# THE CONSTITUTIVE VALUES OF SCIENCE*

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*ABSTRACT*

*Cognitive values are the characteristics that are constitutive of "good" theories, the criteria to which we appeal when choosing among competing theories I argue that, in order to count as a cognitive value, a characteristic must be needed to explain actually made theory choices, and its cognitive significance must be well defended especially in view of considerations derived from the objective of science A number of proposed objectives of science are entertained, and it is argued that adopting a particular objective is dialectically intertwined with commitment to certain social values Then, the ways in which science is, and is not value free is explored briefly, leading to the identification of a level of analysis where values may influence theory choice without causing paradox or threatening the impartiality of soundly made scientific judgments*

## 1. Introduction

What counts as a good scientific theory? What makes a theory rationally acceptable? Empiricists and rationalists alike have long thought that sound scientific judgment was based in its accord with certain rules inductive, deductive, hypothetico-deductive, formalizable within the calculus of probability — rival candidates abound, where the rules either generate the theory or relate it to empirical data (and also to other theories) in the appropriate way Rule-bound

accounts of sound scientific judgment have remained mired in apparently intractable controversy

I wish to explore an alternative approach to the question of what constitutes sound scientific judgments This approach analyses rationality in terms of a set of values ("cognitive values" — **cv**) rather than a set of rules, and proposes that sound scientific judgment is made in the course of dialogue within the community of scientists concerning how well a theory, or competing theories, manifests such values, rather than through individual scientists applying an ideal algorithm The approach, which has been explored thoroughly by (McMullin 1983, 1994, 1996), can be traced back to a paper by Kuhn, "Objectivity, Value Judgment and Theory Choice" (Kuhn, 1977), with anticipations in his "Postscript" to *The Structure of Scientific Revolutions*, where he refers to commitment to such values as "both deep and *constitutive of science*" (Kuhn, 1970, p 185, my italics)

McMullin and Kuhn[1] distinguish **cv** from (moral and social) values[2] They are the criteria to be satisfied by a good scientific theory, they are **constitutive values of science** Scientific theories, of course, are produced, transformed, transmitted and evaluated in the course of scientific practices, which involve the activity of agents in social institutions, and so involve the expression of various values, and not simply of **cv** In this paper, I will not discuss the values expressed in scientific practices and institutions In order to focus and illustrate my argument, consider the following short list, the items of which have been considered **cv**, at least at some moments in the history of science empirical adequacy, consistency, simplicity, fruitfulness, explanatory power and certainty [3]

As in the case of values (Lacey & Schwartz, 1996), when considering **cv** there may be reasonable controversy

about two matters — first about their relative ranking in importance (e g , is explanatory power more important than simplicity?), and secondly about the adequacy of the concrete manifestation of a particular value in a given theory, since **cv** are concretely manifested only more or less (e g , is Copernican theory sufficiently fruitful in the light of its weak consistency with the physical theory of its time?) Thus holding a set of **cv** in common need not imply agreement with respect to theory choice Analyzing scientific rationality in terms of **cv** permits us to recognize that disagreement within the scientific community is consistent with the reasonableness of its practices, though it departs from the ideal (which continues to nourish the pursuit of rule-bound analyses) that reason should point unequivocally to a unique conclusion (Bernstein, 1983)

McMullin maintains that **cv** are *distinct* from values (including the social value of Baconian utility), and that concretely they may be *separated* from them sound theory choice can be reconstructed as responsive only to the **cv** What makes a theory a good one, for McMullin, is that it manifests highly the relevant **cv**, regardless of the values that may be expressed in the practices that produced it [4]

This paper will address two issues [5]

1) How do we settle on a list of **cv**? What arguments establish that its items are individually necessary, and that other proposed items should not be on the list? (Ideally should we have a list of items that are jointly sufficient?)
2) Can **cv** in their concrete embodiments really be separated from values?

## 2. Drawing up the list of cognitive values

I suggest that, in order to be included on the list[6], an item should meet two conditions 1) that it be needed to explain (under rational reconstruction) theory choices actually made by the community of scientists, and 2) that its cognitive or rational significance be well defended

**Cv** must carry both *explanatory and normative burdens* They function in a context that not only makes genuine contact with scientific practice, but also recognizes that scientific practice is open to rational criticism and transformation that is responsive to such criticism [7]

### 2 1 Criteria used in theory choice

In drawing up the list of **cv**, then, the *first* task is the interpretive one of rationally reconstructing key episodes of theory choice and controversy in order to discern the criteria that can reasonably be held to have been deployed by the participants in these episodes Without attempting to characterize fully the conditions for sound interpretative reconstructions, relevant considerations include a) the criteria that scientists, who are innovating or engaged in controversy, say they are using, b) gaps between their actual practice and their words (Laudan, 1984), c) the criteria appealed to (as, e g , articulated in text books) in the general consolidation of a theory, d) the assent of scientists to proposed criteria of theory choice, e) variations and changes in the criteria across fields, episodes and epochs In short, the relevant reconstructions will be grounded in detailed interpretive historical and sociological studies, and interaction with the critical reflections of working scientists McMullin's thought is thoroughly grounded in this way For this reason, his list — which contains most of the

viable items in Note 3 — has the ring of plausibility Even so, I suspect that it is not complete enough, and that what is absent makes a difference

For McMullin the fundamental cognitive value is **empirical adequacy**, "the quality of fit between theory and observation" [8] Looking more closely at this "quality of fit", it seems to presuppose that both theory and data possess certain characteristics that provide further items for the list of criteria that explain how theory choices *are* made

These items are connected with the indispensable role that *experiment* has come to play in modern science Of course, McMullin knows how important experiment is, but it gains no *explicit* mention in his account Yet I think that virtually all working scientists would affirm that, where applicable, "well tested by experiment" is a primary cognitive value Perhaps that is what "empirical adequacy" boils down to, but McMullin — like the logical empiricists before him — uses the vaguer notion of fit with a particular set of observational findings, and so — like the logical empiricists — he develops his argument without reference to the fact that *most* of the observational findings concern objects in experimental settings, rather than objects in the world of ordinary experience [9]

