Three Naturalistic Accounts of the Epistemology of Argument[*]

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Abstract: Three contrasting approaches to the epistemology of argument are presented. Each one is naturalistic, drawing upon successful practices as the basis for epistemological virtue. But each looks at very different sorts of practices and they differ greatly as to the manner with which relevant practices may be described. My own contribution relies on a metamathematical reconstruction of mature science, and as such, is a radical break with the usual approaches within the theory of argument.

Résumé: On décrit trois différentes approche sur l'épistémologie naturaliste des arguments. Chacune utilise les pratiques réussies, qui sont la base de la vertu épistémologique pour chaque approche. Mais chacune emploie des pratiques qui diffèrent largement dans leur façon de décrire les pratiques pertinentes. Ma propre contribution repose sur une reconstruction mathématique de la science mûre, et donc se dégage radicalement des approches typiques.

Whatever the purpose of particular arguments and the contexts within which they occur, epistemic virtue is, arguably, one of the prerequisites for the goal being achieved. Whether the purpose is something akin to truth as in critical inquiry or, by contrast, the determination of a best compromise between competing positions, accurate information that reflects the determinants for the issues at contention is a requirement. And so the question, from whence the epistemic adequacy of arguments. In what follows I will look at three recent attempts to answer the question, they are all naturalist in the broad sense that they rely heavily on what is in order to ground what ought to be. But beyond that shared commitment they differ radically as to what epistemic virtue can be attributed and from whence this essential property is to be derived.

The first of these, James Freeman in his recent book *Acceptable Premises* (2005) draws upon the core intuition of the common sense tradition in empiricism. This takes us quite a ways into the understanding of the epistemological virtue of many non-controversial arguments, and an indication of how controversy is to be analyzed and explored. But, as we shall see, such a stance gives little more than a beginning. For we will argue that epistemological virtue is better understood when

the stakes are high. Commonsense justifications will lead to critical inquiry, where the relative merits of an epistemological stance is evaluated in the light of our doxastic needs.

The second, Robert Pinto, in a recent compilation of essays (2001) and in an unpublished paper, "Reasons, Warrants and Premises," offers an account of epistemic virtue, which relies heavily on critical practices in context, that is relative to the variety of purposes for which reliable information is sought and the correlative epistemic demands put on the information, our 'doxastic attitudes.' This position, as Pinto readily acknowledges, tends toward relativism, which whether acceptable in practice, given our epistemic needs, is manifestly inadequate in theory, for as Harvey Siegel (1987) has forcefully argued, relativism is powerless in just the regard that epistemological virtue is demanded, that is a practice and its standards for argumentation must be grounded in a robust epistemology, that is one that serves to justify the practice.

Third, my contribution will give a sense of how such a robust point view can be developed within a naturalist epistemology grounded in critical practice within disciplined inquiry, looking at the most successful critical practice of all, physical science.

My choice focuses on what Sellars (1963) has called the 'scientific image,' that is the world as seen through scientific theories and their instruments, in contrast to the 'manifest image,' the world as available to ordinary understanding and perception, the obvious concern of both Freeman and Pinto. In both cases, the limits of their positions will point to the relevance of the scientific image. My contribution, a model of truth modeled on scientific inquiry shows the possibility of articulating a rigorous account of such illusive properties as increasing informational and explanatory adequacy, and depth and breadth of connectedness.

Whatever the judgment as to the adequacy of the three approaches, each in its way shifts the theory of argument towards what I have called 'applied epistemology,' that is, looking to successful epistemic practices in order to identify the logic of their success (Weinstein, 1994). That is, as applied epistemologies they are rooted in successful practice. The issues that such a naturalist approach faces can be distinguished between, first, practical questions of which sorts of practice are most productive in terms of our epistemological ends in argumentation, and second, the theoretical question of which practice is most illuminative of epistemological principles. Once distinguished this squares nicely with root concerns in the theory of argument in so far as an essential role of argument is supporting judgments of epistemological relevance, that is applying conditions of adequacy to judgments in particular cases and, as essential, the development of some normative understanding of the principles as correctly used. The standards for argument need to reflect the epistemic goals, and arguments, particularly within the context of critical inquiry, are valuable in so far as they have epistemic warrant appropriate to the context in which they are offered. And as Pinto shows us, these are essentially tied to the

purposes for which the inquiry has been undertaken. But epistemic standards have to be grounded in something deeper than practice on pain of relativistic impotence (Siegel, 1987), and the practice of philosophy calls for very deep grounding indeed. That explains that foundational nature of my own contribution and my search for an approximation to traditional epistemic ideals by attempting to construct a model of truth. But if truth is to be relevant to argument and in particular to critical inquiry truth must be construed as an outcome of inquiry, rather than something external to it. This is obvious to Plato in the *Meno*, and it should be apparent to argumentation theorists as well. For unlike, for example, the study of arithmetic on the one hand and commonsensical problems in ordinary life on the other, truth in many substantive contexts is not available independent of inquiry. This should be apparent, for the utility of inquiry is that it permits the truth to emerge.

1. Freeman: Commonsense Foundationalism

James Freeman, in *Acceptable Premises* (2005), reflects what can easily be seen as the founding intuition of informal logic. That is, that a normative account of argument can be developed focusing on the realm in which the overwhelming majority of arguments occur; that is, in non-specialized contexts in ordinary life, and using no more technical apparatus than is readily available to an educated person. It is this core that supports its vaunted utility as the basis for critical thinking and other good things.

Freeman draws heavily upon this tradition citing Thomas Reid more than any other single author. Like Pierce and Plantinga, Freeman sees the efficiency of epistemologically relevant mental functions as based on a naturalist account of their necessity for successful human functioning (planning, ordinary problem solving and the like). But genetic speculations aside, the essential nature of our faculties, reasoning, sense, memory and the like supports Freeman's acceptance of what he calls 'commonsense foundationalism,' which he sees as furnishing the rejection of 'skepticism' (Freeman, 2005, p. 367ff.).

Freeman combines a logical concept 'presumption,' familiar in discussions of premise acceptability, with a concept he gets from Plantinga, 'belief generating mechanisms.' This gives him his analysis, stated boldly: a statement is acceptable as a premise iff there is a presumption in its favor. (p. 20). And it has presumption in its favor when it is the result of a suitable belief-generating mechanism, with appropriate hedges about challenges, malfunctions and utility (p. 42ff). "We shall be arguing that the principles of presumption connect beliefs with the sources that generate those beliefs. "'Consider the source' could be our motto for determining presumption" (p. 44).

