (the epistemic values) should shape scientists' judgments.

It was in Thomas Kuhn's 1977 paper, "Objectivity, Value Judgment, and Theory Choice," that such canons of inference came to be called "values". Kuhn argued that one cannot generate an algorithm or set of rules for scientific theory choice, and that the process of judgment regarding theories is better characterized as a value judgment, informed by the characteristics desired of good scientific theories, characteristics that in Kuhn's view included "accuracy, consistency, scope, simplicity, and fruitfulness." (Kuhn 1977, 322) By establishing a shared set of values used to inform theory choice, science could remain objective even if *some* values were essential to science. In addition, scientists could disagree about which theories to adopt (as historical work showed they did) and still be working within the canons of scientific inference, as some scientists might emphasize particular values over others or have different interpretations of what instantiated the values properly. What made science objective, on this picture, was an adherence to excluding social and ethical values from the inferential aspects of science. It was this sense of which values should be allowed in (the epistemic values only) at the crucial point in science (when making inferences about which theories to accept) that constituted the value-free ideal. (see also McMullin 1983, Laudan 1984)

Challenges to the Value-Free Ideal

The value-free ideal, a somewhat inaccurate label for the epistemic-values-only-in-scientific-inference ideal, has been challenged in a number of ways. I will describe three main approaches to critiquing the ideal: the descriptive challenge, the boundary challenge, and the normative challenge. These are not meant to be fully distinct challenges, but the thrust of each of the three leads in different directions.

The Descriptive Challenge

The first challenge began in the 1980s, as feminist scholars of science noted that science did not appear to be value-free. Although some scientific claims under scrutiny could be shown to be due to poor methodology, others could not. Instead, they appeared to be the result of either a lack of sufficient alternative explanations or theories, or the result of insufficiently examined background assumptions. Feminist philosophers argued that even good science, science thought to be exemplary, appeared value-laden in important ways. (Fausto-Sterling 1985, Harding 1986, 1991, Nelson 1990, Keller & Longino 1996) Their work showed how fields that carefully gathered evidence, that followed the traditional practices of scientific inference, still managed to produce blatantly sexist results. Examples such as early primatology (Haraway 1989), anthropological accounts of human development (Longino 1990), and biological accounts of sperm-egg interactions (Martin 1996) were shot through with sexist presuppositions that blinded scientists to alternative explanations of phenomena and thus led to acceptance of views later shown to be inadequate. The scientists who did such work were (generally) not committing fraud or allowing social values to shape their inferences in obvious ways, but once the science was scrutinized, it seemed anything but value-free.

The problems unearthed by this work showed the pervasive difficulty of eliminating values from the scientific process and the results produced—you could only test whichever theories were available and you could only test them using your background assumptions. What theories you had available and which background assumptions you held often reflected your values. Values could not be removed from science, on this account.

This line of argument is also tied to the understanding of science as underdetermined by the available evidence (in the tradition of Duhem, Neurath, and Quine, see Brown 2013a), particularly transient underdetermination. (Anderson 2004, Biddle 2013) Although all of the evidence may one day be in and make clear what we should think, as actual epistemic actors, we are not in that position. The evidence does not clearly determine which claims are the right ones, nor does it indicate that we have all the plausible options on the table for consideration, nor even whether our background assumptions are adequate. If a surprising result does arise, we don't know precisely where the problem lies. Against this backdrop of uncertainty, we still make judgments about what is scientifically supported. This has been called the "gap argument" for the role of values in science. (Intemann 2005, Elliott 2011a, Brown 2013a)

The recognition of this gap between theory and evidence, and the possibility that it is filled by values, has led many feminists to call for increased diversity in science and better scrutiny of theories within science. If background assumptions used by scientists often "encode social values" (Longino 1990, 216), we need better scientific practices to uncover such encoding and help us generate background assumptions with better values. Such work led philosophers to consider more carefully the social structure of the scientific community and scientific practices, to see if improving those could assist in both ferreting out these problematic values and ensuring better science. Feminist philosophers invigorated the field of social epistemology, which examines more closely the social conditions of knowledge production and what kinds of conditions we should consider good for reliable knowledge production. (Longino 1990, 2002) I will call this the descriptive challenge to the value-free ideal: that science, even science done well, is not value-free, and so the ideal is irrelevant. This approach turns elsewhere, to social structures, for ideals for science.

Helen Longino, for example, has argued for a set of principles that should structure epistemic communities for robust knowledge production. An epistemic community should instantiate public forums for criticism, prima facie equality of intellectual authority, responsiveness to criticism, and shared values in order to be able to produce claims worth calling "knowledge." (Longino 1990, 2002) Miriam Solomon, in contrast, focuses on the range of "decision-vectors" (influences on decisions scientists make) and argues for two principles to guide the distribution of effort within a scientific community: efforts should be distributed equitably (i.e., proportionally) with respect to empirical successes of different theories, and effort should be distributed equally with respect to non-empirical factors (i.e., there should be no clustering of effort in science for purely social or political reasons). (Solomon 2001) Both of these approaches value diversity in science for creating critical pressure on existing scientific approaches and for bringing new ideas into the fore, fostering debate and discussion. (see also Intemann 2009)

This emphasis on the social structures of science produced by the descriptive challenge has illuminated much about science. By examining how scientific communities should be structured, and in particular how such structures would reveal the hidden values embedded in science, social epistemological approaches have much to teach us about values in science. But such approaches on their own are not enough to take down the value-free ideal *qua* ideal, nor enough to replace it. One could still argue that the goal of science should be the removal of values from science, and social approaches help us ferret out those values, thus leaving the ideal intact. If, on the other hand, one embraced rejecting the ideal, the social level norms (about the structure of epistemic communities) do not tell individual actors what counts as a good argument within those communities. Some guidance on the legitimate (and illegitimate) grounds for inference in science is still needed, so that actors can know what is (and what is not) appropriate argumentation. The section on alternative ideals below takes up this challenge.

The Boundary Challenge

In addition to the descriptive challenge, philosophers critiqued the value-free ideal on another front: on the plausibility that a clear distinction between epistemic and non-epistemic values could be made. The value-free ideal, in its post-Levi/Kuhn form, requires a clear distinction between the values that are allowed to influence theory choice (often called epistemic values) and those that are not (the non-epistemic social and ethical values). If this distinction cannot withstand scrutiny, then the value-free ideal collapses.