In modern science, only observational findings with certain characteristics are of interest and, in turn, only theories with related characteristics are put to observational test Typically, observational findings in the *first* place describe (replicable) phenomena generated in the course of experimental practices, or related practices involving interventions with measuring or perception-extending instruments, and in the *second* place they report quantitative (measurable) or, more generally, "physicalistic" properties and relations of those phenomena Such findings abstract from the multitude of descriptions that could be given of

the same phenomena if they were to be linked directly and explicitly to human practices and to their place and consequences in social and ecological systems — though one can easily report inter-subjectively confirmable observational findings that do not abstract the phenomena from such linkages (§5, 6, Lacey, 1996a) Thus, the observational findings of interest in modern science typically, though not always (Lacey, 1996b), involve a *two-fold selectivity* they are derived from experimental practices, and they involve physicalistic characterizations

Relatedly, an overriding *constraint* upon theories is that typically they deploy only quantitative, mathematical, physicalistic categories, for only such theories can have the appropriate "quality of fit" with the selected observational findings We expect a good theory to display explanatory power (and embody other **cv**) over a wide range of such observational findings (Lacey, 1986, 1990)

I would clarify "empirical adequacy", as used by McMullin and consistent with much scientific practice, to include explicitly the high salience of findings derived from experimental and measurement operations, and I would add an additional criterion "constrain theories to deploy only physicalistic and reductionist categories" The selectivity of empirical data and the constraint on theories go hand in hand, mutually backing each other — the combination I will call a "constraint/selection strategy" (**c/s strategy**), and combining several criteria I will propose that "*consistency with the materialist* ***c/s strategy***", or abbreviated the "*materialist* ***strategy***", is a highly rated criterion of theory choice

Remember, we are still at the level of explaining how theory choice is made! It remains open to this point whether the "materialist strategy" represents a **cv** or

whether its prevalence as a criterion of choice derives from shared social, or other non-cognitive values

## 2 2 Justification that a criterion is a cognitive value

I turn now to the question of how to justify that a proposed criterion is a **cv** There appear to be four broad kinds of consideration that bear on this question, derived from 1) *a priori* theories of knowledge, 2) evolutionary naturalist (Ellis, 1990) and cognitive psychological theories of knowledge acquisition and assessment, 3) considerations about the possibility of the proposed criterion being concretely exemplified in a theory, 4) whether or not it serves the objective of science [10]

Considerations of the first kind often sustain the attempt to ground rule-bound accounts of scientific rationality [11] Those of the second kind often support accounts of scientific rationality as social (Solomon, 1992, 1994) Those of the third kind account for the absence of certain items from the list, e g , the item I have called "certainty" (or even "truth") — either of the Aristotelian kind "necessity" or "intuitive", or the Cartesian "*a priori*", since the character of our scientific practices does not permit the possibility of recognizing the concrete embodiment of such a value In this paper, I will discuss only considerations of the fourth kind

When we turn to "the" objective of science, however, complications abound (Laudan, 1984) There is disagreement about the objective of science — even about whether there is such a thing as "the" objective of science, and a pretty intractable disagreement the realism/instrumentalism issue, e g , has been around for centuries — and, depending on the adopted objective different lists of **cv** may be supported Moreover, it is a difficult in-

terpretive task to discern objectives because of gaps between what people say and what they do, and objectives may vary with field and epoch Nevertheless, for almost four centuries, numerous scientists and realist philosophers have expressed the objective of science somewhat as follows

$O_1$ The objective to science is to represent (in rationally acceptable theories) the structure, process and law underlying phenomena, and thence to discover novel phenomena [12]

This objective reflects a sense that discovery itself represents an institutional value of science It also reflects an explanatory ideal to explain causally is to display a phenomenon as generated from underlying law, process and structure Thence, explanation is both reductionist and materialist, it neither is, e g , teleological, nor need it be determinist If this is the objective of science, it is easy to show that most of the items on the list stated above indeed are **cv** Making judgments informed by them serves the objective of science — and for the same reason, the materialist strategy would appear to represent a **cv** Indeed, the materialist strategy seems to inform the interpretation of all the other **cv** (Lacey, 1990) In accordance with this objective, scientific theory represents objects (things, events, fields, etc ) simply in terms of their structures and components interacting with one another according to mathematically formulable laws They are not represented as bearers of value, or as having a place in human practices Thus explanatory and predictive power is displayed in those spaces and concerning those processes where human, intentional causal influence is not pertinent [13] Nothing follows from this directly about the relevance of theory,

and the phenomena discovered in the course of scientific practices, to human practices in general and to the objects of ordinary experience

Why do we attempt to gain understanding of natural objects through cognitive practices that abstract them from the contexts of human practices in general and from their role in ordinary experience, and from the possibilities open to them in these contexts? It makes no sense to say that, abstracted from human contexts, an object can be understood for what it "really is" An arrow, e g , really is an arrow, a cultural object While it remains true that we can explain the material and formal aspects of its motion best by abstracting from human contexts, we will never understand why it was aimed at a certain target, or the other things for which it can be used, if we abstract from its human contexts (Lacey, 1986)

## 3. Adopting an objective for science

Why adopt the objective, $O_1$? Rather than what? Since I'm sticking to a broadly realist perspective, I won't consider instrumentalist and empiricist alternatives Here is an alternative, one that includes, but is more encompassing than $O_1$

O The objective of science is to encapsulate (reliably, in rationally acceptable theories) possibilities that are open to a domain of objects, and to discover means to realize some of the hitherto unrealized possibilities

In formulating O this way, I have in mind particularly those possibilities open to an object that can only be described when we don't abstract from its human, social and ecological contexts The implications of adopting it

would coincide with those of adopting $O_1$ when dealing with spaces in which human agency is not relevant as a causal factor, so O does not lose contact with what one may normally think of as scientific practice The most important departures from $O_1$ concern the realm of ordinary experience O is motivated by keeping in the foreground the question what kinds of systematic empirically-based understanding ought we seek in order to inform the full array of human practices? Adoption of O would not permit the limitation of relevant observational findings to those that are selected by the materialist strategy

Why adopt $O_1$ rather than the more encompassing, O? Or why has the scientific community largely adopted $O_1$ rather than O? I can think of four (not mutually exclusive) answers (elaborated in Lacey, 1996b)

1) Appeal to materialist metaphysics — then (in the long run) O would reduce to $O_1$

