Underdetermination and Theory-Ladenness Against Impartiality. A Defence of Value-Free Science and Value-Laden Technology

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Abstract

The aim of this paper is to show that science, understood as pure research, ought not to be affected by non-epistemic values and thus to defend the traditional ideal of value-free science. First, we will trace the distinction between science and technology, arguing that science should be identified with pure research and that any non-epistemic concern should be directed toward technology and technological research. Second, we will examine different kinds of values and the roles they can play in scientific research to argue that science understood as pure research is mostly (descriptively) and in any case ought to be (normatively) value-free. Third, we will consider and dismiss some widespread arguments that aim to defend, especially at a normative level, the inevitable value-ladenness of science. Finally, we will briefly return to the connections among science, technology, and values.

1. Introduction

The intrinsic epistemic value of science and scientific knowledge is a topic of wide and varied interest, as demonstrated not only by the great amount of philosophical, historical, sociological, and anthropological reflection on it, but also by the fact that many philosophers, historians, sociologists, and anthropologists of science who aim either to emphasise or to reframe this value are well-known to the general public (some examples include Karl Popper, Thomas Kuhn, Paul Feyerabend, Imre Lakatos, and Bruno Latour). Further, we generally consider ourselves epistemically superior to our ancestors because we possess a more advanced scientific knowledge about the world. For instance, contrary to most of our predecessors, we have knowledge of such phenomena as the speed of light, the structure of the atom, the number of planets in the solar system, the nature of electricity and magnetism, and the gas laws. In retrospect, it is difficult to argue that science makes no epistemic progress and that the growth of our society does not largely depend on it. Defending the intrinsic value of scientific knowledge, of course, we do not deny that an extrinsic value also exists, nor do we ignore the possibility of transferring scientific knowledge into technology. We simply emphasise that scientific knowledge and research aim to increase our understanding of the natural and social world. Scientific research is compulsory both to guarantee real epistemic, economic and social development and to prevent a future decline in our civilised countries.

At a common sense level, however, what science is and what role it has in our society becomes a sort of contradiction. On the one hand, science is regarded as a particularly reliable and uncontroversial kind of knowledge that is able to produce results that are more concrete, more factual, and, in a certain sense, "better" than those produced by other methods of making sense of and explaining the natural and social world (such as art, literature, religion, or even philosophy). On the other hand, however, science is considered something to be concerned about and wary of, a menacing force that leads to our alienation from nature, the mechanisation of our lives, a loss of freedom and humanity, and several inevitable threats against the environment and human life. In the framework of this latter perspective, ethical and sometimes religious values are often employed to attack the intrinsic values of science.

The aim of this paper is to show that ethical, religious and other such considerations with respect to science are basically unjustified and illegitimate and thus should not compromise the progression of scientific research. To begin, in section 2, we will trace the distinction between science and technology, arguing that science should be identified with pure research and that any non-epistemic concern should be directed toward technology and technological research. Next, in section 3, we will examine different kinds of values and the roles they can play in scientific research to argue that science understood as pure research is mostly (descriptively) and, in any case, ought to be (normatively) value-free. Then, in section 4, we will consider and dismiss some widespread arguments that aim to defend, especially at a normative level, the inevitable value-ladenness of science. Finally, in section 5, we will briefly return to the connections between science and ethics.

2. Some reflections on the difference between science and technology

Not only most laymen but also many philosophers take for granted that there is no relevant distinction between science and technology. On their behalf, it is difficult to deny that even if science and technology have evolved separately, they are now closely related and that the boundaries dividing them have become more and more blurred, especially in recent times. Science crucially depends on technological advances, and within technology, there is a great deal of theoretical research. Thus, to avoid any confusion, it is important to distinguish pure research, which characterises scientific theorising, from basic or fundamental research, which instead characterises technological theorising (Agassi 1980).[1] At this point, if we identify science with pure research, there are many good reasons to keep it separate from technology (Franssen, Lokhorst & van de Poel 2009).