Several philosophers have challenged the boundary between epistemic and non-epistemic values. Phyllis Rooney, for example, argued that when we examine the epistemic values espoused by scientists at different historical moments, we can often recognize the non-epistemic values influencing what is thought to be purely epistemic. (Rooney 1992) In examining episodes in the history of physics, Rooney finds cultural or religious values shaping supposedly epistemic values as reasons for accepting or rejecting theories.

Longino argued that the selection of epistemic values by Kuhn and others was arbitrary, and indeed that other values could also be argued to be important criteria for theory selection, including ones that seemed opposite to the canonical ones. (Longino 1995, 1996) She proposed that in contrast to the traditional epistemic values of consistency, simplicity, scope, and fruitfulness, equally plausible are such values as novelty, applicability, and ontological heterogeneity, values that arise out of feminist criticisms of science, criticisms which are motivated by a concern for social justice. For example, feminist scientists value novelty in scientific theories because the traditional theories were so often laden with sexism. Feminist scientists also value ontological heterogeneity so that scientists are more likely to recognize the diversity among individuals they are studying. (Longino 1996, 45-47) How the value-free ideal is to be maintained as a coherent ideal when the boundary between epistemic and non-epistemic values appears to be porous is not clear.

Arguments about how to understand the epistemic values in science have become more complex in recent years. As will be discussed below, examinations of the traditional set of epistemic values within a context of rejecting the value-free ideal have opened up new possibilities and insights about epistemic values. It is possible to have differences in purpose and emphasis among values, including among epistemic and non-epistemic values, without having a clear distinction that can bear the weight of the value-free ideal.

The Normative Challenge

The third challenge to the value-free ideal confronts the ideal more directly. Rather than undermine its plausibility or feasibility, this approach argues that the ideal, *qua* ideal, is the wrong ideal for science. This argument draws from the insights of Churchman, Rudner, and even earlier work by William James (Magnus 2013), but provides a stronger articulation of and basis for those insights. I will call this the normative challenge. (This has been called the "error argument." See Elliott 2011a, Brown 2013a.) Because this approach challenges the ideal *qua* ideal, it must replace the value-free ideal with an alternative ideal by which to manage values in science.

There are several conceptual bases that combine in the normative challenge to the value-free ideal. First, as with the descriptive challenge and arguments from underdetermination, the endemic uncertainty in science is central. That we never have conclusive proof for our scientific theories or complete evidence for our hypotheses means that there is always some uncertainty regarding scientific knowledge. (This was also a key premise in Rudner's argument.) It is because of this uncertainty that there is an inductive gap involved in every scientific claim, and an "inductive risk" that accompanies every decision to make that claim—a risk that one makes an inaccurate claim, or fails to make an accurate one. (Hempel 1965)

Second, the epistemic authority of science, and of scientists, in society is acknowledged. Scientists do not just do science for themselves, but also for the broader society that supports scientific research. Scientists are generally granted, and indeed we think they should be granted, a *prima facie* epistemic authority regarding their research areas. As the bearers of our most reliable source of knowledge, scientists should speak and (mostly) expect to be believed. They should also expect their claims about the world to serve as a further basis for decision-making. If one examines the history of science advising, scientists were brought into the heart of government decision-making increasingly throughout the 20th century, across developed democratic countries, albeit through varied institutional mechanisms. (Douglas 2009, chap. 2, Lentsch & Weingart 2009, Lentsch & Weingart 2011) The rise of scientific epistemic authority is both descriptively manifested and to be normatively desired.

This baseline epistemic authority brings with it general responsibilities to be neither reckless nor negligent in one's actions. (Douglas 2003, 2009, chap. 4) Although this a responsibility every person has, scientists must consider in particular the impact of their authoritative statements, and whether they think they have sufficient evidence for their claims. The inductive risk scientists bear when deciding upon a claim must be confronted. To do so requires considering the context(s) in which scientific claims will likely be used, and what the consequences of making an error would be (whether it is a false positive or false negative error). Evidential sufficiency is not set at a fixed level across all possible contexts. (Wilholt 2013, Holter 2014, Miller 2014a) Although good, solid evidence is generally needed to support a scientific claim (a coin toss will not do), how much evidence is enough, what constitutes sufficient evidence, will vary depending on what is at stake. (see also Elliott & Resnik 2014)

For example, if one is testing a new treatment for a disease, the level of evidential sufficiency will vary depending on whether the disease has an alternative, mostly successful treatment or whether there is no existing treatment, as well as on how deadly or harmful the disease is. If the disease is highly fatal and there is no treatment, a lower threshold of evidential sufficiency is often warranted before we claim the treatment has enough evidence to support its implementation. If the disease is mild and/or we have successful treatments, we can legitimately demand a stricter standard of safety and efficacy before releasing it on the market. Even disciplines have different levels of sufficient evidence attached to them. High energy physics, with theories that are far removed from practical application and thus having few impacts of withholding acceptance (low false negative impacts), can demand very high evidential thresholds, to avoid the embarrassment (and potential for wasted effort) of prematurely accepted (and later proven false) claims. (Staley 2014) Other areas of science, both because of the technical difficulties of achieving very high levels of statistical significance, and because the costs of error are more evenly distributed, legitimately accept a lower threshold (often—but not universally—two standard deviations) for evidential sufficiency.

In addition to the flexibility in standards of evidential sufficiency found in scientific practice, the argument from inductive risk also demonstrates the importance of inductive risk at more stages in the research process than the decision of whether the evidence is sufficient to support the conclusions of a research project. Inductive risk also plays an important role earlier in the scientific process, when data must be characterized. Even here scientists can be confronted with ambiguous events that they must decide what to do with. (Miller 2014a) Should they discard them (potentially lowering the power of their study)? Should they characterize them one way or another? Should they give up on the study until a more precise methodology can be found? Each of these choices poses inductive risks for the scientist, a chance that their decision could be the wrong one and thus that they will incur the consequences of error.

