The Place of Values in Scientific Knowledge

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Abstract. In this paper I argue that the values supported by scientists can have a role in episodes of theory choice. In the first part, I characterize the value- and the rule-based accounts of theory choice. In the second part, I analyze how the thesis of underdetermination of theory by empirical data can be used to argue for a value-based account. I discuss two versions of the underdetermination thesis, arguing that the weaker version, underdetermination by the evidence available at a particular time, is sufficient for establishing the role of values in theory selection. Many authors distinguish between cognitive and non-cognitive values, considering that only the former ones have a legitimate role in theory choice. I defend this distinction, showing that it has both a normative and a descriptive dimension. I argue that cognitive values must not be seen as indicators of truth, but they can be characterized by their relation to the goal of science. In the end, I argue that, in spite of being justified and useful, the distinction between cognitive and non-cognitive values is not clear-cut.
Keywords: science, theory choice, cognitive values, value freedom, underdetermination.

Most of our day-to-day choices and decisions are based on value judgments. Nevertheless, when referring to the scientists' activity, the role of value judgments in their practice, and particularly in the moments they have to choose between two theories, is not as easy to admit. One of the main reasons for this is that, as usually considered, value judgments cannot be completely justified in an objective way. This does not raise any problem for our daily decisions, in which the great diversity of the human preferences and the partially subjective character of choices are generally accepted. However, the role of value judgments in science, which is dominated by the ideal of objectivity, is much more difficult to accept. This view is typically expressed in the form of the well-known "postulate of value freedom," formulated by Max Weber, which has become a generally accepted methodological principle of social sciences. In natural sciences, traditionally less associated with human values, this principle is even less questioned. My article will analyze some questions related to this principle in its general application, to social and natural sciences.

I will argue that value judgments have a role in the theory choice and I will show how this role can be seen. As in many philosophical debates, it is not easy to ask the correct question, and in the first section I will try to shortly characterize the dispute regarding the role of values in science. In the second section, I will argue that value judgments have an important role to play in theory choice. The underdetermination thesis will be the central point of my analysis. Some authors argue that only cognitive value play a role in theory selection. In the last two sections, I will analyze how this class could be delimited and how the distinction between cognitive and non-cognitive values should be construed. In the end, I will shortly summarize the results of my article regarding the postulate of value freedom.

RULES OR VALUES: DISPUTE AND POSITIONS

In this section, I intend to make more precise the question regarding the role of values in science and the possible answers to it. How can we formulate this question, so that it can be relevant for the development of the scientific knowledge? In order to answer to this question, I want to start by analyzing a distinction crucial for a good delimitation of the topic of this article. Two types of decisions of the scientific community can require an explanation or a justification. On the one side, there are some decisions concerning the research areas on which the scientific community has to focus, while, on the other side, there are the decisions concerning the selection of a theory, hypothesis etc. (Dorato, 2004: 53−54). Although the first type of decisions can have an important role for the development of scientific field in a certain historical moment, the second type of decisions are those that shape the scientific knowledge in the long run. In this sense, the decisions of the latter type can be called "internal" to the scientific practice, while those of the former type are rather "external." The influence of value judgments upon the "external" decisions is a fact hard to deny. For instance, the decisions concerning funding of scientific research usually rely on judgments concerning the importance of a certain research area for community, not only (and not mainly) on the epistemic merits of the theories involved. Scientists' choices regarding the development of a research area depends in an important way on extra-scientific factors, for instance on the technological and social needs of the society. In the same time, some scientists can choose to work or not to work in a certain research area, based on some value judgments. For instance, the moral doubts regarding some possible negative results of a research can determine some scientists to abandon that particular area of study. These are ways by which value judgments can influence, even in a significant degree, the scientists' external decisions. Anyway, the influence of value judgments upon external decisions does not represent the theme of this article. I am interested whether the value judgments have the same type of influence upon theory choice, and this is not in the same degree an undebatable fact.[1]

Another distinction drawn by some authors, between *epistemic* and *pragmatic decisions* (McMullin, 1983: 18), can be relevant for the theme of this article.[2] Based on this distinction, McMullin admits that some non-epistemic values can legitimately take part in some pragmatic scientific decisions. For instance, from lack of time or resources, scientists can accept a certain theory and stop searching another. Anyway, McMullin says, the role of non-epistemic values in epistemic decisions is not in the same degree easy to accept. Although McMullin does not define the pragmatic decisions, it can be assumed that they refer to the decisions not related to the goals of science (even if these cannot be precisely delimited).[3] For example, the decision to accept a certain theory because it suits the preferences of some economic groups that can fund scientific research is a pragmatic decision in this sense. One should notice that this distinction is different from that drawn before between decisions regarding theory choice and decisions about the focus of scientific research. This further distinction is done within the field of theory choice, and refers to categories of factors that can influence the theory selection. In some fields the pragmatic decisions can be important, but generally, the epistemic decisions have the crucial role.[4] My paper will concern epistemic decisions and their central role in theory choice.

The two distinctions sketched above offer a delimitation of the topic of this article. There are some moments in the history of science in which two theories designed to explain roughly the same set of empirical data compete to gain the scientific community's adhesion. In such moments, the scientific community has to make a decision. Even if, for a short period of time, it is possible that different scientists support and use different theories, finally they will reach consensus, at least in mature science. Even if in many cases the dispute continues for a long period of time, finally one of the two competing scientific theories will be chosen by all scientific community, and all those accepting the other theory will be considered outside of the scientific community. The process of theory choice can be seen in two ways. First, there are some authors who consider that the scientists' choices are based on few precise rules, which work in all situations as clear-cut criteria of choice. According to a second view, the choice is based on some values, which guide the choice, but do not lead to a definite answer. Next, I will examine the way in which the two theories are supported by Karl Popper and, respectively, by Thomas Kuhn.