First, considering the general concerns of science, we can say that while science has to do with what *is*, technology has to do with what *is to be* (Skolimowski 1966). Second, if the basic goals of science are truth and an improved understanding of the world, the main goals of technology are utility and improved usefulness.[2] If science aims to increase human knowledge by establishing better and better theories about the world, technology aims to satisfy human needs and interests by developing appropriate and efficient artefacts. This distinction implies that any possible application of the fruits of science is simply a by-product, not the primary purpose; pure research can continue indefinitely, regardless of whether it is found to have practical applications (Agassi 1980). Third, scientific knowledge is propositional and involves knowing *that* a certain proposition is true, while technological knowledge is practical and involves knowing *how* to do certain things (Polanyi 1958; Ryle 1949). Fourth, pure scientific problems are confined to a particular science; they are demands for the elaboration of some constitutive elements within a given science. Conversely, technological problems lie outside the jurisdiction of any single science; they are demands for the production of some arte-

1 To make some examples: theoretical physics can be easily identified as an instance of pure research, while applied physics as an instance of basic research; in chemistry, investigating the chemical reactions of a particular compound to learn about its structure is a case of pure research, while trying to synthetically produce a new drug or material is a case of basic research. In biology, studying the molecular mechanisms of cell growth control and signal transduction pathway is an example of pure research, while analysing the effects of pollution on freshwater or marine organisms is an example of applied research. Even in medicine Boorse (1997:47) convincingly argued that there is a difference between "theoretical and practical, pathological and clinical […] On the theoretical level where pathologists operate, it is false that pathology depends on what a person wants or should want to do, how he views a condition, or his life situation. Obviously, such factors determine the clinical or social importance of disease states [...] but they do not affect what is theoretically a disease in the first place".

2 Of course, some philosophers have denied that truth and an improved understanding of the world are the primary goals of science (see, for instance, Cartwright 1999; Dupré 1993; Kitcher 2001; Laudan 1984; van Fraassen 1980). However, in the present paper we do not try to defend this position, but we take it for granted.

fact suitable for the fulfilment of certain human needs (Arageorgis & Baltas 1989).

Each of the above points merits further discussion. However, we believe they are in themselves sufficient to show that any hasty and thoughtless identification of science with technology must be rejected (and indeed, philosophy of technology has been developing independently of philosophy of science). If this is true, then it is possible to acknowledge that ethical and religious values concern technology and technological research, that is, basic or fundamental research, but still argue for the claim that science as pure research might be value-free. For instance, given the distinction between science and technology, the widespread ethical and religious reservations about atomic bombs and cloning cannot be directed against science as such (or, more precisely, against nuclear physics and biology, the knowledge of which is neither good nor bad in itself) but instead, if carefully elaborated, against technology. Other well-known controversial examples involving technology but not science, as we have clearly defined, include the following: chemical and biological weapons, food irradiation, genetically modified organisms (GMOs), greenhouse gases, in-vitro fertilisation (IVF), nuclear power plants, and particle and sound beams. Even if we agree that various kinds of ethical concerns should be properly addressed to technology and its various outcomes, some clarifications are still in order.

To begin, it is important to distinguish between technology in itself and the actual users of technology; thus, should the aforementioned ethical and religious reservations be addressed toward technology in itself or its users? At least a few scholars would be happy to argue that technology in itself is neither good nor bad (in the same manner as science) and that, for this reason, our ethical and religious judgments should only assess its users. Moreover, if one aims to criticise technology as such in general, one would most likely be forced to choose between a difficult and a contradictory position. If one regards technology as a threat against human beings that should be blocked, then one should consistently renounce all technological devices, ranging from mobile phones to cars, computers to electricity, and glasses to penicillin; otherwise, such a position would become incoherent (Amoretti & Vassallo 2010). Finally, technology should not be considered a unique and comprehensive object, as there are many different technologies. As a consequence, we should move away from general ethical reflections on technology as such to develop different specific ethical considerations with respect to particular technologies. In this way, even if some technologies cannot be seen in any positive light and must be criticised, one's judgments would not unjustifiably extend to technology as such nor to other specific technologies. For instance, the atomic bomb plainly represents a bad technology (as it makes extremely easy to kill many people at once), while the nuclear medicine that helps to cure many kinds of tumours is an example of a good technology (as it contributes to save many people's life), and both of them are technological applications of nuclear physics. There are many other cases of good technologies. Some of them – such as ovens, microwaves, washing machines, dishwashers, vacuums, and contraceptives – may seem mundane but have been important in improving women's lives (Author 2003, 2009a, 2009b); others – such as x-rays, echography, vaccines, and antibiotics – have prolonged our life expectancies. If technologies can be either good or bad, it is important to revaluate technological knowledge and to promote critical discussion in order to privilege good technologies and avoid bad ones.

