Duhem-Quine Virtue Epistemology

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ABSTRACT

The Duhem-Quine Thesis is the claim that it is impossible to test a scientific hypothesis in isolation because any empirical test requires assuming the truth of one or more auxiliary hypotheses. This is taken by many philosophers, and is assumed here, to support the further thesis that theory choice is underdetermined by empirical evidence.   This inquiry is focused strictly on the axiological commitments engendered in solutions to underdetermination, specifically those of Pierre Duhem and WV Quine. Duhem resolves underdetermination by appealing to a cluster of virtues called 'good sense', and it has recently been argued by David Stump (2007) that good sense is a form of virtue epistemology. This paper considers whether Quine, who's philosophy is heavily influenced by the very thesis that led Duhem to the virtues, is also led to a virtue epistemology in the face of underdetermination. Various sources of Quinian epistemic normativity are considered, and it is argued that, in conjunction with other normative commitments, Quine's sectarian solution to underdetermination amounts to a skills based virtue epistemology. The paper also sketches formal features of the novel form of virtue epistemology common to Duhem and Quine that challenges the adequacy of epistemic value truth-monism and blocks any imperialist naturalization of virtue epistemology, as the epistemic virtues are essential to the success of the sciences themselves.

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1. As Goes Duhem

The so-called Duhem-Quine Thesis is the claim that it is impossible to test a scientific

hypothesis in isolation because any empirical test requires assuming the truth of one or more

auxiliary hypotheses. If a predicted phenomenon is not produced, the conjunction of the

hypothesis and "the whole theoretical scaffolding used by the physicist" is called into question,

and the experimental situation does not dictate which element must be rejected (Duhem, p. 1954,

p. 185). Holism leads to the underdetermination of theory choice, at least in cases of recalcitrant

observation, since multiple routes of revision are consistent with the relevant empirical

evidence[1]. The thesis of holism itself is widely accepted, although Duhem and Quine diverge on

the proper assessment of its implications, and the associated positions of underdetermination and

empirical equivalence have generated a maelstrom of controversy. While the arguments for

[1] The UD critic might argue that the simple move from holism to UD just shows that the argument employs an impoverished account of theory choice, rather than showing that there is a real problem of underdetermination. While the current inquiry begins with the premise that we are facing a real problem, this is consistent with denying that the argument for UD is supported by an adequate account of theory choice as we are here requiring solutions to UD. Thus , it is agreed that pre-UD accounts of theory choice are inadequate and we work our way to improved successors by examining solutions to UD.

underdetermination continue to be controversial (see Laudan 1990, Stanford 2001, Bonk 2008), the project of *resolving* underdetermination raises unique questions about epistemic value and thus merits consideration in its own right. The present inquiry is strictly focused on solutions to underdetermination, and thus works outside much of the maelstrom. Specifically, this paper examines the epistemic axiology engendered in Duhemian and Quinian solutions to underdetermination.

Pierre Duhem, it turns out, is a virtue epistemologist, or so David Stump (2007) has convincingly argued. According to Stump, Duhem restores determinacy to theory choice through 'good sense'; a cluster of moral and intellectual virtues exercised by scientists seeking to resolve underdetermination. Stump's reading of Duhem is an interesting development in part because *The Aim And Structure of Physical Theory* precedes contemporary virtue epistemology by seventy five years or more, but also because there is currently no form of virtue epistemology focused strictly on resolving problems of epistemic value raised by underdetermination. Stump's attribution of virtue epistemology to Duhem has recently been criticized by Ivanova (2010), but this criticism importantly misreads virtue epistemology as being in the 'justification game' while many virtue epistemologists analyze knowledge as 'virtuously formed true belief' to replace or eliminate justification (see Brady and Pritchard 2006, Fairweather and Zagzebski 2001). Moreover, the issue between Stump and Ivanova appears to be over the proper form of Duhemian virtue epistemology, not whether Duhem is rightly read as a virtue epistemologist at all.[2]

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[2] Ivanova makes significant use of the figure of the 'perfect scientist' as the ideal that actual scientists emulate in resolving UD. This does not represent a real break from a virtue approach as the virtues of the perfect scientist function much like the 'phronimos' for Aristotle, and are still the basis for attributing virtues to actual scientists for Ivanova

This paper considers whether WVO Quine also endorses a form of virtue epistemology. The suggestion that Quine, of all people, is a virtue epistemologist will strike some philosophers as implausible on its face. However, a few observations show this to be more plausible than one might think. Virtue epistemology entered contemporary epistemology through Ernest Sosa as a form of reliabilism, which is regarded as a form of naturalized epistemology (Neta 2008, Fairweather and Zagzebski, 2001, p. 4), and Quine is that movement's founding father. More importantly, Quine is deeply committed to the very principle that led Duhem to the virtues. Duhemian holism is at the heart of almost all of Quine's metaphysical and epistemological positions (Bonk, 2008), from the early rejection of the analytic-synthetic distinction (Quine, 1953), the indeterminacy of translation (Quine, 1960) and the naturalization of epistemology (Quine,1969), to the problem of 'empirically equivalent systems of the world' (1975, 1992). Furthermore, the surprisingly common view that Quine rejects normativity in epistemology is clearly mistaken, since, as we will see, normativities are numerous in Quine's epistemological theorizing. Nozick (1997) appropriately calls Quine the 'theorist of slack', and the prevalence of slack between stimulus and theory puts greater demands on the theorist herself to carry out the naturalistic program. It remains to be shown that the extra burden on the theorist is carried by her virtues, but Quinian virtue epistemology is a real possibility.

Underdetermination arguments, or something very much like them, are more prevalent and less controversial in the history of philosophy than in recent philosophy of science. Goodman's New Problem of Induction, Cartesian demon worlds, freedom vs. determinism, altruistic vs. egoistic explanations of action, inverted spectrums, absent qualia and the whole category or moral dilemmas have the same basic structure as the challenge to scientific

knowledge that Duhem found in the underdetermination of scientific theory by empirical

evidence. The conclusions reached here thus engage a wide range of issues outside of philosophy

of science, most notably to contemporary debates about epistemic value[3]. The current inquiry

also bears on the project of developing a naturalistic virtue epistemology. A naturalized virtue

epistemology will draw heavily upon the sciences, but a reductionist-imperialist naturalization

will not be possible if epistemic virtues are necessary to explain the success of the sciences

themselves.