2) Baconian utility what sort of knowledge serves to inform our core practical projects, those in which we wish to exercise control over natural objects? Elsewhere (Lacey, 1990, 1996b) I have argued that it is knowledge gained under the materialist strategy So, we might adopt $O_1$ because it helps to identify the possibilities of control and the means to realize some of these possibilities

3) Appeal to the sheer interest of the positive outcomes of adopting $O_1$, combined with the virtual certainty of the further success of the practices linked with it — the intellectual interest of established theories and the satisfaction of discovering more of what I will call the "**material possibilities**" of nature Even if these outcomes typically also serve the interests of Baconian utility (and even if social institutions support them largely for this reason), the grounds for adopting $O_1$ (intellectual interest) can be separated from Baconian utility This claim might be reinforced

by appeal to the neutrality of theoretical proposals, thus keeping moral and social values (like the control of nature) values apart from the adoption of the objective, $O_1$ [14] The intellectual interest of the outcomes of practices that serve to realize it provides a positive reason to adopt $O_1$, or at least to consider it worthy of adoption But it does not provide a reason not to adopt O, where it goes beyond $O_1$ or where it leads to exploring some of the possibilities of things that are not included among their material possibilities (see §5 1), even if the exploration of these possibilities might require material and social conditions that would imply restricting the scope of $O_1$-type investigation The latter might have greater intellectual interest, at least for some investigators Given this, 3) gains its force by being combined with

4) There are no well established practices and institutions supporting research instigated by O, insofar as O goes beyond $O_1$ $O_1$ is adopted in effect because there are no known viable alternative ways to follow O — "it's the only game in town" [15]

In the articulations of the tradition of modern science, I think that the adoption of $O_1$ is usually linked with some version of the combination of the third and fourth answers However, I am not convinced that it suffices to separate the intellectual interest of theoretical proposals from the interests of Baconian utility If this is so, then it would follow that *in concrete embodiment* the **cv** cannot be separated from a social value Where does this leave the question of whether or not the materialist strategy is a **cv**? Certainly it is a criterion of theory choice and, given $O_1$, it ought to be Perhaps, however, it should be seen not as an additional **cv** , but rather as an overarching condition that frames the interpretation of the **cv** (Lacey, 1990) — a condition rendered necessary either by the general features of

the chosen object of interest for science, or by the interest of Baconian utility to explore only the material possibilities of things (§7)

Looked at in this way, the materialist strategy is a criterion of theory choice in virtue of the interest in underlying structure, process and law and in the material possibilities of things [16] That interest, and the values that reinforce it, have no implications regarding the specific theoretical proposals investigated and confirmed, and regarding the concrete material possibilities that are encapsulated (The items on the appropriate list of **cv** sort out such specifics ) Indeed, no values could have implications in regard to these matters Different values, however, could lead to interest in different (more encompassing or intersecting) classes of possibilities, the investigation of which might require **c/s strategies** other than the materialist one (§6) There is nothing paradoxical about that The absence of an alternative "scientific game" in contemporary universities and research institutions might reflect only that currently hegemonic values have ensured that the necessary material and social conditions for development have been denied (whether consciously or through structurally maintained mechanisms) to alternatives that reflect different **c/s strategies** The "only game in town" argument is not value neutral, if the lack of alternatives is a consequence of denying the conditions necessary for an alternative to develop

## 4. An elective affinity between science (following $O_1$) and Baconian control

The intellectual interest of satisfying $O_1$ can be *distinguished* from the practical interest of Baconian control, to expand our capacity to exercise control over nature, and to exercise control in a way that is not subordinate to the interests of

other social values (Lacey, 1996b) Not every well confirmed theoretical hypothesis leads (or can lead) to practical applications, and most deep theoretical hypotheses provide understanding of some phenomena that do not belong to either technological or experimental spaces (the spaces in which, paradigmatically, we exercise control over natural objects) Conversely, not every technological innovation reflects applied scientific theories Nevertheless, and consistent with what I have just affirmed, *given our scientific practices*, satisfying the intellectual interest of $O_1$ will serve the interest of Baconian control, and the expanse of the possibilities of Baconian control is severely limited if uninformed by the theoretical proposals generated in accordance with $O_1$

There is a deep "elective affinity", if I may borrow Max Weber's term from another context (Weber, 1946), between adopting $O_1$ and the pursuit of Baconian control The affinity is deepened when adopting $O_1$ is grounded in materialist metaphysics, for this metaphysics affirms that the world "really is" such that all the entities in it are fully characterized by materialist properties and relations, so that — in principle — acting on $O_1$ could give us a complete account of the world Then $O_1$ plays an ideological role in legitimating the preeminence of control as the human stance towards nature At the same time, the hegemony of institutions and practices which embody Baconian control, and the dominant role they play in our lives, often dull our sensibility to the claim or even the intelligibility of modes of understanding that cannot be analyzed in materialist and reductionist ways

Adopting $O_1$ does not have to be grounded in materialist metaphysics While it stimulates seeking for proposals about underlying law, process and structure, it does not have to imply that we can understand all phenomena

in terms of their being so generated However, even when it is not grounded in materialist metaphysics, the elective affinity remains deep, and exhibits at least the following dimensions 1) a dialectic of theoretical and technological developments, 2) scientific research requires material conditions (equipment, instruments, etc) that are a product of advanced technology, and social conditions that derive from institutions that essentially link technological and economic development, 3) theories developed under the materialist strategy, that manifest the **cv** to a high degree, also tend to manifest the value "successfully applied in technological practice", 4) experimental practices provide exemplary instances of control, 5) concepts derived in the course of experimental practices serve for theories that provide understanding of spaces where relevant human agency is lacking The language of theory — even in cosmology — cannot be traced to correspondence between concepts and attributes of things, but to its origin in experimental practices [17]

## 5. In what ways is science value free?

The elective affinity that I have pointed to between adopting $O_1$ and the pursuit of Baconian control leads us to rethink in novel ways the view that science is or ought to be value free, and even the view that value freedom is an ideal [18]