Accepting the distinction between science and technology, we are allowed to defend the intrinsic epistemic dimension of science and to argue that ethical values ought not to obstruct, condition, nor guide the scientific enterprise, conceived as pure research. To put it another way, we would like to extend Rudolf Carnap's motto, according to which "in logic there are no morals" (1934), to other important scientific disciplines (both natural and social: including biology, chemistry, economics, history, physics, psychology, cognitive sciences, and sociology) as far as they are regarded as practicing and pursuing pure research. Again, ethical reflections ought to concern the technological applications of science, but they ought not to be projected on science itself.[3] This thesis can be generalised to involve other kinds of values and considerations, such as aesthetic, cultural, economic, environmental, ethical, ideological, political, religious, and social ones, and thus we label it the ideal of value-free science.

Even if the distinction between science and technology has been recognised, one can still object that ethical and other similar interests cannot be excluded from science because they permeate our society of knowledge and thus also the scientific endeavour, at least to the extent that scientific practices are actually social practices. To rebut this objection, it is sufficient to note that it constitutes an empirical and descriptive claim about science that, as such, cannot dismiss a normative claim such as the one we made about the roles of ethics and other values in science. In fact, generally speaking, no descriptive claim can be relevant from a normative point of view. This reply, as well as the very idea of value-free science, will be elucidated in the next section, as we

3 For this reason, it would perhaps be preferable to avoid a term like "bioethics", as it seems to imply that ethical concerns about biology as such are legitimate, and to replace it with an expression such as the "ethics of biotechnological applications".

will distinguish among various kinds of values and examine their roles in the scientific enterprise.

3. On the different roles of values in science

To begin, it is crucial to reflect on the function of values in science and to recognise that not all values must be ethical, religious, or hastily labelled as non-epistemic. Put another way, values should be divided in two general categories: namely, epistemic (cognitive or constitutive) and non-epistemic (non-cognitive or contextual) values. Even if the distinction between epistemic and non-epistemic values is neither obvious nor definite (Kincaid, Dupré & Wylie 2007; Machamer & Wolters 2004; Putnam 2002), we argue that "epistemic" values include all of those values that may actively contribute to the furthering of our knowledge and that are conducive to truth, understanding, and explanation (Author 2010, 2012; Dorato 2004). Thus, epistemic values are not only admissible in science but even indispensable, as they are constitutive of science itself. In this sense, we include among epistemic values all of those values that Larry Laudan (1984, 2004) and Hugh Lacey (1999, 2004, 2005) label as "cognitive" and consider intrinsic to the scientific practice. According to those authors, cognitive values represent the "properties of theories which we deem to be constitutive of 'good' theories" (Laudan 1984, p. xii), or "characteristics that scientific theories and hypotheses should possess for the sake of expressing understanding well" (Lacey 2004, p. 24). While acknowledging there may not exist an undisputed list (Kuhn 1977; Longino 1990; Quine 1955), we recognise the following as epistemic values: empirical adequacy, explanatory power, unifying power, predictive power, internal consistency, external coherence or consonance, simplicity, problem-solving effectiveness, and fertility.[4] In terms of the social dimension of scientific knowledge, some scholars consider additional "quasi"-epistemic values, including the internal and external heterogeneity of

4 It is possible to object that there is no undisputed list of epistemic values just because any such a list is intrinsically open and temporary (Laudan 1984). For example, the decision concerning the list of epistemic values and the priority order among them might depend on non-epistemic values (Kuhn 1977; Shrader-Frechette 1997). Against these ideas, we believe that epistemic values can be identified and ranked through philosophical intuitions and thus that their inventory and the priority order among them can eventually be recognized as fixed and permanent. Of course, we are aware that this claim and the very legitimacy of philosophical intuitions must be supported in more details, but unfortunately such a defence cannot be done in the present paper.

scientific groups and the public discussion within and across scientific communities. Conversely, we regard as non-epistemic values the whole variegated set of aesthetic, cultural, economic, environmental, ethical, ideological, political, and religious values, all of which some scholars are eager to label "social" values because, legitimately or not, they are taken to be constitutive of good societies (Lacey 2004). Examples include labour productivity, national self-defence, social equality, social well-being, and universal health-care.

