HELEN E. LONGINO

COGNITIVE AND NON-COGNITIVE VALUES IN SCIENCE: RETHINKING THE DICHOTOMY[1]

INTRODUCTION

Underdetermination arguments support the conclusion that no amount of empirical data can uniquely determine theory choice. The full content of a theory outreaches those elements of it (the observational elements) that can be shown to be true (or in agreement with actual observations).[2] A number of strategies have been developed to minimize the threat such arguments pose to our aspirations to scientific knowledge. I want to focus on one such strategy: the invocation of additional criteria drawn from a pool of cognitive or theoretical values, such as simplicity or generality, to bolster judgements about the worth of models, theories, and hypotheses. What is the status of such criteria? Larry Laudan, in *Science and Values*, argued that cognitive values could not be treated as self-validating, beyond justification, but are embedded in a three-way reticulational system containing theories, methods, and aims or values, which are involved in mutually supportive relationships (Laudan, 1984). My interest in this paper is not the purportedly self-validating nature of cognitive values, but their cognitive nature. Although Laudan rejects the idea that what he calls cognitive values are exempt from rational criticism and disagreement, he does seem to think that the reticulational system he identifies is independent of non-cognitive considerations. It is this cognitive/non-cognitive distinction that I wish to query in this paper. Let me begin by summarizing those of my own views about inquiry in which this worry about the distinction arises.

CONTEXTUAL EMPIRICISM

I've argued for a view I call contextual empiricism, according to which empirical, that is, observational and experimental, data constitute the least defeasible grounds of theory assessment. This much is the empiricism of the view. But data underdetermine the theories, models, and hypotheses for which they serve as evidence. Theories and hypotheses always overreach available data. More crucially, the content (and language) of data descriptions and of explanatory hypotheses are different. For example, data can consist of correlations while hypotheses assert causal relations among correlated items. Thus, no purely formal relations can be established between them. Evidential relevance of data is secured instead by background assumptions, with the consequence that the same data can in different contexts serve as evidence for different hypotheses. This is the contextualism of the view.

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Contextual empiricism invites the question what controls background assumptions. If scientific reasoning is so porous to context, what prevents theories from being entirely subjective? My answer, in *Science as Social Knowledge* (Longino, 1990), was that critical interactions among scientists of different points of view were required to mitigate the influence of subjective preferences on background assumptions and hence theory choice.

While intersubjective interaction is a necessary feature of scientific cognition, not just any form of interaction will do. If the point of intersubjective interaction is to transform the subjective into the objective, then those interactions must not simply preserve and distribute one subjectivity over all others, but must constitute genuine and mutual checks. This end can be served by specifying features of the design and constitution of a community that facilitate transformative criticism and enable a consensus to qualify as knowledge. Four such features can be identified.

(1) There must be publicly recognized forums for the criticism of evidence, of methods, and of assumptions and reasoning.

(2) There must be uptake of criticism. The community must not merely tolerate dissent, but its beliefs and theories must change over time in response to the critical discourse taking place within it.

(3) There must be publicly recognized standards by reference to which theories, hypotheses and observational practices are evaluated and by appeal to which criticism is made relevant to the goals of the inquiring community. Such standards serve as ideals regulating normative discourse in a community. That is, by explicitly or implicitly professing adherence to those standards individuals and communities adopt criteria of adequacy by which their cognitive activity may be evaluated. The satisfaction of goals of inquiry is not ascertained privately, but by evaluation with respect to shared values and standards. This evaluation may be performed by anyone, not just by members of the community sharing all standards. Furthermore, standards are not a static set, but may themselves be criticized and transformed, in reference to other standards, goals, or values, held temporarily constant. Indeed, the presupposition of reliance on such standards is that they have survived similar critical scrutiny.

(4) Finally, communities must be characterized by equality of intellectual authority. What consensus exists must be the result not of the exercise of political or economic power, or of the exclusion of dissenting perspectives, but a result of critical dialogue in which all relevant perspectives are represented. This criterion is meant to impose duties of inclusion; it does not require that each individual, no matter what their past record or state of training, should be granted equal authority on every matter.

Discursive interactions reduce the likelihood that the idiosyncratic preferences of individuals will be incorporated in the public body of scientific knowledge. While they cannot eliminate background assumptions altogether, discursive interactions conducted in and among communities satisfying the above conditions not only eliminate the idiosyncratic but insure that no set of assumptions dominates simply by virtue of its commonality or invisibility. The public standards mentioned in con-

dition (3) have two objects. One is to impose obligations on acknowledged members of a knowledge-productive community to attend to criticism that is relevant to their cognitive and practical aims. The other is to limit the sorts of criticisms to which a community must attend to those which affect the satisfaction of its goals. The point of (4) is that such criticism may originate from an indeterminate number of points of view, none of which may be arbitrarily excluded from the community's interactions without cognitive impairment.

I want to focus on the public standards mentioned in the third of these conditions. I originally thought that they contained cognitive values, pragmatic values, and substantive assumptions grounded in either the metaphysical commitments or the social and political commitments of a society, i.e. metaphysical or value-laden substantive assumptions. I argued in *Science as Social Knowledge* that social or non-cognitive values could and did serve as cognitive values. What I did not question, and want to explore more deeply here, is the supposition that the values called cognitive really are cognitive. By "cognitive" here, I mean something like "epistemic", that is, conducing to the truth. There are accounts of knowledge and cognition within which "cognitive" would have a different meaning, but that is not the meaning with which it is used by philosophers promoting cognitive values as solutions to underdetermination.[3]