For example, Douglas 2000 describes a case of scientists attempting to characterize the changes in rat liver slides. The rats had been dosed with an important environmental contaminant (dioxin) for two years at various levels, and then killed and autopsied. Changes to the livers, and whether the rats' livers exhibited carcinogenic changes, were assessed visually. But some of the slides were interpreted differently by different toxicologists. (Douglas 2000 discusses three different sets of evaluations taking place over 12 years.) There were clear inductive risks to describing a liver slide as having a malignant vs. a benign change, or even no substantial change at all. While one might balk at the need for interpretation of the slides, and the expert disagreement regarding it, doing the study over again and culturing the liver tissues would be prohibitively expensive (costing millions of dollars). Weighing the consequences of error could help scientists decide how much evidence was enough, or how sure they needed to be, to assign any particular characterization.

The value-free ideal is thus too restrictive in excluding values from moments of inference in science. It is also too permissive, in that the epistemic values the value-free ideal allows are given too much free rein. Consider, for example, the epistemic value of simplicity. Should scientists select a theory because it is simple or elegant? Only if the world actually were simple or elegant, which it only sometimes is. Other times it is complex and messy. To allow such a value to play the same role as evidence gives too much weight to such a value, and moves science away from its core empiricism. (Douglas 2009, chap. 5) Because scientists have responsibilities to be neither reckless nor negligent, and thus to consider and weigh the consequences of mistakes, and because scientists always confront inductive risk in doing studies and making claims, the value-free ideal is the wrong ideal. It is also the wrong ideal because it allows epistemic values too much ability to influence science. Taken together, these arguments seem destructive of the value-free ideal *qua* ideal.

Nevertheless, we cannot do without some ideal for values in science. The descriptive challenge and resultant emphasis on social structure in science are insufficient sources of alternative ideals. In addition to norms for social structures, we need norms to address the concern that values could be used in place of evidence. It would be deeply problematic for the epistemic authority of science if we were to decide what best characterizes the rat liver slide is what we would like it to be or we were to decide that a drug is safe and effective (or not) because we would like it to be (or not). In order to understand what is or is not a good use of values in scientific reasoning, we need an alternative ideal for values in science.

Alternative Ideals for Values in Science

There are several contenders for a replacement ideal, once the value-free ideal is set aside. As noted above, allowing any values to play any role whatsoever seems to open the door to wishful thinking and a complete undermining of the value of science to society. What to say in the face of these concerns has brought out a number of distinct arguments. Some of these ideals depend upon rethinking the terrain of values that can influence science, particularly the nature of epistemic values.

Re-thinking Epistemic Values in Science

As noted above, some philosophers have challenged the boundary between epistemic and non-epistemic values as being too porous to support the value-free ideal. But with the value-free ideal set aside, there has been renewed interest in a possible topography of values to articulate a new ideal.

One approach has been to redefine what is meant by epistemic and to acknowledge the context dependence of epistemic values. In his 2010 paper, Daniel Steel argues epistemic values should be defined as those values that "promote the attainment of truth." (Steel 2010, 15) Some of these values Steel suggests are "intrinsic," that is, "manifesting that value constitutes an attainment of or is necessary for truth." (Steel 2010, 15) Examples of such values include empirical adequacy and internal consistency. This is a rather small set of values, as others such as Laudan (2004) and Douglas (2009) (where they are called "epistemic criteria") have noted. Extrinsic epistemic values, on the other hand, "promote the attainment of truth without themselves being indicators or requirements of truth." (Steel 2010, 18) Examples include simplicity, external consistency, testability, and open discourse in science. Whether such values actually promote the attainment of truth will depend upon the context. For example, external consistency promotes truth only when the additional theories one is being consistent with are true. With this account of epistemic values in hand, Steel argues that non-epistemic values are allowable in science only so long as they do not "hinder or obstruct the attainment of truth." (Steel 2010, 25)

Douglas (2013), on the other hand, has articulated a different terrain for the traditional epistemic values. Starting with a core set of values (similar to Steel's intrinsic epistemic values), one can then make further distinctions among the remaining values from the Kuhnian set. For example, one can distinguish between values that are instantiated by the claims or theories on their own and values that are instantiated by a scientific claim and the evidence that supports it. Douglas 2013 notes that conflating these two different ways in which a value is instantiated in science has led to some confusion. For example, simplicity applied to and exemplified in a theory on its own is properly not epistemic, but at best a reflection of the fact that simplicity makes theories easier to work with. (Douglas 2009, 107) On the other hand, simplicity instantiated by a theory in relationship to evidence (e.g., a best fit curve) is in fact a good reason to adopt a theory and is properly epistemic (i.e., indicative of truth). (Forster & Sober 1994, Douglas 2013) With this distinction in hand, one can distinguish between epistemic values (reliable guides for inference) and cognitive values (attributes of theories that make them productive or easier to use). These complexities in the terrain for epistemic values are then reflected in replacement ideals.

Distinguishing Roles for Values in Science

Douglas (2009) both argues against the value-free ideal for science and proposes an alternative ideal to properly constrain values in science. The alternative ideal depends upon a distinction between two kinds of roles for values in science: a direct role and an indirect role. In the direct role, the values serve as reasons in themselves for the choices being made and directly assess those choices. For example, when a scientist decides to pursue a particular project because she is interested in the subject, her interest in the subject is a value judgment that serves in a direct role for the decision to pursue it. She pursues a project *because* of her values. Similarly, when a scientist decides not to use a particular methodology because it would cause extreme suffering in the primates on which he is experimenting, his moral concern for suffering in primates is a value that serves in a direct role in his decision not to use that methodological approach. He decides not to use that method *because* of his values. Douglas (2009) argues that the direct role is acceptable (indeed, often laudable) in deciding which projects to pursue, in making methodological choices, and in deciding what to do with the science produced, i.e., in the "external" phases of science.

This direct role is to be distinguished from an indirect role for values in science. In the indirect role, the values help determine whether the evidence or reasons one has for one's choice are sufficient (sufficiently strong or well supported), but do not contribute to the evidence or reasons themselves. In the indirect role, values assess whether evidence is sufficient, by examining whether the uncertainty remaining is acceptable. A scientist would assess whether a level of uncertainty is acceptable by considering what the possible consequences of error would be (false positives, or false negatives), using values to weigh those consequences. In this way, the indirect role captures the concerns over inductive risk, by using values to weigh the consequences of error in order to assess evidential sufficiency. The values do not contribute to the weight of evidence, as that would be the values serving in a direct role. Douglas 2009 argues that in the "internal" phases of science, in evidence characterization and interpretation, i.e., when scientists decide what to make of the available evidence, (non-epistemic) values should play only an indirect role.