Given the distinction between epistemic and non-epistemic values, it is now possible to rephrase the thesis we stated in the previous section (that ethical values and considerations ought not to obstruct nor condition the scientific enterprise) in more general terms: sciences ought to be free of non-epistemic values. The ideal of (non-epistemic) value-free science, however, incorporates several distinct views about ways in which science and non-epistemic values do not, or ought not to, relate, and thus it must be analysed in greater detail. One way to conduct this analysis is to follow Lacey (1999), who suggests that the (non-epistemic) value-free ideal should be articulated into three different components. Thus, the thesis that science is, or ought to be, (non-epistemic) value-free means that autonomy, impartiality, and neutrality are, and ought to be, considered three constitutive values of scientific practices and institutions.

According to the condition of autonomy, scientific methodologies and standards, domains of investigation, research strategies, priorities, and directions to pursue are, or ought to be, established by the scientific community itself, without any aesthetic, cultural, economic, environmental, ethical, ideological, political, religious, and social interference from the outside in order to promote and enhance scientific progress. Put another way, scientific research is, or ought to be, conducted in independent endeavours and self-governed institutions that are free from any outside interference. As a descriptive thesis, autonomy is patently false. Scientific research mostly depends on financial and material conditions provided by external institutions, such as national governments, international organisations, private foundations, and industries. It follows that non-epistemic values interfere with scientific practices and play a certain role in favouring different fields of investigation. As a normative thesis, however, autonomy is more difficult to evaluate. On the one hand, it is easy to see that non-epistemic values can slow or even block scientific progress by obstructing certain research strategies and directions. Let us think, for example, about the role played by ethical and religious values in restraining studies on Darwin's theory of evolution or in impeding medical research on stem cells (especially in certain countries). On the other hand, however, it is possible to argue that a plurality of non-epistemic values can contribute to expanding our knowledge of the natural and social world, as they guarantee that different domains of investigation and research strategies are equally pursued and thus increase the number of new competing theories and hypotheses (Haraway 1991; Harding 1998; Longino 2001). For instance, it has been claimed that feminist values contributed to the development of many relevant alternative theories and hypotheses, as in the case of Barbara McClintock's pioneering work on genetic transposition (Keller 1983). Perhaps these two opposing instances can eventually coexist; non-epistemic values ought to be admitted into scientific enterprise insofar as they comply with the promotion of new research methodologies, strategies, and directions without impeding, slowing, or compromising rival ones. More importantly, however, it is compulsory that non-epistemic values do not hinder the general development of scientific progress. Because there are both epistemically legitimate and illegitimate ways for non-epistemic values to influence the scientific enterprise, other correlated problems should be addressed. How is it possible to promote "good" non-epistemic values that advance pluralism, progress, the attainment of truth, and the avoidance of error while preventing the advancement of "bad" non-epistemic values that slow and obstruct the search for knowledge and yield viciously circular reasoning? Moreover, how can we avoid the possibility of a cultural or social community that promotes as "good" non-epistemic values some assumptions, premises, or methodologies that are patently antiscientific (such as creationism) or horrifying (such as those at the core of Nazi anthropology and biology)? A feasible solution might be to exploit the concepts of dialogic interaction and democratic discussion (Longino 1990, 2001) to maintain that cultural and social communication, public critical scrutiny, and cooperative dialogue are tools appropriate for the discovery and eventual eradication of all antiscientific and horrifying assumptions, premises, and methodologies from the scientific enterprise. However, we believe that the very opportunity for any dialogic interaction or democratic discussion would be contested and eventually forbidden by anti-democratic social communities, in which case the easier route is most likely to ideologically consider "bad" non-epistemic values to be "good" ones (Author 2010, 2012). For these reasons, we feel that the best solution is defending the condition of autonomy as a normative thesis that prescribes how scientific methodologies and standards, domains of investigation, research strategies, priorities, and directions to pursue ought to be established. In any case, it is pivotal to stress that refusing the condition of autonomy, as a descriptive thesis, a normative thesis or both, does not really affect the ideal of (non-epistemic) value-free science, at least from a genuinely epistemic point of view. This claim will become clearer after the following discussion of the second condition.