Belief-generating mechanisms are of a variety of sorts. These psycho/social constructs are presented in what might be seen as a philosophical anthropology, that is, a theory of persons seen in their most obvious light. Belief-generating mechanisms need to be adequate to the four-fold analysis of statements: analytic,

descriptive, interpretative and evaluative (p. 97ff); and they need to engage with three sorts of beliefs: basic, inferred and received (p. 109). Descriptions, for example, rely on the belief-generating mechanisms of perception, which includes perception of qualities, natural and learned signs, introspection, and memory (p. 124ff). Perceptions are of three sorts, physical, personal and institutional. Institutional perceptions are presented on the model of "learned constitutive rules" (p. 136). This last is crucial for the modern condition: once mastered, systems of cognitive organization are manifested through mediated perception and enormously increase the range and relevance of sense perceptions, natural signs, and classifications. How far the notion of constitutive rule takes us into this broad and fascinating realm remains to be seen.

Whatever concerns are to be raised, however, we have to grant Freeman's main thesis. That is, we can account for many of our acceptable premises by virtue of their genesis. For if, as seems obvious upon reflection, we argue often and argue well on countless occasions, it should come as no surprise that the various mechanisms by which we come to our premises can be articulated in defensible ways. We should grant Freeman's point immediately. There are mental (and social) structures of many sorts that are reliable as the basis for judgments ranging as Freeman sees, from the logical to the evaluative and including essentially, perceptual judgments and modest generalizations based on memory and other aspects of common sense. And of course, judgments that rely on the testimony or expertise of others. All of the kinds of belief generators have clear instances with presumptive status in contexts that permit easy resolution. As Freeman shows by examples, there are contexts for each one of them that yield acceptable premises. The key to the adequacy of belief generating mechanisms is that they are reliable.

We can begin our discussion of Freeman by immediately conceding that if the target is radical skepticism, Freeman has won the day. We just accept as obvious that we argue from acceptable premises all of the time, because in whatever relevant sense of mechanism, there are things about us and about how we operate epistemically, that, for all practical and many theoretical purposes, work just fine in enumerable instances.

The issue becomes interesting for me when there are questions to be asked. Although I will look at the three most basic belief generating mechanisms, a prior intuition, individual reports (based on sense perception) and memories, the challenges I will raise will be readily seen to apply even more severely to the more complex 'mechanisms' including institutional intuitions and other intuitions that support causal and other general claims.

Freeman asserts 'some premises are straightforwardly acceptable as basic premises without argument…. However suppose one is faced with a 'hard 'case… Here the requirement is to justify the judgment that a particular premise is or is not acceptable as a basic premise…we call making such a determination an exercise in epistemic casuistry' (p. 319). For a priori intuition, Freeman requires that it certify

a basic premise as both true and necessarily true (p. 323). The issue as Freeman sees it requires a challenge; that is, unless a challenger is aware of improper functioning, the presumption for the reliability of her faculty of a priori intuition remains as does the presumption for the statements for which it vouches (ibid.). The decision is made more complex because of the possibility of 'pragmatic consideration' that is 'that cost of accepting the claim if mistaken is higher than the expected cost of gaining further evidence' (ibid. and elsewhere). This caveat is included in all of the discussions of belief generating mechanisms, but will be sidestepped here.

Freeman's account of a priori intuition, like his other forms of belief generating mechanisms requires that it not be malfunctioning. With sensory intuition this is more readily fleshed out. A prior intuition is another thing entirely. When does an a priori intuition malfunction? Is this the same as logical error? But then identifying malfunctioning intuitions depends upon a prior commitment to logical adequacy. This is, of course, what we have available to us, we call it 'logic.' And although in dispute in areas, the basic outline is available in logical theory. But one does not comprehend logic theory by intuition alone. One must understand logic, that is, the correctness of the intuition is a function of the informed intuitions of logicians and others who study the field. This of course is a far cry from what various native abilities permit the job to get off the ground. And where is this basis? Students of logic who fail to get *modus ponens* may certainly be seen to have a failure of logical intuition, but what of students who are skeptical of the various complex logically true statements typified by tautologies such as 'if A then, if B then A.' The idea of a 'malady' of the a priori intuition presumably could be exemplified by a variety of examples, some rather simple and others quite deep. Simple cases include students who tend to confuse conditional with biconditionals, or better, someone who fails the Wason test, that is, not taking into account FT instances of conditionals when checking all cases.

These are telling examples; many sorts of people fail at identifying the a priori status of such items on many sorts of occasions, including those trained in logic. It frequently has to be clearly explained for even people with experience in the field. So clearly, it is not the intuitive nature of the underlying logic that is at stake. Rather, and obviously, it is the underlying coherence of the theoretic understanding of logic that marks the error. The acceptability flows not from its genesis in a priori intuition but from its genesis (and constant reconstruction) in logical theory. And these are quite different things, for the status of the later is, as in all theory, provisional and open to the advance of inquiry, and so its birthright as an intuition is at best the beginning of the story.

Although we may ultimately rely on something like a priori intuition, it is deployed in conjunction with an apparatus (the 'institution' of first order logic), which in this case is fairly clear, and which includes a meta-theory that permits of the deepest intuitions, both obvious and surprising to be expressed, discovered and

abandoned. The problems of completeness of sub-theories of first order logic; the equivalence of alternative systems of proof, not to mention real problems for intuition such as Russell's paradoxes, Lowenheim-Skolem and Gödel incompleteness all play havoc with our intuitions, and logic is richer for the havoc they play. For all of these test intuition by the complex constructions of logical inquiry, that even if ultimately 'intuitive' to those in the know, remain far from the attempts to grapple with logical inference that we find in students and in the everyday application for even propositional arguments. This is seen in a priori sciences other than logic as well. The notorious problem of the square root of 2, the well known story of Hobbes and his rejection of a counter-intuitive theorem in Geometry, Cantor's problem and many others all point to the fundamental irrelevance of strong intuitions in the face of theoretic advance. That is not to deny that there are necessary a priori intuitions: failure to get *modus ponens* stops logic in its tracks. It is to say that which intuitions these are remains unknowable until the advance of inquiry, which, while using these very intuitions, sees them as defeasible as the inquiry progresses. This does not result in a challenge to the notion of a priori intuition, but rather makes any one of them suspect. Such fallibilism is generally healthy, but it precludes the sort of generative story that Freeman tells from being more than the beginning of the story. For me the story gets interesting when we start to talk about revision of our intuition. That is, when we engage with inference. Freeman draws the line in roughly the place I do and sees inference as another issue. But my point is that being acceptable as a premise ultimately relies on inference, although all inferences do start with some, putatively acceptable premises. And so for me the epistemological interest of presumption is not when it succeeds but when it fails.