In short, the alternative to the value-free ideal is that (non-epistemic) values should be constrained to the indirect role when scientists are characterizing phenomena and assessing hypotheses with respect to available evidence. If values were allowed to play a direct role, the values would be reasons to accept a hypothesis or to characterize phenomena, and this would shift science away from empiricism. Most problematically, values in a direct role during evidential assessment would be equivalent to allowing wishful thinking into the heart of science. If values could play a direct role in the assessment of evidence, a preference for a particular outcome could act as a reason for that outcome, or for the rejection of a disliked outcome. In the indirect role, acting to assess evidential sufficiency, values do not have such potency.

Kevin Elliott (2011b, 2013) has raised a conceptual challenge for the direct vs. indirect role distinction. He has argued that it is not clear what the distinction refers to, whether it is a distinction about the logical role for values or a distinction about which kinds of consequences are important, intended or unintended. Conceptually, the distinction is first and foremost about the logical role for values in science, in particular about assessing whether evidence is sufficient for a claim (or specific phenomena are sufficiently captured by a description). One relevant consideration for assessing evidential sufficiency is whether the uncertainty regarding the claim is acceptable. In assessing the acceptability of uncertainty, one considers the two directions of error, false positive or false negatives, and the potential consequences of these errors. Values are used to weigh the seriousness of these consequences.

One may wonder, however, what the role is for the epistemic values (as described above—the genuinely epistemic values such as internal consistency, empirical adequacy, or explanatory power of a theory with respect to evidence). These values should be conceived of as part of the epistemic evaluation of science—they help us assess how strong the evidence is in relationship to the claim being made, or whether the claim is even an adequate contender for our consideration. (Douglas 2009, Douglas 2013) As such, they are central to the assessment of *how much* uncertainty we have (and less about the *acceptability* of such uncertainty, where inductive risk considerations arise). They have what Matthew Brown has called "lexical priority," along with the evidence. (Brown 2013a) Once these values have been utilized to assess how much uncertainty we think there is, the other values (social, ethical, *and cognitive*) must compete to help weigh whether the evidence (and its relationship to the theory) is enough. It is here that inductive risk is crucial, that the indirect role is central, and that a direct role is prohibited.

One can ask further, however, whether this distinction between the roles for values in science is useful in assessing what scientists do. Because the distinction between a direct role (the value serves as a reason for a choice) and an indirect role (values are used to assess the sufficiency of evidence) depends upon the reasoning of the scientist, and the actual reasoning is not always transparent—even to the scientists themselves—the distinction may not be helpful in policing acceptable and unacceptable roles for values in science in practice. (Elliott 2011b, Steel & Whyte 2012, Hicks 2014) Daniel Steel & Kyle Powys Whyte have argued that their alternative ideal, that "non-epistemic values should not conflict with epistemic values [both intrinsic and extrinsic, i.e., any value that is truth-promoting] in the design, interpretation, or dissemination of research that is practically and ethically permissible," does better than an ideal that is based on the roles that values play in the reasoning of scientists. (Steel & Whyte 2012, 164) Their essay examines the methodological choices and interpretations of evidence in environmental justice research. (Unfortunately, the test is not as incisive as one could hope for, as both a direct and an indirect role for values are allowable for methodological choices in science—see below.) But in order to apply this ideal, we need to know which extrinsic epistemic values are in play in a given context, which means knowing which ones will promote the attainment of the truth. Depending on where the truth lies, this can change from context to context, and be only apparent in hindsight, well after the dust has settled. (Elliott 2013)

One need not intuit, however, a scientist's reasoning in each particular instance for the role-based ideal to be useful. (No ideal for reasoning can meet such a standard.) Instead, one can look at patterns of argumentation to see whether, for example, scientists respond in appropriate ways to new pieces of evidence. (Douglas 2006) If values serve in an appropriate indirect role, new evidence (particularly evidence that reduces uncertainty) should shift a scientist's claims. If a scientist remains intransigent, either he must espouse particularly strong values (a strong concern for the impacts of a false positive, for example, with no concern for a false negative) or his values are playing an improper direct role. In either case, there are grounds for rejecting that particular scientist's views. If we disagree with their weighing of inductive risk, we should not rely on them. (Douglas 2015) If they are using values in an improper role, we should not rely upon them either. Finally, the purpose of an ideal is as much about guiding our own reasoning as for policing the behavior of others. We need some sense of when and how using values is appropriate in science, without the benefit of hindsight, before we know where the truth lies.

Arguing for the Right Values in Science

Another approach taken to the problem of a replacement ideal has been to argue for scientists adopting the right values. For example, in her book *Philosophy of Science After Feminism*, Janet Kourany argues for an ideal of socially responsible science. (Kourany 2010) In this ideal, science should meet jointly both epistemic and social standards. It is science instantiating the right values that is important to Kourany, whether those values influence the external or internal parts of science. As Kourany argues, the ideal of socially responsible science "maintains that sound social values as well as sound epistemic values must control every aspect of the research process." (Kourany 2013, 93-94) One can view Kourany's position as requiring "the joint necessity of evidence and values." (Brown 2013b, 68) Getting the values right is thus central to having a responsible science. Kourany argues for more intensive discussion both within scientific specialties and with the groups affected by scientific communities for developing the codes that will guide responsible science.

Kevin Elliott (2013) has argued that rather than focus on the different roles that values can play in science, we should focus on the various goals scientists have in addition to epistemic goals, and ensure those goals are both clearly articulated and that the values employed further them (see also Elliott & McKaughan 2014). As he says, "a particular value can appropriately influence a scientist's reasoning in a particular context only to the extent that the value advances the goals that are prioritized in that context." (Elliott 2013, 381) If a scientist prefers a speedy test to an accurate test, then they should make that clear and use the faster test. Such an approach "allows non-epistemic values to count as reasons for accepting a model or hypothesis as long as they promote the goals of the assessment." (Elliott 2013, 381)

Daniel Hicks further argues that "philosophers of science should undertake a deeper engagement with ethics" in order to grapple with a fuller picture of the aims of science and the aims of other endeavors of which science is a part. (Hicks 2014, 3; see also Anderson 2004) Hicks thinks we should analyze whether certain values, particularly non-epistemic values, should have priority in a particular context based on what the constitutive goals are for that context. Thus, in analyzing the machinations of the pharmaceutical industry, Hicks suggests that placing profit motive over good science only appears to make sense for the industry, but in fact it is self-undermining, because the ultimate aim of the industry is not profit but good health. (Hicks 2014) Distorting science is wrong not because of the harm it does to science, or our epistemic enterprise, but because doing so subverts the correct order of values, placing profits over health. It is this sort of analysis that Hicks thinks we can use to assess whether the influence of values is legitimate or not in science—analyzing whether we have the right values prioritized.