Impartiality is the core tenet of the (non-epistemic) value-free ideal because it is critically related to the intrinsic epistemic dimension of science. Impartiality is a thesis regarding properly accepted theories and hypotheses. The only grounds for choosing a theory or hypothesis among different rivals and then soundly (that is, not just provisionally) accepting it are, or ought to be, the exhibition of various epistemic values to a suitably high degree (empirical adequacy, explanatory power, unifying power, predictive power, internal consistency, external coherence or consonance, simplicity, problem-solving effectiveness, and fertility). Accordingly, aesthetic, cultural, economic, environmental, ethical, ideological, political, religious, and social values do not have, or ought not to have, any role in the judgments involved in choosing and soundly (not just provisionally) accepting a theory or hypothesis. From a descriptive point of view, we are inclined to agree with Dorato (2004) that our best science tends to be impartial, at least in the sense that impartiality as a norm is *de facto* accepted by scientists. Nevertheless, it is most likely true that at least some scientific theories have been soundly accepted also on the basis of some non-epistemic values; still, this is just an empirical and descriptive claim that in no way affects impartiality as a normative thesis. As such, we believe that impartiality is compulsory and that it must be firmly defended; the only values that ought to be involved in soundly accepting a theory or hypothesis are epistemic ones. We will return to defend this point in the next section, in which we will discuss and refute some common objections to the impartiality thesis. Before moving to the third and final component of Lacey's definition, however, two clarifications are in order. First, even if autonomy has been traditionally considered a good method to secure impartiality, it is indeed possible to have the latter without the former (that is, how theories and hypotheses are soundly accepted or discarded is in principle independent of how they have been formulated). Second, the claim of impartiality presupposes that there is a significant difference between epistemic and non-epistemic values, as indeed we have shown above.[5]

Of the three conditions characterising the ideal of (non-epistemic) value-free science, neutrality is the most questionable. According to it, scientific theories and hypotheses do not, or ought not to, imply any judgement about non-epistemic values nor favour any particular set of non-epistemic values

5 One could obviously object that there is no real difference between epistemic and non-epistemic values. In this case, the thesis of impartiality could hardly be defended. Even if, as we have already said in the previous section, no full defence of the dichotomy between epistemic and non-epistemic values can be properly done in the present paper, we still want to make explicit that such a dichotomy is necessary for our argument.

more than others. As a descriptive thesis, neutrality seems to be patently false; through detailed case studies, some scholars have shown that at least some scientific theories and hypotheses do actually privilege specific non-epistemic values more than others (Taylor 1967; Tiles & Oberdiek 1995). From a normative point of view, neutrality seems to be problematic, as well. To demonstrate this, it is sufficient to evaluate whether our judgements about the goodness/badness of certain non-epistemic values ought to be completely separated from empirical facts and/or our scientific knowledge of the world. Is it right to accept some non-epistemic values over others without contemplating any empirical facts and/or scientific knowledge? If the answer is positive, then one could legitimately endorse sexist values about the cognitive inferiority of women without being concerned about grounding them on any relevant empirical study showing, for instance, that women are intellectually incapable of doing mathematics. Vice versa, even if scientific studies show that there is no relevant cognitive difference between men and women, one could thereby continue advocating sexist values about the cognitive inferiority of women. Hence, we agree with Anderson (2010) that the ground for evaluating and accepting non-epistemic values ought not to be utterly detached from relevant empirical evidence and scientific knowledge. Of course, it does not follow that we must accept the converse. Thus, it is still possible to argue that the ground for evaluating empirical evidence and accepting scientific knowledge ought not to include non-epistemic values (as the condition of impartiality prescribes).