This can be seen easily in his next class of statements kinds, descriptions. Freeman construes these as sense perceptual but sees their scope to extend to the identification of summary and even non-projective generalizations (pp. 126-7 and pp. 345-6). Freeman offers a similar account here as well. He begins by asserting a presumption for first-person reports of perceptions unless the challenger is 'aware of evidence that her perceptual mechanism is not functioning properly or that the environment in which this perception is occurring is anomalous' (p.326). Again, if his point is there are perceptions that have presumption, he is correct. But how far does this point take us? Again, we look at the most basic case. Visual perception is both highly reliable and a mechanism in the clearest possible sense. The physiology of sight is well understood including the neurological basis in the brain. And so malfunction is easily diagnosed and accounted for in terms of the mechanism. That, of course, is not what Freeman has in mind. Rather it is the functioning of vision that is the 'mechanism' he is interested in. We know we are malfunctioning when we have issues, and when we have issues we go to the eye doctor. Short of very simple tests, response of the retina to light, eye charts and the like, the identification and remediation of a visual malfunction is a complex combination of phenomenology (what you say is taken seriously), long experience with coherent

symptoms, and focused and frequently efficient choices of test-sequences as when the Doctor changes lenses back and forth asking, 'Which is clearer, this or this?' But all of this, even the eye charts, rely not on the quality of the visual intuition of the patient, but on this intuition in combination with a long experience, codified in 'institutional' (professional practice) the technology the supports the examination and underlying understanding of how deformities in the visual mechanism is to be compensated for by choice of lens shape. And so again, whatever the presumption, that for example, a first person report is correct, it is the interaction with a mode of inquiry that settles the case. Having seen well in the past is no argument against needing glasses, although it is a sufficiently reliable index of function that new patients frequently complain when confronted with the need to remediate. The same is clearly true for all sensory reports. We don't have to have a history of auditory delusions for our reports to be delusional. The reports just have to be sincere and out of sync with the understanding of others. The distinction between perceptions and, for example, dreams is not vividness but continuity and coherence. Eyewitness testimony relies on corroboration not eye tests.

Another major source of beliefs is memory and of course Freeman is correct to write that we remember all sorts of things and rely upon them extensively: 'Memory, as long as what is remembered is distinct and not vague, again is a presumptively reliable belief-generating mechanism' (p. 329). But when we look at memory we notice first that much of it is dispositional in the sense of knowing how, and so the issue of functioning is clearly tied to performance rather then some internal vividness or other phenomenological marker (p. 141). For propositional memory it would be, perhaps, rude to question someone's vivid memory of events etc. except when they prove incoherent with another narrative. But politeness aside and looking at the phenomena in general, we now know that whether or not accompanied by phenomenological states that support conviction, even within the agent, memories are tied to coherent networks of other memories, peculiarly connected, with all sorts of other affective and classificatory bundles in the mechanism that supports them, the knowing brain. This is manifest in behavior in well-known ways and accounts for memory bias of all sorts. (Brainard and Reyna, 2005) Memories that enter into public narrative are even more fraught with difficulty as all sorts of biasing choices of centrality and focus distorts memories in ways that are well known within cognitive psychology. This alters the perspective on what makes memory reliable. To ask if someone remembers (except in the context of first-person interviews that do no more than report opinions) is to engage with an inquiry into the memories' surround. Whether internally in terms of introspective narratives or more importantly externally in reports of first-person experiences for the purpose of offering useful information, our acceptable memories are those that can serve as premises because of their coherence with other things we remember, which in turn are judged by their coherence and so on.

I won't go through Freeman's other belief mechanisms for I believe my point to be made. The remaining belief generating mechanism all having to do with

generalities including 'subjunctives' that support counterfactuals whether empirical or 'institutional,' that is, codified by experts in light of the best evidence and firmest opinions (p. 171ff. and p. 347ff.). I leave it to the reader to provide examples of similar complaints to those just raised, which I believe to be all too available in the history of science and in common affairs. Generalities of whatever sort rely on their persistence as inquiry advances, the founding intuition rarely even affords a clue as to their reliability. Even so truncated a discussion gives us a clue as to another way of looking at things, moving from the genesis of a belief, to how it fares when scrutinized in light of various doxastic ends.

2. Pinto: Critical Contextualist

Robert Pinto in a recent compilation of his efforts presents an interesting contrast with Freeman's view. As we shall see Pinto's work engages with the crucial notion of 'critical practice,' thereby placing the source of epistemic virtue outside of psychological belief generators and into the sociological. But this is no mere shift of foundation, it carries consequences for the problems that Freeman's view bring to fore, and deeply challenges the root notion that it is intuition that is the source of our beliefs.

The concern with critical practice grows out of Pinto's logical concerns, the relation of argument to persuasion (Pinto, 2001, chapters 1 through 3) and most essentially, the relation of inference to argument (*op. cit.*, chapter 4 and elsewhere). As he puts it 'arguments are invitations to inference' (*idem*, p. 36ff.). The move has many virtues. Pinto contrasts his view with the more standard view seeing argument as a relationship between premise and conclusion. His recommendation has immediate fruitful consequences. As is well known, the standard view of inference makes looking at the truth of premise secondary to the ascertaining of the relationship of support from among the premises. And the adequacy of argument is seen on some analogue to validity. Although informal logicians express similar concerns offering variations on the truth of premises— acceptability and the like, Pinto's move towards inference consolidates such concerns by seeing premises in light of the inference to be drawn. This shifts the discussion to an interesting complex of issues and outcomes.

The focus on inference enables him to make significant contributions to the notion of argument appraisal. Argument seen as 'an invitation to inference' calls for assessment in terms of the reasonableness of the premises and the inference seen in respect of a range of doxastic attitudes, construed to be broader than belief (*idem*, chapters 2 and 3). Unwilling to commit to the task of a general theory, Pinto sees himself as offering reminders in the sense of Wittgenstein rather than an alternative theory (*idem.*, p. 129) Pinto is concerned with how particular arguments function. Such a naturalistic approach leads to general issue of non-deductive inference in a very broad sense and yields insight in relation to problems of relativism. Pinto opts for what he calls 'sophisticated epistemic relativism' which he expresses

as: 'There is no set of epistemic standards or criteria of which it can be said that it is uniquely correct or correct *sans phrase'* (*idem.*, p. 54). He distinguishes inferences from the their argumentational outcomes, e.g. persuasion in the standard view. He had already argued (chapter 2) that a range of doxastic attitudes, indicating six levels of conviction including such modifications as 'being inclined to believe and suspecting' are all possible outcomes of argument (*idem.*, p. 12). He expands the conception from differing levels of conviction to qualitatively distinct outcomes such as desiring, hoping, and intending, fearing etc. Arguments that support such a range of doxastic and non-doxastic outcomes are judged in light of particular outcomes as indicated by the relevant attitude. This is an important move for it moves the issue to the substance of the propositional (or even a non-propositional, p. 17ff.) attitude rather than to a ubiquitous notion of belief, to which other doxastic attitudes tend to be reduced. He summarizes this provocative line of thought as the very general claim that '*argumentation is the attempt to modify conscious attitudes through rational means*' (*idem.*, p. 19, italics in the original). Pinto's intuition is that it is the attitude that is the argumentational goal that determines the criteria by which supporting inferences should be evaluated.