I take the common view of value freedom to involve three (idealized) theses — impartiality, autonomy and neutrality — which I summarize as follows[19] *Impartiality* sound scientific judgments, about the "acceptance" of a theory with respect to a given domain, rests solely upon considerations of how fully the **cv** are manifested in the theory (in light of the available empirical data and other accepted

theories) — regardless of how the theory may accord with or serve the interests of any value perspective [20] *Autonomy* agendas of scientific inquiry tend to reflect the interest of the scientific community in establishing more and better proposals about which theories manifest the **cv** to a high degree, and discovering novel phenomena that will further this interest *Neutrality* except in the case that a well confirmed theoretical proposal contradicts a presupposition of a value (or cultural) perspective, scientific proposals neither support nor undermine any particular value perspective, and — in principle — can be applied within any value perspective [21]

*Impartiality*, I think, can be preserved For the sake of clarity, however, it is important to highlight that it is a thesis pertaining to accepting a theory of a domain or domains of phenomena (Note 20) A "good" (acceptable) theory encapsulates possibilities of objects (and explains their features and behavior) in a domain, which is specified by certain boundary conditions or by a certain mode of description, it does not identify all their possibilities The **c/s strategies**, under which the theory was developed, express the general features of the class of possibilities that can be encapsulated in it Under the materialist strategy, e g , an acceptable theory encapsulates the material possibilities of things, those that can be characterized as generable from the underlying law, structure and process of things, it also provides comprehensive understanding of phenomena of many spaces defined by boundary conditions which obtain where human causal agency is not relevant Values are still pervading the scene, but only to lay out what features of the spaces and what possibilities are of interest, not what the concrete possibilities are Values are relevant to answering Why was a theory **of this kind** entertained, generated and developed? (Why were the **c/s strategies** adopted?) But

they (and the fact that it fits the strategies) play no proper role in answering Why was **this** theory accepted? In the case of the materialist strategies, we can say that the **cv** — interpreted in the light of such values as Baconian control (Note 27) — suffice to explain sound scientific judgments (under $O_1$) I think that this remains an important ideal (often departed from in fact)

If I am right that scientific inquiry is framed by **c/s strategies**, and that these are adopted partly in the light of value considerations, then *autonomy* cannot be defended in general And even if it is considered to apply only within the framework of particular **c/s strategies**, it faces severe problems Within the materialist strategies, e g , which may be thought to be the important case, I suggest impressionistically that relatively little on current research agendas fits with it I will risk a generalization insofar as research — call it "fundamental research" — is aiming towards establishing more and better proposals about underlying structure, process and law, *autonomy* holds within tolerable limits As I stated $O_1$, the objective includes deploying theory to discover novel phenomena Autonomy highlights those novel phenomena that themselves lead us to deeper insights into underlying law, process and structure But, often, the quest for novel phenomena as such — **any** novel phenomena that we can come up with using the results of fundamental research — is seen as following $O_1$ Much contemporary research is the quest for novel phenomena of interest to non-scientific institutions, e g , the military, agribusiness, and the electronics and pharmaceutical industries (This is fleshing out some of the elective affinity referred to in §4 ) But scientists tend to treat the phenomena in abstraction from this social context, in their own minds they are simply following $O_1$ That doing so is also serving special interests is seen as having nothing to do with the science And

(in accord with *impartiality*) it does have nothing to do with making sound judgments about what are the material possibilities of things Nevertheless, the interest in the discovery of most of these phenomena, and hence the direction of the research, comes not from contribution to fundamental research but from the values and interests of powerful institutions [22]

*Neutrality* seems to me to be simply false — unless one qualifies it in what amounts to being a *paradoxical* way That qualification is, in brief, that established theoretical proposals can in principle be applied within any value framework, provided that the framework includes the value of the preeminence of Baconian control, or that it endorses that control is the characteristic human stance towards nature The paradox here is seldom noticed, I believe because that control — as distinct from attunement, harmony, or whatever relationship might serve one's prioritized social values — in the characteristic human stance towards nature is deep in modernity's self-understanding, deeply embodied in hegemonic productive practices and an integral part of mainstream international economic development objectives (Lacey, 1986, 1996a) Then, that neutrality implies accord with this value seems almost self-evident Yet it does remain paradoxical I don't think that, even in principle, neutrality can be approached in the ideal Scientific discoveries of novel phenomena, I already claimed, tend to serve certain special interests, they cannot characteristically be applied in all value frameworks (Note 21) [23]

## 5.1 An example of the lack of neutrality research on the seed

Consider as an example the "green revolution" (Lewontin, 1991, Shiva, 1991a) Put in a very sketchy form, the green

revolution is based on the following phenomenon two low-yielding varieties of wheat (or other crop) may be produced in isolation, and from them may be produced hybrid seeds that produce high-yielding plants, with yields very much greater than those obtained from plants that are grown from regular field-fertilized seeds (The low-yielding "pure" varieties are obtained by trial and error separation out from field-fertilized seeds ) The phenomenon is real, and its celebrated applications have been widely acclaimed These applications, however, require certain conditions the planting of relatively large tracts of land, mechanization, high inputs of water, fertilizers, pesticides, etc , which have generated consequences such as flight to the cities, unemployment, social disruption, pollution, soil deterioration and ecological devastation That is, the applications could not serve and indeed undermined the social values of social and ecological stability

Moreover, the seed has become in large measure a commodity[24] (rather than a biological entity generated each year as part of the crop, with only occasional need to buy new seed), and third world agriculture has become more inserted into the international economy in ways that serve the special interests of agribusiness, a sector of landowners and some related industries, the bearers of the value of Baconian control The application has served some values but not others, and it cannot be made to serve both In response it will be said, no doubt, that the scientific application did not contribute to undermine the old value framework, rather, that framework *was* no longer viable as manifested by widespread hunger Alleviating hunger, presumably a shared value among the relevant parties, could only be satisfied with the new arrangements, a view reinforced by the conviction of the pre-eminence of control

Shiva (an Indian ecofeminist, physicist, philosopher) points out that while the Green Revolution has provided conditions for many more people to be fed, it has also produced a redistribution of the hungry And Lewontin asserts that the hybrid seeds were not necessary to produce the higher yields According to the same underlying genetic theory that informed the hybrid seed research, Lewontin maintains, comparable yields could be obtained from appropriately selected "pure" (non-hybrid) varieties — and used in ways more compatible with social and ecological stability, but of little benefit to the agents of "modernization" Yet virtually no research has been undertaken to improve the selection of "pure" varieties of seeds From the perspective of $O_1$, research either on the hybrid or the "pure" varieties is "equally scientific", but only one research program has been effectively followed Such episodes illustrate that neutrality (and also autonomy) do not characterize much of the research under $O_1$ [25] More generally, theories are especially attuned to be applied in projects shaped by the values that are dialectically linked with the **c/s strategies** under which they have been developed

## 6. Why not adopt O?

I asked why adopt $O_1$ rather than the more encompassing O I said, but did not elaborate, that my formulation of O was motivated by the question what kinds of systematic, empirically-based understanding ought we seek in order to inform the full array of human practices, or more modestly, in order to inform the array of human practices responsive to one's social values?