2. What It Takes To Be A Virtue Epistemologist

It will be helpful at the outset to establish a criterion for when an epistemic theory will

count as a virtue epistemology. The considerable diversity of positions that fall within the kind

presents a challenge to identifying any one feature that would itself qualify an account as such.

Nonetheless, there are enough core commitments shared by most practitioners to constitute what

Heather Battaly (2001) calls a thin concept of epistemic virtue that is thickened in different ways

and to different extents by different philosophers. We also have a number of distinct positions

that uncontroversially count as paradigm cases of the kind according to its practitioners.

Collectively, this should give us a standard with which to assess whether Quine is kin.

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[3] In "The Value Problem and the Underdetermination Problem" (*Virtue Epistemology Past and Future, forthcoming*), I argue that there is good reason to see these as one problem, or one as an instance of the other, and that a plausible solution to the value problem from John Greco functions as a solution to a priori forms of underdetermination.

An epistemological theory will be a virtue epistemology only if the normative properties of beliefs evaluated in a theory derive from the normative properties of its agents.[4] This is the familiar 'direction of analysis thesis', which is widely accepted as the core commitment of virtue epistemology (Greco, 2004). In this respect, virtue epistemology resembles virtue ethics, which defines a good act in terms of good character. While proper directionality can be cashed out in various ways, recent treatments converge on the requirement that one's cognitive success must be 'because of' one's cognitive ability, or in virtue of one's virtue.[5] Knowledge is a success from competence or ability. This etiology confers a value on a successful performance that it would, *ceteris paribus*, not otherwise possess and avoids a range of counterexamples based on luckily true beliefs. Virtue Epistemology is thus claimed to have the advantage of creating a source of epistemic value in addition to truth and the resources for avoiding Gettier problems. It also shows that the epistemic standing of a belief can depend on facts about the believer without undermining its status as knowledge.

The defining intuition of virtue epistemology is then that properties of persons rather than beliefs have primary epistemic value, and that the epistemic value attributed to beliefs derives from the epistemic value attributed to persons. Call this the Axiological Requirement (AR)[6]. Any theory satisfying (AR) will identify certain facts about persons (p-facts) as epistemic-value-generating facts (ev-facts), such that, when a belief (P) is appropriately related to an ev-fact, (P) will attain some epistemic value because it is so related.

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[4] For a very good recent discussion of epistemic normativity see pp.70-91 in Sosa (2007)

[5] Notable examples include Sosa (2007) and Greco (2009)

[6] Some aspects of a theory might be virtue theoretic, while others are not, so (AR) should be read as determining only whether a specific epistemic value is virtue theoretic, not the theory as a whole.

Complications arise when we find weak and strong readings of the Axiological Requirement, which support agent-focused and agent-based virtue epistemology respectively (Brady and Pritchard, 2006). An epistemic theory will be merely agent focused if the virtues are ampliative resources that add something new to an independently defined epistemic norm, reference fixing devices, indicators, regulative principles of epistemic practice, or illuminating 'protagonists' for concepts outside of epistemology.[7] In none of these cases are epistemic virtues the bottom level terms in which core epistemic concepts themselves are defined. If an account of epistemic value satisfies (AR), but the value generated by the relevant p-fact is not epistemically fundamental, this will be Weak VE.

Despite the lack of semantic clout in defining knowledge, an aretaic model of a non-aretaic epistemic theory may enable other important epistemic endeavors, such as learning and understanding, since we might come to understand non-aretaic epistemic concepts better by investigating them under aretaic descriptions, or learn how best to achieve non-aretaically defined epistemic goals. Weak VE may thus be useful and important for non-aretaic accounts of knowledge, and for epistemic endeavors that do not purport to define knowledge.

The strong reading of (AR) claims that an epistemic theory is agent based if its core epistemic concepts are defined in terms of the virtues, where the virtues themselves are not defined by an independent epistemic norm. The virtues themselves tell us what counts as having knowledge, justification or other core epistemic properties. An account of epistemic value that satisfies (AR), with the added stipulation that the relevant p-facts must generate *fundamental*

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[7] For a nice discussion of such cases see Battally (2006)

epistemic values, will be a Strong VE.[8] Some argument is given below for regarding epistemic

value commitments engendered in solutions to underdetermination as epistemically fundamental,

but it will be presupposed here that whatever resolves underdetermination is a core epistemic

property, though not necessarily of justification, or even knowledge[9]. The more salient issue for

present purposes is whether these epistemic values will derive from facts about persons.

A theory that satisfies only the weak reading of (AR) will not be the kind we are

interested in here. Any non-virtue theoretic epistemic theory (T) could have an aretaic

formulation (T-1) that realizes some ampliative value that (T) itself does not. Taking this as

sufficient for genuine virtue epistemology thus risks triviality. There may, however, be non-

trivial ways of satisfying (AR) that are still short of Strong VE. It may be necessary that certain

p-facts obtain, or need to be known, in order to successfully define all core epistemic concepts,

but where these p-facts are not fundamental ev-facts according to the definitions they enable.

Some fact about a certain person, perhaps a scientist, may be the *only* way to pick out some

epistemically valuable property (P), but (P) can still be deemed epistemically valuable for other

reasons. Cases of this sort will be in play when we consider Quine's naturalism and sectarianism.

However, it appears that an epistemic theory may satisfy the strong reading of (AR) and

still fail to be a virtue epistemology in a meaningful sense. Suppose there is a strong virtue

theoretic element to some aspect of theory choice, but this is just 1/100 of the total relevant

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[8] A paradigm case of Strong VE is Zagzebski's (1996) definition of knowledge as "a state of belief arising out of acts of intellectual virtue" and an act of intellectual virtue A is "an act that arises from the motivational component of A, is something a person with virtue A would (probably) do in the circumstances, is successful in achieving the end of the A motivation, is successful in achieving the end of the A motivation, as is such that the agent acquires a true belief (cognitive contact with reality) through these features of the act." A more succinct example of Strong VE is Sosa's (2007), given in terms of performances that are accurate, adroit and apt, and which are aptly are so.

[9] The epistemic standing of interest here is being uniquely choiceworthy, which may or may not be tied to knowledge, and can be a standing of interest even if knowledge is not.

variables. This could hardly be called a virtue theory, even if that one variable is fully virtue-theoretic. Even if Quine were to have a strongly virtue-theoretic resolution to underdetermination, it would not follow that his theory is plausibly deemed a virtue epistemology.