The import of this move to a qualified and contextualized image of inference will be at the center of his reformulated theory in 'Reasons, Warrants and Premises,' offering both the direction that the study of inference should move, and a crucial test for such a point of view. Pinto's arguments and my own predilections prompt me to move in similar directions. But that does not alter the key question for argument evaluation: whether to accept the invitation to inference in support of the outcome, whatever its doxastic nature. Pinto sets his position in relation to the positions he rejects. The strategy here, and in later essays, is to argue that the range of inferences that need to be evaluated can not be characterized in the terms of formal logic or the alternatives that informal logic provides.

Not surprisingly he rejects the idea that the inferences need be as strong as entailment in the classical sense (*op. cit.*, p. 38) and sees his earlier concerns with the range of doxastic and non-doxastic attitudes in terms of Peirce's notions of habits of mind and guiding principles (*idem.*, p. 40). This raises a version of what will be an essential critical question. Can habits of mind and guiding principles be articulated in a fashion sufficient for the normative constraints needed if an invitation to inference is be accepted on, roughly, epistemological grounds—that is, because it moves the cognitive purposes of argument forward?

Early on, Pinto indicates an underlying normative substructure—and this will become a major theme in his reformulation of his point of view—'a practice of criticism' (*idem.*, pp. 43-4). As we shall see, Pinto will eventually see the appeal to critical practice to be as a good as we can get, something short of a full theory of inference, but yet strong enough to ground our normative endeavors. Looked at generally, Pinto's strategy is to broaden the purview from the logical to the contextual. So, in the discussion of coherence as a basis for belief (*idem.*, chapters 7 and 8) he

begins with a narrow logical view of coherence and quickly shows it to be inadequate (p. 64ff.). The discussion, driven by a range of examples and with reference to relevant philosophical positions, moves the discussion of coherence to the context. Viewed psychologically, in terms of coherence as a hallmark of the validity of inferencing, Pinto looks to an overview that will offer a sense of the subjects 'understanding' that could furnish a psychological surrogate for the reasoning process, something akin to a narrative whole, but which, unfortunately, does not seem to be available (*idem.*, p. 71, see also chapter 12). Coherence is viewed as the 'objective correlate' of such nuanced understanding and requires that a critical overview of the domain to be available to understanding (*idem.*, pp.70-1). Reasoning 'takes place on the basis of understanding that involves an overview of the domain we are reasoning about' (*idem.*, p.67). He offers a number of constraints, including:

> (a) to make intelligent nondeductive inferences from any body of data we need a grasp of what the plausible alternative are to the hypothesis we are adopting and we cannot have that without some *general* understanding of the ideas we are reasoning about
>
> (b) to make intelligent deductive inferences from any set of assumptions or premises, it is not enough to assure ourselves that our conclusions follow from the premises we have strong reasons to accept; we also need assurance that our conclusion doesn't run counter to propositions that are more entrenched than the premises from which our inferences begin; and to have such assurance we need a *general* understanding of the field we are reasoning about. (*Idem.*, p. 67.)

He continues:

> When we learn to engage in argumentation, and when we learn to make all but the most rudimentary inferences, we are initiated into an intersubjective practice of criticism that enables us to appraise inferences on the basis of certain broadly or commonly recognized features and/or standards… that this practice of criticism in its developed form cannot be reduced to that application of any simple or straightforward sets of rules… 20th century epistemology—and in particular, 20th century philosophy of science—has made us aware that the goodness of our most fateful and highly prized inferences does not yield to any simple analysis in terms of patterns or guiding principles. And yet the value of those inferences, is not something that is arbitrarily accepted; rather it is something that is open to discussion and rational evaluation. (*Op.cit.*, p. 81.)

But this, of course, creates an enormous problem for Pinto, for once the complexity is known, a theory of inference looks further away rather than closer. This may not daunt Pinto who eschews contributing a theory of inference, but it should concern us. For if inference in the complex sense of critical practice and with all of the modifications across the range of appropriate doxastic attitudes is to lead to an account of epistemic virtue, something much worse than relativism raises its head, that is vacuity or anarchy. If we are to have a normative theory of argumentative virtue we need a theory of how arguments are made good. But Pinto's relativism

has an enormous yield. It focuses us on differences and should make us agnostic about the possibility of getting a general theory, all at once. The downfall of the theory of argument may very well be the drive to come up with a unified account too soon. But whether unified or not, some general account is required if we are to have a theory of virtue in argument at all.

But where to begin? In "Reasons, Warrants and Premisses", Pinto sees a deep general structure supporting the myriad of argumentation contexts that his work's insight forces us to accommodate. Although he works from ordinary examples, choosing apples is the most detailed, the generality he provides can be easily extended to all sorts of arguments. What Pinto sees in the work of David Hitchcock is a refocusing of the problem of warrant through the notion of enthymeme and an elegant solution to the problem of from whence premises that are required if an argument is to be warranted. Epistemology moves forward from premise acceptability to the acceptability of those crucial premises that serve as warrants for inferences.

Hitchcock's solution is deceptively simple (Hitchcock, 1998). A missing premise that can serve as a warrant can be generated from the other premises and the conclusion by generalizing across content expressions. If done with appropriate care, the generalization indicates a substantial connection between the other premises and the conclusion, and so the solution does not suffer from the triviality of seemingly similar suggestions such as the construction of the minimal conditional, 'if premises then conclusion' added to the premise set. Generalizing on non-logical variables is of course an ancient insight. Pinto sees Hitchcock needing to admit generalizations with scope less than the standard requirement, universality across a class. Generalizing need not be universally quantifying, but only requires sufficient generality to get the job done. This rather obvious move has profound consequences for logic, for if the quality of generalization is a property of the generalized predicates rather than of the quantifiers and connectives we can't possibly have a formal logic, for formal logic is just an account of the architecture we have moved beyond. Naturally there will be a formal logic associated with such inferences, some version of non-monotonic logic no doubt. And thanks to an essential contribution of Arnold Koslow (2000) we do not have to deal with traditional logicians task of defining connectives and the like. Koslow shows that any logic can be described just in terms of its inference structure. That puts the focus just where it is required, for Hitchcock and Pinto tell us what an inference structure adequate to substantive argument needs to look like. An inference structure has to be sensitive to the substantive relations between extra-logical terms and to the restrictions on power in the entailment relationships (the strength of the 'inference ticket' or alternatively that depth of commitment to the warrant). That is, entailments range from very weak to almost as strong as you can get. Pinto's rule for choosing apples relies on an inference that is super-weak, you are always ready to except exceptions both in terms of outcomes and in terms of circumstances, yet it happily satisfies his

wife's demands. On the other end of the spectrum chemical formulas support inferences of the most robust sort, although the history of science warns us to always be ready to accept modifications in light of deep theoretical restructuring of their surround.

