A FUNCTIONAL APPROACH TO CHARACTERIZE VALUES IN THE CONTEXT OF 'VALUES IN SCIENCE' DEBATES

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ABSTRACT: This paper proposes a functional approach to characterize epistemic and non-epistemic values. The paper argues that epistemic values are *functionally homogeneous* since *(i) they act as criteria to evaluate the epistemic virtues a hypothesis ought to possess, and (ii) they validate scientific knowledge claims objectively.* Conversely, non-epistemic values are *functionally heterogeneous* since they may promote multiple and sometimes conflicting aims in different research contexts. An incentive of espousing the functional approach is that it helps us understand how values can operate in appropriate and inappropriate ways in scientific research and inappropriate influences can eventually be prevented. The idea is to argue that since non-epistemic values are functionally heterogeneous, they cannot provide objective reasons for the acceptance of a hypothesis. However, their involvement is necessary in certain research contexts and the problem is the involvement of these need not be always legitimate. By analyzing a case from chemical research, I demonstrate that how non-epistemic values might influence scientific research and, then, I go on to demonstrate that how a proper understanding of the functions of different kinds of values might promote the attainment of multiple goals of a particular research in a legitimate and socially relevant way.

KEYWORDS: science and values, functional approach, non-epistemic values, inductive risk

1. Introduction

At present, there are multiple debates about values and science. One such debate is whether values or norms should have any role in theory choice in science. The second debate is that, if we admit values, which values we should admit in the choice of a hypothesis? In other words, which values may influence science and how their influences can be evaluated.[1] This paper discusses the second debate in a detailed way.

[1] Matthew J. Brown, "Values in Science beyond Underdetermination and Inductive Risk, *Philosophy of Science* 80, 5 (2013): 829-839, Joby Varghese, "Influence and prioritization of non-

One way of drawing the dividing line between admissible values and inadmissible values in science is to characterize the admissible values as "epistemic" and the inadmissible values as "non-epistemic." But many have argued that it is difficult, perhaps impossible, to draw a principled line between epistemic and non-epistemic values.[2] This paper attempts to resolve the problem of epistemic/non-epistemic distinction by adopting a characterization grounded on the functions of various values. The paper also employs a functional approach to characterize epistemic and non-epistemic values because, at the end of the day, the ultimate goal of this distinction, from a pragmatic point of view, is to carefully avoid sneaking of illegitimate influences of values into scientific research which may bring unsolicited epistemic and non-epistemic ramifications.

This paper proposes and defends a characterization of both epistemic and non-epistemic values in terms of their functions. In section 2, I briefly analyze the questions concerning the nature of epistemic values. In section 3, I characterize epistemic values as functionally homogeneous. I demonstrate that the functional homogeneity of epistemic values can be depicted in twofold ways; *(i) they act as criteria to evaluate the epistemic virtues a hypothesis ought to possess, and (ii) they validate scientific knowledge claims objectively.* Section 4 discusses the characterization of non-epistemic values. These values are characterized as functionally heterogeneous because these values may promote multiple and even conflicting functions. I argue that a proper assessment of this heterogeneity is necessary to understand how values can operate inappropriate and appropriate ways. The reason for adopting the functional approach to characterize epistemic and non-epistemic values is that a large section of the ongoing debates on science and values is concerned with distinguishing the legitimate[3] and illegitimate influence[4] of non-

epistemic values in clinical trial designs: a study of Ebola ça Suffit trial," *Synthese* (2018): 1-17, Joby Varghese, "Philosophical import of non-epistemic values in clinical trials and data interpretation," *History and philosophy of the life sciences* 41, 2 (2019): 14, https://doi.org/10.1007/s40656-019-0251-4

[2] Phyllis Rooney, "On Values in Science: Is the Epistemic/Non-Epistemic Distinction Useful?" in *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, Vol. 1 (Chicago: University of Chicago Press, 1992), 13-22, Phyllis Rooney, "The Borderlands Between Epistemic and Non-Epistemic Values," in *Current Controversies in Values and Science*, eds. Kevin C. Elliott and Daniel Steel (London: Routledge, 2017), 31-45.

[3] A legitimate influence is that which promotes the attainment of the goals of a scientific research in a scientifically better and socially relevant way.

[4] An illegitimate influence of values in scientific research might obstruct the attainment of the goals the research and it might also cause the production of a biased research outcome.

epistemic values when their influence is necessary[5] in certain scientific research contexts. In fact, the illegitimate influence of values always stems from the employment of certain values in different phases of scientific research when it is necessary.

Looming over the discussion about values is a discussion of what science is. We have two main theories: *the picture theory* which puts forth the view that science presents pictures of the world[6] and *the problem theory* which says that science is a problem-solving activity.[7] The picture theory has a low view of non-epistemic values, and consigns non-epistemic values to the dustbin labelled "logic of discovery." The problem theory is more accommodating towards non-epistemic values and rejects the distinction between the logic of discovery and the logic of justification. In sub-section 4.1, by analyzing a case from chemical research, I show that how non-epistemic values might influence scientific research. Then, I go on to demonstrate how a proper understanding of the functions of different values might promote the attainment of multiple goals of a particular research in a legitimate and socially relevant way. On top of that, an advantage of adopting functional approach is that the aims approach, which is generally used to distinguish the legitimate and illegitimate influence of non-epistemic values, can be further strengthened.[8]

2. Questions Regarding the Nature and Characterization of Values

The discussion on the concepts of epistemic and non-epistemic values and their distinction is a significant part of the present debates on science and values. In the subsequent sections, I will quickly brush through these concepts. The term

5 Necessary involvement of values includes such scenarios where the problem of underdetermination and the problem of inductive risk arise. Policy related and socially relevant scientific research might also require necessary involvement of values in different stages of the research.