In sum, (i) even if science is unquestionably not autonomous (descriptively), it ought to be (normatively), at least as far as non-scientific values are used to slow and obstruct science instead of promoting pluralism and progress; (ii) our best science mostly is impartial (descriptively) and, in any case, it ought to be (normatively); and (iii) science is often not neutral (descriptively) and ought not to be (normatively). Given Lacey's definition of (non-epistemic) value-free science as autonomous, impartial, and neutral, we would be forced to admit that science is not, and ought not to be, value-free. However, because we believe that impartiality is the condition that best captures the idea of (non-epistemic) value-free science from a genuinely epistemic point of view, we think that it is still possible to maintain that science regarded as pure research mostly is (descriptively) and, in any case, ought to be (normatively) value-free. Thus, in the next section, we will limit ourselves to the defence of the normative thesis that science ought to be impartial.

4. A defence of the impartiality of science

When one philosophically analyses science, one should be interested in its ascertained epistemic value, not in its presumed ethical or, broadly speaking, non-epistemic value. In this view, we will analyse some objections to the thesis of impartiality: a theory or hypothesis ought to be chosen among different rivals and then soundly (not just provisionally) accepted only upon the degree of the epistemic values it exhibits (other interesting objections against the non-epistemic value-free ideal – that, however, we will not consider here – have also been raised by Douglas 2009; Dupré 2007; Elliot 2011; Kitcher 2011; Wilholt 2009; Winsberg 2010).

To begin, some feminist epistemologists have used the thesis of the underdetermination of scientific theories by empirical evidence (Duhem 1954; Quine 1953) to conclude that non-epistemic values not only are, but also ought to be, integrated into the scientific enterprise; thus, science is not, and ought not to be, impartial (Longino 1990; Nelson 1990). According to the thesis of underdetermination, any empirical evidence alone is not sufficient to determine the truth value of a scientific theory nor to inform a choice between two or more rival alternative theories (that is, theories which are mutually inconsistent). This assertion depends on the thesis of the empirical equivalence of theories by empirical evidence. In its most radical form, this claim suggests that any scientific theory T *always* admits, or might admit, an alternative theory T* that is empirically equivalent to T in the sense that T and T* entail the same body of empirical evidence and thus would successfully pass all of the same empirical tests. A weaker form asserts instead that any scientific theory T *at some moment* admits, or might admit, an alternative theory T* that is empirically equivalent to T (Psillos 1999). Thus, two kinds of underdetermination can be distinguished: permanent and temporary underdetermination (Author 2010). In any case, the conclusion must be that the choice of T instead of T* (or *vice versa*) is underdetermined by any empirical evidence.

According to some feminist epistemologists, if the thesis of underdetermination is correct, then we face a dilemma. On the one hand, because empirical evidence alone is, or might be, insufficient to inform our choice between two or more alternative and empirically equivalent theories, we may be forced to accept sceptical or relativistic conclusions about scientific knowledge. On the other hand, to avoid any sceptical and relativistic scenario, we may prefer to use non-epistemic values to reduce the scope of choice among alternative theories to only one option, thus arriving at the decision to consider only one particular theory. In this sense, non-epistemic values are useful and ought to be included in the scientific enterprise because they make scientific knowledge and epistemic enhancement possible. The argument based on underdetermination can be summarised as follows:

(1) If science is impartial, then we ought not to consider non-epistemic values in soundly accepting any scientific theory;
(2) Scientific theories are underdetermined by empirical evidence;
(3) If scientific theories are underdetermined by empirical evidence, then we cannot soundly accept any scientific theory solely on the basis of its relation to empirical evidence (i.e. its empirical adequacy);
(4) If we cannot soundly accept any scientific theory solely on the basis of its relation to empirical evidence, then, if we do not want to incur sceptical or relativistic consequences, we ought to consider non-epistemic values before soundly accepting any scientific theory;
(5) We do not want to incur sceptical or relativistic consequences;
(6) We ought to consider non-epistemic values before soundly accepting any scientific theory;
(C) Thus, science is not impartial.