According to a conception widespread until the half of the past century, in the cases in which scientists in a certain field have to choose between two theories devised to explain the same set of facts, some precise rules for assessment and comparison of scientific theories will offer an univocal result. A paradigmatic supporter of this view is Popper, for which the falsifiability rule plays the central role as a rule of theory choice. According to Popper, the selection of a theory against another one is reducible to the confrontation between the two theories, separately considered, and empirical data. The falsifiability rule, according to which the theories that are incompatible to empirical data should be rejected, is the main criterion by which the confrontations between two theories are to be settled.

Popper admits that a logically compelling falsification of a scientific theory cannot be achieved. Thus, theoretical statements cannot be tested separately, but only in groups, containing also some auxiliary hypotheses, not belonging to that theory. According to the *modus tollens* rule, the falsity of an observational statement can show only that one of the statements in that group is false. However, the supporter of a theory can „blame" any of the statements and even the auxiliary hypotheses and, as a result, the theory would not be rejected. Anyway, after a while, such defensive maneuvers will become more and more artificial, leading to a complicated theoretical construction. Thus, in a relatively short time, the attempts to defend in such a way a scientific theory will become unsuccessful and the false theory will lose the support of the scientific community.

According to a second conception, the theory comparison is based on a set of values, and the theory that conforms better to these values wins the scientific community's support. One of the most significant authors who sustain this theory is Kuhn. According to him, when two scientific theories are in dispute, the scientific community will choose the one that conforms better to a set of characteristics. Without claiming exhaustivity or originality, Kuhn lists five such characteristics: accuracy, consistency, scope, simplicity, and fruitfulness. These characteristics play the role of some values, guiding the scientists' choice, but not offering a determinate answer. Thus, from at least two reasons, it is possible that scientists would not agree to the result of a certain assessment. First, scientists can have different opinions regarding the theory that performs better from the point of view of a certain characteristic; secondly, although agreeing in this regard, they can give more importance to different characteristics. Consequently, two scientists can support distinct theories without giving up their rationality.

Nevertheless, at least in mature science, the competition between two theories will not indefinitely last and finally the scientists will reach consensus. Two factors contribute to the final selection of a certain scientific theory. First, after a period of competition, one of the two scientific theories will show its obvious superiority, performing better from the point of view of all (or most) characteristics, and this will lead to choosing it. Secondly, the scientists' selection of a particular theory is a reinforcing process. A scientific theory that has a small advantage against another will be preferred by more scientists, who will develop it and who will gather new evidence for it. The other theory will remain in its initial state. In time, virtually all scientists will support one theory while the other will become obsolete, all those who defend it being considered outside the scientific community.

The difference between a rule-based account of theory choice, as supported by Popper, and a value-based account, as defended by Kuhn, does not consist necessarily in the nature of factors that are seen as influencing the theory selection, but rather in the role attributed to these factors. In the rule-based account, these factors play the role of strict choice criteria, and if a theory that does not meet one of these criteria is rejected by honest researchers. In a value-based account, the factors relevant for theory selection do not work as strict criteria, but rather guide theory selection, so a theory performing worse in terms of one factor can be rationally supported by the scientific community, due to a better performance from another point of view. In a value-based account, the subjective elements can have a role, since the scientists can ascribe different weights to the factors involved in theory selection. In this way, the debates between scientists can find an explanation, which is difficult in a rule-based account.

Another element is relevant for a complete examination of the dispute between Popper and Kuhn, and generally that between the value and rule-based accounts of theory choice. Should we consider these models as normative or descriptive? As developed by Popper, the rule-based model is mainly normative. Popper admits that apart falsification rule, many other factors can actually influence the actual choice of the scientists. For instance, Popper does not deny that there were episodes in the history of science in which some scientists, even important ones, refused to follow the falsification rule. But this is a sign of lack of honesty and an impediment to the progress of science. Therefore, falsification rule has rather a normative function. On the contrary, as developed by Kuhn, the value-based model has mainly a descriptive function, referring to the way in which scientists actually make their decisions.[5]

The argument above, according to which the rule-based account is mainly normative and the value-based account descriptive can lead to the conclusion that these two models are not in a real dispute, since they have different objects. But this is not a correct approach. First, any normative choice theory model should take into account, at least in a certain degree, the real scientific activity and the history of science. In the same way, Popper argues that his falsificationist theory can deal with some important episodes in the history of science.[6] It is true that many important episodes in the history of science show that scientists often try to avoid their theories to be falsified, but this can only delay the rejection of a refuted theory. Therefore, the falsification rule has also a descriptive import, explaining how some theories were actually rejected.

On the other hand, Kuhn's account has not only a descriptive dimension, but also a normative one (2000: 130). Kuhn's conception was criticized for mistaking between these dimensions and also for its implication that any actual scientists' decision is correct. It is true that Kuhn states that there is no neutral normative point from which we can prescribe to the scientists the right choice. However, in some moments, the decisions of particular scientists to defend a theory can be considered wrong or even irrational. So, Kuhn does not affirm that all actual scientists' decisions are correct. Furthermore, even if Kuhn argues that most of the scientists' decisions are rational and correct, this is not simply stated, but argued, at least implicitly. First, Kuhn starts from the fact that science is a rational and successful enterprise (1970: 207−208), and these characteristics can be explained only by the fact that, at least generally, the scientists' decisions are correct. Secondly, the community character of scientific knowledge has also a function in this regard. In Kuhn's view, the decision to choose a scientific theory is better understood as decision of a group, not of an individual scientist. This will remove scientists' subjective preferences for some values. For instance, a scientist can ascribe a greater importance to the precision of a theoretical prediction, while for another one simplicity has the central place. The group decision is the resultant of these particular preferences, which remove the excessive effect of the personal scientists' preferences.