6 Bas van Fraassen, *Scientific Representation: Paradoxes of Perspective* (Oxford: Oxford University Press, 2008), 269-288, Ludwig Wittgenstein, *Tractatus Logico Philosophicus: Logical-Philosophical Treatise* (The Edinburgh Press, 1922), 25-30, Bertrand Russell, *The Philosophy of Logical Atomism* (London: Routledge, 2009), 110-125.

7 Kenneth F. Schaffner, *Discovery and Explanation in Biology and Medicine* (Chicago: University of Chicago Press, 1993), Larry Laudan, "Why Was the Logic of Discovery Abandoned?" in *Scientific Discovery, Logic and Rationality*, ed. Thomas Nickles (Dordrecht: Reidel, 1980), 173–183.

8 Daniel J. Hicks, "A new direction for science and values," *Synthese* 191, 14 (2014): 3271-3295, Kristen Intemann, "Distinguishing between legitimate and illegitimate values in climate modeling," *European Journal for Philosophy of Science* 5, 2 (2015): 217-232, Varghese, "Influence and prioritization," 1-17.

"epistemic value" has been characterized in various ways according to the questions posed against such values. There are three general questions one might ask about epistemic values.

> (I) What does it mean to say X is an epistemic value, for example, what makes something an epistemic value versus some other kind of value?
>
> (II) Which particular values are epistemic values; for instance, are values such as simplicity, novelty, and ontological heterogeneity epistemic values?
>
> (III) What role should epistemic values play in guiding a theory or a hypothesis choice?

Before we critically examine these questions, a clarification on a general point is worth noting in the context of this paper. Although 'epistemic' and 'non-epistemic' are technical terms and technical terms must have their definitions stipulated, the current debates in values in science have been more concerned with the functions of these values rather than defining them. Moreover, an important debate on science and values is concerned with the question: how to distinguish the legitimate influence of values from possible illegitimate influences and prevent such illegitimate influences? So, this paper does not seek to furnish any kind of definition of these values; rather, the attempt is to highlight the functions of these values and characterize them by invoking the functional approach. Holding this view in mind, let us resume the discussion concerning the general questions regarding epistemic values.

Although the above-given questions are posed separately, they are interrelated. The relation is that they give rise to different points of agreement and disagreement among philosophers who have tried to address these issues. The first question is concerned with defining what an epistemic value is. While responding to the first question, some have argued that epistemic values are truth-conducive.[9] They propose the view that epistemic values should be acknowledged on the grounds that they are capable of promoting the attainment of truth. On the other hand, there are others who have argued that epistemic values must only advance certain scientific aims which might also include other cognitive goals besides truth. This has also led to different terminology being used in the literature, such as

[9] Ernan McMullin, "Values in Science," in *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association – Symposia and Invited Papers*, eds. Peter D. Asquith and Thomas Nickles (Chicago: University of Chicago Press, 1983), 3–28, Daniel Steel, "Epistemic Values and the Argument from Inductive Risk," *Philosophy of Science* 77, 1 (2010): 14-34.

cognitive values vs epistemic values,[10] which is a lengthy debate, which I am not going to take up in this paper.

The second question is an extension of the first question which is concerned with defining epistemic values. Moving on to the second question, we might find that even among those who agree with what it is to be an epistemic value, there are debates about which particular values might fit that criterion. Popper argues that a high degree of falsifiability must be considered as an epistemic value.[11] Bas van Fraassen suggests that simplicity or explanatory scope should not be termed as epistemic values and the only value he seems to be admitting is empirical adequacy.[12] Hilary Putnam, on the other hand, argues that the list of cognitive values ought to include instrumental efficacy.[13] Then, there are others who argue that a clear-cut epistemic non-epistemic distinction is not possible.[14] They advocate the view that values such as simplicity which often falls into the category of epistemic values may also incorporate non-epistemic concerns. On a similar vein, Longino also puts forth the claim that novelty, applicability, and ontological heterogeneity might very well operate in the same way as certain alternative constitutive values function.[15] Interestingly, the list of accepted epistemic or constitutive values might vary in accordance with the person's commitment to a particular school of thought.

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[10] Larry Laudan, "The Epistemic, the Cognitive, and the Social," in *Science Values and Objectivity*, eds. Peter Machamer and Gereon Wolters (Pittsburgh: University of Pittsburgh Press, 2004), 14-23, Heather Douglas, *Science, Policy, and the Value-Free Ideal* (Pittsburgh: University of Pittsburgh Press, 2009), 87-114.

[11] Karl R. Popper, *The Logic of Scientific Discovery* (London and New York: Routledge, 1959), 57-73. Falsification, according to Popper, is an epistemic value and he argues that what is unfalsifiable is unscientific and what is falsifiable is scientific. A falsifiable theory or hypothesis is that which can be put to test by which the hypothesis could conceivably be refuted.