COGNITIVE VALUES

There have been a variety of proposals as to what count as cognitive values, but there is a great deal of overlap among most of those proposals. In his essay "Objectivity, Values, and Theory Choice", Thomas Kuhn discussed five values that scientists use to guide their judgements in choosing between competing theories (Kuhn, 1977). These are accuracy, simplicity, internal and external consistency, breadth of scope, and fruitfulness. Kuhn had a lot to say about these values and how they functioned; his overall claim was that they constituted objective grounds for theory choice. The elements on Kuhn's list (with the exception of fruitfulness) are just the sorts of consideration that end up in philosophers' lists of what, besides agreement with observational and experimental data, counts for the truth (or acceptability) of a theory or hypothesis. For example, Quine and Ullian, in *The Web of Belief*, list as virtues of a hypothesis conservatism, modesty, simplicity, generality and refutability (Quine and Ullian, 1978). Indeed, when drawing a distinction in *Science as Social Knowledge* between what I called constitutive and contextual values, I used items like empirical adequacy (used interchangeably with accuracy), simplicity, and explanatory power (used interchangeably with breadth of scope) as paradigmatic examples of constitutive values (Longino, 1990).

Although certain items, like simplicity and generality (which overlaps with breadth of scope and explanatory power), consistently recur on philosophers' lists of cognitive virtues, other items are less universally proposed. Laudan, in his paper "Demystifying Underdetermination", proposes internal consistency, the (correct) prediction of surprising results, and variety of evidence (Laudan, 1990). The first is

fairly universally accepted, especially if it means nothing more than satisfying some basic logical principles like the principle of non-contradiction. Correct prediction of surprising results comprises two criteria: correct prediction, which we can understand as comparable to accuracy and empirical adequacy, and the surprising or unexpected character of what is predicted. About the former there is general agreement, about the latter, very little.[4] The role and importance of variety of evidence is also disputed.[5] Paul Churchland (1985) identifies simplicity and explanatory power as cognitive or epistemic virtues that enable us to go beyond mere (and for Churchland, highly problematic) empirical adequacy. What seems presupposed in these discussions is that it is possible to identify some properties of theories as cognitively virtuous. This means that judgement guided by these virtues or standards is more likely to lead to true or at least rational belief.

Theoretical virtues can be and are invoked in a variety of contexts: there is theory choice, but also retrospective appraisal, rationalization of commitments made, plausibility assessment, etc., not to mention hallway gossip. Different elements in these lists will be more salient in some contexts than others.[6] My aim here is not, however, to illuminate theory choice specifically or to distribute the cognitive virtues to their appropriate normative contexts. It is instead to cast doubt on the very idea of a cognitive value or virtue, where we mean by that a quality of theories, models, or hypotheses that can serve independently of context as a universally applicable criterion of epistemic worth.[7] For convenience and brevity, I shall focus my argument on the virtues enumerated by Kuhn, beginning with a closer look at what they are.

Accuracy

This virtue is what others might call empirical adequacy, i.e. the observational content of a theory or hypothesis should be in agreement with observational and experimental data. Preference will be given to those models, hypotheses, and theories whose observational elements or consequences are in greater consonance with data as compared with alternatives. As I have argued elsewhere (Longino, 1995), accuracy and empirical adequacy are not as straightforwardly applied in evaluative contexts as might be hoped. And in any case, arguments about the underdetermination of theory by data require that other considerations be brought to bear on theory assessment. That is, given that accuracy or empirical adequacy mean only that the observational content of a theory is in accord with observational data and that the full content of a theory extends in various ways beyond that observational content, other criteria must be invoked in the assessment of the empirical, but non-observational, content. For example, the observational content of elementary particle theory is the predictions of the data various kinds of detector will produce under given circumstances. The particles, their properties, interactions, and disintegrations, are all hypothesized as underlying or causing the manifestations observed in bubble chambers or data tapes. That part of the theory which is about particles cannot be directly assessed since our access to particles is mediated by

instruments and theory about those instruments. We cannot assess the truth of statements about particles as we can the truth about the frequencies of certain kinds of signal produced in detectors. Hence the lists of virtues contain additional elements intended to assist in the discrimination among different theories that could be used to account for the same phenomena.

Internal Consistency

The theory or hypothesis contains no contradictions.

External Consistency

The theory or hypothesis is consistent with presently accepted theories in other fields. Quine and Ullian's version of this virtue is conservatism, which they gloss as favoring the hypothesis disconsonant with the fewest number of sentences in the web of belief, including observational ones.

Simplicity

This is a notoriously difficult criterion to pin down. Kuhn says a simple theory brings order to phenomena that would otherwise remain disparate or confused. But this still leaves many ways in which a theory might be simple. Some gloss simplicity as having to do with the order of equations used in a theory or the continuity of the curves used to generate the data points in a graph of the data.[8] Another interpretation, and I think the more common one, is ontological. Any theory (or model, or hypothesis) stipulates an ontology, i.e. it characterizes what is to count as a real or basic or causally effective entity in its domain as well as the kinds of process in which such entities participate. The simpler theory is the one that stipulates fewer entities or fewer processes.[9] Newtonian mechanics, which applies to a universe of bodies characterized by extension, hardness, impenetrability, mobility and inertia, is a prime example of a theory exhibiting the virtue of simplicity, in comparison with its Aristotelian predecessor which held that there were four (sublunary) elements, each with distinctive properties. One might also characterize simplicity in terms of the number of basic or underived principles of a theory, but this shades into the next virtue.

Breadth of Scope

Again there are various ways to characterize this criterion. Kuhn explicated it as requiring that the consequences of the theory extend beyond those the theory was originally developed to explain. Other philosophers talk of explanatory power or generality, by which they mean the diversity of phenomena that can be explained by a single or single set of basic or underived explanatory principles.[10] Newtonian mechanics also exemplifies this virtue, since a variety of hitherto different phenom-

ena (from falling bodies to orbiting planets) were brought under the unifying explanatory umbrella of the three laws of motion.