Therefore, in most cases (even if not always) the scientists' decisions are correct and from this we can infer that the general lines of action followed by scientists, which explain many historical episodes, are rational solutions of the scientific community. In this way, the choice principles with an important descriptive and explanatory role are also acceptable from a normative point of view. So, a good account of theory choice will have both a normative and a descriptive function. On the one side, such an account represents a good reconstruction of scientists' behavior in many historical moments; on the other side, the reliance on some value judgments is justifiable also from a normative point of view. However, the normative and the descriptive questions are different and can be discussed distinctly, even if there are good grounds to consider that persistent patterns in theory choice are justified from a normative point of view. Occasionally, some decisions of the scientific community can be considered inadequate, but such moments are an exception rather than the rule and they require an independent explanation. Furthermore, in order to show that the scientists' choice in a certain moment was wrong or even irrational, is not enough to specify a case in which the scientific community rejected a theory that later proves itself better. In many cases, this choice is determined by the fact that at the moment of its first formulation, the theory was not developed enough to outperform its rivals. Therefore, the scientists' choice was rational and only further development of that theory could prove its superiority. Heliocentric theory, for instance, was fully accepted long time ago after its elaboration, by Copernicus, at the half of sixteenth century. Anyway, until the seventeenth century, there had not been many rational grounds to accept the heliocentric model against the geocentric one.

Among the supporters of the value-based account, some consider that a distinction between cognitive and non-cognitive values is required and that only the former category of values has an important and justified role in the history of science. In the next section, I will argue for a value-based account of theory choice, and in the third part I will discuss the distinction between the two categories of values.

VALUES AND UNDERDETERMINATION

It is difficult to argue against the Popperian falsification-based model. It is hard to deny that scientific theories should be tested, and rejected when they are proved to be incompatible with empirical evidence. In this case, what role could remain for the values listed by Kuhn? If indeed, only one theory were in conformity with all empirical data, that theory would be selected and scientific values would lose any function in theory selection. Thus, the falsification rule plays a central role in theory choice. However, there are (or at least there could be) moments in the history of science in which alternative theories fit equally well the empirical data and are, consequently, empirically equivalent. In the case in which two empirically equivalent theories compete, values can acquire a role in theory choice.

Therefore, thesis of underdetermination of theory by empirical data is a necessary condition for the thesis that values play a role in theory choice. The problem of a value-based theory choice rises only if a set of empirical data allows the possibility of more than one theory that cannot be concomitantly accepted by the scientific community. If this condition is not satisfied, the decision regarding the acceptance of a theory will be taken only on the basis of the empirical evidence, and the disputes regarding theory choice will be settled only on this basis. But if more than one theory, in the same degree in agreement with empirical data, were built, the competition between them would be settled by recourse to the value criteria. These will come as second-level criteria, "filling the gap" between the empirical evidence and theory. The Kuhnian value criteria become additional elements for choosing among those theories that are in agreement with all empirical data.

I have showed that thesis of underdetermination of theory by empirical evidence is a necessary condition for a value-based model of theory choice. Is the underdetermination thesis correct? In this article I will not approach straightforwardly this question, but I will bring some arguments to make some version of this thesis more plausible and I will examine whether these versions are sufficient to argue that values have a role in theory choice.

First, we need to distinguish between empirical laws and theoretical laws. The former are generalizations of observational sentences, while the latter explain the former, by non-observational terms and statements. The issue of underdetermination does not characterize the empirical laws, but only the theoretical level. It is likely that the same set of empirical laws would be justified by more than one set of theoretical statements and in this case underdetermination thesis would be true. The existence of many sets of theoretical statements that justify the same set of empirical laws is even more probable for highly general theories, which are very difficult to test. For instance, from the general theory of relativity only few observational sentences, which can be directly tested against empirical evidence, can be deduced (Kuhn, 1970: 26). Even when empirical testing is possible, in most cases, some measurements of physical magnitudes, which can be realized only in a certain range of approximation, are involved. From this reason, when the predictions of a scientific theory are in an approximate accord with empirical data, the theory can be considered corroborated, at least until developing better means of measurement. Thus, the probability that, at a certain moment of time, at least two theories would be in agreement with empirical data increases.

The argument above shows that the underdetermination thesis is plausible, at least for highly general scientific theories. Nevertheless, even if from the evidence available at a moment two theories are empirically equivalent, there is a principled difficulty to prove that no possible empirical test will support one of the two theories against the other. In this regard, an important distinction should be made between two versions of underdetermination thesis. According to the first one, called „transient underdetermination" (Sklar, 1975: 380) or „underdetermination in practice", there are situations in the history of science when two theories explain similarly well the empirical data available at a certain moment. Anyway, it is accepted that any future data that would become available could affect the empirical equivalence between the two theories. According to the second version, called "radical underdetermination" or "underdetermination in principle," there are theories among which no possible empirical data can decide. These two theses are significantly different, since the first one is an empirical thesis about some episodes in the history of science, but the second one cannot be directly tested by examining history of science. In the same time, the radical underdetermination thesis is stronger, since it states that no future empirical evidence would confirm a theory against the other.