But although such a logic cannot possibly be formal, its very complexity points to the need for it to be mathematical. The use of mathematics (in logic, metamathematics) to describe complex symptoms is hoary with age and unparalleled in practical application. Logicians should not confuse formal and mathematical logic, although historically such confusion is understandable. A metamathematical account need be no more than a mathematical description of any logical system and does not prejudice the substantive properties of the system. To confuse the two is to open up the doors to logical chaos, paradox and even worse, bad analogies, for the properties of mathematical description are not the same as the properties of the object described and vice versa. Metamathematics as a descriptive language has enormous power, for the understanding of the tools of metamathematics is among the most rigorous in the intellectual repertoire, while it permits of the consolidation of vast domains through concise abstract formulations. So it is to metamathematics that I will turn but only after some rather extensive preliminaries.

3. Weinstein: Truth through Inquiry

The complexity inherent in Pinto's account, both by virtue of the ranges of doxastic attitudes and the enormous complexity that the notion of generalizing on substantive predicates with all of the rich variety of the underling strength of generalizations across concept types, might make us despair of ever getting a handle on how arguments work, except in some crude outline of heuristics or perhaps by relinquishing normative epistemology and focusing on broad general principles of the sort that pragma-dialecticians propose. That is, rules governing dialogue indifferent to the internal complexity of the subject matter being discussed and focusing on the dialogic interactions instead. This has proved very helpful in understanding the over-all architecture of argument. But as long as the argument stage is left unresolved, and there is no reason to share in the optimist view, sometimes present in pragma-dialectics, that logic can take care of itself, there is little insight to be got from pragma-dialectics into the deep epistemologies that support the role of acceptable because true(ish) premises in furnishing warranted conclusions.

Freeman at the end of his book sees the possibility of an alternative account, that he equates with the metaphor of a network drawn from Quine (pp. 374-5). He rightly laments that this is no more than a metaphor. One way of looking at my work in critical thinking and applied epistemology is as an attempt to make sense of this metaphor. Previously, I focused on what I saw were the crucial aspects of disciplined discourse as a prototype of adequate argument. I too was very general, identifying the language of the disciplinary frame with special concepts, substantive

rules of inference and paradigmatic practices (Weinstein 1990). Although I think all of that is correct and perhaps useful it doesn't touch on the logical issues. It wasn't until I began to reconsider my work begun some time ago on the notion of reduction in science that I realized that I had the beginning of a solution. In my earlier discussions of applied epistemology (Weinstein, 1994) as well as my 'ecological approach' to critical thinking I relied heavily on the availability of powerful modes of inquiry that were no less likely candidates for an epistemological foundation than common sense, in that they represented enormous amounts of warranted and useful knowledge. It seemed to me that epistemologically, in the scientific era, the special disciplines were more appropriate as a paradigm than common sense. Which, although rooted in our success in knowing many ordinary things, was riddled with error. And moreover, that the logical lessons available from the exploration of such a range of successful inquiry would be more valuable than those learned from the success of individuals arguing about ordinary affairs. The reason was that my candidate for the most successful inquiry I knew, physical chemistry, could be seen to have the sort of structure that mirrors some of the deep intuitions of philosophers as to the unity of the known. I saw the epistemological effectiveness of physical chemistry to be drawn from three obvious and powerful desiderata for any inquiry clearly exemplified by the history of the discipline. That is, that over time, physical chemistry showed, on average, an increase in the breadth of its application to a range of cases, increasing depth in the levels of explanatory frameworks that accounted for the increase in range because of the great increase in explanatory yield when a heretofore unrelated explanatory frame (set of laws) enables whole hosts of phenomena to be given chemical or physical models, that is, explained by the same or analogous principles, themselves connected by increasingly deep chains of explanation: the grand reductions, organic chemistry and material science (metallurgy, crystallography, etc.) and all of this with increasing refinement both in the ability to measure and compute.

This was a difficult story to tell but yet seemed readily amenable to mathematical expression because all of the criteria are scalar, at least roughly, that is depth, breadth and articulatability all permitted of rough linear order. The rational reconstruction that results has metamathematical interest and permits of elaboration in a way that may very well support its application in artificial intelligence and the creation of expert systems since it, in principle, enables weights to be assigned and calculated for the warrant of items and thus their power in sustaining inferences. But more important it seems to me to furnish a structure in terms of which interesting logical concepts can be saliently explicated, including the three that I see as central to logical theory, truth, entailment and relevance. This moves me away from the weak entailments of ordinary inference to the strong entailments of mature scientific theories. For informal logicians, however, an immediate question arises: why mimic the mathematical by looking for strong substantive entailment measures? I am interested in very strong entailment relations because I am interested in truth. I won't argue for that interest, rather rely on the work of Harvey Siegel (1987) to

support the untenability of the alternatives. So the problem for me is how to define a notion of truth adequate to inferences in the complex sense of Pinto and Hitchcock, that approaches the power of the traditional model of inference.

Freeman tells us is that we have many unexceptional beliefs generated by a variety of mechanisms and reflecting a broad range of abilities, both individual and corporate. Pinto adds that these beliefs, or in his happy phrase 'entitlements,' include a broad range of creedal kinds, what he calls 'doxastic attitudes' nicely suited to the enormous variety of interests and concerns that require reasonable argument. Pinto's examples of micro arguments that exemplify the range of purposes and epistemic contexts set a standard for adequacy of any account. An account of the epistemology of argument must speak to the range of epistemic entitlements across the range of context and of epistemic need. Warrants, as inference tickets require only as most robustness as the epistemic demands put on conclusion requires and have only as much logical power as the quality of the background knowledge affords. This is an embarrassment of riches. Such a welter of small things offers a dizzying variety of kinds and concerns. So we take a page from Plato's *Republic*; not daring to address the small in its particularity, we look to the large and seek some structural principles. Rather than look at the dizzying variety of epistemic tasks for which argument is required, let us look at the largest and most imposing of the knowledge structures available in the last century, that is physical chemistry. And in doing so, instead of working from weak ordinary entailments we start at the other end with the strongest substantive relationships among terms. This leaves open the possibility of weakening the model to make it applicable to less epistemologically demanding concerns. Taking our clue from the history of logic we construct an ideal model and put off worrying about approximations that capture more ordinary cases.