[12] Van Fraassen, *The Scientific Image* (Oxford: Oxford University Press, 1980), 41-68. According to van Fraassen, a theory is empirically adequate if the observable phenomena are "embedded" in the theory. All actual observable phenomena are relevant to a theory's empirical adequacy. In order to be empirically adequate, a theory should be able to accommodate more than just the phenomena which have been actually observed but the phenomena that will be observed.

[13] Hilary Putnam, *Reason, Truth and History* (Cambridge: Cambridge University Press, 1981), 136-37. Putnam argues that cognitive values of coherence, simplicity, and instrumental efficacy are entirely arbitrary but a part of our idea of human cognitive flourishing, and hence is part of our idea of total human flourishing, of Eudemonia.

[14] Rooney, "On Values in Science," 13-22, Rooney, "The Borderlands," 31-45, Steel, "Epistemic Values," 14-34,

[15] Helen E. Longino, "Cognitive and Non-Cognitive Values in Science: Rethinking the Dichotomy," in *Feminism, Science, and the Philosophy of Science*, eds. Lynn Hankinson Nelson and Jack Nelson (Dordrecht: Kluwer, 1996), 39-58.

It is the third question I am more concerned with for the present purpose of the paper, i.e., the functions different values ought to play in the evaluation of a hypothesis. In what follows, I offer a detailed characterization of both epistemic and non-epistemic values.

3. The Functional Approach

The question regarding the appropriate and inappropriate influences of values is set in the background assumption that values perform diverse roles and their employment might promote multiple and sometimes conflicting research aims. Apparently, the origin of the illegitimate or inappropriate influence of values in science lies in the adoption of such values which are not consistent with the pre-specified primary or secondary aims of a particular scientific research. So, it is important to analyze how different values play different functions in science regardless of the different phases[16] of scientific research. Once we are in a position to understand how their functions vary according to the research context, it might be an undemanding task to prevent the illegitimate influence of certain values in certain research contexts. In the following sub-sections, I develop the Functional Approach Principle (FAP).

FAP states:

> Different values promote multiple and even conflicting goals in a particular research context. The involvement and the functions of both epistemic and non-epistemic values are legitimate in a scientific research context if and only if the functions each particular value performs during the evaluation of a scientific hypothesis are consistent with the pre-specified aims of the research.

The notion of consistency in the context of our discussion does not refer to logical consistency. On the other hand, it refers to the compatibility between some values and certain pre-specified aims of a particular scientific research. A value is consistent with the pre-specified aims of the research if and only if that value, in no way, obstructs the attainments of the aims of the research. Nonetheless, certain values are consistent with the pre-specified aims of the research to a certain extent and once their influences exceed their limit, they might obstruct the attainment of the pre-specified aims. In other words, if the influence of a particular value goes beyond its limited role, at that point of time that particular value becomes inconsistent with the pre-specified aims of the research and the influence of that value in that

[16] Different phases of scientific research are (i) the pre-epistemic phase, (ii) the epistemic phase, and (iii) the post epistemic phase. However, there are still debates going on regarding whether it is possible to make a clear cut distinction among these phases.

particular research context becomes illegitimate. However, the question which remains is that how we can know whether the values to be employed are consistent with the pre-specified aims of the research and, if at all they are consistent, in which cases they cease to be inconsistent. In order to address this question, I endorse the aims approach which, in simple terms, states that that the choice of values must be made in such way that the chosen values may *promote* the attainment of pre-specified research goals.[17] On the other hand, the functional approach states that the chosen values must be *consistent* with the pre-specified aims of the research. The starting point of the functional approach is the assumption that science often strives to achieve multiple goals and the aims approach also assumes the same. In the following sections, I offer a detailed account of homogeneous/heterogeneous characterization of values and defend the scope of this characterization in science and values debates. I also put forth a revised form of aims approach which, I argue, is a better account because of the adoption of the functional approach.

3.1 Epistemic Values - Values with Homogeneous Functions

I categorize epistemic values as functionally homogeneous since they perform two important functions during the evaluation of a scientific hypothesis. The homogeneous functions of these values can be portrayed in twofold ways. These two functions are:

(i) these act as criteria to evaluate the epistemic virtues[18] a hypothesis, a theory or a model ought to possess; and

(ii) these validate scientific knowledge claims objectively.

The functional homogeneity does not imply that every value which performs these two functions can be used as substitutes for other values which might also duly perform these functions. For instance, it is absurd to say that empirical adequacy which satisfies the two functions can be replaced for explanatory power which also satisfies the same functions. It is very intuitive that these values are qualitatively different even though they are functionally homogenous. The string that binds together these two functions in a homogeneous way is the act of scientific

[17] Kevin C. Elliott and Daniel J. McKaughan, "Nonepistemic Values and the Multiple Goals of Science," *Philosophy of Science* 81, 1 (2014): 1-21, Kristen Intemann and Inmaculada de Melo-Martín, "Social values and scientific evidence: the case of the HPV vaccines," *Biology & Philosophy* 25, 2 (2010): 203-213, Intemann, "Distinguishing," 217-232.

[18] Epistemic virtues are those qualities a hypothesis should possess in order to be certified as acceptable. For instance, epistemic significance, credibility, a high degree of confirmation etc. can be considered as epistemic virtues.

knowledge production and validation and, hence, the term "homogeneity" has been used in a less stringent sense. That is to say, "the functional homogeneity," I talk about in this context, is stipulated only to the functions of epistemic values, i.e., their functions as criteria to evaluate the epistemic virtues a hypothesis ought to possess, and validating knowledge claims objectively. In what follows, I make an attempt to synchronize the functions of epistemic values under the term homogeneity and then characterize these values from an epistemic standpoint. The idea is to argue that values which perform the above-given functions are integral parts of the production and confirmation of scientific knowledge because without the employment of relevant epistemic values the production and the assessment of scientific knowledge is not warranted.