The example (§5 1) can help to illustrate why we might adopt O, rather than limit our compass to $O_1$, or adopt alternative **c/s strategies** to which research that fol-

lows $O_1$ becomes subordinate If one's value perspective includes the Baconian pre-eminence of control in the way described, then one will adopt $O_1$ The point of O will be apparent to those whose social values make them critics of the preeminence of control, where the critics maintain that the embodiments of Baconian control require practices and institutions that can only be maintained in an economic order which inherently has undesirable consequences e g , unacceptable inequalities, patriarchal relations, alienated labor, class-based relations of domination Thus, such critics will ask how shall we interact with nature so as to serve the coming to be of an alternative social order, which (e g ) embodies a different view of social justice, or which serves the values of social and ecological stability? For this end, what will be the characteristic way — or more likely, ways — of interacting with nature? What kind of strategies (alternative to the materialist strategy, or to which the materialist strategy is to be subordinated) should be brought to bear in order to gain empirically grounded knowledge that would serve that end? There can be interesting mixtures of premodern and postmodern answers to these questions, many who pose questions like these (e g , Shiva, 1991a, 1993a, and references in Lacey, 1996a) have pointed to the contemporary salience of traditional agricultural knowledge (e g , in India, in the Andes, in the Amazon region), knowledge which is neither reductionist nor constrained by the materialist strategy

In our example, holding the value of maintaining social and ecological stability, one would focus $O_1$-type research upon the possibility of high-yield "pure" varieties It would explicitly direct research efforts in this way because one had also investigated the social context and consequences of various potential applications of research on the seed Looked at in this way, O-type research would involve

the investigation of social possibilities in the context of $O_1$-type research, and point $O_1$-type research in a given (value-laden) direction It would also make the critical point that mainstream $O_1$-type research was pointing the research in a different (value-laden) direction

But it is not obvious to me that the biological (and the material) can always be demarcated from the social in this way — where social inquiry complements and partially directs the biological inquiry, but where the biological possibilities are discerned only in relation to the fundamental underlying genetic theory Sometimes there may be such a profound *interaction* between "natural" and social variables that an adequate encapsulation of possibilities could not derive from research that draws upon the abstractions into the standard disciplines In another of Lewontin's examples (Lewontin, 1991), on the causation of tuberculosis, he presents such an interactionist account So, minimally, adopting O leads to a richer interdisciplinary approach, but it also opens up the possibility that we may need to address certain questions in ways that cut across the standard disciplinary lines

This leads me to ask can even the material possibilities of spaces be explored and charted generally when one abstracts from the social arrangements and practices that shape those spaces? Might it not be that new social arrangements would bring about hitherto unthought of material relations and phenomena — following from the possibility that the complexity and subtlety of social arrangements supervenes on a degree of material complexity which lies beyond our powers to capture with the materialist strategy?

Adopting O leads to asking such questions, but O is too general to provide any concrete direction to research endeavors Research presupposes a framework provided by

a **c/s strategy** We might consider $O_1$ the objective of an **approach** to science, the approach that proceeds under the materialist strategy, one — I have argued — that bears elective affinity to the value of Baconian control $O_1$ provides one concrete way to follow O Another approach might have the objective, $O_2$ To encapsulate (reliably, in rationally acceptable theories, or systematically organized bodies of knowledge) possibilities that are available to human interaction with a domain of objects [in our example, objects interacted with in agricultural practices] that could serve to strengthen the manifestation of the value of social and ecological stability, and to discover means to realize some of the hitherto unrealized possibilities [26]

One cannot adopt O in the same way that one may adopt $O_1$, $O_2$, etc To adopt O is to recognize that the adoption of a particular approach needs justification that cannot be provided by arguments based in the **cv** alone, to recognize that we must answer Why $O_i$ rather than $O_j$? It might seem that to adopt O would be to legitimate any approach (that produces theories that manifest the **cv** to a high degree), to encourage a multiplicity and diversity of approaches for the sake of gaining access to many and diverse possibilities, and to treat different approaches as complementary to one another Abstractly, that makes sense In context, however, approaches, such as $O_1$ and $O_2$, compete, for research within any one approach requires material and social conditions, which may be available only under a particular organization of society Moreover, the realization of one class of possibilities (e g , a large array of novel material possibilities) may preclude the realization of others (e g , those consistent with social and ecological stability) in the same place at the same time In context, it may not be possible for two approaches to develop together with independent dynamics, rendering non-viable the ideal

of identifying all the possibilities of nature or all those open to human practice Where there is this contextual incompatibility, one approach may come to play a subordinate role within another I think that any approach that is viable today will have to permit at least a subordinate place for the approach $O_1$ (Note 25) That is because practices of the control of nature (though not necessarily practices involving unsubordinated and expanded exercise of control) are present within any value perspective, and because the world of our lived experience contains phenomena (that cannot be avoided) that are well grasped in theories developed under the materialist strategy (Lacey, 1986) But that is not an argument to adopt $O_1$ rather than another approach that may have affinities with one's values

## 7. A general picture

In conclusion, I will attempt to sum up the argument in a general picture that delineates how **cv** and values play their respective roles in the processes whereby we come to accept scientific theories

There are **levels of selection** involved in making theory choices At **one** level **c/s strategies** play a role They serve to eliminate, even from provisional consideration, theories that do not fit the constraints They function (logically, not necessarily temporally) first In principle, with respect to a given domain of phenomena, an array of incompatible theories will fit the constraints, the play of the **c/s strategies** is insufficient to determine which theory to accept (fourth sense of "accept", Note 20) Then (logically) at the **second** level, from this array one of the theories may be accepted Here, the play of the **cv**, in the light of the empirical data and other accepted theories that are available, is decisive

When choosing theories, there are two significant questions to consider

1) What characteristics must theories have to even be provisionally considered?