Fruitfulness

This criterion is unique to Kuhn, but I think he is correct in identifying it as a criterion used by scientists in evaluating theories. A fruitful theory generates new findings or discloses new relationships. Another way of understanding fruitfulness is that by suggesting new hypotheses, it generates problems or questions that the theory can be used to answer. Kuhn, in a footnote, remarks that a young scientist, choosing between two theories knows that the choice will bear on her future research career. She will, if she has any sense, choose the one that promises "the concrete successes for which scientists are normally rewarded" (Kuhn, 1977, p. 322, n. 6). Fruitfulness could be considered a richer version of refutability. I will discuss this suggestion below.

To say that these are values or virtues is to say that they are properties that theories can have or can have to a greater or lesser degree. In practice, no theory can possess all of these properties to the maximum, since some of them are in a certain amount of tension with each other, particularly accuracy and breadth of scope. Thus, an optimum theory exhibits some balance of these desiderata. These traditional virtues could be thought of as explicating what "best" means in inference to the best explanation. The need, however, to trade-off maximum satisfaction of one virtue against another could be interpreted as an argument against these virtues having any epistemic status at all.[11] But their philosophical interest does not thereby melt away. Even if we disallow *inference* to the best explanation, i.e. the inference that because H offers the best explanation of *e* and *e*, therefore H, the virtues could still be thought of as an explication of how a good, better, or best scientific theory is to be characterized, and, hence, of the (internal, scientific) grounds for preferring, in prospect or in retrospect, one theory over another. This, I think, is what Kuhn was suggesting. In the absence of alternatives, and because they are routinely invoked in discussions of scientific values, it is easy to think of them as constitutive values of science (and thus cognitive in some broad sense of cognitive). Let us see, then, whether consideration of some alternatives permits this classification.

SOME FEMINIST THEORETICAL VIRTUES

Feminist writing about the sciences reveals a quite different set of desiderata. Here one finds empirical adequacy, but also novelty, ontological heterogeneity, mutuality of interaction, applicability to human needs, and diffusion or decentralization of power. There are undoubtedly others, but (as Kuhn said about his list) this list is enough to make the points I want to make.

   The traits listed are generally invoked singly or in groups of two or three and for the most part become evident as values in the context of their use.[12] No one (to my knowledge) has offered them as a package. But when they appear in feminist work they function, like the more traditional candidates for cognitive or scientific values, as virtues; that is, as qualities of a theory, hypothesis, or model that are regarded as desirable and hence guide judgements about them. I shall refer to them as virtues, values, standards, criteria, continuing to ignore the differences between those concepts for purposes of this discussion. Let me begin by offering some interpretation of the elements of this alternative set based on the contexts in which they've been deployed. Then I shall discuss their relation to the more standard virtues.

Empirical Adequacy

Empirical adequacy is the one item common to both the traditional and the alternative set. A good deal of feminist effort has gone into discrediting research programs that purport to show a biological etiology for differences ascribed on the basis of sex. The (feminist) scientists involved in this effort – scientists such as Ruth Bleier, Anne Fausto Sterling, Richard Lewontin, Ruth Doell – have concentrated on discrediting such research by showing that it fails minimal standards of empirical adequacy, either through faulty research design or improper statistical methodology. I take their appeal to empirical adequacy in the context of their critiques to constitute an implicit endorsement of the standard. Empirical adequacy is valued for, among other things, its power when guiding inquiry to reveal both gender in the phenomena and gender bias in the accounting of them. It is, of course, a standard shared with race- and class-sensitive research communities as well as with most mainstream communities. Failure to meet the standard in a strong sense, i.e. the generation of statements about what will or has been observed that are incompatible with what has actually been observed, is grounds for rejection of the hypothesis or theory in question. In practice, most research communities reserve judgement when one of their central theories is shown to fail the test of empirical adequacy, unless the failure can be made overwhelming and an alternative theory is available to perform much of the same work.

Novelty

By novelty, I understand models or theories that differ in significant ways from presently accepted theories, either by postulating different entities and processes, adopting different principles of explanation, incorporating alternative metaphors, or by attempting to describe and explain phenomena that have not previously been the subject of scientific investigation. Several thinkers have endorsed the novelty of a model or theory as a value. Sandra Harding seems to do so explicitly when she calls both for "successor science" and for "deconstructing the assumptions upon which are grounded anything that resembles the science we know" (Harding, 1986). And one can read Donna Haraway's invocation of the visions of certain science fiction

writers as an appeal for or endorsement of a departure from entrenched assumptions, particularly those having to do with the immutability of boundaries between animal and human, organism and machine. Only new frameworks which have eschewed such boundaries, she suggests, will be appropriate for the new circumstances of 21st-century life (Haraway, 1992).

Treating novelty as a virtue reflects a deep skepticism that mainstream theoretical frameworks could be adequate to the problems confronting us, as well as a suspicion of any frameworks developed in the exclusionary context of modern European and American science. Since mainstream traditional frameworks have been used in accounts that either neglect female contributions to processes biological and social, or that treat as natural alleged male superiority in various dimensions, something new will be required to address phenomena in a non-androcentric way and to ensure that invidious distinctions underpinning gender oppression are not persisting in reformed theories and models. Novelty could, of course, have stronger and weaker interpretations. The strong interpretation demands new frameworks and theories to replace current ones in the domains in which they are currently employed. On the weaker interpretation, new frameworks are to be sought in satisfying a demand for scientific understanding of hitherto neglected phenomena.