Matthew Brown has urged for a return to a more pragmatic image of inquiry (drawn from John Dewey), which considers the incorporation of values in science a necessary and ongoing feature. (Brown 2012) Brown further urges us to be wary of accepting the "lexical priority of evidence," both because evidence may in fact be suspect and because value judgments are often the result of careful inquiry and reflection, even grounded in empirical information, rather than mere subjective preferences. (Brown 2013a, Anderson 2004) Brown urges that we coordinate evidence, values, and theory in our inquiries, and that all must fit together well in a way that "resolves the problem that spurred the inquiry" at the start of the process. (Brown 2013a, 837) Success is defined as resolving the problem that spurred the inquiry, and it assures us that the parts of inquiry have ultimately worked properly.

One might wonder whether these approaches undermine the particular empirical character of science, by suggesting that values can play an even broader array of roles in scientific inference, as long as they are the right values. For example, even with the requirement of joint satisfaction of epistemic and ethical considerations for theory acceptance, we can be faced with situations where the evidence strongly supports a theory we find unwelcome because of our value commitments. Should we reject such a theory solely because it does not live up to our value judgments (as the epistemic reasons for it are strong)? Whether such approaches can avoid the problems of wishful thinking (or excessively motivated reasoning) remains to be seen. Regardless, if one examines the broader set of contexts in which values influence science, getting the values right proves to be paramount.

More Locations for Values in Science

Thus far, we have discussed the value-free ideal, its challengers and contenders for replacements, including further examinations of the nature of epistemic and cognitive values. This debate has focused primarily on the assessment of evidence and the crucial moments of inference in science. But values play a role in science at far more than these "internal" aspects of science. Values also help shape the direction of research, the methodologies pursued, and the ways in which research is disseminated and applied. Whether or not one judges the challenges to the value-free ideal as successful, the debate about values in inference only scratches the surface of the full range of ways in which values influence scientific practice. And this broader array has proven to crucially influence what evidence we have to examine and which theories or hypotheses get pursued. Regardless of the proper place of values in inference, the broader array of locations of values in science deeply shapes what we claim to know. (Okruhlik 1994) Depending on what research we do and how we collect evidence, our inferences will be substantially altered. Considering this broader array raises an interesting set of challenges for philosophers of science. Restricting roles for values across this array is inappropriate—values play both direct and indirect roles legitimately in the locations discussed below. Whether the emphases on diversity arising from the social epistemic approaches to science are sufficient remains an open question.

Values in Research Direction

Values deeply shape which projects scientists pursue. From societal decisions of which projects to fund, to corporate decisions for which projects to pursue (and how to pursue them), to individual decisions for where to place effort, the evidence we eventually have to consider depends upon scientists', institutional, and societal values. The decisions here can be fraught. For example, decisions on whether (and under what conditions) to pursue potentially dangerous research must weigh the potential epistemic and societal benefits of pursuit against the potential societal risks of pursuit. (Such research is often called "dual-use" but sometimes the danger has little to do with intentional uses.) In examples such as "gain-of-function" research on pathogenic viruses, such weighings are fraught and highly charged value-based debates. (Douglas 2014a, 975-977, Casadevall, Howard, & Imperiale 2014, Evans 2014, Lipsitch 2014)

Additional examples of the importance of values (and institutional structures instantiating values) in shaping scientific research agendas are found in the work of Hugh Lacey and Philip Kitcher, among others. Although a staunch proponent of the value-free ideal for scientific inference (for whether to accept or reject scientific theories), Lacey has argued for greater attention to which research projects are taken up, noting that how what looks like a good project can be deeply shaped by (potentially problematic and one-sided) social values. (Lacey 1999, 2005) He has focused in particular on agricultural research, comparing the intensive efforts to create mass-marketed GMOs with more locally based agro-ecology research and finds the imbalance of efforts problematic. Kitcher has elucidated tensions regarding whether some research should be pursued at all, questioning whether democratic societies should support research that seeks to empirically undermine presumptions of shared equality central to democratic systems. (Kitcher 2001) These questions of which knowledge is worth pursuing (as evaluated from within liberal democracies) remain pressing.

Values and Methodological Choices

In addition to which projects to pursue, among the most important decisions a scientist makes concern the methodologies they use. These can be general questions, such as whether to utilize human subjects in a controlled setting or whether to observe humans and attempt to find a naturally occurring control cohort. These can be very specific detailed questions, such as whether to utilize a particular source of information (e.g., death certificates vs. medical records, or census tracts vs. zip codes (see Steel & Whyte 2012)) as being sufficiently appropriate or reliable for a study. At both the specific and general level of questions, values play a vital and potent role.

The importance of values in methodological choices can be readily seen in the ethical prohibitions we have for some options. (Douglas 2014b) Despite the knowledge we might gain, we rightly do not think it acceptable to round people up involuntarily and submit them to various experimental conditions. Regardless of whether we think the conditions might harm or help the people subjected to them, to do so without their informed consent is deeply unethical. This reflects a strongly held (and well justified) concern for human autonomy that the value of knowledge does not trump. Beyond human subject research, ethical considerations have the potential to restrict other areas of research as well, arising, for example, from ethical concern over inflicting unnecessary suffering on animals. What counts as an acceptable or necessary level of suffering is contentious.

The ability of social and ethical values (such as the concern over human autonomy or animal suffering) to restrict the avenues of research open to scientists speaks to the potency of values in methodological choices. Values can legitimately play a powerful and direct role in deciding which research projects can and cannot be pursued. But, at the same time, we do not want social and ethical values to determine the epistemic outcomes of research. We know there are techniques scientists can employ to "game" the research process, skewing results in a particular favor. How should the pervasive, potent, and potentially problematic influence of values here be managed?