The aims of modern science clearly indicate the fact that the aims are diverse in nature.[19] For instance, Ronald Giere and Bas van Fraassen argue that representations might very well be assessed in different ways.[20] It can be through the affairs that those representations bear to the world and sometimes it is in connection with the several uses to which they are employed. Since representations can be evaluated in different dimensions, it is plausible to think that the decisions regarding the acceptance of a hypothesis might also depend on various epistemic and pragmatic considerations. However, the point is that the functions epistemic values perform during the assessment of a hypothesis do not change according to the aims of the research. Their functions remain intact irrespective of the research contexts and aims. Martin Carrier argues:

> Epistemic values are employed in assessing how well hypotheses are confirmed by the available evidence. They are used for singling out acceptable hypotheses. Acceptance can either mean the belief that a hypothesis (or model or theory) is sufficiently confirmed or the recognition that the hypothesis is useful for building further theoretical considerations on it.[21]

The account of acceptance advocated by Carrier has two-fold implications, and in both cases, epistemic values play inevitable roles. The first notion of acceptance is in relation to the idea of a mental acceptance of a claim likely to be true which is to be

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[19] Wendy Parker, "Confirmation and Adequacy-for-Purpose in Climate Modelling," *Aristotelian Society Supplementary Volume* 83, 1 (2009): 233–249, Philip Kitcher, *Science, Truth, and Democracy* (New York: Oxford University Press, 2003), 55-82, Intemann and de Melo-Martín, "Social values," 203-213, Varghese, "Influence and prioritization," 1-17, Elliott and McKaughan, "Nonepistemic values," 1-21.

[20] Ronald N. Giere, "How Models Are Used to Represent Reality," *Philosophy of Science* 71, 5 (2004): 742-752, Van Fraassen, *Scientific Representation*, 141-184.

[21] Martin Carrier, " Values and Objectivity in Science: Value-Ladenness, Pluralism and the Epistemic Attitude," *Science & Education* 22, 10 (2013): 2547-2568.

confirmed. The second notion of acceptance is allied with the usefulness of a hypothesis to present a new knowledge claim or to add something more to the existing knowledge. The thrust is that although epistemic values which are involved in these two cases of acceptance are different, their functions remain unchanged, i.e., they function as criteria for the evaluation and acceptance of a hypothesis.

Let us consider the first function of epistemic values, i.e., they act as criteria for evaluating the epistemic virtues such as epistemic importance or a high degree of confirmation of scientific knowledge claims. The epistemic importance often influences the choice and the pursuit of theories or models in scientific research, and this importance is often influenced by epistemic values. Consider the standard curve-fitting problem. For example, while fitting a curve to a data set, the scientists often choose between either a higher-order polynomial or a lower order polynomial. The former has the advantage of measuring the data more accurately but makes the curve less simple while the latter effects the curve simpler, albeit less accurate. If the epistemic merits of each polynomial are considered, each of them has a different epistemic advantage(s) over the other. One is more accurate but less simple, and the other is more simple but less accurate. Here, the epistemic importance of the polynomials can be measured on the basis of epistemic values such that the choice between these polynomials is made in accordance with their abilities to fulfil certain expectations in a particular research context. For instance, econometricians have a preference for solving curve-fitting problems using linear regression, thereby choosing simplicity over accuracy. On a similar vein, one may argue that epistemic values are the essential yardstick of epistemic importance.[22] The epistemic importance I endorse here has implications for some sense of objectivity. That is to say; it does not have anything to do with the psychological states of an individual scientist; rather, it concerns what appears to be significant to the scientific community in general.

Having said this, a minor yet a significant point, on curve fitting, is worth noting. The example of curve-fitting seems to show that epistemic values can conflict and in such cases, it is not clear whether one ought to prefer a higher-order or lower-order polynomial since one may be simpler but less accurate or vice versa. Obviously, the curve fitting problem shows that epistemic values can also conflict. However, the point is that accuracy can be trumped by simplicity in a particular research context because simplicity better fulfils certain expectations in that particular context where accuracy at least does not have the same weight as simplicity. The example also gives cues to answer the question that when it is legitimate to give less weight or priority to accuracy. A prudent answer would be

[22] Carrier, "Values and Objectivity," 2547-2568.

that it depends on the value's viability to satisfy certain pre-specified aims in that particular research context in a better way than other alternatives do.