Ontological Heterogeneity

As mentioned in the earlier discussion of simplicity, any theory posits, implicitly or explicitly, an ontology; that is, it characterizes what is to count as a real or causally effective entity in its domain. A theory characterized by ontological heterogeneity (or ontological diversity) is one that grants parity to different kinds of entities. Ontological homogeneity, or uniformity, by contrast, characterizes theories that posit only one sort of causally efficacious entity, or that treat apparently different entities as versions of a standard or paradigmatic member of the domain, or that treat differences as eliminable through decomposition of entities into a single basic kind. The criterion of heterogeneity is found in two quite different sorts of discussion in the feminist literature on the sciences, which emphasize different aspects of the criterion. One is the respect for particularity and individuality urged by feminists in a variety of research contexts.[13] Feminists writing about biology have urged that we take account of individual differences among the individuals and samples that constitute the objects of study.[14] Although she was not herself a feminist, Barbara McClintock's attention to the individual kernels of a cob of corn (which helped her to recognize an underlying pattern of mutability) has been taken as a paradigm of what a feminist attitude to nature ought to be.[15] Primatologist Jeanne Altmann has insisted on methods of observation that descriptively preserve the differences among the primates and groups of primates that she studies (Altmann, 1974). This methodological focus on individual differences is a form of particularism – an insistence on the priority of particulars to abstractions.

Treating individual differences as important and not to be elided in abstractions or idealizations which smooth out heterogeneity is valuing heterogeneity, taking it as a basic aspect, if not of the natural world, of one's theories of it. One may have a variety of reasons for so valuing models that preserve heterogeneity. One may, for example, think that such a model more accurately captures the diversity of the experienced world.[16] But the reason feminists have embraced this aspect of the work of McClintock, Altmann, and others is connected, I think, to the second discussion I draw on here: the rejection of theories of inferiority. Theories of inferiority are supported in part by an intolerance of heterogeneity. Difference must be ordered, one type chosen as the standard, and all others seen as failed or incomplete versions.[17] Theories of inferiority which take the white middle class male (or the free male citizen) as the standard grant ontological priority to that type. Difference is then treated as a departure from, a failure to fully meet, the standard, rather than simply difference. Ontological heterogeneity permits equal standing for different types, and mandates investigation of the details of such difference. Difference is resource, not failure.

Mutuality of Interaction

While the prior criterion values theories that are pluralist with respect to entities, this criterion values theories that treat relationships between entities and processes as mutual, rather than unidirectional, and as involving multiple rather than single factors. Many feminist scientists have taken complex interaction as a fundamental principle of explanation. Evelyn Keller's (1983) account of the work of Barbara McClintock and her defense of an interactionist perspective in her *Reflections on Gender and Science* (Keller, 1985) may provide the best known examples, but scientists from icons like Ruth Bleier and Anne Fausto Sterling to much less well known practitioners have eschewed single factor causal models for models that incorporate dynamic interaction, models in which no factor can be described as dominant or controlling and that describe processes in which all active factors influence the others. This perspective has been employed in areas ranging from neuroscience to cell biochemistry by scientists self-consciously practicing science as feminists as well as, of course, by non-feminists. It has also been endorsed in texts devoted mainly to reflections about the sciences.

One thing noted by feminist proponents of mutuality is that simple models of single factor control make one party (the dependent as distinct from the independent variable) to an interaction a passive object rather than an agent. This has been the fate of female gametes in accounts of fertilization and of female organisms in accounts of social structure. Asymmetry of agency in the physiological context is used to naturalize asymmetry in the social. These naturalizing arguments are explicit in sociobiological stories attributing the presumed docility of females and activity of males to anisogamy, i.e. the different sizes of the female and male gametes, which involve different kinds of "parental investment". Informally, there is bidirectionality of support: asymmetric models of gametic fusion depend for their

plausibility on social ideologies of gender, but their persistence in medical and bio-
logical textbooks thereby reinforces the social ideologies. As Emily Martin shows,
the personification of egg and sperm in these contexts is one way of effecting the
conflation of the natural and the social (Martin, 1991). Replacing simple asym-
metric models of single factor control in social contexts with more complex models
of social interaction makes visible the role of gender in the structure of social insti-
tutions and the role of private, domestic (traditionally, women's) work in main-
taining the activity and institutions of the "public" sphere. Similarly replacing
models of energetic sperm acting on passive eggs with models of mutual interaction
reveals the egg's considerable contribution to the process of gametic fusion.[18]

Applicability to Current Human Needs

This and the next are pragmatic criteria, and more relevant to decisions about what
theories or theoretical frameworks to work on than to decisions about plausibility.
That is, heterogeneity and mutuality of interaction concern the content of models
and theories while applicability and diffusion of power concern the effects of their
adoption. This criterion favors research programs that can ultimately generate ap-
plicable knowledge. Many, but not all, feminists in the sciences have stressed the
potential role of scientific understanding in improving the material conditions of
human life, or alleviating some of its misery. Scientific inquiry directed at reducing
hunger, promoting health, assisting the infirm, protecting or reversing the destruc-
tion of the environment, is valued over knowledge pursued either for political dom-
ination, i.e., science for "defense", or for knowledge's sake.[19] As expressed in
feminist contexts, this is not just a call for more applied science, such as is heard in
the halls of Congress, but for research that can be directed towards meeting the
human and social needs traditionally ministered to by women. The applicability cri-
terion could be understood, then, as requiring research into hitherto neglected areas
and hence triggering the novelty criterion in its weaker interpretation.

Diffusion of Power

This criterion is the practical version of the fourth criterion, the one favoring
models that incorporate mutual rather than dominant–subordinate relationships in
explanatory models. This one gives preference to research programs that do not
require arcane expertise, expensive equipment, or that otherwise limit access to
utilization and participation. This feature has emerged as a value in a number of
different contexts. Feminists in engineering and in economics have condemned
requirements of mathematical achievement far beyond what is required for suc-
cessfully engaging in these fields.[20] Other feminists, such as Hilary Rose (1983)
and Ruth Ginzberg (1987), have urged a revamping of traditional distinctions to
include widely distributed practices such as midwifery as scientific practices. They
urge that such practices be used as models for feminist science practice. Feminist
health professionals urge a preference for medical practices and procedures that

empower the individual woman either to make decisions about her health or to retain control over her own body. And ecofeminists and feminists in developing regions urge the development of technologies that are accessible and that can be locally implemented (Sen and Grown, 1987). Diffusion or decentralization of power interprets the above-cited elements of the applicability criterion as knowledge of soil conservation, intensive small-scale sustainable agriculture, promoting health by preventive measures such as improved hygiene rather than high-tech interventive measures available only to the few, protection of the environment by conservation and widely dispersed renewable energy technologies.