This is not merely an academic question. As detailed by Michaels (2008) and McGarity & Wagner (2008), scientists have perfected ways of structuring research projects so that they appear to be an open ended process of inquiry to the casual observer, but in fact are set up to generate a particular result. Torsten Wilholt, for example, describes a case where researchers were ostensibly testing for the estrogenic potential of particular synthetic substances (due to concern over hormone disruption) but ensured a negative outcome to the study by testing the substances on a mouse strain known for estrogen insensitivity. (Wilholt 2009) Other ways of ensuring particular outcomes include using an insufficient exposure or dosage level so that no difference between the dosed and control group appears, doing multiple trials and publishing only the successful ones (an approach trial registries are attempting to thwart), and using inappropriate testing conditions so that results are irrelevant to actual practice. (Wickson 2014)

So, although values can legitimately restrict the methodological choices of scientists, we don't want such values to shape research so that genuine tests are avoided. For this decision context, discussing roles for values is not helpful. What is needed is a clear examination of the values employed, and whether they are the right ones.

If researchers choose to use a non-coercive methodology when working with human subjects for ethical reasons, we should applaud them not because of the role the values are (or are not) playing, but because the researchers are displaying or using the right values. And if researchers deliberately select a research method so that particular desired results are produced (i.e., the results are practically guaranteed by the methods chosen so no genuine test is possible), we should excoriate them not for the role values are playing but for the values on display; in this case, an abuse of the authority of science while giving short shrift to the value of genuine discovery, for whatever other interest or gain is being sought.

Yet there is still difficult conceptual terrain to be explored. As Steel & Whyte (2012) note, it is acceptable for ethical and moral considerations to trump epistemic ones in shaping methodological choices. How extensive are these considerations? How are we to weigh, in cases where the values are contested—e.g., in potentially dangerous research (because the methods are risky to humans or to the environment) or in cases where animal suffering must be inflicted in order to pursue a particular research program—which is more important, the value of the knowledge to be gained or the ethical issues at stake? Values in methodological issues force us to confront these difficult problems.

Values Everywhere Else

Values in inference, in decisions about which projects to pursue, and in decisions about which methodologies to employ do not exhaust the places where values influence science. Consider these additional locations:

• The language we choose to use can embed values in science. Sometimes these choices hinder or hamper the ability of scientists to do good work (as in the case of using the term “rape” to describe duck behavior, Dupré 2007) and sometimes the value-inflected language choice can make research epistemically and socially stronger (as in the decision to call a collection of behaviors “spousal abuse,” Root 2007). This issue does not belong to social science in particular; natural science domains can also have value-inflected language debates. (Elliott 2011a) An analysis of how values embedded in language, or in the “thick concepts” which are often central topics of investigation, should be managed, and with what ideals, remains a challenge. (Alexandrova 2014)

• Values can play an important role in the construction and testing of models. As Biddle & Winsberg (2010) note, models, especially models of great complexity, often have a particular historical development that reflect certain priorities (e.g., scientists want to reflect temperature patterns more than precipitation patterns), which then become embedded in how the models work. These priorities are value judgments, and they are value judgments which subsequently affect how different modules in the models combine and how we estimate uncertainties regarding the models. Winsberg 2012 further argues that we cannot unpack all the value judgments embedded in models, nor can we capture them all in uncertainty estimates, nor can we expect scientists to be fully aware of what they are doing. What this means for the use of models—particularly complex computer models—in scientific assessments of public import remains unclear, except that more work needs to be done. (Parker 2014)

• Values are crucial in deciding how to use and disseminate science. Even if potentially dangerous research is pursued (see above), debates about whether to disseminate the knowledge gleaned are as fraught with value judgments as decisions about whether to pursue that research. Despite a baseline Mertonian norm of openness, some research should potentially be kept confidential. (Douglas 2014a) This can be true because of a desire to avoid weapons proliferation or because of a desire to protect the privacy of individuals involved in the research.

Implications for Science in Society

What is perhaps most interesting about the wide ranging discussion concerning values in science is how important the conceptualization of science and society is for what one thinks the norms should be. The normative challenge to the value-free ideal, that what counts as sufficient evidence could vary by context and the implications of error, is perfectly rational. Indeed, it has been noted by epistemologists such as John Heil (1983) and the burgeoning interest in pragmatic encroachment among epistemologists. (Miller 2014b) If one is to object to a role for values in science, or to the presence of particular values in science, one has to do so on the grounds that the role of science in society makes the presence of values problematic (e.g., Betz 2013). And this is where the debate is properly joined. Given the rationality of, and need for, values in science, how should we conceive of the relationship between science and society? Does the importance of science in society place additional constraints or requirements on the presence of values in science?

The inductive risk argument gains its traction because of the view of responsibilities of scientists articulated in Douglas 2003, 2009. Is this the right view? More specifically, do particular institutional contexts in which scientists operate (e.g., within advising structures, academia, private industry, government science) alter the nature of the role responsibilities scientists have, even in ways that alter their general responsibilities? If institutional demands clash with general moral responsibilities, what should scientists do?

The relationship between science and democratic societies also needs further exploration (following on the work of Brown 2009 & Kitcher 2001, 2011). Should scientists' judgments be free of social and ethical values to preserve democratic ideals (as Betz 2013 has argued), or should they be value explicit (Douglas 2009, Elliott & Resnik 2014) or be embedded in value-laden collaborations to preserve democratic ideals (Douglas 2005, Elliott 2011a)? Stephen John has argued that having varying standards for scientists' assertions depending on the expected audience is an unworkable approach (John 2015), and has argued instead for uniform high evidential standards for the public assertions of scientists. Is this the right standard, or should scientists' assertions be more nuanced, carrying with them clear expressions of why scientists think the evidence is enough, so that audience members can interpret them properly? Would such an approach be more workable than the complex institutional structures John proposes (e.g., distinguishing between public and private assertions, and generating different norms for each, and structuring institutions accordingly)? Further, what is the correct basis for trust in science by the broader society, and what role should values play in science given that basis? (Wilholt 2013, Elliott 2006)

In short, what the values in science debate forces us to confront is the need to theorize—in a grounded way, assessing actual science policy interfaces, actual practices of science communication, and actual research decision contexts—what the proper role of science in society is. It is exactly where philosophy of science should be.