In case that the thesis of underdetermination-in-principle is true, the role of values as a "bridge" covering the gap between theories and evidence (McMullin, 1983: 14, 19) is easy to accept. If any potential evidence were not enough to select between two competing theories, values could be used for this. Unfortunately, it is very difficult to argue for the radical underdetermination thesis, since it requires the identification of all observational statements that can be deduced from a certain theory, which seems an accomplishable task only in some determinate contexts. In the best case, we can argue that radical underdetermination is possible, but this thesis is not useful for this paper. However, the weaker thesis of transient underdetermination is generally accepted as a fact of scientific life (Sklar, 1975: 381). Thus, generally, scientists have only few possibilities to test the newly created theories, for at least two reasons. First, the earliest elaborations of the scientific theories are not very precise and detailed and for this reason only few empirical consequences can be drawn from them. Furthermore, in many cases, theories are originally elaborated only to explain a certain class of empirical facts, and many other observational consequences are not explored. Secondly, most of the observational statements drawn from a certain theory cannot be easily tested, as this requires new instruments of experimentation, which will be developed only later. This difficulty of testing the new theories makes more likely the existence of two theories with the same class of testable consequences. As time passes by, the class of observational consequences of the theory and the class of testable consequences will increase.

But is the weak version of the underdetermination thesis enough to establish a role for value judgments in theory selection or the stronger version is needed? This problem can be made clearer in the following way. According to transient underdetermination thesis, there are some moments in the history of science when two rival theories are in the same degree empirically adequate, given the whole evidence available at a moment. In such a case, two options are opened to each scientist and to the whole scientific community. The first one is to try to find new empirical data for a theory and against another, and to withhold the judgment until such data are found; the second one is to select one of the theories by using some value judgments. In the first case, in a situation of transient underdetermination, scientist will not adhere to a theory based on value judgments. Therefore, the values judgments would not play a role in theory selection. In the second one, scientists will adhere, at least provisionally, to one of the competing theories based on some value judgments. For instance, scientists can prefer the simpler theory, even if the available empirical evidence does not favor it against its rival.

Generally, scientists cannot carry their activity without working on the basis on a certain theory, which will guide their experimental work, and so a state of complete indifference between two theories in dispute the scientific activity is impossible. This is the reason why, in cases of empirical equivalence, scientists should choose a theory, using value judgments. Anyway, a distinction between two stages of theory choice should be made. The first stage refers to the provisional choice of a group of scientists to adhere to and to develop one of the competing theories, while the second one marks the scientists' definitive choice of a certain theory. However, a clear-cut line cannot be drawn between these two stages and it is difficult to find a point in which the competition between two theories can be considered definitively settled. The scientists' value-based adhesion to a scientific theory is provisional, since new data can show its empirical inadequacy, "leaning the balance" towards the rival theory. From this reason, it could seem that the scientists' value-based support for a theory should be considered rather a personal belief, without a significant importance for the development of science, since only a crucial experiment can conclusively settle the dispute between two theories.

Anyway, the provisional adherence to a theory, in cases of transient underdetermination, can have relevance. There are cases in which a theory becomes generally accepted by the scientific community based on its better performance in terms of values, not because a crucial experiment shows that its rivals are not empirically adequate. For instance, during the Chemical Revolution, many years after the Lavoisier's *Treatise*, a crucial experiment showing the superiority of the oxygen theory against the phlogiston theory had not yet been carried out.[7] In spite of the underdetermined choice between the two theories, scientific community generally accepted the new oxygen theory. Thus, in 1807, when most, if not all, chemists had been already convinced by the superiority of the oxygen theory, Humphry Davy stated that he supports the latter one not because his final "conviction in its permanency and truth," but based on its "simplicity and beauty" (Siegfried, 1963: 257). In such cases, the value-based adhesion of scientists to a theory plays an essential role, since, if most scientists support a theory, they will try to develop it and to ensure its coherence. In time, the chance of the rival theories to show their superiority will decrease, even in the absence of a crucial experiment. This was also the case with the phlogiston theory, which scientists gave up even without a decisive argument showing its inferiority.

COGNITIVE AND NON-COGNITIVE VALUES

In the previous section, I have showed that values can have a legitimate role in theory choice. Still, one cannot conclude from this that all values have the same legitimacy to be used in theory selection, and in this regard, many authors draw a distinction between cognitive and non-cognitive values (c/n distinction).[8] According to this solution, the factors that can influence the choice between two competing scientific theories are classified in two categories. First, there are cognitive values, such as accuracy, consistency, simplicity, coherence with established scientific theories, or explanatory and predictive power, which are inherent to scientific practice and explain most of the scientists' choices. In addition, in some historical moments, an important role is played by social, political and cultural values. For instance, the compatibility with the accepted religious beliefs was in some cases an important element, explaining the rejection of some scientific theories, otherwise adequate from the point of view of the cognitive values.

The distinction between cognitive and non-cognitive values acquires at most authors both a descriptive and a normative dimension (Lacey, 1997: 6). From a descriptive point of view, cognitive values has the central role in theory choice and taking them into account is essential for explaining the important episodes of theory choice in the history of science. From a normative point of view, the cognitive values are those that should steer the theory choice process and that are legitimately used by scientists to justify a certain theory. The non-cognitive factors, such as the drive for power, money and prestige, can influence the selection of a theory, but they cannot justify it. Although at most authors the two dimensions are not clearly delimited and the normative dimension can appear in a "weaker" form,[9] the distinction drawn here between a normative and a descriptive dimension is useful, even if only as an idealization. The descriptive dimension of the distinction involves only a delimitation of the factors that plays a central role in theory choice, without the suggestion that these factors would have more legitimate use in theory choice than the others. Next, I will examine in which sense this distinction has a normative import, analyzing in the same time the relationship between the two dimensions.