The various proponents of these standards have had different ideas about how they work or ought to work in inquiry. If we treat them as components of a community set of public standards as I am suggesting, we take them as regulative ideals shaping the normative discourse in a scientific community, that is, as criteria invoked in the assessment of theories, models, and hypotheses, guiding their formulation, acceptance and praise, disparagement and rejection, and pursuit or abandonment. As Kuhn noticed of the values he discussed, these alternative virtues require further interpretation to be applied in a given research context, they are not simultaneously maximally satisfiable, and they are not subject to hierarchical ordering or algorithmic application.

Since empirical adequacy is almost universally recognized as a value, and since others of these characteristics have been endorsed as virtues by non-feminists, one might well wonder what about these standards is specifically feminist.[21] Several answers to this question can be discerned in the texts in which these virtues have been endorsed.

One approach holds that these characteristics express a feminine or female orientation to the world, i.e. that women either because of biology or social experience are more likely to understand the world via theories characterized by these traits. This is said primarily of the substantive and pragmatic virtues. Women are said, for example, to be more inclined to perceive mutual influence and interaction than unidirectional single factor control, and to be more interested in research that will improve the conditions of life. What would be feminist, then, would be treating as theoretical virtues characteristics of women's ways of thinking about the natural and social worlds. The problems with this approach are, first, that there's no evidence that women are inclined biologically or culturally to understand the world in these ways; second, that even if they were, we'd still need an argument that these are traits that ought to be valued in theory construction and assessment; and third, that it creates a need to explain the endorsement of these virtues by non-feminists. Of course, if one is antecedently convinced, as some advocates of these virtues are, that the world really is constituted of heterogeneous entities that interact in complex ways, the need for such an argument will be much less apparent than it is to one less certain. But if the world is such as to be more adequately understood via theories exhibiting these virtues, then they ought to be promoted as general theoretical virtues and not just as feminist theoretical virtues.

A second approach suggests that women are more likely to value the characteristics of theories because they are outsiders to mainstream science and so less likely to be acculturated to the values of the mainstream. This avoids the problem why nonfeminists would endorse the virtues, but it is an even less plausible candidate for grounding the claim that the virtues would be feminist. Neither female biology nor feminine conditioning, but marginality explains the appeal of these virtues. Marginality, however, is common to any group excluded from the practice of science and so not specifically feminist. Furthermore, while marginal status may alienate or free those marginalized from mainstream values, in some cases preference for alternative values may be the basis of marginalization. And, as is the case for the previous approach, the empirical data supporting the view that marginalized groups are likely to endorse these virtues in particular has yet to be brought forward.

Rather than look to sociological or psychological facts about who uses them, I have suggested that we look to the work these virtues can do for specifically feminist inquiry (Longino, 1994). In the account given above of each of the virtues, I suggested how inquiry guided by them would be thought to reveal gender, either in the form of bias about the phenomena or as a phenomenon in the domain itself, or to reveal the activities of women or females in the domain. Revealing gender means more than mentioning females or even treating males and females as in some relation or other. Revealing gender in a feminist context means revealing an asymmetric power relation that both conceals and suppresses the independent activity of those gendered female. This relation is sustained by social institutions and symbolic practices and is itself made invisible as a relation of power by, among other things, naturalizing models in the life and behavioral sciences of sex and gender relations. The relation of feminist theoretical virtues to the aim of revealing gender is not that gender is always and everywhere revealed, but that if a context is gendered (in the sense of being structured by gendered power asymmetries), inquiry guided by these virtues is more likely to reveal it or less likely to preserve its invisibility than the traditional virtues.

The aim of revealing gender and/or the activities of those gendered female is, I propose, what makes inquiry feminist. Feminist theoretical virtues will be those that serve this aim. Thus, satisfying it is a bottom line requirement on theoretical standards. I should emphasize that I am not arguing here that the virtues I have discussed so far *are* the theoretical virtues feminists should adopt. I think such a claim needs further discussion and argument. What I do propose is that the basis on which such a claim should be argued and disputed is the contribution any proposed virtue can make to furthering feminist goals in inquiry. If the virtues that have been discussed here are feminist, it is because they satisfy this bottom line requirement, and not because of any intrinsic, statistical, or symbolic association with women or cultural femininity.

UNDOING THE DICHOTOMY BETWEEN COGNITIVE AND NON-COGNITIVE

So far, I have described two sets of what I am calling theoretical virtues. An exemplar of a traditional set comprises such items as accuracy or empirical adequacy, in-

ternal and external consistency, simplicity, breadth of scope, and fruitfulness. An alternative list contains empirical adequacy, novelty, ontological heterogeneity, mutuality of interaction, applicability to human needs, and diffusion of power. The virtues of the traditional set are usually recommended as cognitive or epistemic virtues or as constitutive values of science, that is, they are taken to conduce to truth or rational belief or they are taken to be characteristic virtues of (good) scientific theories. I argued about the second set that they are neither uniquely nor intrinsically feminist, but that feminists could argue that theories exemplifying them would be more likely to satisfy feminist cognitive aims (which are also socio-political aims) – namely to make women and female-identified phenomena as well as gender relations more visible. Does this mean that we have one set of virtues that are social or political and one set that are cognitive? If that were the case we would have no real question of choosing between them and could dismiss scientific inquiry performed with feminist concerns in view as mere ideology, not science at all. If we examine contrasting pairs from the two sets, however, it doesn't seem that the dichotomy underwriting this dismissal can be sustained. Rather than examine all possibilities, I shall take three: external consistency and novelty; simplicity and ontological heterogeneity; fruitfulness and the feminist pragmatic virtues.[22]