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References

Alexandrova, A. (2014). "Well-being and Philosophy of Science." *Philosophy Compass*, 1-13.

Anderson, E. (2004). "Uses of value judgments in science: A general argument, with lessons from a case study of feminist research on divorce." *Hypatia*, *19*(1), 1-24.

Betz, G. (2013). "In defence of the value free ideal." *European Journal for Philosophy of Science*, *3*(2), 207-220.

Biddle, J. (2013). "State of the field: Transient underdetermination and values in science." *Studies in History and Philosophy of Science Part A*, *44*(1), 124-133.

Biddle, J., & Winsberg, E. (2010). "Value judgements and the estimation of uncertainty in climate modeling." In Magnus, P. D., & Busch, J. (Ed.) *New waves in philosophy of science* (pp.172-197). Palgrave Macmillan.

Brown, M. B. (2009). *Science in democracy: Expertise, institutions, and representation*. Cambridge, MA: MIT Press.

Brown, M. J. (2012). "John Dewey's logic of science." *HOPOS: The Journal of the International Society for the History of Philosophy of Science*, *2*(2), 258-306.

Brown, M. J. (2013a). "Values in science beyond underdetermination and inductive risk." *Philosophy of Science*, *80*(5), 829-839.

Brown, M. J. (2013b). "The source and status of values for socially responsible science." *Philosophical studies*, *163*(1), 67-76.

Casadevall, A., Howard, D., & Imperiale, M. J. (2014). "An epistemological perspective on the value of gain-of-function experiments involving pathogens with pandemic potential." *mBio*, *5*(5), e01875-14.

Churchman, C. W. (1948). "Statistics, pragmatics, induction." *Philosophy of Science*, 249-268.

Douglas, H. (2000). "Inductive risk and values in science." *Philosophy of Science*, 559-579.

Douglas, H. (2003). "The moral responsibilities of scientists (tensions between autonomy and responsibility)." *American Philosophical Quarterly*, 59-68.

Douglas, H. (2005). "Inserting the public into science." In Massen, S. & Weingart, P. *Democratization of Expertise? Exploring novel forms of scientific advice in political decision-making* (pp. 153-169). Dordrecht: Springer.

Douglas, H. (2006). "Bullshit at the interface of science and policy: global warming, toxic substances and other pesky problems." In *Bullshit and Philosophy* (pp. 215-228.), Gary L. Hardcastle and George A. Reisch (eds.), Open Court Press.

Douglas, H. (2009). *Science, policy, and the value-free ideal*. Pittsburgh, PA: University of Pittsburgh Press.

Douglas, H. (2011). "Facts, Values, and Objectivity." *The Sage Handbook of the Philosophy of Social Science*. Sage Publications, 513-529.

Douglas, H. (2013). "The value of cognitive values." *Philosophy of Science*, *80*(5), 796-806.

Douglas, H. (2014a). "The Moral Terrain of Science." *Erkenntnis*, *79*(5), 961-979.

Douglas, H. (2014b). "Values in Social Science." In Cartwright, N. & Montuschi, E *Philosophy of Social Science: A New Introduction* (pp. 162-182) Oxford, UK: Oxford University Press.

Douglas, H. (2015). "Politics and Science Untangling Values, Ideologies, and Reasons." *The ANNALS of the American Academy of Political and Social Science*, *658*(1), 296-306.

Dupré, J. (2007). "Fact and Value." In Kincaid, H., Dupré, J., & Wylie, A. (Ed.), *Value-Free Science?: Ideals and Illusions* (pp. 27-41). Oxford, UK: Oxford University Press.

Elliott, K. C. (2006). "An ethics of expertise based on informed consent." *Science and engineering ethics*, 12(4), 637-661.

Elliott, K.C. (2011a). *Is a Little Pollution Good for You? Incorporating Societal Values in Environmental Research*. New York: Oxford University Press.

Elliott, K. C. (2011b). "Direct and Indirect Roles for Values in Science." *Philosophy of science*, *78*(2), 303-324.

Elliott, K. C. (2013). "Douglas on values: From indirect roles to multiple goals." *Studies in History and Philosophy of Science Part A*, *44*(3), 375-383.

Elliott, K. C., & McKaughan, D. J. (2014). "Nonepistemic values and the multiple goals of science." *Philosophy of Science*, *81*(1), 1-21.

Elliott, K. C., & Resnik, D. B. (2014). "Science, policy, and the transparency of values." *Environmental Health Perspectives*, *122*(7), 647-650.

Evans, N. G. (2014). "Valuing knowledge: a reply to the epistemological perspective on the value of gain-of-function experiments." *mBio*, *5*(5), e01993-14.

Fausto-Sterling, A. (1985). *Myths of gender: Biological theories about women and men*. New York, NY: Basic Books.

Forster, M., & Sober, E. (1994). "How to tell when simpler, more unified, or less ad hoc theories will provide more accurate predictions." *The British Journal for the Philosophy of Science*, *45*(1), 1-35.

Haraway, D. J. (1989). *Primate visions: Gender, race, and nature in the world of modern science*. Routledge: New York and London.

Harding, S. G. (1986). *The science question in feminism*. Ithaca, NY: Cornell University Press.

Harding, S. G. (1991). *Whose science? Whose knowledge?* Ithaca, NY: Cornell University Press.

Heil, J. (1983). "Believing what one ought." *The Journal of Philosophy*, 752-765.

Hempel, C. G. (1965). "Science and Human Values." In *Aspects of Scientific Explanation*. 81-96. New York, NY: The Free Press.

Hicks, D. J. (2014). "A new direction for science and values." *Synthese*, *191*(14), 3271-3295.

Holter, B. (2014). "The Epistemic Significance of Values in Science." Retrieved from the University of Calgary. (http://hdl.handle.net/11023/1317)

Intemann, K. (2005). "Feminism, underdetermination, and values in science." *Philosophy of science*, *72*(5), 1001-1012.

Intemann, K. (2009). "Why diversity matters: Understanding and applying the diversity component of the National Science Foundation's broader impacts criterion." *Social Epistemology*, *23*(3-4), 249-266.