This objection does not land for the current inquiry, and is likely to be ineffective when it does. Our interest here is to find out whether Quine's solution to underdetermination is virtue theoretic, and is thus restricted to just that aspect of his epistemology, regardless of what proportion of overall theory choice this turns out to be. Moreover, if a solution is indeed virtue-theoretic, then, if a theory counting as scientific knowledge or as having top epistemic standing requires that there be no other theory with equal epistemic standing relative to the same body of evidence, this single virtue theoretic factor in overall theory choice will be very large in significance, even if it remains small in number. This holds even where the other variables do all the heavy lifting prior to the point of facing underdetermination because, *ex hypothesi*, they do nothing after that point and this point must be gotten past. It could turn out that solving underdetermination has little or nothing to do with knowledge or epistemic success, or that there really is no such problem in the first place, and in either case the virtue theoretic factor could indeed become insignificant in overall theory choice. These considerations are beyond the scope of this paper. If we grant that underdetermination is a problem, whatever resolves it will be a significant aspect of our epistemology.

An account that satisfies the Axiological Requirement must also have an appropriate epistemic psychology because an epistemological theory might be agent based without being virtue based. Thus, only certain kinds of p-facts can be ev-facts in a virtue based epistemology.

It is conceivable that a moral or epistemic good is defined in terms of states of a person, and that the value of their acts or beliefs derives from these states, say the content of their motives, but if we are a character trait skeptic like Doris (2002) and Harman (2009), the relevant agent states will be neither constitutive nor component of any virtue. Also, it will not suffice to regard any good or useful property of a person as a virtue, as Hume appears to do. The features of a person to which VE shifts focus must be of a specific ontological kind. Thus, we have an Ontological Constraint (OC) on the Axiological Requirement.

There are at least three ways in which (OC) is met in the current literature. Virtues are defined as a person's *faculties* by Sosa (1991) and Greco (1999), a person' *skills* by Sosa (2007), Greco (1993) and Bloomfield (2000), and as their *character traits* by Zagzebski (1996), Montmarquet (1993), and Code (1987). These reflect Thomistic, Platonic and Aristotelian approaches respectively, and will differ in both the kind of p-facts that generate epistemic value and how these p-facts must stand in relation to epistemic ends in order to confer epistemic value on a belief. Virtuous faculty attributions require only external success in bringing about epistemic ends and are explained in terms of accuracy relative to the aim of truth. Attributions of skills or character traits require more than accuracy because success must be explained in terms of a techne or motivational state respectively. To have an excellence of character requires a normative commitment to the end one reliably attains, whereas to have a skill simply requires that the end attained is due to a competence involving training, understanding and discipline. Skills and character traits are also *acquired* excellences, and thus ground some form of epistemic responsibility or credit not easily found in the faculty approach. The way a virtue epistemology satisfies (OC) will likely constrain the kinds of epistemic values attributable to beliefs in (AR).

Finally, there are paradigm cases of VE which practitioners agree count as members of the kind. Here we gloss over some complexities of each type, as they are many. *Virtue reliabilism* is the view that knowledge is true belief grounded in a person's stable, truth conducive (reliable) habits and cognitive faculties, including memory and perception (Sosa, 2007). *Virtue responsibilism* is the view that knowledge is a true belief formed through the conscientiousness, impartiality and sobriety of the agent, as well as other virtues of character that arise from a desire or motivation to achieve truth and avoid error (Montmarquet, 1993). The *Neo-Aristotelian* approach claims that knowledge is a belief that arises from a deep and enduring acquired excellence of a person such that the person is both motivated by and successful at achieving certain intellectual ends (truth, understanding, wisdom) through their excellence (Zagzebski, 1996). A similar view of John Greco's (2009) that avoids commitment to Aristotelianism is that S knows that p only in cases where (a) S is subjectively justified in believing P by virtue of the cognitive dispositions S manifests when thinking conscientiously and (b) as a result of this S is objectively reliable in believing p.

In each case, knowledge is accounted for by describing some feature of a person of an appropriate ontological kind in virtue of which their beliefs earn epistemic standing. The positions described above need not be taken as competitors, or sources of ultimate disagreement, as different accounts of virtue may be appropriate for analyzing different types of knowledge and suitable for different epistemic interests. However, in the next section we will see that a faculty approach that is merely reliabilist will not suffice to resolve underdetermination.

With the above in mind, we can evaluate Quine's account according to the Axiological Requirement, the Ontological Constraint, and proximity to paradigm cases. First, we examine the virtue-theoretic solution of Pierre Duhem.

3. Duhemian Virtue Epistemology

Pierre Duhem's contention that scientific theories can only be tested in conjunction with auxiliary hypotheses leads to the well-known worry that a scientific theory can never be definitively refuted, and that multiple strategies of revision are equally viable options in the face of disconfirming observations. The epistemic problem raised is to explain how theories are rationally chosen when empirical evidence underdetermines theory choice. Absent a solution, we are either absent an explanation of how scientific knowledge is possible, or left with a radically revised account it.[10] More desirable is a rational solution that avoids radical epistemic implications, though this victory will be hard fought since it is our best rational methods that lead us to underdetermination.

David Stump (2007) argues that Duhem's solution is found in a cluster of moral and intellectual virtues called 'good sense', and has much in common with contemporary work in virtue epistemology. Duhem's guiding image is "the scientist who acts as an impartial judge and makes a final decision." (ibid., pg. 155). Scientists exercising good sense converge on one uniquely choiceworthy theory, and it is precisely this fact that makes it the choiceworthy theory. Impartiality, sobriety, intellectual courage, humility, rectitude and probity are the virtues that steer scientists between timidity (retaining the theory being tested but not the auxiliaries) and

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[10] This point can be put in terms of unique epistemic standing rather than knowledge.

boldness (rejecting the theory being tested) in the face of underdetermination (ibid.) According

to Stump, while Duhem does not have a full blown epistemic theory, it is clearly the moral and

intellectual virtues of good sense that allow scientists to proceed rationally in making theory

choice determinate (ibid., pg. 150). Duhem meets the challenge to scientific knowledge from

underdetermination with the virtues.[11]