External Consistency or Conservatism vs. Novelty

Kuhn recommended consistency with accepted theories in other domains, Quine and Ullian recommended the theory that least disrupts the web of belief. If we take accepted theories in other domains to be true, then obviously, to the extent it can be determined, consistency or the avoidance of inconsistency with those theories is a good guide to truth. But then, even in its broader, web of belief, version, the value of this criterion is dependent on the truth status of those accepted theories, or sentences in the web, consistency with which is recommended. The novelty criterion recommends theories and models that depart from accepted theories. It recommends disregarding consistency with other theories, and not being hamstrung by conservatism. Different interpretations of the two criteria can produce different articulations of contrast,[23] but what interests me here is their socio-political valence. The socio-political basis for the criterion of novelty is the need for theoretical frameworks other than those that have functioned in gender oppression by making gender invisible. External consistency, in a context in which theories have had that function, perpetuates this invisibility. Those satisfied with the status quo will endorse this criterion, and the effect of its endorsement is to keep from view the ways in which currently accepted theories are implicated in the legitimation of gender oppression.

   Donna Haraway (1986) has pointed out, for example, how the retention of a sociobiological framework in Sarah Blaffer Hrdy's feminist primatology replicates problematic moves in liberal feminism, which perpetuates the framing assumptions about individualist and self-regarding human nature of liberal political theory. In both the primatological and the political case, the (liberal) feminist turn is limited to

claiming for females what has been reserved for males without challenging the deeper assumptions about human (and animal) nature involved in both the scientific and the political program. And Susan Sperling (1991) develops a similar argument with respect to the functionalist and sociobiological frameworks she identifies in most of the feminist primatology of the last twenty-five years. Her point is that it preserves essentialist and determinist concepts of gender, its feminism being restricted to revaluing the roles of females in primate evolution. The models advanced by these primatologists thus satisfy the mainstream virtue of external consistency. Paying attention to females, making them more central to the analysis, corrects omissions of androcentric field work and does thereby advance what I have termed the central feminist cognitive aim. However, by leaving the theoretical scaf-folding in place, these critics argue, the work under discussion fails to challenge the ways in which sociobiological analysis naturalizes the social relations of capital-ism. While a few women may benefit in such a system, the vast majority are impoverished. Gender relations under capitalism are intricately entwined with class and race relations. Thus, feminist primatology that utilizes sociobiological analy-tical tools is only partially revealing of gender by privileging, Haraway and Sperling argue, middle class gender relations. Even though it has been resisted in certain quarters, one reason the feminist primatology has been taken seriously is its conservativism with respect to basic theory. According to Haraway and Sperling, its exemplification of this traditional virtue is also a cause of its political regressiveness.

Endorsing novelty is not claiming license to depart from the standard of empiri-cal adequacy. The feminist critic can argue that new theories would (or might) produce new observational content about qualitatively different but nevertheless observable phenomena. The empirical data associated with the more standard theories might just lose their salience or even dissolve in the context of an alter-native model.[24]

Simplicity and Ontological Heterogeneity

Pursuing another contrast, we can see how certain interpretations of the simplicity criterion are laden with socio-political values. The interpretation that contrasts with ontological heterogeneity is an ontological one: the simpler theory is the one po-siting the fewest different kinds of fundamental entity (or of causally effective entity). This encourages us to find ways of treating putative entities which are not members of the privileged class either as epiphenomena, as constructions that can be disassembled into collections of entities of the privileged class (cells into mole-cules, molecules into atoms, etc.), as parts of members of the privileged class, or as variants whose deviations from the standard can be disregarded. To suppose the social world is composed of just one or a few kinds of basic entity (e.g. rational self-interested individuals in neoclassical economic theory) erases the differences among persons, including their social positions, that are fundamental to how they act. Economics, for example, treats the head of household as the main economic

actor – assuming its (his) dominance in the household – and assuming that the interests of other members of the household – spouse, partner, children, elderly parent – are identical with those of the head. By erasing the independent interests of other household members from theoretical view, these models prop up an oppressive family structure (one person – "the benevolent patriarch" – is *supposed* to make the decisions) and indirectly legitimate the assumption by welfare policy makers, family policy makers, etc. that this structure is the primary and appropriate family structure in our society.[25]

This treatment of the household preserves the uniformity of the effective entities in economic theory. Thus, it satisfies the virtue of simplicity. Now, suppose we have some alternative theories that, say, treat the household as an internally heterogeneous zone, structured by gender. Such feminist theories of the household disrupt the uniformity of effective entities posited in the more standard neoclassical theories. The heterogeneity of ontology tolerated in such theories helps to make visible gender relations and the activity of those gendered female in the household and its interactions with the larger economic context. If we suppose that we have equally empirically adequate models, can the virtue of simplicity be used to rule out this alternative theory? Only if simplicity could really be shown to be a criterion of truth or likelihood. For one committed to a metaphysical view about the simplicity of the universe, the greater parsimony in postulation of entities might be indicative of the greater likelihood of truth of the simpler theory, but this is now relative to the truth of the metaphysical view. But if one has no grounds for this metaphysical view, metaphysics *and* method are operating in the service of politics.