Jeffrey, R. C. (1956). "Valuation and acceptance of scientific hypotheses." *Philosophy of Science*, 237-246.

John, S. (2015). "Inductive risk and the contexts of communication." *Synthese*,*192*(1), 79-96.

Keller, E.F., Longino, H.E. (eds). (1996). *Feminism and Science*. Oxford, UK: Oxford University Press.

Kitcher, P. (2001). *Science, truth, and democracy*. Oxford, UK: Oxford University Press.

Kitcher, P. (2011). *Science in a democratic society*. Amherst, NY: Prometheus Books.

Kourany, J. (2010). *Philosophy of Science After Feminism*. Oxford, UK: Oxford University Press.

Kourany, J. A. (2013). "Meeting the challenges to socially responsible science: reply to Brown, Lacey, and Potter." *Philosophical studies*, *163*(1), 93-103.

Kuhn, T. S. (1977). "Objectivity, value judgment, and theory choice." In *The essential tension*, ed. Thomas Kuhn, 320-339. Chicago, IL: University of Chicago Press.

Lacey, H. (1999). *Is science value free?: values and scientific understanding*. New York, NY: Routledge.

Lacey, H. (2005). *Values and objectivity in science: the current controversy about transgenic crops*. Lanham, MD: Rowman and Littlefield.

Laudan, L. (1984). *Science and values: The aims of science and their role in scientific debate*. Oakland, CA: University of California Press.

Laudan, L. (2004). "The epistemic, the cognitive, and the social." *Science, values, and objectivity*, 14-23.

Lentsch, J., & Weingart, P. (Eds.). (2009). *Scientific advice to policy making: international comparison*. Barbara Budrich.

Lentsch, J., & Weingart, P. (Eds.). (2011). *The politics of scientific advice: Institutional design for quality assurance*. Cambridge, UK: Cambridge University Press.

Levi, I. (1960). "Must the scientist make value judgements?" *Journal of Philosophy*, 57, 345-357.

Lipsitch, M. (2014). "Can limited scientific value of potential pandemic pathogen experiments justify the risks?." *mBio*, *5*(5), e02008-14.

Longino, H. E. (1990). *Science as social knowledge: Values and objectivity in scientific inquiry*. Princeton, NJ:Princeton University Press.

Longino, H. E. (1995). "Gender, politics, and the theoretical virtues." *Synthese*,*104*(3), 383-397.
Longino, H. E. (1996). "Cognitive and non-cognitive values in science: Rethinking the dichotomy." In Nelson, LH. & Nelson, H. *Feminism, science, and the philosophy of science* (pp. 39-58). Dordrecht: Kluwer.

Longino, H. E. (2002). *The fate of knowledge*. Princeton, NJ: Princeton University Press.

Magnus, P. D. (2013). "What scientists know is not a function of what scientists know." *Philosophy of Science*, *80*(5), 840-849.

Martin, E. (1996). "The egg and the sperm: How science has constructed a romance based on stereotypical male-female roles." In Keller, E.F., Longino, H. (Ed.) *Feminism and Science* (pp. 103-117). Oxford, UK: Oxford University Press.

McGarity, T. O., & Wagner, W. E. (2008). *Bending science: How special interests corrupt public health research*. Cambridge, MA: Harvard University Press.

McMullin, E. (1983). "Values in science." In Asquith, P.D., Nickles, T. (Ed.), *PSA: Proceedings of the biennial meeting of the 1982 Philosophy of Science Association vol. 1* (pp. 3-28). East Lansing, MI: Philosophy of Science Association.

Michaels, D. (2008). *Doubt is their product: how industry's assault on science threatens your health*. Oxford, UK: Oxford University Press.

Miller, B. (2014a). "Catching the WAVE: The Weight-Adjusting Account of Values and Evidence. " *Studies in History and Philosophy of Science Part A*, 47, 69-80.

Miller, B. (2014b). "Science, values, and pragmatic encroachment on knowledge." *European Journal for Philosophy of Science*, *4*(2), 253-270.

Nelson, L.H. (1990). *Who knows: From Quine to a Feminist Empiricism*. Philadelphia, PA: Temple University Press.

Okruhlik, K. (1994). “Gender and the biological sciences.” *Canadian Journal of Philosophy*, *24*(sup1), 21-42.

Parker, W. (2014). “Values and uncertainties in climate prediction, revisited.” *Studies in History and Philosophy of Science Part A*, *46*, 24-30.

Proctor, R. (1991). *Valuefree science?: Purity and power in modern knowledge*. Cambridge, UK: Harvard University Press.

Rooney, P. (1992, January). “On values in science: Is the epistemic/non-epistemic distinction useful?.” In *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* (pp. 13-22). Philosophy of Science Association.

Root, M. (2007). “Social Problems.” In Kincaid, H., Dupré, J., & Wylie, A. (Ed.), *Value-Free Science?: Ideals and Illusions* (pp. 42-57).

Rudner, R. (1953). “The scientist *qua* scientist makes value judgments.” *Philosophy of Science*, 1-6.

Staley, K. (2014). “Inductive Risk and the Higgs Boson,” presented at Philosophy of Science Association Meetings, Nov. 2014, Chicago Il.

Steel, D. (2010). “Epistemic Values and the Argument from Inductive Risk.” *Philosophy of science*, *77*(1), 14-34.

Steel, D., & Whyte, K. P. (2012). “Environmental justice, values, and scientific expertise.” *Kennedy Institute of Ethics Journal*, *22*(2), 163-182.

Solomon, M. (2001). *Social empiricism*. Cambridge, MA: MIT press.

Wickson, F. (2014). “Good Science, Bad Researchers and Ugly Politics: Experimenting with a Norwegian Model,” presented at the American Association for the Advancement of Science Annual Meeting, Chicago.

Wilholt, T. (2009). “Bias and values in scientific research.” *Studies in History and Philosophy of Science Part A*, *40*(1), 92-101.

Wilholt, T. (2013). “Epistemic trust in science.” *The British Journal for the Philosophy of Science*, *64*(2), 233-253.

Winsberg, E. (2012). “Values and uncertainties in the predictions of global climate models.” *Kennedy Institute of Ethics Journal*, *22*(2), 111-137.