While the descriptive part of the c/n distinction is not too much discussed, many authors doubt that this distinction in its normative interpretation can be defended. They doubt that a class of cognitive values, which can be legitimately used in theory selection, can be delimited. Many of these criticisms of the normative part of the distinction come from feminist position; these authors try to show mainly two things: that, at least in some cases, non-cognitive values can have a legitimate role in theory selection, and that even cognitive values are finally justified by some non-cognitive values (Longino, 1995: 383−384). This and the following sections will provide an answer to the first argument, while, due to lack of space, the second one will not be examined.

I will start by replying to an argument against the c/n distinction, which starts from the underdetermination-based argument discussed in the first section. This argument shows that more than one theory in accord with all evidence known at a certain moment can be formulated, which justify the use of value judgments as an instrument for selecting one of the theories that are in accord with all evidence. But, the argument runs, exactly the same type of argument can justify the use of the non-cognitive values. If we accept only the cognitive values, theory choice will continue to be underdetermined and, for this reason, non-cognitive values may also be used. In a stronger version of the counter-argument, the two types of values have the same status, so the potential underdetermination can be solved using cognitive or non-cognitive values. In a weaker version, cognitive values have priority, but if they are not enough (and this situation is usual), the non-cognitive values may be used.

It is true that the non-cognitive values are in many cases not sufficient for a decisive choice of the scientific community and for obtaining the scientific consensus. As Kuhn argues, scientists can have different value hierarchies or can disagree on which theory is better from a certain point of view. Anyway, this is not a good argument to use any criteria to select one of the theories; their relevance should be argued for.[10] Even if this is true, critics of the c/n distinction reply, a further argument is needed to legitimate the cognitive values against the non-cognitive ones. Why should scientists accept cognitive, but not non-cognitive values? The supporters of c/n distinction should find a ground for the difference between these two types of values.

The best solution to justify the delimitation between the two types of values would be to consider that cognitive values are indicators of truth, i.e. theories characterized by cognitive values are more likely to be true. McMullin (1982: 18) is one of the authors who justify the cognitive values (called *epistemic* by him)[11] in this way. This approach can offer a clear criterion of delimitation and provides a clear answer to the question regarding the reason for which the scientists should follow, and actually follow, the cognitive values. If truth is the goal of science and the cognitive values are indicators of truth, then their achievement is a desirable thing. The truth will not function as a value at the same level with the others, but as a first-level value, with a justifying role. Unfortunately, this account faces some counterarguments. McMullin's (and, generally, the realist) way to draw the c/n distinction is based on two completely independent premises: (1) Truth is the ultimate goal of scientific knowledge, and (2) Cognitive values, to which scientists should conform when choosing a theory, should be justified by their relation to the goal of science.[12, 13] As a result, cognitive values, acceptable to be used in theory choice, will be those promoting the goal of science, i.e. truth. In the rest of this section, I will argue against (1), while in the last one I will refer to (2).

To start with the first argument against (1), the account that see cognitive values as indicator of theoretical truth presupposes a realist view of science, according to which the theoretical statements can be true or false, in the same way as observational statements.[14] But this view is questioned by the supporters of underdetermination thesis. Therefore, the champions of the value-based account, which, as I have showed, have to defend the underdetermination thesis, support an antirealist thesis that raises questions regarding the role of values as indicators of truth. Anyway, the defenders of a realist justification of cognitive values have an answer. It is true that underdetermination could raise some worries for the realist, but it is the radical version of underdetermination, not the transient one, that could have these results. In this case, cognitive values would become strategic means which can help scientists to select the most likely theory to be true from two or more theories confirmed in the same degree, at a certain moment. This is certainly a coherent account, but it can meet a counterargument, too.

How can we know that cognitive values are indeed good marks of truth? Two strategies to argue for this are open. First, one could try to show that an empirical relation can be drawn between cognitive values and truth-value, and that scientists do use this relation to increase the probability to find the true theory. Secondly, one could try to find an a priori relation between cognitive values and truth. Both strategies face a significant problem. In order to examine the relation between cognitive values and truth, we have to be sure that a certain theory is indeed true. But this seems impossible, since, at least theoretically, serious alternatives even to our well-established theories can be devised, and in this case radical underdetermination is at least possible.[15] So, for a realist justification of cognitive values, an argument that at least some theories are impossible to be threatened by radical underdetermination is required, but such an argument seems difficult to give. Furthermore (although this is not an essential element in my argument), in the case of radical underdetermination, it is doubtful even that we can safely talk about the truth-value of a theory, at least in a full realist sense, as the two underdetermined empirically equivalent theories cannot be both true, but, in virtue of how the world is, we cannot ascribe the truth to any of them (Newton-Smith and Lukes, 1978: 87−88).

A second way to argue against a realist justification of cognitive values is by showing that some scientific values have a significant role in theory choice, and this role cannot be justified by their relation to truth. Simplicity, a value that undoubtedly had a significant role to play in many theory choice moments, is maybe the best example. Next, I will shortly refer to one of these moments, the famous Copernican Revolution. As generally known, in order to explain some astronomical observations, the Ptolemaic model assumed that planets move in small circles, called *epicycles* along a larger circle called *deferent*. Copernicus rejected this model on considerations of simplicity, and replaced it with a simpler one, in which Earth goes around the Sun and epicycles were not required. The simplicity of the new model plays a central role in this episode[16] and in many others. Nevertheless, this role cannot be justified by recourse to truth (Van Frassen, 1980: 90; Newton-Smith and Lukes, 1979: 81). Thus, without a teleological theory according to which the world is created by an rational being who endowed it with harmony and beauty, we cannot argue for the fact that simpler theories are more likely to be true. Therefore, the role of simplicity in theory choice is not based on its role as an indicator of truth.[17] There were some theory choice episodes in which such a belief in the simplicity of the nature based on (almost) religious arguments played a role in history of science. However, this type of argument cannot have a significant role in scientific practice as a whole. So, the central role of simplicity in some theory selection episodes is not the result of its function as a mark of truth.