Fruitfulness and the Feminist Pragmatic Virtues

Fruitfulness, for Kuhn, referred to the capacity of a theory to generate problems or puzzles demanding solutions and to provide the resources with which to solve them. This, of course, means more opportunities to articulate connections between the theory and putatively established phenomena as well as other theories. While fruitfulness might be interpreted in more pragmatic ways, one might also see fruitfulness as a kin to refutability: a theory that generates more problems for solution than another is a theory that offers more opportunities for its confirmation and disconfirmation than that other.[26] The generation of problems, however, is not purely internal to a theory but depends on its relations with other theories and the state of instrumentation and experimental sophistication available at any given time. A theory might be fruitful in one context, but not in another.

The same might be said for the feminist practical virtues – a theory might exemplify them (or we could attribute them to a theory or model) in one context but not in others. But the contrast lies in the following: the feminist practical virtues favor theories and models that can be used to improve living conditions in a way that reduces inequalities of power. Taking them seriously requires looking beyond the immediate (internal) context of research to the ways in which that research might or might not be developed. This in turn requires taking stock of the social, political,

and economic context in which development might take place. Fruitfulness is by contrast conservative in that it is inward looking. Understood as the capacity to generate either puzzles or predictions whose non-fulfillment will count as refutations, it directs attention away from the social and technological applications of research, whether they be beneficial or harmful. There is a further dimension to this contrast. One of the consequences of incorporating these quite specific and politically informed pragmatic values into a set of community standards of inquiry, is that the thesis of the political neutrality of science becomes itself a political rather than a methodological or epistemological position.

CONCLUDING REFLECTIONS

I've argued that by identifying values of a scientific community other than the traditional ones we can get insight into important features of the latter. In particular, I've tried to give some reasons for thinking that those traditional values are not purely cognitive (if at all), and that their use in certain contexts of scientific judgement imports significant socio-political values into those contexts. That is, I've argued, by comparing them with contrary theoretical virtues, that in specific research contexts the traditional virtues have a demonstrably political valence. I don't want to say the traditional virtues are always politically regressive, but that the fact that they sometimes are means that we cannot treat them as value-neutral grounds of judgement. There may be reasons for relying on them in a given context, just as there are reasons for relying on the alternatives in certain contexts. But the arguments we can give for them will be context-limited in their validity.

I do not, therefore, want to claim that the virtues or criteria I've discussed have fixed and absolute socio-political meanings. Furthermore, whatever valence they have in a given situation will be modified by their interaction with whatever other values are brought to bear, the relative priorities assigned to these values, and the reasons for which they are being endorsed in that situation. And the social context in which they are used will also make a difference. Thus, it is not clear that treating simplicity as a theoretical virtue would have the same socio-political resonance in a socio-political context which values diversity and equality. But in *our* context, in which diversity and equality are granted lip service but made to defer to more important social values like order and economic competitiveness, and in which the physical and life sciences possess a greater cognitive authority than other intellectual sources of value, it does serve anti-progressive ends. Similarly, heterogeneity could, in a context other than our own, fail to be a theoretical virtue with a liberatory potential.

If the cognitive virtues, that is, the standards that regulate discursive interactions in a scientific community, lose their context-independent, universalist, status, as I have been advocating, then what is left to adjudicate scientific disputes? If underdetermination undermines even empirical adequacy's ability to put a definitive, uninterested, end to disputes, are we not faced with either anarchy or the rule of the powerful – a tyranny of the majority? I think these worries are pressing against the

background of certain conceptions of scientific inquiry and of scientific knowledge, and perhaps against the background of a hope of a truth that could adjudicate the hurly-burly of the political. Without fully addressing here what I take to be this background, let me offer the following.[27]

To the extent cognitive anarchy does emerge as a consequence of the view outlined here, it is a global, rather than local anarchy. Locally, communities will and must adopt standards that express their aspirations. It's just that these standards – like the aspirations that ground them – are provisional and subject to modification as a consequence of interaction with other communities as well as with the world a community seeks to know. This is why I would describe the view as pluralist rather than anarchist. In any case, there's hardly enough diversity now – a little more could improve things significantly in some of the sciences.

As for the danger of tyranny of the majority, I admit that the criteria of community interaction outlined in the opening pages of this essay, especially the fourth, are idealistic. But they function as, among other things, grounds for the critique of actual practices. While idealistic, they are no less powerful than the truth is in the face of brute force; that is, they are practically ineffective, but serve nevertheless to animate critical reflection and, where appropriate, resistance. The fourth criterion, requiring equality of intellectual authority, invalidates consensus that is achieved by means other than free and open critical discourse, by, for example, tyranny of the majority. Tyranny of a minority, one could say, is what we have now, and its problematic nature is only revealed by the kind of critique advanced here and elsewhere by like-minded analysts. We should worry more about the concealing of political agendas behind the mantle of scientific neutrality than about the consequences of abandoning the illusion of neutral arbiters of our cognitive practices.

One can see the claim I have been defending – that the traditional virtues have a political valence – as leading to a dilemma: either the traditional virtues cannot be taken as constitutive of "best explanation" or of "science" in some social-value neutral sense, that is, we cannot maintain the dichotomy between cognitive and non-cognitive values, *or* the doom sayers are right and science is just a vehicle for the maintenance of political control: "science is politics by other means", to generalize Haraway's (1986) paraphrase of Clausewitz. We can reject this second leg of the dilemma only if we can be satisfied with at best local, sometimes politically grounded, and always negotiated, vindications of virtues and the pluralism this entails.

Center for Philosophy of Science and Department of Women's Studies, University of Minnesota, Twin Cities

NOTES

[1] This is an expanded and revised version of the essay "Gender, Politics, and the Theoretical Virtues" (Longino, 1995). I am grateful to members of the Philosophy Departments at Carleton College, St. Olaf College, the University of Toronto, the History and Philosophy of Science Department at Indiana

University and the Committee on the Conceptual Foundations of Science at the University of Chicago for their comments, and to Marta Gonzalez-Garcia and Lynn Hankinson Nelson for their instructive readings of earlier drafts of the essay.