At the beginning of this sub-section, I have underscored the claim that during the confirmation process, epistemic values play certain pivotal roles. Every scientific hypothesis needs to be confirmed to a certain degree in order for them to be treated as a part of the body of scientific knowledge. Epistemic values have a significant role to play while scientists try to confirm a hypothesis under study. If there are two or more empirically equivalent accounts, then the choice is often made in terms of a particular account's ability to attain certain epistemic aims. For instance, suppose the first account is built upon a large number of unrelated hypotheses while the second one appeals to a few overarching principles, although both of them are empirically equivalent.[23] However, the commitment to coherence or simplicity or broad scope favours the latter approach because, in such kind of evaluation of accounts assessed in light of any or some of these values, the data, obtained which act as evidence, favours the more unifying account even if both the approaches are empirically equivalent. In such cases, the scientific community often invokes the help of epistemic values for choosing between empirically indistinguishable alternatives. Carrier argues that when there is a tiebreaker situation between competing accounts that conform to the data to approximately the same degree, the scientists appeal to values that transcend the requirement of empirical adequacy.[24]

Secondly, epistemic values function as a constraint for validating scientific knowledge claims objectively. A significant criticism that value-laden account of science often confronts is that the involvement of non-epistemic values in scientific inquiry might destroy the scientific objectivity. However, philosophers like Longino and Douglas have argued that non-epistemic values – contextual values in Longino's terms – can legitimately influence scientific inquiries without undermining

[23] An example of empirically equivalent theories is Heisenberg's matrix mechanics and Schrödinger's wave mechanics in the 1920s. Both of them dealt with understanding quantum mechanics. Initially, scientists preferred wave mechanics and even now some do because the theory fitted better with tradition and it also used familiar mathematical tools and techniques. On the other hand, while those of matrix mechanics were in less common usage in physics, finally it provided a mental image which could be more easily visualized. Eventually, it was shown that both theories are empirically equivalent and people use whichever is the more convenient formalism for a problem. For instance, sometimes the emphasis is put more in the wave formulation because this is much easier for most quantum problems. Matrix mechanics is highlighted because it is simpler while dealing with the harmonic oscillator.

[24] Martin Carrier, "Underdetermination as an epistemological test tube: expounding hidden values of the scientific community," *Synthese* 180, 2 (2011): 189-204.

objectivity.[25] Ideally, epistemic values depict the features of knowledge we consider worthwhile irrespective of the particular contexts in which the knowledge is used. Some of the well-known epistemic values which are cherished in any scientific inquiry are empirical success, predictive accuracy, breadth of explanatory scope and unification, simplicity, and problem-solving effectiveness. These values could plausibly be considered as the features of a lot of scientific knowledge claims which are objective in nature. Values cannot function as a criterion of scientific knowledge claims if they are employed in isolation without any background assumptions or contexts. For instance, predictive accuracy cannot function as a mark of scientific knowledge in the absence of standards of acceptable empirical approximation.

In a nutshell, the functions, epistemic values perform during the evaluation of a hypothesis, are homogenous in nature. However, the claim that epistemic values are homogeneous is constrained only to the functions of these values to act as criteria to evaluate the epistemic virtues such as epistemic significance, credibility, and a high degree of confirmation and to validate scientific knowledge claims objectively.

3.2 Non-epistemic Values – Values with Heterogeneous Functions

In contrast with epistemic values, non-epistemic values are social, political, moral, commercial, religious or any other values which belong to various disciplines. These values are integral elements in forming the culture and customs of any society, and these values are held to be desirable by different social groups or communities.

In the previous sub-section, I characterized epistemic values as homogenous in terms of their functions in scientific inquiries. On a similar vein, I characterize non-epistemic values as heterogeneous with regard to the functions they perform. First of all, non-epistemic values are those values which do not perform the two important functions which epistemic values do during the production, evaluation, and confirmation of scientific knowledge. Further, non-epistemic values are functionally heterogeneous since they perform a variety of roles in order to promote the attainment of different objectives a particular discipline aspires to achieve. The expression "heterogeneous functions," in a naïve sense, means that although the values found in different disciplines such as politics, ethics, business, etc., fall under the category of non-epistemic values, there are qualitative differences among these values, their functions vary and sometimes these values even promote conflicting aims in different research contexts. In this sense, it is plausible to argue that non-epistemic values perform diverse functions. We are also justified in assuming that

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[25] Heather Douglas, "The irreducible complexity of objectivity," *Synthese* 138, 3 (2004): 453-473, Helen E. Longino, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (Princeton: Princeton University Press, 1990).

this functional heterogeneity is a significant characteristic of non-epistemic values in the context of values in science debates since most of the current controversies in science and values are centered on evaluating the functions of non-epistemic values when their influence is necessary in certain scientific research contexts.

The debates on science and values mainly focus on the repercussions of the influence of non-epistemic values in scientific research and assessing the influences. The following sub-sections demonstrate that although the influence of non-epistemic values is necessary in scientific inquiries, the influence of these values can turn out to be inconsistent because of their functional heterogeneity. The real problem is identifying which non-epistemic values should influence the research when multiple competing sets of values are engaged and when they influence, how we know whether their influence is legitimate or illegitimate.

The appropriate and inappropriate influences of non-epistemic values are parasitic on the employment of these values. A value is neither legitimate nor illegitimate without its employment in a particular context. Once a value is employed in order to perform certain functions in a specific research context, then with its relation to the pre-specified research aims and its consistency in promoting those aims, the legitimacy of the influence of that particular value can be assessed in that particular research context. The idea is to argue that since non-epistemic values are functionally heterogeneous, the choice of the values must be made in such a way that the chosen values may be consistent with the pre-specified aims of the research. In the following sub-section, I explore two important functions of non-epistemic values and characterize them as functionally heterogeneous.

3.2.1 Non-epistemic Values as Guiding Hands to Show Directions

The defenders of the traditional account of value-free ideal argue that, although non-epistemic values constitute a wide range of considerations such as political, religious, personal, commercial, social and ethical, they do not reliably promote any epistemic goal because these values seldom act as an indicator of a good scientific theory.