Thirdly, in a realist justification of the cognitive values, the ultimate goal of scientific activity is truth. However, some true statements are completely uninteresting or lack explanatory power (Rolin, 13-14). So, even if we accept truth as a valid goal of science,[18] other qualifications should be added. Tentatively, the goal of science can be defined (not necessarily fully) as the production of true statements with a high explanatory and predictive power. If truth (without any qualification) cannot be considered as the goal of science, some other values, not related with truth, can also be accepted as cognitive values, since following them also promote the goal of science. However, inasmuch as truth is kept as a goal of science, some cognitive values can be justified by the fact they are truth-conducive, and in this case the class of the values with this property (epistemic values) would become a subset of the class of cognitive values.

JUSTIFICATION OF COGNITIVE VALUES

After rejecting the first premise of the realist justification, I will try to keep the second one, which is essential for the c/n distinction. Thus, the problem of the delimitation of a class of cognitive values is necessarily related to the problem of the goal(s) of science (Pournari 2007: 673−674).[19] This premise is the result of a general way of approaching human practices (or fields of activity). According to this view, originated in Aristotle's work, each such practice can be characterized by a goal, and the values relevant for the evaluation within the respective field are related to this goal.

The concept of cognitive value seen in this way has a normative content in two related senses. First, in the limits of scientific activity, cognitive values are indicators of achieving the goal of science, being by this as worthy to follow as that goal. Since this characterization involves the idea that the cognitive values are specific to science, the term *constitutive* is a good equivalent of this sense of *cognitive*. The scientist qua scientist has the duty to act in conformity with this goal, and so with cognitive values.

Secondly, as achieving the goal of science is a generally desirable thing for the human life (as, for instance, the predictive power of a theory increase our control of nature), scientists has a *prima facie* duty as a human being to act in conformity with these values. However, this duty is only *prima facie*, since non-cognitive values can have a legitimate impact on theory choice. For instance, a scientist can give up defending an adequate theory from a cognitive point of view because of its harmful social effects. This situation can be better described as a case in which a scientist as a human being is influenced by non-cognitive values, which can "trump" the cognitive ones. Generally, human beings are steered by non-cognitive values, so there is no reason why scientists would be not.[20]

As I have showed, it is doubtful that truth (without qualifications) can play the role of the goal of science. The goal of science has in fact more than one component, partly independent; for instance, the explanatory power of a theory is such a component partly independent from truth. In this case, some cognitive values (which can be called "primitive") will be justified as components of the goal of science, while others ("derivate") by the relations with the former. The main advantage of the realist justification is that all cognitive values are reduced to a single and undisputable goal, truth. If we characterize the goal of scientific activity by many, partially independent, components, the danger is to justify the cognitive values in a circular way. If a certain value is not related with the goal of science, other components could be added, and then the justification of cognitive values by this goal would become circular.[21] In order to alleviate the difficulty, two things are required. First, an independent justification, even partial, of the primary values is required, and secondly, some cognitive values, as many as possible, should be justified by their relation to the primary ones. Next, I will examine separately the two requirements.

Even if there could be justified debates about the precise formulation of the goal of science, some things could prove helpful in this regard. The most important role in this regard is played by the observation of the real goals that guide the practice in fields paradigmatically considered as scientific. What do they aim to achieve? This way of justify the goal of science, and so cognitive values, could raise two typical criticisms. The first one is that of circularity, since this solution depends on the prior identification of some scientific fields. However, although some fields lay at the boundary of science, it cannot be denied some that activities are paradigmatically scientific and the identification of the goal of science could start from them. The second criticism concerns the relation normative/descriptive, as this solution is based on descriptive statements regarding the actual goals of scientists, trying to draw normative conclusion, since the concept of *cognitive value* has such content. I have already answered to this type of criticism in the first part, where I have showed that the norms constantly followed by scientists are justified also by a normative point of view.

Other two elements can be useful for the formulation of the goals of science. First, some characteristics of the scientific enterprise are indisputable. For instance, scientific knowledge is guided by experience, which represents the final arbiter when judging scientific theories. Secondly, the instrumental utility of a scientific theory is not a characteristic *sine qua non*. Even if many adequate scientific theories lead to applications vital for people's daily lives, the utility of those scientific theories is not a relevant factor in theory evaluation. Both characteristics are useful to distinguish science from other human practices, no less important than science: art for the first characteristic and technology for the second one (Kuhn, 1983: 567). Secondly, the objectives of science are not only compatible, but also intercorrelated, supporting and justifying each other. For instance, even if the explanatory and predictive power of a theory represent different goals, a scientific characteristic attaining the former objective is likely to attain the latter, too. This intercorrelation can help us reject some objectives as valid for science; if an objective not related to the others generally accepted objectives were introduced, this fact would be a serious counterargument against its acceptance.

The discussion above concerns the goal of science and, consequently, the cognitive values that can be seen as components of this goal. A distinction regarding the relation between the goal of science and cognitive values in this account and in the realist one should be highlighted. In a realist account, and generally in a fundationalist account, all cognitive values are means or indicators of achieving the goal of science. In a non-fundationalist account some cognitive values are components of the goal of science. The distinction between the two relations, *indicator of* and *component of*, is significant, since the former presupposes a logically independent definition of the goal of science, while the first does not. Hempel (1981: 404) is one of the authors who consider that the cognitive values can be seen as components of a good theory, but not as means for achieving the goal of scientific knowledge. This goal is to build theories characterized by explanatory and predictive power, simplicity, internal and external coherence, etc. (Hempel, 1981: 404), and the cognitive values are components of this goal. A goal of science logically distinct from these desiderata cannot therefore be formulated. As I have already noticed, in this case, the relation between cognitive values and the goal of science will not provide them a non-circular justification. This is the reason why at least some cognitive values have to be further justified. I offer such a justification for the value of simplicity.