2) Which (if any) of the theories, with these characteristics, is to be accepted?

One's adopted **c/s strategies** are key to answering 1) To answer (2), we need to identify the appropriate criteria that an accepted theory, under the strategies, must satisfy According to *impartiality*, the **cv** are those criteria [27] At the level of concrete theory choice only the **cv** properly play a role [28] This is consistent with values playing a role, not *alongside* the **cv** but at the level of where the **c/s strategies** function, interacting dialectically with the strategies **C/s strategies** are adopted because of interest, typically derived from values, in the possibilities that may be encapsulated in theories constructed and consolidated under the strategies The strategies, as it were, lay out the general features of the possibilities of interest A properly accepted theory encapsulates the concrete possibilities

One may adopt **c/s strategies**, then, because of their relationship to one's values, the possibilities that one hopes to encapsulate are those that may inform one's moral and social projects That does not mean (always or even typically) that one eliminates from consideration theories that do not fit the strategies because one believes that they are false, but rather because they do not provide a means to identifying the possibilities of interest Adopting a particular strategy does (and can) not commit one to the truth of any theory, rather it frames the quest to construct and consolidate theories of certain kinds — but it provides no guarantees that the quest will be successful Not all strategies are like the materialist strategy, such that the world

lends itself to revealing certain of its possibilities (that can be realized through our interactions with it) in the course of research under them Persistent failure to develop theories, which manifest the **cv** to a high degree, under given strategies is (*ceteris paribus*) a decisive ground to abandon those strategies Thus, the adoption of strategies is not only linked dialectically with values, but also is under long-term empirical constraint [29]

A theory is properly accepted (rationally believed to encapsulate the possibilities) of a domain only if it manifests the **cv** to a high degree according to the highest standards (Lacey, 1996c, in progress) for assessing the degree of manifestation of the **cv** in theories The values, that make these possibilities interesting and that may motivate the provisional entertainment of theories that fit the **c/s strategies** dialectically linked with the values, play no role in such judgments of acceptance ("Fact" is not being derived from value, even though in concrete embodiment the **cv** and the values are inseparably manifested ) The values do not function alongside the values The distinction of levels is methodologically and logically essential

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## Keywords

Cognitive values, control of nature, value-free science

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## Notes

[*] Presented at III Encontro de Filosofia Analítica, Universidade Federal de Santa Catarina, Florianopolis, S C , September 19, 1995 An earlier version was presented at a symposium, "Val-ues in Science", in response to a paper by Ernan McMullin, Greater Philadelphia Philosophy Consortium, La Salle University, September 17, 1994 More recent discussions at The University of Melbourne (March-May, 1996), Universidade de São Paulo (August-October, 1996), Universidade Federal de Santa Catarina (October, 1996) and elsewhere have helped to clarify parts of the argument I acknowledge particularly the contributions of Howard Sankey, Otavio Bueno, Eduardo Barra and Lynn Nelson

[1] (McMullin and Hempel 1983) refer to "epistemic values" or "epistemic virtues" rather than "**cv**" (Longino 1990) refers to **cv** as "constitutive" as distinct from "contextual" values of science She also raises the question of whether the constitutive values — those properly invoked when theory choices are being made — may include certain social values, in addition to **cv** More recently, she has questioned whether there is a clear distinction between cognitive and other values (Longino, 1995) (Laudan 1984) provides an extensive account of the grounds for rationally adopting **cv**, and (Bernstein 1983) discusses Kuhn's views on **cv** in depth and with subtlety, paying attention to exactly what is involved in the rule/value contrast

[2] Where "values" is unqualified in the text, it will mean "non-cognitive values", usually "moral and social values"

[3] The following is a more extensive, but still incomplete list (drawn from a wide variety of sources) of **cv** that play a role (or, in the history of science have played a role) in the evaluation of scientific theories Clearly not all of them can be affirmed together, some of them are no longer viable, and some of them are disputed In this paper I do not attempt to settle on a definitive list

**1) Empirical adequacy**

Does the theory "fit" the available data? Does it exhibit predictive power among them? Is it empirically testable? Is it falsifiable? Is it highly vulnerable to falsification? Can its re-

lationship with them be articulated in terms of inductive rules? — so that its posits contain no "hypothetical" terms (Newton)? Is it rich in informational content about a significant (and expanding) array of empirical phenomena (Bueno, 1996)?

a) Intersubjective acceptance of the data

b) Primacy of experimental and quantitative data

c) Importance of data which reflect the richness, complexity and variation of ordinary experience

d) Have the data been collected in the light of (i) their being representative of the potentially available data, (ii) their relevance to potential falsification of the theory, (iii) their relevance to putting the theory into critical competition with alternative theories, (iv) their relevance to defining clearly the limits of application of the theory?

e) Accuracy of data, precision

f) Does the theory fit with the unrefuted content of earlier theories?

**2) Consistency**

a) Within the theory itself

b) With other accepted theories, "consonance" (McMullin, 1994)

c) With prevailing views about the general nature of the object of inquiry (paradigms, research programs, research traditions)

**3) Simplicity**

a) Harmony, elegance, parsimony, economy

b) Conceptual clarity, clearness and distinctness (Descar-tes), formalizability, intelligibility

c) Absence of *ad hoc* features (see Lakatos, 1978, on various senses of "*ad hoc*"), "coherence" (McMullin, 1994)

d) Efficient in use

**4) Fruitfulness (fertility, fecundity)**

a) Generate new questions

b) Open new research programs

c) Occasion the discovery of novel phenomena, prediction

d) Solve puzzles (Kuhn), open to extensions enabling problems to be solved (McMullin,1994)

e) Anticipate novel possibilities (Lacey, 1996c)

f) Utility — practical, technological, "prediction and control"

**5) Explanatory power**

a) Provide explanations of phenomena in a wide array of domains, depth (Bhaskar, 1986)

b) Unify a diverse range of phenomena, and of other theories, "consilience" (McMullin, 1994, interpreting Whewell)

c) Provide access to the underlying law, process and structure of phenomena

d) Account for all the aspects and dimensions, all the causes and effects of phenomena, responsive to their particularity, concreteness and uniqueness (Aristotle)

e) Enable the construction of a narrative that accounts for what is unsound and what is sound in antecedent theories (MacIntyre, 1977)