Virtue epistemologists often argue for the insufficiency of process reliabilist theories of

knowledge. Underdetermination poses a challenge not only to process reliabilism, but to virtue

reliabilism as well. Stump argues that a consequence of Duhem's view is that   "Reliability is an

insufficient criterion for deciding between competing scientific theories because it can leave the

choice before two equally good theories unsettled. The scientist must choose, so other criteria

must come into play." (ibid., pg. 155) Given two equally reliable theories, the value of reliability

is insufficient to ground a choice between them. The addition that virtue reliabilism makes to

process reliabilism is that a faculty is the item that must be reliable, and this move may confer

advantages in addressing counterexamples based on how a belief was formed (e.g., strange and

fleeting processes, Gettier cases, crystal balls) or the environment within which the faculty is

operating. But, underdetermination presents the very different challenge that two or more rival

theories will be grounded in equally reliable virtues, or that one reliable virtue will have two

evidentially equivalent but incompatible theoretical outputs. If virtue reliability is our only

epistemic value, each theory will enjoy equal epistemic standing and we are again left with no

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[11] Compare Duhem's approach with Stroud (1984, pg. 248), who notes that our continued acceptance of a theory in the face of underdetermination "could only be explained by appeal to some feature or other of the knowing subjects rather than of the world they claim to know" and this typically is seen as "undermining our knowledge of the world". Duhem and VE in general does not regard this turn to the subject as a problem, if it is a turn to their epistemic virtues.

grounds to distinguish one theory as uniquely choiceworthy. Appealing to the reliability of our virtues is simply not sufficient for a solution here because equal reliability is built into the problem. If one theory were to be so distinguished, there would be no problem of underdetermination to begin with.

Duhem's account easily satisfies the strong reading of (AR). The objectivity that restores determinacy is in the scientist, not the science (ibid., 153). Independent of this connection to the virtue in the agent, the theory lacks unique epistemic standing. Importantly, it cannot be the other way around - Duhem cannot analyze the concept of virtue here as the qualities of mind or character had by those who believe the objectively choiceworthy theory, or who respond to the choiceworthiness of the choiceworthy theory. For Duhem, there is no uniquely choiceworthy theory independent of it's being deemed choiceworthy by virtuous scientists.

Duhem does not explicitly state that his virtues are character traits rather than skills, but this is the most natural reading, and he is justifiably be read as satisfying the Ontological Constraint in either case. The more interesting point is that the epistemic values of good sense are continuous with the epistemic values underlying the hypothetico-deductive method, though perhaps understood through a distinct mode of presentation. This suggests that a single form of rationality, or at least a single set of epistemic values, can both underlie scientific method and resolve epistemic obstacles facing it[12]. The scientist applying the hypothetico-deductive method and the scientist exercising good sense in response to underdetermination can see each other as engaged in a common rational endeavor. Resolving underdetermination thus does not require a radical departure from core scientific rationality.

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[12] But see the Objectivity Problem of section 5 to see that this will not be easily accomplished.

Stump's reading of Duhem gives us a novel form of virtue epistemology; no existing form of virtue epistemology is shaped around the project of resolving underdetermination. Let us call any Duhemian inspired virtue epistemology *D-VE*. Taking Stump's Duhemian account as the model, some features of D-VE will include the following: non-UD contexts are *not* regulated by an aretaic epistemic axiology. Let method and evidence reign when they can. When working within a UD context, epistemic normativity becomes aretaic with the express purpose of resolving UD. The epistemic agent must be rational in resolving UD, where, if we follow Duhem, what counts as 'being rational' will be continuous with pre-UD epistemic values. Being epistemically virtuous in D-VE requires success in making theory choice determinate and that we do so in a rational way.

A few things follow immediately from this initial characterization: rationality within UD will have to be different from rationality outside of UD. The latter leads to UD and hence cannot be its solution. Yet, post-UD aretaic epistemic values must specify a way of being rational that is consistent with pre-UD non-aretaic values. What to count as a proper continuity relation will have to be carefully spelled out. However this is analyzed, this part of the theory is where we get substantive intellectual virtues.

An explicit aim of D-VE is what I call 'epistemic uniqueness', that one and only one theory emerge as choiceworthy. The kind 'choiceworthy theory', and perhaps knowledge itself, must emerge as *sui generis*, a genera with a single species. The epistemic axiology of D-VE will thus necessarily include uniqueness. It may be that all or most epistemic theories countenance this value, though it is rarely if ever made explicit in definitions of knowledge. In D-VE, it is a constitutive end of the virtues.

Finally, it is unlikely that this form of virtue epistemology will have a veritically monistic axiology. The value of evidence is grounded in the value of truth, but whatever feature of a theory shows it to be uniquely choiceworthy cannot, *ex hypothesi*, count as evidence for it. If it did, underdetermination would not hold in the first place. Thus, the epistemic value of the virtues of good sense cannot be evidentialist, otherwise the choiceworthy theory will turn out to be the one better supported by evidence. Furthermore, uniqueness simply does not appear to be veritic, since it does not make a theory more likely to be true *per se*, it just gets rid of the competition. However, if we adhere to the continuity requirement, this break from truth cannot be complete since the subject still has to be conducting himself rationally according to (or continuous with) pre-UD epistemic values, and these will most likely be centered on truth. Doing both is the special achievement of this kind of VE. While we need something outside of veritic norms and rule governed rational methods, we want uniqueness to emerge from rational activity.

The outline of the above species of virtue epistemology is just that, and will have to be examined in more detail to constitute a full blown theory in competition with, or alongside, the current range of options in the field. The continuity requirement, for example, might be abandoned or analyzed in a number of different ways, and a value monist may argue for a veritic reading of uniqueness. For present purposes, we want to see if Quine espouses anything like Duhemian virtue epistemology.

4. Epistemology Naturalized As Virtue Epistemology?

Since a minimal condition for being a virtue epistemology is that normativity has a central role, Quine's move to naturalize epistemology may quickly show that he is not one. Quine

infamously asks (1969, p. 75), "Why all this rational, creative reconstruction? Why not see how this construction really proceeds? Why not settle for psychology?" This is often taken as Quine's repudiation of normative epistemology in favor of a merely descriptive successor that tells us how the human subject moves from sensory input to theoretical output, and led Jaegwon Kim and others to charge that naturalized epistemology is not epistemology at all because it is non-normative (Kim, 1988). If the "normativity charge" holds water, Quine is against virtue epistemology because he is against normative epistemology. Even if epistemic virtues were to figure prominently in a descriptive epistemology and thus satisfy the Ontological Constraint, the account will not satisfy the Axiological Requirement if the virtues do not function normatively.