[2] There are a variety of ways of formulating and demonstrating underdetermination. This formulation is supported by arguments in Longino (1990, Ch. 3) and is consonant with Bas van Fraassen's (1980) distinction between the truth and the empirical adequacy of a theory. See Elizabeth Potter's essay in this volume for discussion of other versions of the underdetermination thesis.

[3] I suspect, in fact, that "cognitive" may be used in preference to "epistemic" because it has a certain vagueness that "epistemic" does not, and it should be noted that not all advocates of this solution use it. McMullin (1983) speaks, for example, of epistemic and non-epistemic values. These are issues to be pursued in another paper.

[4] See the Symposium on 'Do Explanations or Predictions (or Neither) Provide More Evidential Support for Scientific Theories?', (Brush, Achinstein, and Shimony, 1995).

[5] See van Fraassen's (1983) comments.

[6] I owe this point to a comment by Ian Hacking.

[7] I am not addressing the question whether there might not be traits of *cognizers* that could be termed virtuous. These would, of necessity, be different sorts of traits than the traits of models, theories, or hypotheses under discussion here.

[8] Some have understood simplicity as having to do with the character of the calculations needed for derivations in the theory, but this is to treat simplicity as a matter of ease of use, rather than as a property of the theory or its principles.

[9] Of course, there may be a trade-off, as a model using fewer kinds of entities may require more kinds of processes to account for a given range of phenomena than a model which uses more kinds of entities. That is, there may be an inescapable degree of complexity that must be built in somewhere.

[10] Philip Kitcher (1993) has argued for unification as a scientific desideratum. This, for present purposes, can be considered as a variation on breadth of scope. Kitcher, it might be argued, has a more precise measure in mind than the notion of breadth of scope allows.

[11] This is the position taken by van Fraassen, excepting, of course, empirical adequacy (1989, pp. 40–64; 131–150). It has much to recommend it, from a God's-eye point of view. But bundling and dismissing the so-called cognitive virtues saves them from the political critique to which I wish to subject them.

[12] I first discussed what I have called the feminist theoretical virtues in Longino, 1993b. I used them again in a discussion of the possibility of feminist epistemology in Longino, 1994. The exposition of the next several pages borrows from those earlier publications.

[13] Stephen Kellert suggests that the virtue at play is particularism, rather than heterogeneity. This is a suggestion worth exploring in a fuller treatment of the very idea of feminist virtues.

[14] See Bleier (1983), Keller (1985), Fausto-Sterling (1985).

[15] McClintock's embrace of heterogeneity in the phenomena is carried through to her explanation of those phenomena which involves the invocation of different kinds of causal factor and the resistance to subsuming one to the othe (Keller, 1983, 1985).

[16] Philosopher Nancy Cartwright clearly wants our (interpretations of) scientific theories to allow that the world is constituted of highly diverse entities and seems herself committed to a metaphysics of heterogeneity (Cartwright, 1987, 1995). It is less clear that she would want our theoretical (as distinct from our phenomenological) ontologies to exhibit heterogeneity.

[17] Evelyn Keller detects what I would describe as a commitment to ontological homogeneity in the Human Genome Project's ambition to map the genetic complement of a "normal" human being. Who determines what will count as normal? she asks (Keller, 1992). Elisabeth Lloyd raises similar issues in her essay "Normality and Variation," stressing the variability among humans and the value-laden character of judgements about normality (Lloyd, 1994).

[18] To the best of my knowledge, although Margolis and Sagan (1986) gloss "fertilization" as nucleic fusion, no one else has used this obviously superior alternative expression to refer to the process generally referred to by "fertilization." The latter term, conveying action upon something, facilitates asymmetric thinking where "fusion" does not.

[19] Mary Tiles's essay "A Science of Mars or a Science of Venus?" argues for the inevitability of such social choices in the pursuit of scientific knowledge (Tiles, 1987). Kristina Rolin argues that the search for knowledge for "knowledge's sake" underdetermines the direction of inquiry. Particular kinds of knowledge are sought (Rolin, unpublished ms).

[20] This is not a rejection of mathematics but of requiring mathematical knowledge that is not necessary for the discipline. Such requirements restrict who will be able to engage in engineering or in economic analysis to those with certain intellectual skills (which are not actually employed in those fields) and not others, and thus shape the knowledge and products of those fields.

[21] For example, Levins and Lewontin (1985) embrace both heterogeneity and a strong form of interaction they label "dialectical" as features of dialectical biology. Literary scientists Stephen J. Gould and Lewis Thomas endorse interaction as a principle of explanation. Whatever sympathies with feminism they may have, it is not feminism that leads them to heterogeneity or interaction. Indeed Gould (1986) explicitly says that gender or feminism have nothing to do with it. It's just a matter of good science. Finally, Noretta Koertge, upon hearing an early version of these arguments at Indiana University, argued that these (at least heterogeneity) should not be taken as feminist virtues at all.

[22] There is discussion of additional contrasts, including a discussion of problems with the concept of empirical adequacy, in the earlier version of this essay (Longino, 1995).

[23] For example, novelty at least within some limits is required to earn the highest accolades within mainstream science. Only when such novelty does not challenge accepted theory (as in the case of the discovery of the top quark) or when the web of belief has been sufficiently repaired (as was the case for Barbara McClintock) are those accolades extended. On the other hand, the ideal of unified science requires, in the end, a set of theories that are not only mutually consistent, but all equally consequences of a set of basic principles. To the extent novelty licenses fundamentally different explanatory principles for different phenomena, it is contrary to the ideal of unified science.

[24] See Longino (1990, Ch. 7; and 1987) for examples.

[25] For discussion, see England (1993) and Strassman (1993).

[26] This was suggested to me by David MacCallum.

[27] A question from Lorraine Daston persuaded me that it would be important to address this issue. I have discussed what I take to be part of the background in Longino, 1993a.

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