As indicated, the choice of chemistry has long standing in my work, where, for a period of time my main focus in thinking about informal logic and argumentation was the role of disciplined knowledge, what I called 'applied epistemology' (Weinstein, 1994). More recently I have moved from such pragmatic interests to the logical foundations of such a view, both to afford a secure foundation for the theory of argument and for its promise as an aid to constructing knowledge structures with the study of artificial intelligence. The first of these pursuits may give informal logicians pause, for informal logicians, until recently, have rarely engaged with foundational concerns, taking a more Wittgensteinian approach that looks to successful practice rather than deep foundations. Informal logic may not need a foundation, but a wrong foundation is a positive evil leading to deep errors, and Tarski's foundation is just the wrong one. For a theory that supports the equivalence ''snow is white' iff snow is white' presupposes model relations in which mappings are clear and defined in terms of stable model structures. That is clearly the case in arithmetic, but there is much too argue about that cannot be captured in arithmetic constructions. That of course is not to deny the importance of arithmetic or the pragmatic importance of the theoretic fact that once we have

a model it will have a model in arithmetic. And if my view is consistent there is an arithmetic model of changing inquiry as well. That is trivial, since it follows from the first if we have a model of such change. What is decidedly not trivial is whether we have a model of change (Weinstein, 2006).

Hitchcock's work has immediate yield for it shows us how to do away with extensional interpretations by dealing with content expressions in a direct way. But of course that leaves open the aspect of generalization that the extensional model provided. That is to say an account of what generalization (logically) comes to and an indication of the strength with which the generalizations hold. The traditional account (all, some, none) was fine as far as it went and formal logic had much to say about it, but unfortunately it told us very little about how generalizations function in an enormous range of essential cases where they are neither extensional (universal) nor statistical. Extensionality gives us a clear view of entailment, here seeing probabilistic entailment as a species of the genus. But our reasoning with warrants goes far beyond this. Hitchcock gives us the clue to continue, but it is Pinto who begins to see what the stakes are. For generalizations play many roles and fit many purposes, and the extensional model with its standard theory of truth tells us very little about much of what we want to do. Pinto's general use of entitlement points us in the right direction. The many things we require demand correlative degrees of robustness. His example of a rule of thumb for buying sweet apples indicates the sorts of arguments both he and Freeman explore, that is ordinary arguments at relatively low stakes for which ordinary information and common sense are adequate. But, as indicated, we have bigger fish to fry.

There are two philosophical intuitions that support the choice of physical chemistry as the paradigm for epistemology. The first is as old as Plato's love affair with geometry. We can get no better than our best available knowledge structures if we want a model from which epistemologists might draw their understanding. Like Kant and Newtonian physics, the philosopher will do well to heed the call of the most effective practice, lessons are to be learned from the most successful human engagement with coming to know. The second is that physical chemistry forms a coherent structure that sufficient logical complexity to offer exemplifications of how our ideas hang together.

Like all human knowledge, including the logical, physical chemistry begins in intuition. Two of Freeman's belief generating mechanisms are at the beginning of the process. Sense perceptions (including such relatively recondite sense percepts as taste: acids were initially defined in terms of their feel on the tongue) are essential as well as the ability to identify natural kinds. Of course, contrary to Freeman and his reading of Peirce, the identification of natural kinds in Chemistry was fraught with error and was subjected to extensive revision as the field progressed. As essential were the early discoveries of deep principles, such as the conservation of mass as determinative of the key procedure of weighing carefully, and of course, various primitive ideas about atomic theory. These higher-order intuitions, as applied to the weighing and sorting of physical objects offered the beginning of an

interesting layer of chemical models. Ranging from the crude models of Dalton to the sophisticated models in organic chemistry. Some of these are found fairly early as the result of the application of new concepts, procedures and technology, and the result, over a century, intervening layers of practical applications understood both in terms of their experimental outcomes and their success, forming a roughly stable body of generalizations that permitted analogical application to similar cases as chemistry advanced. Thus, not only are there levels of description, but accepted descriptions at a particular level reach out to neighboring phenomenon on the same level creating nests of similar chemical knowledge, for example the differentiation of acids and bases, the distinction of metals, the analysis of the family of substances formed by carbon rings, the structure of crystals and the like. Major theoretic advance, however, occurs when these nests of analogous chemical generalizations are subsumed under higher levels of laws and models as began with the development of physical chemistry. This started moving rapidly in the nineteenth century with enormous advances in chemical knowledge, but the power of unification is best seen with the Periodic Table of Elements at the core. It offers powerful substantive model that is the engine that has driven chemistry from its creation until now, for it opens the door to the deeper connection between chemistry and the maturing physics of the molecule, that atom and ultimately theories of elementary particles (Langford and Beebe, 1969). The yield, modern physical science with all of its riches.

The image should be clear. A knowledge structure, its end points in experience (or other sorts of intuitions as in mathematics) increases in depth as higher order explanations capture (generally, only in part) aspects of the lower order generalizations as explananda. It expands laterally in breadth both through analogy as similar discoveries form nests of similar classifications and through common causal and other functional connections. This breadth is substantive (that is, more than additive) when a nest of similar generalities are subsumed under a higher order explanatory theory and these create the major advance in both theory and practice. These are the grand unifications, as classes of similar and even apparently dissimilar phenomena are seen to be the result of the same underlying forces and geometry. In addition to all of these, across the range of different components of the structure, understanding, frequently manifested in measurements, are expected to increase in precision. Chemical understanding requires the relationship be better borne out in the details of the process, driven by deep principles such as the conservation laws that set ideal values to which experiments are to increasingly approximate. Chemistry as a knowledge structure can be seen to yield three essential criteria of epistemic adequacy: breadth of applicability (at all theoretic levels); depth of theoretic understanding; and progressive improvements of measurement and other relevant describabilia as understanding improves.

This can be seen in the physical sciences construed as the roughly unified structure with the Periodic Table of Elements at the core and the array of supporting and supported knowledge structures understandable in its terms. Uses of physical

knowledge whether in explanations, or practical application draw upon data (actually models of data) that are reconstructed through theoretic vocabularies according to appropriate inference procedures (subsumption under laws; performance of acceptable transformation as in balancing chemical equations and the like). But most important, the physical sciences are constructed around core theories and procedures, even given the discontinuities (Cartwright, 1983). The discontinuities, once the concern of radical philosophers of science (notoriously, Feyerabend, 1975) are clearly only problematic if our ideal is the sort of model relations drawn from the mathematical paradigm, that is to say, explanation and reduction as requiring deduction in the standard sense. A more adequate account of scientific truth shows how discontinuities are well managed and how progress towards greater coherence is assessed. Setting too high a standard for coherence robs us of the epistemic richness of the dynamics of knowledge production and assessment. A standard as high as deductive certainty freezes the dynamics into the useless statics of all or nothing confirmation, a situation rarely if ever encountered outside of the contrived worlds of textbook examples and philosophers' discussions.