The admissible and inadmissible roles of non-epistemic values in science have been discussed extensively, and without copious dispute, many philosophers and scientists hold on to the view that the involvement of non-epistemic values is necessary in the pre and post-epistemic phase of scientific investigations. There are several accounts of pre-epistemic, post-epistemic, and epistemic phase distinction which are compatible with the proposal that is being taken for granted for the purpose of our current discussion.[26] Although this division varies widely, in general,

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[26] Elizabeth Anderson, " Uses of Value Judgments in Science: A General Argument, with Lessons

the pre-epistemic phase is where the theories or hypothesis are formulated, and methodologies are selected, and the post-epistemic phase is where the accepted hypothesis or the outcomes of the study are put into use either for the production of further scientific knowledge or technology.[27] In the pre-epistemic phase, values can channel scientific research in particular directions. For instance, non-epistemic values play a crucial role when funding agencies encourage researchers to pursue socially relevant lines of investigation. Similarly, values can influence the way in which scientific research is applied in the realm of public policy or technology development, and it is a post epistemic scenario. In general, it is relatively uncontroversial to claim that non-epistemic values influence scientific research in the above-mentioned activities which occur in the pre or post epistemic phases. In such cases, these values act as guiding hands to show directions in scientific research and technology and this function of non-epistemic values is quite well accepted by both the critics and the defenders of the value-free ideal.

3.2.2 Non-epistemic Values as the Promoters of the Research Goals

Traditionally, the epistemic/non-epistemic distinction was thought to reflect a difference in the kind of aim about which the value is concerned, in other words, those that promote scientific or epistemic aims against those that deter or fail to promote such aims. One of the focal questions in values in science debates is whether non-epistemic values can legitimately influence the internal aspects of scientific research which include inferences from experimental data to theories or hypotheses. The defenders of the value-laden account of science answer positively and there become the debates more interesting. The critics of value-free account of science argue that the place of non-epistemic values cannot be undermined in certain scientific research because they play decisive roles even in the epistemic or internal phase of the scientific research.

4. Right Tool for the Job – The Functional Approach

Let us return to the discussion of heterogeneous functions of non-epistemic values and analyze why and how different competing sets of non-epistemic values need to be necessarily involved when the research enmeshes the problem of inductive risk. The analysis is based on the functional approach, which is primarily employed for distinguishing the legitimate and illegitimate influence of non-epistemic values

from a Case Study of Feminist Research on Divorce," *Hypatia* 19, 1 (2004): 1-24, Douglas, *Science, Policy*, 44-65, Brown, "Values in science," 829-839.

[27] Hicks, "A new direction," 3271-3295.

when their involvement is indispensable. I also argue that functional approach is the best candidate to address the problem of inductive risk because the approach suggests which set of non-epistemic values is consistent with the pre-specified objectives of the research and diagnoses which values are legitimate based on its consistency with the aims of the research. Moreover, a richer understanding of the heterogeneous functions of non-epistemic values might better capture the epistemic and non-epistemic repercussions of accepting or rejecting a hypothesis. In the following sections and sub-sections, I analyze a case study from chemical research which involves the problem of inductive risk. By exploring this case, I demonstrate how the legitimate influence of non-epistemic values during the research would promote the attainment of the research objectives in a better way. In order to assess the legitimacy of the chosen values, I employ the functional approach. Let us consider the problem of inductive risk.

4.1 The Problem of Inductive Risk

The critics of the value-free ideal have successfully argued that there are occasions even in the internal phase of scientific inquiry where the involvement of non-epistemic values is necessary. An instance of such a scenario is when scientists confront the problem of inductive risk.[28] Inductive risk is the possibility that one may make a mistake in rejecting or accepting a hypothesis that is under study. The problem of inductive risk is rampant in different phases of scientific inquiries. The case which I am going to analyze in this sub-section is concerned with the problem of inductive risk while making the decisions regarding the choice of methodology for conducting lab experiments.

Wilholt[29] draws attention towards a case from chemical research which involves the problem of inductive risk. The primary aim of this particular chemical research study was to find out whether there was an association between certain adverse health effects and their exposure to bisphenol A (BPA), an organic synthetic compound.

[28] Heather Douglas, " Inductive Risk and Values in Science," *Philosophy of science* 67, 4 (2000): 559-579, Carl G. Hempel, *Aspects of Scientific Explanation; And other Essays in the Philosophy of Science* (New York: The Free Press and London: Collier-Macmillan, 1965), 1-19, West C. Churchman, "Statistics, Pragmatics, Induction," *Philosophy of Science* 15, 3 (1948): 249-268, Richard Rudner, "The Scientist Qua Scientist Makes Value Judgments," *Philosophy of Science* 20, 1 (1953): 1-6.

[29] Torsten Wilholt, "Bias and values in scientific research," *Studies in History and Philosophy of Science Part A* 40, 1 (2009): 92-101.