**6) Truth, certainty**

a) Known truth of fundamental principles

b) Necessity, self-evidence, indisputability, *a priori* character

c) Deductive structure of theory

d) Verisimilitude (Popper)

The **cv** (qualities and relations of scientific theories and empirical data) should not be confused with the "scientific virtues", qualities of scientists that are supposedly nurtured and depended upon in scientific practices e g , objectivity, detachment, integrity, honesty, open-minded, humble in the face of the evidence, etc These virtues are often appealed to in defenses of *autonomy* (§5)

See also Note 20 for further clarification

[4] This formulation permits a constructive pragmatic role for non-cognitive values in the formation and consolidation of a theory Moreover, it cannot exclude the possibility that in actual fact a non-cognitive value (overtly or covertly) may explain why there is agreement in the scientific community, on a particular theory (In the latter case, of course, it denies that agreement is soundly based ) Thus, McMullin would be entirely sympathetic, e g , to those efforts by feminist philosophers of science to uncover male "bias" in the support of certain theories in biology and

psychology (e g , Longino, 1990), but he would resist the necessity of replacing such "bias" by another "bias", except perhaps as a motive to investigate an alternative hypothesis He also recognizes the phenomenon of the under-determination of theory by empirical data, and that in the situation where underdetermination is vast the only way at present to select among competing theories may be through use of non-cognitive values — but, then, the selection is provisional and for the sake of investigation, it cannot lead to sound theory choice if only hypotheses selected in the light of those values are investigated The thesis (*impartiality*, §5 below) that "sound theory choice can be reconstructed as response only to the **cv**" represents a value and not necessarily a fact, it functions as an ideal or aspiration about choices of scientific theories, that can be manifested in the case of actual theory choices more or less

[5] I develop my argument within a broadly scientific realist framework The thrust of my conclusion does not depend on this, and could easily be rearticulated to address any variety of empiricist perspectives I am doing this because McMullin's work is my point of departure, and my disagreements with him are not connected with his espousal of scientific realism For a detailed and compelling discussion of the cognitive value of "empirical adequacy" (and also "rich in informational content of empirical phenomena") in the context of constructive empiricism, see (Bueno 1996)

[6] The list, and relative ranking of **cv**, may vary with scientific discipline, since the criteria that a good scientific theory must satisfy, and their interpretations (Lacey, 1990), may vary with the character of the phenomena with which a theory is dealing See (Lacey 1991, 1992) for some discussion of criteria of theory choice in the social sciences, where interpretive methodology is used See also Note 27

[7] The burdens must be carried in the long run by the scientific community, short term or individual departures **may** pragmatically serve the interests of science (Solomon, 1992, 1994, Feyerabend, 1975)

[8] McMullin proposes that the **cv** — other than "empirical adequacy" — which he calls complementary to it, can be classified

into three categories a) **internal cv**, including, e g , items 2a and 3 in the list in Note 3, **contextual cv**, e g , items 2b and c, and c) **diachronic cv**, those which are expected to be more fully manifested with the passage of time, e g , items 4 and 5

[9] McMullin says "theory is created in the first place to account for a particular set of observational findings " Yes — *and* many observational findings pertain to phenomena that were created or singled out for observation for the sake of testing theories

[10] Laudan has proposed that the identification and adoption of **cv** can be rationally reconstructed in terms of a "reticulated model", which (paraphrased into my terminology) involves two-way interactions between each pair of the triad {theories, scientific practices, **cv**} (Laudan, 1984, p 63) E g , **cv** "justify" scientific practices, and scientific practices "exhibit the realizability" of the **cv**, and theories (chosen in the course of scientific practices) and **cv** "must harmonize" My account, in requiring that **cv** be criteria of theory choice actually used in scientific practice and in including the third consideration, incorporates Laudan's

His account, however, does not distinguish between **cv** and **c/s strategies**, and does not involve significantly my fourth consideration At times, he seems (his terminology is somewhat slippery!) to hold that the objective of science simply is to gain theories that manifest highly the **cv** that are currently adopted in scientific practice

[11] It is fairly typical to adopt "consistency" as a cognitive value on the basis of *a priori* considerations This has been challenged by (da Costa & Bueno 1996), who maintain that only "nontriviality" (not all statements well formed with the categories of a theory be affirmed in the theory) can be defended in this way

(Hempel 1983) maintains that, in order to be considered a **cv**, an item must be open to "objective" appraisal (cf Bernstein, 1983), and (Popper 1959) that it must play a role with respect to the severe criticism of a theory

[12] Historically earlier formulations have built in such tougher restrictions as mechanism and determinism

[13] Initial and boundary conditions may be the product of human

action, and final conditions may have human consequences, then, the realm of relevance of theory is what happens between the initial conditions, characterized materialistically — under the boundary conditions, characterized materialistically — and the final conditions, characterized materialistically

[14] One might even make a gesture in the direction of the motivation behind O by acknowledging that natural science cannot get at all the possibilities of objects, but only the material possibilities, and then point to the role of other disciplines sociology, economics, ecology, etc for discerning possibilities under different conditions Given O, there would need to be further argument that the material possibilities can be appropriately demarcated in this way from the full range of possibilities (§6)

[15] Hempel, in a somewhat different way to Laudan (Note 10), expresses the view that the objective of science is to gain theories that manifest highly the **cv** He proposes (Hempel, 1983, p 91) that the objective of science may be put as "seeking to formulate an increasingly comprehensive, systematically organized worldview that is explanatory and predictive" Then he goes on to suggest that adopting a suitable set of **cv** may be regarded as "attempts to articulate this concept somewhat more fully and explicitly" In this way to participate in practices in a quest for products that more fully manifest the **cv** becomes in effect the objective, the **cv** define the objective of science, rather than gain justification from it

Such a view might be reinforced by Putnam's arguments (Putnam 1981, 1990) that the activities and virtues involved in gaining knowledge are partly constitutive of human flourishing Then, we adopt $O_1$ for want of alternative ways to gain knowledge (theories that manifest the **cv** highly) systematically Such a view is also reflected in Kuhn's analysis that historically an old paradigm has (must have?) a unique successor