In the appendix below I include a meta-mathematical model of emerging truth that attempts to capture these intuitions. As in many non-standard analyses of truth, the model offered here is sensitive to the preponderance of evidence and changes in the evidence. In contrast to the standard mathematical construal of truth, truth based on the paradigm of mature physical science requires ambiguity in evolving model relations. Truth, in the final analysis, is identified with the progressive appearance of a model that deserves to be chosen (so both the intuitions of correspondence and coherence are saved) but the model, not unlike in Peirce, evolves as inquiry persists. It is the substance of how judgments of epistemic adequacy are made antecedent to the truth predicate being defined that is the main contribution of the construction below. In place of strict implication contrasted with induction in its various senses, the construction permits of degrees of necessity reflective of the extent of model relations, that is, it permits inferences within models (that are relatively strict) to be reassessed in terms of the depth and breadth of the field of reducing theories from which models are obtained. That is to say the theory of truth yields a theory of entailment that permits of degree (Weinstein, 2006). It affords a systematic way to organize, articulate and evaluate changes in the field of theories in terms of which the evidence is interpreted and explained. This is accomplished by the identification of two different sorts of functions. First, fairly standard functions that map from a theory (construed as a coherent and explanatory set of sentences) onto models, that is, interpretations of theories in a domain (Appendix, 3-3.3) and a second, much more powerful set of functions, that map from other theories onto the theory, thereby enormously enriching the evidentiary base and furnishing a reinterpretation now construed in relation to a broader domain (Appendix 4-4.3). This is the insight that reflects the choice of physical science as the governing paradigm. Mature physical science is characterized by deeply theoretical reconstruals of experimental evidence, laws and theories in

light of higher order theories as they are seen to unify here-to-fore independent domains of physical inquiry. These unifications, or 'reductions' offer a massive reevaluation of evidentiary strength and theoretic likelihood. It is the weight of such reconstruals in identifying the ontology that grounds the truth predicate that the construction attempts to capture. And in so far as the formalism captures what is salient in physical theory it affords a vision of emerging truth that may have significant implications for the computation of epistemic adequacy in systems that include a rich and theoretically structured data-base as in medical diagnostic systems.

Mature physical science is also characterized by the open textures of its models and the approximations within which surrogates for deductions occurs (in the standard account idealizations and other simplifications). The construction here attempts to make sense of the need for approximations and other divergences among models at different levels of analysis and articulation by offering intuitive criteria for assessing the epistemic function of the approximation in light of emerging data and the theoretic surround (Appendix, 1-2). The yield is a notion of truth as a function of the history of theoretic adequacy (Appendix, 5-6.33).

The construction enables us to distinguish particular models and their history across the field, giving us criteria for preference among them. It is this *ex post facto* selection from among the intended models in light of their history that affords ontological commitment and the related notions of reference and truth. The main contribution of the formal model is how it elucidates the criteria for model choice in terms of the history of a scientific theory embedded within a complex scientific structure of evidence and related theories. We define plausible desiderata, not only upon the theory and its consequences, but also in terms of the history of related theories that donate models to the theory under appropriately selected reduction relations. Reductive inferences are theoretic connectors that donate sets of models down a chain (Appendix, 4-4.4) and in doing so subsume inferences within another conceptual framework. Epistemically, they transform the understanding of the micro inference in terms of broader and more pervasive vocabularies and inferential procedures drawn from here-to-fore unrelated domains of understanding. Computationally they add whatever weight the reducing theory has to the reduced. And to the extent that the reducing theory has power of its own, increases the epistemic adequacy of the reduced theory in a manner that 'swamps the posteriors'. That is we don't have to wait for instance confirmation over time to readjust our priors. Our priors are always being readjusted as a function of the effectiveness of our theories across the board. And we search for our posteriors accordingly.

Reductions offer the large unifications that support reconstruals of empirical understanding. Such 'seeings as' are rife in modern physical science and constitute the major advances in the domain. They include, but are not limited to seeing minerals as crystals, seeing chemical substances as molecules, seeing biological functions as organic chemical interactions, seeing mental events as neuro-physiological etc. It is the structure of the field under these reduction relations,

and in particular the breadth and depth of the model chains donated by interlocking reducing theories that determine the epistemic force and ultimately the ontology of the theory.

The intuitive appeal of the construction is first, based on accepting the brute fact that mature physical science is the most effective epistemic enterprise available, and thus a likely paradigm for a theory of truth; second, on the construction having captured what is essential in mature physical science, in this case the elaboration of how a theory takes weight from the epistemic surround, rather than merely in light of confirming evidence; and third, in terms of the novelty and richness of the formal construction. Its prima facie novelty is readily seen when contrasted with truth drawn from standard account. Rather than seeing truth as true in a model that is available independent of the truth seeking process, truth is an emergent property that becomes clearer as our truth gathering practices converge on a model.

The construction here attempts to give mathematical substance to views that see epistemic adequacy tied to a web of theories as in Quine, and see truth as inherently tied to inquiry, as in Peirce, in a manner that both calls for and hopefully supports computation.

4. Consequences for Epistemology

The intuition my view reflects may be stated boldly: true theories ramify. A theory, whatever its initial intended models, takes its ontological commitment in light of how the theory fares in relationship to other theories whose models it incorporates under reduction. That is, we fix reference in light of the facts of the matter, the relevant facts being how the theory is redefined in the light of its place in inquiry as inquiry progresses. The awareness by inquirers of the history of success of scientific structures enables them to set standards for model choice rationally, in terms of plausible criteria based on successful practice. The formal model enables us to look at the history of approximations to the original interpretations of the theory (intended models) in terms of their goodness-of-fit, and most crucially the relations between ontologically relevant models donated from above (from reducing theories) reinterpreting or even replacing intended models. That is, it enables us to look at how intended models fare under the impress of higher-order reducing theories. Finally, it permits a natural definition of truth internal to the scientific structure (Weinstein, 2002). Truth is defined as an ideal outcome as in Peirce but with mathematical content as in Tarski. Truthlikeness becomes a quantifiable metric as the theories in the structure move towards truth. That is, as the intended models of reducing theories substitute for intended models of reduced theories, increasing the confirmatory basis and the depth of explanatory adequacy. The confirmatory basis is increased since under reductions, confirming evidence of theories connected via reduction indirectly confirms the reduced theory as well. If my intuitions could be modeled with actual assignments of physical properties and relations, the model

chains and their relations could be displayed, weighted and evaluated. Designing such an array would require a period of testing and adjustment, possibly through computer simulations of fragments of physical theory. The yield would be a rational reconstruction of argumentation in a substantive field of inquiry. And it offers an available formal metaphor for increasing truthlikeness as the outcome of inquiry of the sort found in physical chemistry, our presumptive candidate for a naturalist ontology, that is realist within a theoretic framework, which as Putnam has shown us is the most we can hope for (Putnam, 1983).