Many researchers like vom Saal et al.[30] argued that the outcomes of various studies showed that the exposure to BPA could cause several serious health issues such as prostate and breast cancer, neurobehavioral problems, obesity, reproductive abnormalities, etc. in humans. However, scientists like Ryan et al. disagreed with these findings and argued that their study outcome showed '*no association between certain adverse health effects and the exposure to BPA.*'[31] The difference between the two research outcomes, one concluding the association between the adverse health effects and the exposure to BPA positively and the other one concluding the association negatively, was that the first one was conducted by non-profit organizations and the second one was conducted by those research institutes which were funded by the industries. There were 119 studies which were conducted by the government agencies and except 10 studies, all other studies showed that BPA is toxic and its use is harmful. On the other hand, 11 studies which were designed and conducted by the industries concluded that there was no association between adverse health effects and the exposure to BPA. It seems that the researches which were funded by the industries were carried away by structural bias[32] against finding positive effects of BPA. Vom Saal et al. point out what went wrong with all those researches which were conducted by the financial support of chemical companies:

> [F]or toxicological studies conducted without appropriate positive controls and that report only negative findings for a test chemical, interpretation of the negative results is not possible and violates basic rules governing experimental research design and analysis, specifically the need for a valid positive control[33] when test results for a drug or chemical with a known mode of action are uniformly negative.[34]

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[30] Frederick S. vom Saal, Susan C. Nagel, Barry G. Timms, and Wade V. Welshons, "Implications for human health of the extensive bisphenol A literature showing adverse effects at low doses: a response to attempts to mislead the public," *Toxicology* 212, 2-3 (2005): 244-52.

[31] Bryce C. Ryan, Andrew K. Hotchkiss, Kevin M. Crofton, and L. Earl Gray Jr, "In Utero and Lactational Exposure to Bisphenol A, In Contrast to Ethinyl Estradiol, Does Not Alter Sexually Dimorphic Behavior, Puberty, Fertility, and Anatomy of Female LE Rats," *Toxicological Sciences* 114, 1 (2010): 133-148.

[32] Sheldon Krimsky, "Do Financial Conflicts of Interest Bias Research?: An Inquiry into the 'Funding Effect' Hypothesis," *Science, Technology, & Human Values* 38, 4 (2013): 566-587. Krimsky claims that "Structural bias," is an adoption of certain methods or norms which would distort (over- or underreport) the effects being studied.

[33] Positive control is a test scientists perform against something when they know what the effects of that will be. Negative control is a test scientists perform against something when they know that the test will have no effect.

[34] Frederick S. Vom Saal and Wade V. Welshons, "Large effects from small exposures. II. The importance of positive controls in low-dose research on bisphenol A," *Environmental*

There are two significant methodological errors that were committed by the researchers who concluded that there was no association between certain adverse health effects and the exposure to BPA. Firstly, they did not employ a positive control. Secondly, they used a particular strain of rats as model organisms for conducting the experiment. These rats which are known as Long Evans (LE) rats are not really sensitive to estrogen. Consequently, these particular test rats reduced the probability of finding the toxicity of BPA to a large degree. This instance from chemical research clearly shows that the problem of inductive risk might creep into any phases of scientific research which might eventually affect the study outcome and bring about severe epistemic and non-epistemic corollaries.

4.2 Saving the Inductive Risk Scenario

In the case of BPA, the aim of the research was to find out if there was an association between certain adverse health effects and the exposure to BPA. Test of BPA in the mice which were conducted by the government agencies clearly showed that there is an association. However, some industry-funded studies came up with a negative result because the industry-funded research chose such a model organism for the trial which was insensitive to estrogen. Furthermore, the doses fed to the models were also insufficient. These inappropriate methodological choices led to the production of dubious and inadequate data which eventually affected the outcome of the research in a negative way.

Karl Popper, in his famous work *The Logic of Scientific Discovery*, talks about the philosophical foundations of scientific methodology. Popper argues that science is not an inductivist venture, where truth is built up from the data that are consistent with a hypothesis. According to him, scientists must pursue to falsify a hypothesis and a distinguishing feature of any good scientific theory is that its hypotheses pass the test.[35] Hence, under the methodology put forth by Popper, one should look for such an instance which might falsify a hypothesis that is to be confirmed. A hypothesis can be confirmed only if there is no falsifying instance happens. Let us explore how we can adopt this methodology in the case of BPA and similar kinds of researches. Vom Saal and Welshons argue:

> [I]t is a common event in toxicological studies conducted by the chemical industry for purposes of reporting about chemical safety to regulatory agencies to provide only negative results from a study in which no positive control was included but

research 100, 1 (2006): 50-76.

[35] Popper, *The Logic*, 57-73

from which positive conclusions of safety of the test chemical are drawn.[36]

The point is that the scientific validity of any experiments with animal models might be questioned if the experiment does not take account of both negative control and positive control doses. In the case of BPA research, the structural bias instigated the researchers to choose such a methodology for the experiment so that they could find what they wished to find. Wilholt and Biddle[37] argue that it is a clear case of *preference bias* which occurs when the researchers are heavily influenced by their preferences and studies are conducted in such way as to amplify the probability of obtaining the preferred outcome. The problem of inductive risk involved in the choice of the methodologies, particularly the choice of an insensitive model organism, brought about the production and sharing of corrupted research outcome. While designing and conducting scientific research, there might be multiple (epistemic and non-epistemic) goals researchers may try to achieve and every aim of that research might also accompany certain epistemic as well as non-epistemic repercussions. Having set up this framework where scientific research is concerned with multiple aims, let us examine the possible aims of BPA research and the implications and consequences of the primary aim being overridden by other aims.