In some contexts, the principle of simplicity is a particular case of a general principle of human rationality, the principle of parsimony (or Occam's razor), according to which theoretical elements (assumptions, hypotheses, concepts) without an explanatory role should be eliminated. As a result of the application of this principle, the theory that will prove simpler will gain the adhesion of scientists. For instance, during the Chemical Revolution, around 1800, after Lavoisier's new oxygen theory had won the dispute with the old phlogiston theory, some supporters of the phlogiston theory stated that the new theory had not showed that the concept of phlogiston does not have a real referent. They tried to show that the principle of phlogiston can survive, together with the principle of oxygen. Nevertheless, although the "hybrid theory" was not internally incoherent, the explanatory role of the phlogiston was very low (Pyle, 2000: 114). The "hybrid theory" did not conform to the Occam's razor and the new theory of oxygen performed better from the point of view of simplicity.

The desideratum of simplicity cannot be reduced in all situations to the Occam's razor. In other contexts, simplicity is in a strong relation with other values, such as explanatory and predictive power. The following example, which illustrates in a simplified way many situations in some fields of science, will prove this aspect.[22] Suppose that we have two physical magnitudes and two quantitative laws that relate them. According to an ordinary mathematical result, on the basis of any *n* pairs of values for the two magnitudes, a polynomial function of degree *n* that expresses the correlation between the two magnitudes can be identified. But exactly because this result is mathematically warranted, the function will not be safely extrapolated to new cases. The *n*-degree function is built in ad-hoc manner, only to deal with empirical data available at a certain moment, and, from this reason, it lacks explanatory and predictive power. If, after gathering many empirical data, the two magnitudes can be correlated by a linear function, then there are good grounds to consider that the correlation obtained can be extrapolated to new cases. Therefore, in this context, the simpler correlation, have, *ceteris paribus*, greater explanatory and predictive power than the more complex ones.

In conclusion, in these two cases, simplicity is justified as cognitive value because, in the first case, it is a particular case of the value of parsimony, supported by a general principle of rationality, that should be accepted also in science, or because, in the second case, it is related to other (probably primary) cognitive values, like explanatory and predictive power. These two arguments provide general strategies for justifying and delimiting some cognitive values. But is this delimitation clear-cut? In the rest of this last section I will argue in favor of a negative answer.

The explanatory power of the theory is one of the most important factors in evaluation of a scientific theory. In many cases, the criteria of an adequate explanation include the agreement with some metaphysical assumption, which becomes a relevant factor in the evaluation of the scientific theories. The dispute regarding gravitational force can provide us a relevant example in this regard. When Newton formulated his theory of gravitation, Leibniz replied by stating that this theory cannot offer o good explanation, because, in the absence of further development, it assumes that two physical bodies can act upon each other, while separated in space. On the contrary, Newton affirmed that although it would prove useful, a further explanation is not necessary (Hesse, 1955: 340). So, the metaphysical presuppositions according to which two bodies not in contact with each other can causally interact without intermediation of other bodies was, for Leibniz, a relevant factor in theory evaluation. Can we consider such factors as non-cognitive ones? I believe that such a general view would not be in accordance with the scientific practice, as the metaphysical or theological presuppositions have, in many cases, a central role in the evaluation of the scientific theories. On the other side, there were cases in which metaphysical or theological assumptions operate rather as non-cognitive factors. In the dispute in the sixteenth and seventeenth centuries between the geocentric and the heliocentric model of the universe, the presupposition that, from religious considerations, Earth should be put in the center of the Universe, acted rather as a non-cognitive, external factor. Therefore, a clear-cut distinction between cognitive and non-cognitive factors cannot be drawn in all cases.

McMullin (1982: 19−20) is one of the authors that shows that the case of conformity with metaphysical or theological assumptions raise some difficulties for a clear-cut distinction between cognitive and non-cognitive values. Anyway, he considers that conformity with a theological world-view is a "non-standard epistemic factor," i.e. a primarily non-epistemic factor that can work, in some contexts, as an epistemic factor. But this formulation can obscure the serious consequences that this type of examples brings for the c/n distinction. First, the concordance between a theory or an explanation and certain theological or metaphysical presupposition cannot be included in all cases in the category of cognitive or non-cognitive factors, without a further analysis. This analysis requires taking into account the character of the presupposition in a specific historical context. So, the inclusion of a particular presupposition in one of the two classes will depend on the historical context in which it appears. Finally, even such examinations may not provide a verdict regarding whether the conformity with a certain metaphysical assumptions can be seen as a cognitive or non-cognitive factor in theory choice.

In the end I will summarize the consequences of my article for the postulate of value freedom. First, this methodological principle should not be understood simply as independence from any value judgment. As I have showed, in the case in which two theories are in the same degree in conformity with available evidence, some values can justifiably play the role of a tiebreaker between the two theories. I have argued that a distinction between cognitive and non-cognitive values can be drawn, and that the former ones have the main role in theory choice. Anyway, this distinction must be seen with some reservations in two regards. First, in some cases, the scientist as human being may have good reasons to take into account some non-cognitive values, too. Secondly, a precise criterion for the delimitation of cognitive values cannot be provided.