It is now widely recognized that Quine does not intend the elimination of normativity (Hylton 2007, Haack 1993, Houkes 2002, Gibson 1987). Quine unambiguously denies that naturalized epistemology is non-normative in "Reply to White", where he states that "naturalized epistemology does not jettison the normative for the indiscriminate description of ongoing processes"(Quine, 1986, p. 664). *The Pursuit of Truth* contains a whole section dedicated to epistemic norms where Quine clearly emphasizes the continuity of the normative (doctrinal) side of naturalized epistemology with traditional epistemology, as it remains committed to the crowning principle of empiricism, which can be read descriptively and normatively: *nihil in mente quod non prius in sensu (*Quine*, 1992 , p. 72)

Quine is thus clearly out to revise, perhaps radically, rather than to eliminate epistemic normativity. However, beyond the most general endorsement of empiricism, we have no indication of the specific content or structure of epistemic norms and thus nothing to assess under (AR). A more specific, but underdeveloped, commitment to epistemic normativity first

stated in "Reply To White" is that traditional epistemic norms become the norms of the "technology of truth seeking...or in a more cautiously epistemic term, prediction...it is a matter of efficacy toward an ulterior end, truth or prediction…The normative here, as elsewhere in engineering, becomes descriptive when the terminal parameter is expressed" (Quine, 1986, pp. 664-665).   Quine retains the "technology" account years later in *Pursuit of Truth* where it is described as the technology of anticipating future sensory stimulation. Epistemic technology is Quine's successor to traditional epistemic norms.

Quine is unfortunately succinct in describing the details of epistemic technology. Technology might just be a way of describing an adequate means and nothing more, it may enjoin specific features of technology as commonly understood, or even richer normative concepts like techne and praxis. To narrow this a bit, let us take naturalistic epistemic technology as some artifact or instrument that enables the project of predicting future sensory stimulation, which may include the hypothetico-deductive method and scientific hypotheses. Both improve our predictive powers beyond what we have in brute induction (see Quine, 1981, p. 57). The better account appears to be hypotheses distinguished by the hypothetico-deductive method rather than the method itself. While Quine is no innatist, he claims that the hypothetico-deductive method is the development of an innate expectation that similar episodes will have similar sequels (1981, pg. 56), and thus is better seen as a basic human capacity, with scientific hypotheses as its technology. In addition to scientific hypotheses, Quine includes methods of inducing predictions from them, including statistics, random deviation, and heuristics. (Quine, 1992, p. 20)

This is a start, but to be assessable under (AR) we need to know what makes such a piece of technology good or excellent, and how technology supports the epistemic appraisal of beliefs. We cannot simply say that technology is good if it reliably or even very reliably reaches the end of truth or successful prediction. This yields the platitude that good technology does what it is supposed to do, but tells us nothing about the properties in virtue of which it succeeds. These details of epistemic technology will have to be gleaned from the naturalist's descriptive project rather than the concept of epistemic technology itself.

One discovery made in the naturalistic explanation of how the scientist "posits bodies and projects his physics from his data" (Quine, 1969, pg. 83) will be the norms and methods guiding the physicist's projection. Having no higher access to truth than our current scientific theory, the norms and methods here described will be the state of the art in the technology of truth seeking. Quine further hints at how *de facto* findings about his scientist's projection function normatively when he tells us that "our position in the world is just like his" (ibid) We too go from irradiated retinas to a theory of the world, a science of sorts, and we should be guided by kindred norms and methods. The norms and methods discovered in naturalistic explanation thus fix the standards of epistemic appraisal for scientist and layman alike.

This tells us how technology can be regulative, but not what features distinguish good from bad technology. Quine is more direct on the qualities of good epistemic technology in *The Pursuit Of Truth* where he states that, " normativity comes in with the conjuring of hypotheses. Five virtues to seek in hypotheses are: Conservatism, generality, simplicity, refutability, modesty." (Quine, 1992 pg. 20) Quine's point here is normative, as the adequacy of any specific hypothesis can be assessed, but it is also a discovery of naturalism as these are the features of

hypotheses that scientists actually aim for. Like Duhem and Hempel, the process of theory construction is not algorithmic or rule governed for Quine because "creating good hypotheses is an imaginative art, not a science. It is the art of the science." (Hylton, 2007, p. 84) Theoretical virtues are marks of good epistemic technology, but there is no rule or set of rules for engineering virtuous theories.

Quinian epistemic normativity now has sufficient content to assess under (AR). While we have the overt use of virtue terms, Quine's virtues are virtues of theories, not theorists. Theoretical virtues are not conferred upon a belief or hypothesis because of p-facts involving the way it was conjured up by a scientist, or because of any p-facts about scientists at all. Satisfying an agent independent standard for counting as virtuous is what makes a hypothesis count as such. While this standard can only be the one accepted by the scientist whose projections we study as naturalists, this fact about scientists simply fixes a reference, and it will be features of the hypotheses picked out which makes them simple, modest, refutable and the like. While persons (scientists) are part of the technology that produces virtuous theories, they do not do the right kind of work to satisfy a strong reading of (AR). The virtues countenanced by naturalism reside in the science, not the scientist.

The reference fixing role of certain facts about scientists warrants a closer look. Importantly, the content of theoretical virtues cannot be fixed *a priori* for Quine, but only by empirical investigation into actual scientific practice. We find that, while the properties in virtue of which a theory counts as simple, modest or refutable can be picked out by descriptions that do not refer to persons, p-facts about scientists are ineliminable in explaining how these properties become value conferring. Facts about scientists are not what makes a theory simple, fruitful, explanatory

or conservative, but it is the fact that scientists converge on these properties of theories that makes them epistemic-value conferring properties. Thus, p-facts about scientists are what make certain facts about scientific theories ev-facts.

However, this kind of p-fact is not doing the right kind of work in conferring epistemic value. Scientist's select theoretical virtues as guided by previous predictive successes and failures in theory formation, and in time develop capacities to form theories with these virtues. These capacities are likely to be reliable because they track properties of successful theories, but they have the wrong direction of analysis.   The independently determined epistemic standing of successful scientific theories is what makes the properties that our scientist takes as virtues count as such. It is thus the success of scientific theories that makes the disposition to formulate virtuous theories a virtuous capacity.