The primary aim of conducting BPA research was to find out if there was an association between adverse health effects and the exposure to BPA. Similarly, some other subordinate non-epistemic repercussions might follow if the research concludes that there is an association between adverse health effects and the exposure to BPA. For instance, if the research concludes that BPA is harmful, then it follows certain non-epistemic repercussions such as minimization of social cost both in finance and healthwise, severe restrictions in the use of BPA by industries, and probably a huge financial loss to the industries. On the other hand, if the research concludes that BPA is not harmful as Ryan et al.[38] concluded when it is actually harmful, this conclusion is also followed by some other non-epistemic repercussions such as an increase in the social cost, free use of BPA products, an increase in the profit margin of the industries which are involved in manufacturing BPA products, etc. In this scenario, it is plausible to assume that a form of structural bias really crept into the research methodology of industry-funded research and eventually ended up in the production of a biased research outcome.

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[36] Vom Saal and Welshons, "Large effects," 50-76.

[37] Justin Biddle, "Institutionalizing Dissent: A Proposal for an Adversarial System of Pharmaceutical Research," *Kennedy Institute of Ethics Journal* 23, 4 (2013): 325-353, Wilholt, "Bias and values," 92-101.

[38] Ryan, Hotchkiss, Crofton, and Gray Jr., "In Utero," 133-148.

As I understand, the pursuit of profit is a motivating factor for the chemical and similar research industries to take up novel research endeavors to make the world better from a social utility point of view. Hence, according to the functional approach, the quest for profit which is a non-epistemic value is consistent with the aims of the research, and it is legitimate. However, this particular non-epistemic value ceases to be consistent if it goes beyond its presumed functions by corrupting the research and undermines all other competing non-epistemic values such as social or moral values. It is evident that the influence of a non-epistemic value – quest for more profit – illegitimately influenced the research design, especially the choice of animal model for the experiment. This influence is illegitimate because the primary aim of the research was undermined by certain non-epistemic factors such as industrial profit which also initiated more non-epistemic consequences such as adverse health effects and the increase in social costs. Hence, the influence of commercial values, in this case, is not consistent with the primary aim of the research and therefore, illegitimate.

I have already underscored the point that since non-epistemic values perform heterogeneous functions, they can influence scientific research both in legitimate and illegitimate ways. The consequences of the acceptance or rejection of a hypothesis can be seen in different ways. It is not the case that the knowledge one acquires through accepting or rejecting a hypothesis is not just limited to that particular research instance. It has large implications since such knowledge might be used for pursuing further related researches. Hence, it becomes the responsibility of the scientists that they may prevent the entry of any such illegitimate influence of values which might produce a corrupted research outcome.

Consider a hypothetical scenario in which non-epistemic values might legitimately influence the choice of more rational methodological decisions. In the case of BPA, non-epistemic values such as care for human and animal health, reduction of the financial burden to the society, etc. should have influenced the research while confirming the hypothesis because these values, although non-epistemic, are consistent with the primary aim of the research and hence, their involvement is legitimate. They are consistent with the primary aim of the research because had these values influenced the trial designs and the methodologies; the researchers would have alternatively designed the trials with appropriate positive control doses and alternate animal models. That is to say, when there is a problem of inductive risk, the employment of non-epistemic values should be made in such way that the chosen values may reduce the degree of inductive risk and also may promote the attainment of the pre-specified aims of the research. In the case of BPA, the functional approach clearly tips off why the involvement of care for human health is legitimate, and the quest for profit is illegitimate. In this case, care for human and animal health would have prompted the researchers to take up a positive control test with an alternate model organism which, in turn, would have eventually led to the finding of the association between adverse health effects and exposure to the BPA. Hence, the employment of non-epistemic values of care for human and animal health is legitimate in this context. On the other hand, another non-epistemic value - the quest for profit – corrupted the research and impeded the attainment of the primary aim of the research because its involvement led to the production and distribution of distorted knowledge claims through the choice of inappropriate and biased methodologies and controls. Hence, the involvement of the quest for profit, in this context, is illegitimate.

Conclusion

This paper made an attempt to characterize epistemic and non-epistemic values in terms of their functions. Epistemic values are characterized as functionally homogeneous because every epistemic value fulfills two important functions which are necessary for knowledge production and evaluation. These are: (i) they act as criteria to evaluate the epistemic virtues a hypothesis ought to possess, and (ii) they validate scientific knowledge claims objectively. On the other hand, non-epistemic values are characterized as functionally heterogeneous because their functions vary. The rationale behind the legitimate as well as the illegitimate influence of non-epistemic values in scientific investigation is their functional heterogeneity. By critically examining BPA research, I argued that in certain research contexts, especially when scientists confront the problem of inductive risk, the involvement of non-epistemic values is necessary. However, I pointed out that necessary involvement does not necessarily imply legitimate involvement and hence, the illegitimate influence of non-epistemic values must be carefully eschewed from scientific inquiries.

To sum up, non-epistemic values such as moral, social, scientific, or commercial values can operate in many ways in different phases of scientific research, and because of their functional heterogeneity, their influence might turn out to be illegitimate sometimes. Therefore, distinguishing the differences among the functions the non-epistemic values perform during different phases of scientific research is necessary to assess whether the influence of these values is legitimate or illegitimate.[39]

[39] I thank Professor Prajit K. Basu, Department of Philosophy, University of Hyderabad, for the useful comments on the several earlier versions of this paper.