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Acknowledgments. This paper was supported by the strategic grant POSDRU/89/1.5/S/62259, Project "Applied social, human and political sciences. Postdoctoral training and postdoctoral fellowships in social, human and political sciences" cofinanced by the European Social Fund within the Sectorial Operational Program Human Resources Development 2007-2013.

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[1] In the following, for convenience, I will refer only to the decisions concerning theory choice, not to those concerning the choice of a certain hypothesis, scientific language, etc, but the discussion can be easily extrapolated.

[2] Giere (2003: 20) draws a distinction similar with that of McMullin between *epistemic belief* and *practical action*. This way to draw the distinction involves a separation between beliefs and actions. But, in order to be relevant for the reconstruction of some episodes in the history of science, epistemic beliefs should involve also types of action (see also Kukla, 1992: 495). Epistemic beliefs are important because they manifest themselves in scientists' actions. Scientists who have different beliefs act in different ways, for instance they will choose to carry different experiments, to take different measurements, in accord to the theory they support.

[3] I am not sure that the McMullin's example is adequate, since the decision to consider a certain scientific theory as acceptable and to stop searching another to replace it can be motivated completely by scientific reasons.

[4] I will return to this in the third section.

[5] Although I am not arguing here for such a general thesis, I think that generally the rule-based models are construed as normative models, and the value-based models as descriptive ones.

[6] See, for instance, *Conjectures and Refutations*, 48, for an historical exemplification of a situation in which a theory (Einstein's theory of gravitation) gained further support from a confirmed prediction.

[7] Many authors (including Popper) consider that, during the Chemical Revolution, the experiment showing the increase in weight of metals during combustion played the role of a crucial experiment. Anyway, an argument comes against this view. This result had already been known many years before Lavoisier building his theory (Partington and McKie, 1937) and the responses of the adepts of the phlogiston theory cannot be considered ad-hoc. Particularly, Priestley, one of the most important supporters of the phlogiston theory, gave an interpretation to experiments by which Lavoisier rejected phlogiston theory – an interpretation that cannot be

considered irrational, given the knowledge available at that moment (Toulmin, 1957).

[8] McMullin, 1982; Lacey, 1997, and Intemann, 2001 are only few papers that discuss this distinction. For the same distinction, or a similar one, sometimes other terms are used, such as internal/external (Faye, 2008: 125), constitutive/contextual (Longino 1995: 384), epistemic/non-epistemic (McMullin, 1982; Rooney, 1992). There are some important differences between these distinctions, but they have roughly the same goal.

[9] A good example of an author who supports a weak form of normativity is Longino, who draws a distinction between constitutive and contextual values. The normative import of her distinction is apparent even in the characterization of the cognitive value as "the source of the rules determining what constitutes acceptable scientific practice or scientific method" (Longino, 1990: 4). Anyway, she does not reject completely the use of contextual values, considering that, at least sometimes, they can work as constitutive values, legitimately applicable in theory choice situations.

[10] In order to make a comparison, if, in a sport competition, two teams cannot be separated by a set of criteria, this is a good argument for devising a further criterion, but, anyway, this is not a good argument for using any criterion to separate them.

[11] As will be developed next, McMullin consider that epistemic values are those that can be justified as indicators of truth. The phrase *cognitive values* can be used in a wider sense, as values justified to be used in theory choice. The way in which McMullin identifies the class of epistemic values does not preclude in principle the existence of a more comprehensive class of cognitive values. Anyway, he does not delimit such a class of cognitive values, and implicitly consider that the only cognitive values are the epistemic ones. From this reason, I can safely talk about cognitive values in his case.

[12] This condition can be satisfied by considering the cognitive values as indicators of truth or as means for achieving the truth.

[13] From now, I will talk about a single goal of science, having, possibly, many components, or objectives. Alternatively, we could refer not to more than one component of a single goal, but to more than one goal of science. The distinction is purely linguistic.

[14] This is the reason for which I will call the justification of cognitive values as marks of truth "the realist justification of cognitive values."

[15] Kyle Stanford shows in many papers that this is not only a theoretical possibility.

[16] Kuhn (1957: 169–170) shows that the Copernican model was not unambiguously simpler than the Ptolemaic one. In spite of this, historically, the simplicity played an important role in Copernican Revolution (Martens 2009, esp. 263).

[17] Einstein is the most quoted scientist for his belief in the simplicity of nature in this version, but this is not a fully accepted account in the literature. To give a less famous example, few years after the Chemical Revolution, interval in which chemists had discovered a significant number of chemical elements, Humphry Davy expressed his belief that the future scientific practice would prove that the number of

elements is actually much smaller, a belief based, for him, on the faith in a harmonious world. (H. Davy, *Elements of Chemical Philosophy*, p. 60, apud Siegfried, Jo Dobbs, 1968: 289). This argument made him skeptical about the new Lavosier's theory.

[18] Laudan (1984) doubts that truth can be considered a goal of science, since scientists cannot be sure when it is achieved.

[19] I will not argue here for the fact that a relevant c/n distinction depends on an account of the goal of science, and I am not sure that there is an argument for this going far enough.

[20] I think that this distinction can solve many sterile debates about the role of non-cognitive values in scientists' decisions. A detailed analysis of the reason why the scientists as human beings should *prima facie* abide to the values of science, and of the cases in which other values could become more important, is beyond the approach and goals of my paper.

[21] Actually, the main characteristic of the realist account is that all cognitive values are justified by their relation with a goal with a single component, be it truth or another one (for instance empirical adequacy). We can call this type of account *fundationalist*, while the other, based on many objectives, can be called, by contrast, *non-fundationalist*.

[22] This approach of the simplicity problems was initiated by Popper and is followed in many papers, such as Forster and Sober, 1994; Kieseppä, 1997, etc.