The case above may not be as clear cut as it appears, since it may yet turn out that facts about past scientists constitute some part of the positive epistemic standing of successful scientific theories.   This is taken up in the following section. Also, our scientist may track the virtues of past scientists, rather than virtues of their theories, in forming dispositions to develop virtuous theories. Adequately resolving these issues requires further inquiry into the history and practice of science than is possible here. Accordingly, it will be premature to conclude from the role given to Quine's scientist that the relevant facts about her are ev-facts.

Regarding the Ontological Constraint, since Quine is loathe to admit anything agent-like between the meager input and the torrential output, it is hard to see how it could be met. Quine's behaviorism eschews the ontological commitments needed to justify reading any p-facts about

scientists as virtues. Quine has faced consistent pressure to give up this point of his philosophy, but the Quine of EN is stoutly committed.

Quine's move to naturalize epistemology thus leaves us at some distance from both of the main planks of virtue epistemology. However, one finding of naturalism is that our physics is woefully underdetermined by sensory evidence, even with our best epistemic technology in hand. In *The Pursuit of Truth* (Quine, 1992, p. 99), Quine says that it is unlikely that one theory will be uniquely choiceworthy even if we include consideration of their theoretical virtues. Since the theoretical virtues introduced above are not sufficient to make theory choice determinate, our current state of epistemic technology is not sufficient. To show us the way out of the woods, or perhaps how to live in them, further epistemic technology will be necessary. Theoretical virtues may not secure Strong (VE), but neither do they secure a uniquely choiceworthy theory.

5. Underdetermination and Empirically Equivalent Theories Of The World

Quine offers at least four formulations of underdetermination and his arguments for each has critics (see Bergstrom, 1993). These problems may indeed be Quine's, but they are not ours; only solutions are of interest here. Let the following frame the epistemic problem of empirical equivalence, shelving for the moment worries about the argument that would establish it: For every theory T-1 there is some distinct and incompatible theory T-2 such that T-1 and T-2 cannot both be true, T-1and T-2 have identical observational consequences, and are thus confirmed and disconfirmed by the same observational evidence. Any two theories that are empirically equivalent will either be equivalent in their theoretical virtues, or cannot be epistemically

distinguished over empirical equivalents on the basis of their theoretical virtues. Thus, every theory has at least one empirical equivalent and any epistemic value earned from possessing theoretical virtues will not be a sufficient basis for theory choice. Thus, there is no reason to believe in any theory rather than its empirical equivalent.

Quine has vacillated between sectarian and ecumenical solutions over the years (see Quine 1992, Gibson 1987, Bergstrom 1993). The latter is the line of strict empiricism, granting "the cache of truth equally to each of the empirically equivalent theories" (Quine,1992, pp. 98-101). This would be the position of a neutral, objective arbiter of theories that maintains integrity to empiricist values. Quine notes a number of problems with this approach, in particular it runs afoul of the norm of simplicity because the conjunction of theories neither predicts nor explains anything new, and is thus no more empirically adequate than either theory alone. A different objection raised by Roger Gibson (1987) points to the difficulty of executing the naturalized epistemologist's explanatory project. Are there now many explanatory projects, many physicists, many technologies, many worlds? This does not sound like the project Quine describes in EN. From the perspective of naturalism, the ecumenical solution is counter-productive and Quine has expressed resistance to it, without going as far as outright rejection (Quine, 1992, p. 100). Some single theory must be endorsed to give us a single explanation of how the scientist projects his physics from his data.

The other solution is the sectarian line, where one theory is deemed uniquely choiceworthy. One motivation here is Quine's 'maxim of minimum mutilation' (1992, pg. 14). Since no alternative theory has shown itself to be more choiceworthy, this principle counsels that the theory within which we realized that there are empirically equivalent alternatives is the one

to which we should remain faithful. If there is a fact of the matter that determines which of the equivalent theories is uniquely worthy of assent, it is the fact that determines which of them counts as one's own. This fact quickly pares the field of candidates down to one. The indeterminacy of meaning may show that there is no such fact (see Gibson, 1987, Searle 1987), but we adhere to the policy of restricting our concern to the epistemic axiology engendered in Quinian solutions, not their justifiability even by his own lights.

For better or worse, one theory gets unique epistemic standing on the sectarian line, and Quine is able to get out of the problematic established by empirical equivalence. Concern now shifts to how this unique epistemic standing has been earned. We have nothing like Duhem's laudable virtues of objectivity and neutrality, in fact quite the opposite. As the name given to this solution suggests, the choiceworthy theory 'earns' its standing through partiality to one's own.[13] While this sounds more like a vice epistemology than a virtue epistemology, neither (AR) nor (OC) requires that what counts as an epistemic virtue need comport with tradition.

Quine and Duhem both achieve uniqueness, but in completely opposing ways. Despite the prima facie unattractiveness of Quine's determinacy restoring values, they might be just what we need. How exactly will objectivity and neutrality succeed in distinguishing one theory over others if they are empirically equivalent? A virtuous Duhemian scientist considering empirically equivalent theories may end up like Buridan's Ass caught between Max Black's balls. As neutral, objective arbiters of truth, we are left without a basis for theory choice Call this the

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[13] The maxim of minimum mutilation might help present this as an epistemically principled partiality, although the principle contributed by the maxim is one that generally favors partiality to one's going theory of the world. Nonetheless, it typically counsels how to retain and *revise* a theory, and it just so happens that here it counsels retention without revision.

Objectivity Problem for Duhemian VE.[14] Quine might thus be right to urge doing something very different because virtuous Duhemian scientists are too objective to succeed.

Disagreement with Duhem aside, is Quine's solution a virtue epistemology? In order to get unique epistemic standing for (T) on the sectarian solution, we need to add the p-fact that our scientist's home theory is (T), and it is because of this fact that (T) has an epistemic value not enjoyed by its equivalent rivals. Unlike the previous section, p-facts here satisfy the 'because of' requirement and are constitutive of the epistemic standing (T) has over it s rivals. However, the fact that a certain theory is 'one's own' does not appear to have the right ontology. The p-facts in virtue of which determinacy is achieved are not states of character, capacities, skills, or any interestingly agentive property, as they are for Duhem, and must be to satisfy (OC).