This argument can be attacked on different points. First, premise (2) does not specify the type of underdetermination considered. It is worth noting that the more radical thesis, according to which any scientific theory T *always* admits, or might admit, an alternative theory T* that is empirically equivalent to T, is problematic both from an empirical and a theoretical point of view. On the one hand, the history of science shows that the various instances of underdetermination are quite meagre and merely transitory (such as the one between the Ptolemaic and the Copernican theory). At present, those who argue for underdetermination based on historical cases are able to point to only a few examples of alleged empirically equivalent theories (the theory of special relativity and the ether theory as proposed by Lorentz, Fitzgerald, and Poincaré as well as standard quantum mechanics and Bohmian mechanics). Why should these be considered permanent instances of underdetermination rather than temporary ones? (Author 2012) On the other hand, the body of empirical evidence entailed by a scientific theory can change over time, and we cannot foresee the nature of this change. Thus, we cannot predict that underdetermination will not be resolved. In addition, it is difficult to imagine an algorithm capable of artificially producing interesting cases of empirically equivalent theories (Laudan & Leplin 1991): that is, truly and not merely verbally different empirically equivalent theories (Carnap 1966). Similarly, difficulties arise when attempting to think of an a priori argument that does not intrinsically depend upon the confirmation theory one prefers to accept (Douven 2008). Hence, it is possible to conclude that underdetermination is, at best, merely transitory. In this case, however, premises (3) and (4) would fail. More precisely: against (3), if underdetermination is just temporary, then it is reasonable to expect that soundly accepting a scientific theory solely on the basis of its relation to empirical evidence will sooner or later be possible; against (4), if soundly accepting a scientific theory solely on the basis of its relation to empirical evidence will sooner or later be possible, then there is no interesting reason to make use of non-epistemic values. If we are faced with a certain case of underdetermination, the correct epistemic advice would not be "appeal to non-epistemic values to avoid sceptical or relativistic conclusions"; rather, it would be "look for new empirical evidence" (Amoretti & Vassallo 2010). Thus, if one is faced with two or more empirically equivalent theories, it is necessary to seek further empirical evidence or to wait until new empirical evidence becomes available (for instance, the development of new technologies can make accessible previously unimaginable data). Even if the pursuit of new empirical evidence may require that a scientist provisionally adopts one of the two rival theories on the grounds of non-epistemic values, it is important to note that this would not undermine the impartiality thesis, as it explicitly refers to *soundly* accepted theories.

Second, premise (4) can be attacked directly. The thesis of impartiality does not state that a scientific theory is, or ought to be, chosen among different rivals and then soundly accepted merely on the basis of its relation to empirical evidence (i.e. its empirical adequacy). The degree of other epistemic values exhibited is also fundamental to this decision. Sceptical or relativistic consequences can thus be avoided without employing non-epistemic values. It seems highly improbable that two rival alternative theories could be empirically equivalent and also able to satisfy to the very same degree all epistemic values (not only empirical adequacy, but also explanatory power, unifying power, predictive power, internal consistency, external coherence or consonance, simplicity, problem-solving effectiveness and fertility). As a matter of fact, even if it tends to become more fictional than real science (Dorato 2004), one could still reply that, at least in principle, two rival alternative theories might perform equally well in light of the above desiderata and still be different (Kuhn 1977). It is worth noting, however, that it is highly difficult to understand why two theories as such should be considered different *from an epistemic point of view* (which is what really matters) because they differ neither empirically nor theoretically. Moreover, in the best scenario, the argument based on underdetermination does not show that non-epistemic values *must be* included in scientific practice but only that *they may* be, which is a weaker conclusion (Intemann 2005).

Another possible criticism of the impartiality thesis emerges from the idea of the theory-ladenness of observation (Hanson 1958; Kuhn 1970) and shows that empirical evidence as such is already intrinsically value-laden. Roughly, the argument proceeds in the following manner. Any empirical evidence normally comes from observation, and any observation is intrinsically theory-laden; any theory always includes some non-epistemic values; that is, theories are intrinsically value-laden. Thus, any empirical evidence is intrinsically value-laden. A similar objection to the idea of impartiality has been developed by Helen Longino (1979). Any observation can be regarded as empirical evidence only in light of certain background assumptions; background assumptions always include some non-epistemic values; that is, they are intrinsically value-laden. Thus, any empirical evidence is intrinsically value-laden. The first line of reasoning has a problem with demonstrating that any observation is actually theory-laden. A classical example may be helpful. If Tycho Brahe and Johannes Kepler, who held alternative theories about the motion of the planets (the Ptolemaic and the Copernican theories, respectively) could look at the very same dawn, they would see different things: one, the sun rising and, the other, the horizon falling. Even if this story seems to show that observation is conditioned by one's own background theories, well-established psychological results demonstrate that this is not always the case; therefore, some constraints are in order. Let us take the Müller-Lyer illusion, where two lines of the same length appear to be different. Even if we know that the two lines have exactly the same length (and thus this information is contained within the body of our theory), we still perceive them as different. To generalise, many scholars agree that if two organisms with the same perceptual and sensory psychology interact with the same stimuli, they normally observe the very same thing (Fodor 1984). Both arguments, however, share the same difficulty. Even if we admit that any observation is intrinsically theory-laden or that any observation can be regarded as empirical evidence only in light of certain background assumptions, it is still at least questionable that both theories and background assumptions must always include some non-epistemic values, that is, that they always are intrinsically value-laden. Thus, the further statements are far from justified (Amoretti & Vassallo 2010, 2012).