[16] Where I use the term "underlying structure, process and law", McMullin uses "causal structure of the natural world" I resist his terminology The causal structure of the natural world is not confined to underlying structure, process and law Material objects constitute an integral part of the world of ordinary

experience, and in our world of ordinary experience many of these objects are technological objects, so that it is part of their causal structure that they play roles in human projects and social institutions Values that conflict with Baconian control, if manifested to a significant degree, can lead (causally) to a different causal structure for the material objects of the world of ordinary experience

[17] The argument of this section has been developed in much greater detail in Lacey 1996b

[18] By "value" here I mean "non-cognitive value" Cf Note 2

[19] Precise statements and detailed criticism of these three theses are offered in Lacey (in progress) See also Lacey 1996b, 1996c

[20] "To **accept** (choose) a theory, T" has various senses I distinguish (Lacey, 1996c, in progress) the following

1) to provisionally entertain T,
2) to commit to a research agenda framed by T,
3) to endorse that T is better confirmed than available rivals,
4) to endorse that T is properly placed in the stock of knowledge or of rationally acceptable beliefs, or of items that (according to available methodological canons) require no further investigation (since further investigation would involve only additional replication of what has been many times replicated),
5) to adopt T, to apply it in practice

In *impartiality*, as I have stated it, "accept" is used in the fourth sense, concerning which acceptance of T is always acceptance of T *of a particular domain or domains*, D T is accepted of D

Clearly, *impartiality* does not apply concerning senses 1), 2) and 5) of "accept Values play important roles in the practice and application of science The view that science is value free does not deny this obvious fact

The list of **cv** laid out in Note 3 has been constructed having in mind what should be the characteristics of a theory to be accepted in sense 4) If we have in mind senses 1) and 2) — and thus think of the role of theories in the conduct of research, as distinct from which theories we accept at the "end" of a research episode — other "**cv**"s might be added to the list, and become highly rated e g , plausibility (Bhaskar, 1986), novelty (Longino,

1995), able to explain the hitherto unexplained (Kitcher, 1993)

Note also that some of the items on the list (e g , fruitfulness) might be considered to be "values" that ought to characterize **c/s strategies** rather than, or as well as, theories

[21] In this statement of *neutrality*, "support" and "undermine" can be given logical or causal interpretations In Lacey 1996c (in progress) I develop several different (logically independent) versions of *neutrality*, corresponding to these different interpretations

[22] Such phenomena *can* become the focus for further fundamental research — and, thus, the special interests which they serve may get their mark inserted into fundamental research This is worth further investigation

[23] The argument of §5 1 and 6 is developed more fully in Lacey 1996a

[24] The potential of the seed to become a commodity cannot be represented in theories generated under the materialist strategy, for it involves abstracting from the seed's place in a system of social relations Shiva has developed this point in interesting ways, e g

"The commoditised seed is ecologically incomplete and ruptured at two levels 1) It does not *reproduce* itself, while by definition, seed is a regenerative resource Genetic resources are thus, through [bio]technology, transformed into a non-renewable resource (2) It does not *produce* by itself It needs the help of inputs to produce As the seed and the chemical companies merge, the dependence on inputs will increase, not decrease And ecologically, whether a chemical is added externally or internally, it remains an external input in the ecological cycle of the reproduction of seed "

(Shiva, 1993a, p 144 Cf , Shiva, 1991b, 1993b)

[25] There is a weaker thesis of neutrality within every value (cultural) perspective there are practices that could be "improved" through access to theoretical understanding (NOT any confirmed scientific proposal can, in principle, be applied in any value perspective!) I think that this weaker thesis can be sustained (Lacey, in progress) Thus, even if one adopts a version of O that goes beyond or is skewed to $O_1$, it will encompass some

research governed by $O_1$ but subordinate to appropriate social constraints

[26] Clearly a large class of approaches could be generated by making appropriate substitutions in $O_2$ (Lacey, in progress) This point reflects " the possible ways that a thing can be depends upon the configuration of practices within which they become manifest" (Rouse, 1987, pp 160–161)

I think that the best of recent feminist (e g , Longino, 1990) and neo-Marxist (e g , Lewontin, 1991) critiques of current science are rooted in approaches, with **c/s strategies** linked to values such that $O_1$ gains only a subordinate place As such they are thoroughly intelligible and do not require either the imposition of value upon fact, or the conclusion that *impartiality* is false

[27] It is not obvious that the criteria must be the same regardless of the **c/s strategy** adopted My suggestion is that the **cv** (whatever list of them is settled upon) always constitute these criteria This is because they are grounded in O, rather than the specific objectives of particular approaches $O_1$, $O_2$, etc But a particular **cv** may be interpreted differently in the context of different approaches "Empirical adequacy", e g , has no precise meaning outside the context of a particular **c/s strategy**, and "explanatory power" under $O_1$ will be interpreted provide explanations (in terms of generability from underlying structure, process and law) of phenomena in a *wide range* of domains, and under $O_2$ account *fully* for all the aspects of the phenomena of interest, especially as they impinge on one's prioritized values (For the distinction between "wide ranging" and "full" explanation, see Lacey, 1986, 1990, 1996a ) This matter needs more analysis and discussion

[28] If, given the state of investigation, the **cv** do not suffice to make a choice, no theory may properly be accepted, and the matter must remain open to further investigation If, in actual fact, a theory is accepted under these circumstances, a value has (improperly) played a role *alongside* the **cv** in making the judgment of acceptance (Longino 1990) and (Nelson & Nelson 1995) provide examples of such judgments Cf Note 4

[29] I also take it as a reason, *ceteris paribus*, to adopt a strategy, $S_1$,

rather than another, $S_2$, that there are compelling arguments that the possibilities that can be identified under $S_1$ include any that can be identified under $S_2$, or that those identified under $S_2$ represent limiting cases of those identified under $S_1$

O'Hear has criticized other views that link the objectives of approaches to science with social values "We cannot assume in our scientific work one version of a specific value and then expect that nature is obligingly going to fit it" (O'Hear, 1989, p 228) My account is not open to this criticism I think that only views that grant a role to values alongside the **cv** are