A closer reading of sectarian determination makes a stronger case for (OC). The important property of a theory for the sectarian is more plausibly read as '*remaining* one's own as empirically equivalent rivals are encountered over time', rather than simply 'being one's own now'. Seen diachronically, the sectarian solution is an ongoing, temporally extended practice requiring sustained, consistent commitments to resist assenting to equally viable choice options encountered during scientific inquiry while maintaining the empirical adequacy of one's home theory. Sectarianism is a discipline that requires continued identification and maintenance, not a singular declaration or decree, and thus requires loyalty[15]. Moreover, it is only because of her

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loyalty that the naturalist's explanatory project survives the discovery of its underdetermination. Under sectarianism, the scientist's loyalty succeeds as an ev-fact because it is in virtue of being the object of the scientist's loyalty that a theory achieves unique epistemic standing. Loyalty to (T) generates the value of uniqueness for (T), and most certainly avoids the Objectivity Problem facing Duhem in the process.

Epistemic loyalty can be a vice when it involves discounting relevant evidence and leads to cognitive indolence. To see that this is not the case here, consider Neurath's sailor and the web of belief as additional aspects of sectarian loyalty. The familiar metaphor of the busy sailor rebuilding his ship while at sea rather than on dry dock appears in many places in Quine's work to assert that philosophy and science are continuous, that there are no bright lines separating scientific disciplines, that all hypotheses are revisable, and to the perspective change of naturalism itself. In these many ways, Quine describes how a scientist remains loyal to his going theory of the world while making improvements to that very theory in light of ongoing testing and new discoveries. For our purposes, the metaphor of Neurath's sailor elucidates the norm of theory retention and revision fundamental to a proper understanding of sectarian loyalty.

> "As scientists we accept provisionally our heritage from the dim past, with intermediate revisions by our more recent forebears; and then we continue to warp and revise. As Neurath has said, we are in the position of a mariner who must rebuild his ship plank by plank while continuing to stay afloat on the open sea. How do we decide on such retention and revisions?...by considerations of simplicity plus pragmatic guess as to how the overall system will continue to work in connection with experience." (Quine, 1966, p. 208)

The intuitive, non-rule governed process that guides revision and retention where method and evidence no longer suffice is, in these respects, similar to Duhem's good sense. Quine describes it as a 'pragmatic guess' rather than an exercise of virtue, but this may be more of a difference in style than content between the two views. If Neurath's sailor describes the process of sectarian loyalty, theory choice becomes determinate through the exercise of a skill set, not a bland bias.

We can further explicate these skills as those exercised in modifying the web of belief in ways that respect the center-periphery distinction in the face of ongoing sensory experience. Statements in the center of the web are held solely for their contribution to the overall workability of the system, while statements at the periphery are held partly for their contribution to the overall working of the system, but largely for their link to experience (Sher, 1999, p. 94). A statement of logic at the center can, however, be revised due to a conflict at the periphery through a "chain of connections that begins and ends at the periphery." (op. cit.) Quine's sectarian scientist requires good judgment to know which kinds of revisions to make or withhold, and there is no algorithm that dictates how it shall be done. Knowing when the more radical change to the interior is needed and when a change at the periphery will suffice is quite similar to knowing when recalcitrant experience calls for boldness and when for timidity (respectively) on Duhem's account. Sectarian loyalty and objective neutrality are coming much closer together.

The only barrier to a virtue theoretic solution at this point is Quine's ontological obstinacy against positing something agentive between the meager input and the torrential output, his behaviorism. Neuraths's sailor and the web of belief clearly provide the ingredients of a skills based virtue epistemology, and the importance of loyalty makes a character based account an option as well. But, we need some sort of psychology for our sectarian scientist to warrant

attributing a virtue epistemology of either kind to Quine. This will need to be an acquired

competence for the ascription of a skill, and a motivation-disposition for the ascription of a

character trait. We have shown that the facts relevant to sectarian loyalty have the right direction

of analysis, now we must show them to be the right kind of facts. As naturalists, the psychology

we can attribute to Quine's scientist will be the psychology described in the science itself. The

section that follows examines a lesser known essay of Quine's in which he gives a rare account

of the nature of motivation and moral behavior. This will clarify the kind of epistemic

psychology reasonably attributed to our sectarian scientist.

5. A Genealogy of Epistemology

    A third, and largely unnoticed, source of epistemic normativity is found in "On The

Origin Of Moral Values" (Quine, 1981). The ostensive purpose of the essay is to provide a

naturalistic explanation of moral values, but the epistemology of moral training receives much of

Quine's attention, specifically how successful induction is essential to the formation of moral

habits. Our interest is in the evolution of motivation and technology described here, rather than

the content of moral values themselves.

    Like Schlick, Quine places moral values "among the sensual and aesthetic ones"' (ibid.,62).

Though we all begin as egoists, "each pursuing exclusively his own private satisfactions",

altruistic values are "trained into us" and allow our individual "scales of value to blend in social

harmony" (ibid, 58). Successful training thus takes its human subject from primitive, prudential

behavior in service to our "innate likes and dislikes" to moral behavior, and it will be a change in

motivation that marks the difference the two. Quine here gives us a naturalized explanation of

action in terms of the "bi-partite nature of motivation: belief and valuation intertwined…the cortex and the thalamus." (ibid, 55) Properly understood, "all acquisition of dispositions to discriminatory behavior, requires in the subject this bipartite equipment: it requires a similarity space and requires some ordering of episodes along the valuation axis." (ibid, 56) These basic evaluative and inductive dispositions are altered through moral training, and it is only with this modified motivational equipment that one can properly be said to act morally.

Moral training is habituation according a specific pattern of reinforcement and extinction of responses where rewards and penalties must be correctly paired with behaviors types, utterances and innate likes and dislikes. Successful induction is thus essential for successful moral training, which proceeds through a simple pattern of conditioning: <If action A, then reward> and <If action B , then penalty>, where rewards and penalties are keyed to primitive-prudential satisfactions, and (A) and (B) are moral and immoral behaviors respectively. We then move to, if (C) is more similar to (A) than (B), then reward, and if (C) is more similar to (B) than (A), then punishment (ibid., 56). As moral training continues, our "Similarity standards that led to bad predictions get readjusted by trial and error. Our inductions become increasingly explicit and deliberate, and in the fullness of time we even rise above induction, to the hypothetico-deductive method." (ibid., 57) This is the epistemic side of moral development.

The other element of motivation is the innate 'value axis' of private satisfactions. These function as inducements to morally sanctioned behavior which "are indulged in at first only for their inductive links to higher ends: to pleasant consequences or the avoidance of unpleasant ones at the preceptor's hands. Good behavior, insofar, is technology." (ibid., 57)[16] Morally

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[16] This appears to be Quine's first explicit linking of normativity and technology.

sanctioned behavior (A) is technology for prudential value satisfaction in moral training. Successful inductions by the subject of the training is necessary for (A) to attain the status of technology for him.