For the sake of argument, let us allow that scientific theories always contain non-epistemic values, that empirical evidence is intrinsically value-laden, and that, finally, non-epistemic values are required to soundly accept a theory. As a matter of fact, this assumption is not completely improper (Harding 1986, 1991, 1998), at least for the human and social sciences, such as anthropology, history, psychology, and sociology. Because of their specific areas of study, these fields are more inclined than natural sciences to include non-epistemic values. If one believes that brute facts or pure data do not exist in human and social sciences and that the objects of knowledge are fundamentally shaped by cultural, historical, and social forces, then it would be straightforward to state that non-epistemic values cannot be completely eradicated from scientific theories and practices. However, we strongly believe that a feasible solution to the problems raised by the presence of non-epistemic values in the scientific enterprise, one that could preserve the core tenet of the (non-epistemic) value-free ideal, that is, impartiality as a normative thesis, would be the defence of the traditional distinction between the context of discovery and the context of justification. Better yet, because these terms may be misleading, we argue for the need to maintain a plausible distinction between a descriptive context that illustrates how a theory or hypothesis is actually chosen among empirically equivalent rivals and (provisionally or soundly) accepted and a normative context that prescribes how a theory or hypothesis ought to be chosen among empirically equivalent rivals and then soundly accepted. If we distinguish between a descriptive and a normative context, it is not useful to insist that scientific enterprises are always permeated by non-epistemic values due to their undeniable pragmatic aspects, as these aspects belong to the former context rather than to the latter. In the normative context, well-established scientific methods, epistemic values, and acquired empirical evidence are all that matter.

In sum, even if some doubts remain, we are inclined to recognise that our best science mostly *is* impartial. More importantly, however, we have established our main point: science *ought to be* impartial and, because impartiality is the core tenet of the ideal of (non-epistemic) value-free science, we can conclude that science understood as pure research ought to be value-free.

5. Concluding remarks

In this paper, we argued that science understood as pure research ought not to be affected by ethical and other non-epistemic values and defended the traditional ideal of (non-epistemic) value-free science. Science ought to be autonomous insofar as non-scientific values are used to slow and obstruct science instead of promoting pluralism and progress, and – more importantly

– science ought to be impartial. To conclude, we would like to briefly return to a few connections among science, technology, and ethics and to outline two more reasons in favour of the ideal of (non-epistemic) value-free science. First, as far as the knowledge of the natural and social world is concerned, scientific knowledge is often considered to be more reliable than ethical, aesthetic, or religious knowledge (Vassallo 2006); hence, there is no obvious reason to ground the former on the latter. Second, some scholars may be eager to radically naturalise ethics itself; in this case, ethics would become a branch of natural science, and ethical judgments would be considered as natural facts to be investigated through scientific methods and standards (Foot 1978, 2001). If this naturalisation were feasible, then the very possibility of a genuine ethics of science, which does not need science to be substantiated, would be cast into serious doubt. Although scientific knowledge must be freed from ethical and other non-epistemic values, this assertion cannot be extended to technological knowledge. Non-epistemic values are certainly relevant in deciding to support "good" technologies that are useful for the whole society or for subordinated and marginalised groups, enhancing social well-being, or increasing life expectancy. Similarly, non-epistemic values aid the decision to avoid "bad" technologies that endanger the environment, non-human animals, particular social groups or innocent creatures.

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