While induction establishes the necessary links between private ends and moral means which allow for its possibility, our behavior is not moral until, by "a process of transfer", we come to value morally sanctioned behavior for its own sake. For both "the man with felony in his heart that behaves himself for fear of the law" and "the child who behaves himself in the course of moral training: his behavior counts as moral only after these means get transmuted into ends." (ibid, 58) We are told that if we tell the truth, we will get what we want, at which point truth telling is merely the technology of prudence, but in time we come to value truth telling for its own sake. The same holds for fishing and the fish to which it is a means (ibid., 59) Quine calls this process the "transmutation of means into ends". Only when we act on transmuted values do we act morally, when what was previously valued as a means comes to be valued for itself.

To summarize these points, the Quinian origin of moral values can be represented as follows: we want to explain the origin of normative statements like: (1) S ought to A. As noted in section 4, when explaining epistemic technology, Quine (1986) says that the normative becomes descriptive when the terminal parameter is expressed. Thus, the naturalistic expansion of (1) will express the 'terminal parameter' and get us to the descriptive claim: (2) If S does A, then S will get what he wants (w). When S is motivated to do (A) because of (2), (A) is technology for (w), and for that reason not yet a moral act. With the transmutation of means into ends, "by a process of transfer, we come to prize the former not only as a means but for itself".

(A) is now valued for it's own sake, and we are back to the normative claim: (1) S ought to A. Post-transmutation, (A) is moral behavior for S and no longer mere technology.

Inverting Quine's formulation, we can say that the descriptive (2) becomes the normative (1) when the terminal parameter is *suppressed*. Through the "acquisition of dispositions to discriminatory behavior" and means-ends transmutation, we successfully suppress the terminal parameter through moral training and arrive at moral values. The naturalist's explanation shows how the normative is given descriptively by expressing the terminal parameter, but also how the descriptive gave birth to the normative by suppressing the terminal parameter.

We now consider a different instance of this move to explain the origin of epistemic values. Successful induction was shown to be necessary for (A) to be technology for (w); utterances, ostensions, behavior types, personal desires, slaps and sugar plums must be aligned in order for S to be habituated to do (A) according to (2). Thus, we have: (3) If S reasons well, S can get what he wants (w). Reasoning well is now technology for (w), mere prudence and not yet *episteme*. The same process of transmuting means into ends then gets us: (4) S ought to reason well. With this move, we describe the origin of epistemic values, and the technology (means) for achieving epistemic values will give us full blown epistemic norms in: (5) If S <substitute your favorite belief forming process>, S reasons well. We will likely complete (5) with the principles guiding Neurath's sailor, the sectarian scientist and the physicist projecting his theory from his data, but what to count as adequate or best technology here is an empirical question. However these details turn out, we now see epistemology as the study of the technology of truth seeking.

Quine's account of moral values above has plenty to offer for a more complete understanding of epistemic technology, normativity and his epistemology generally.[17] We specifically needed a psychology to ground some reading of the nature of the p-facts that keep theory choice determinate for our sectarian scientist. Quine clearly describes success in predicting future sensory stimuli as a skill, the acquired "disposition to discriminatory behavior" that explains our success in moral training. We can now explain the sectarian's success in making theory choice determinate as success from a competence, and thus from the scientist's virtue in the sense of a skill. However, what makes these activities describable as truth seeking rather than pleasure seeking is the shift in motivation in going from (3) to (4). The motivation attributable to S is salient in explaining the kind of success their behavior constitutes, and this suggests reading the sectarian's p-facts as character traits. Whether we ultimately go with a skills or character trait reading, the inclusion of acquired competencies and motivations provides a basis for attributing credit and responsibility to our loyal scientist, both of which are epistemic values countenanced by virtue epistemologists.

The more plausible reading seems to be that the activities of the sectarian scientist as expanded by Neurath's sailor and the web of belief are best described as a set of skills and competences that do not require the cognitively complex motivational component of character traits. The means to good reasoning in (5) need not be valued for itself, and thus can remain so much technology skillfully employed to bring about our epistemic ends.

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[17] Hilary Kornblith's very interesting paper "Epistemic Normativity" (1993) finds Quine's account of epistemic normativity as technology wanting because it does not explain why the terminal parameter should have significance. The account above would appear to ground the normative force of epistemic hypothetical imperatives ultimately in our innate likes and dislikes, which will then bear some resemblance to Kornblith's account which grounds the normative force of epistemic norms our desires. A full examination of this interesting connection would take us too far afield.

6. Duhem-Quine Virtue Epistemology

   The pieces of Quinian normativity here examined add up to a form of virtue epistemology, but it takes some putting together. The role of actual scientific practice in section 4 and the sectarian loyalty understood through Neurath's sailor and the web of belief of section 5 get us to (AR). Securing (OC) remained a challenge and required extrapolating from Quine's rare inquiry into motivation and moral value in section 6, which also gave us greater insight into the connection between technology and normativity.

   We can now meaningfully speak of a Duhem-Quine virtue epistemology. The defining commitment of this form of virtue epistemology is that the aim of the virtues is to resolve underdetermination and confer the value of uniqueness. Furthermore, the virtues that succeed in doing so cannot derive their epistemic value from being truth conducive. The epistemic axiology of any Duhem-Quine VE will thus not be veritically monistic. However, there are important differences between the Duhemian and Quinian variants. Quine's sectarian virtues are best read as skills, as opposed to the character traits of Duhem's 'good sense'. More important, we have a disagreement over the epistemic value of the virtues of loyalty and objectivity.   The Objectivity Objection of section 5 remains a challenge for the Duhemian account, but the Quinian account faces an equal challenge in defending loyalty as an epistemic virtue, and thus will face it's own Loyalty Objection.

   Developing a complete Duhem-Quine virtue epistemology will require a number of issues to be worked out, including whether and how post-UD axiology will be continuous with pre-UD axiology, whether epistemic value monism might still remain a viable position, and

whether the needed virtues require the depth of character ascriptions. Differences aside, a virtue-theoretic solution to underdetermination will be a significant point for any attempt to naturalize virtue epistemology. While any naturalized account of epistemic virtue will give a central role to the sciences, we see here that the epistemic virtues are essential to the success of the sciences themselves.

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