The deep epistemic intuition should be clear. A theory, whatever its intended interpretation, makes its ultimate commitments in light of how the theory fairs in relationship to other theories whose models it incorporates under reduction. That is, we fix reference and therefore truth in light of the facts of the matter, the relevant facts being how the theory is redefined in light of its place in inquiry as inquiry progresses.

It is the awareness on the part of inquirers of the history of success of scientific structures that enables participants in the inquiry to rationally set standards for model choice in terms of plausible criteria, based on successful practice. Crucially, the formal model enables us to look at the history of approximations, and most essentially, goodness-of-fit relations between models donated from above, from reducing theories, and the original interpretations of the theory. Truthlikeness becomes a quantifiable metric as the theories in the structure move towards truth, that is, as the intended model of strong reducing theories substitute as intended models for reduced theories. Finally, it permits of a natural definition of truth internal to the scientific structure. Truth is defined in an ideal outcome. (Appendix, 6-6.33; Weinstein 2002 offers an elaborated discussion).

Even given all of these virtues, why should argumentation theorists and informal logic tolerate such an idiosyncratic extension of their methods, especially with its resonance with just those methods against which informal logicians inveighed so heavily? Its value is first to show that it can be done. That is, complex knowledge structures can be described mathematically in a manner that supports weighting and connectivity, both obvious criteria in natural argument. Second, like Tarski, it gives an abstract metaphor that then supports the elaboration of particular less global and even non-mathematical intuitions. It is a truism of ordinary argument that interlocutors come to argumentation with belief stores. It is a travesty to think argumentation can disregard levels of commitment in the name of simple tests like consistency. We give up items in our belief stores with more or less difficulty and good arguers strike at available targets. This requires the structure of commitments to be, at least in principle, theoretized if we are to have a theory of argument at all. Consulting an oracle is evidence of despair both in logic as in life. A test of the structure is to take a range of examples we seem to understand and see to what extent the criteria of breadth, depth and articulatability can confirm and give substance to our intuitions. But that is to call for a research agenda. All a paper of this sort can hope to do is to intrigue future participants in the agenda.

Appendix

Scientific Structures: A Model of Emerging Truth

I have attempted to make the formalism more available by forgoing the usual array of Greek letters, italics and the like. Lower case letters name individual functions, models or sentences; upper case letters are (ordered) sets of such items; double upper case letters are (ordered) sets of such (ordered) sets. Ordered sets are indicated by angle brackets. All indices, asterisks etc. are written on the line. An item is often used as its name; use/mention should always be clear in context. I use '|-' to mark implication; '||-' for semantic entailment; '|-e' is our defined restriction on implication appropriate to explanations in mature physical science. I use 'U' for set theoretic union. A 'field' is a structured set of sets, with various elements ordered in a variety of ways. Ordered sets enable us to keep track of items and discuss relations among them.

1. A scientific theory, T, is a set of sentences, $\{t_1,...,tm\}$. The *explanandum*, s, is a sentence. The *explanans*, Tc is the longest sequence, $tc_1,...,tc_n$, of truth functional components of T and |- (Tc iff T). We say that T explains s, in symbols, T|-e s, just when:

a) Tc implies s,

b) Tc does not imply not-s,

c) for some tc_i in Tc, tc_i is a nomic generalization,

d) for any tc_i in Tc, neither tc_i implies s, nor s implies tc_i, and

e) there is no sequence of sentences $r_1,...,r_k$, available within the set of sentences accepted by the discourse community that accepts T, such that, for some sequence of $tc_1,...,$ tcj in Tc

i) $tc_1,...,tc_j$ implies $r_1\&,...,\&r_k$,

ii) $r_1,...,r_k$ does not imply $tc_1\&,...,\&tc_j$,

iii) upon replacing $tc_1,...,tc_j$ in Tc by $r_1,...,r_k$, in symbols Tc_r, Tc_r implies s.

Since our concern is with physical science there is an obvious constraint that a substantial number of the tc_i's will describe experimental or other empirical phenomena. As required by condition (c), some of these are nomic generalizations. Condition (d) prohibits explanatory 'bushes' (circularity). Condition (e) is the ground for relevance.

2. The basis for the construction is a scientific structure defined as an ordered triple, TT = <T, FF, RR>, where:

a) T is a theory closed under an appropriate consequence relation, Con, where Con(T) = {s: T|-e s}.

b) FF is a field of sets, F, such that for all F in FF, and f in F, f(T') = m for some model, m, where either:

    i) m ||-T, or

    ii) m is a near isomorph of some model, n, and n||-T.

    iii) FF is closed under set theoretic union: for sets X and Y, if X and
        Y are in FF, so is X U Y.

  c) RR is a field of sets of functions, R, such that for all R in RR and
    every r in R, there is some theory T* and r represents T in T*, in
    respect of some subset of T, k(T). We close RR under set-theoretic
    union as well.

FF includes primary evidence based on what T predicts or explains. RR includes secondary evidence based on the 'reduction' of T to another theory T*. The notion of reduction relies on the availability of 'effective representing functions,' a purely syntactic operator that maps formulas and variables of some theory, one to one, onto formulas and variables of another theory, and, in addition, preserves identity. An *effective representing function*, r, represents T in T* in respect of a non-empty subset k(T), of expressions of T, such that for every expression e of k(T), if e is in k(T) then r(e) is an expression e* in (T*). An important property of such representing function is: r *reduces* T to T* is equivalent to, for every model m of T there exists a model m* of T* such that, for every sentence s of k(T), s is true in m if and only if r(s) is true in m* (Eberle, 1971).

This enables us to define key notions, articulating the history of T under the functions in F and R of FF and RR respectively. An example of the sorts of construction is the basic notion of model chain. The intuition of a model chain permits us to formalize the intuition that a progressive theory expands its domain of application by furnishing theoretic interpretations to an increasingly wide range of phenomena. The basic interpretation is the intended model. Thus, theories have epistemic virtue when all models are substantially interpretable in terms of the intended model, or are getting closer to the intended model over time.

3. We define a model chain, C, for theory, T, as an ordered n-tuple $<m1,…,mn>$, such that for each mi in the chain, $m_i = <d_i, f_i,>$ for domain d_i, and function f_i, $d_i = d_j$, and where for each i and j, $i < j \leq n$, m_j is a realization of T later in time than mi.

A realization can be thought of as an experimental array or other set of data acceptable in the light of the standards in the field of inquiry that T sits. We say 'realization' because the various mi's may not be models of T, rather, near enough approximations. This is a consequence of the pragmatic turn that pervades the construction.

3.1. Let m* be an intended model of T, making sure that f(T) = m for some f in F, and that m||-T. We then say that C is a progressive model chain if:

a) for every m_i in C, m_i is isomorphic to m*, or

b) for most pairs m_i, m_j in C, i,j, $i < j \leq n$, m_j is a nearer isomorph to m* than m_i.

The notion of a progressive model chain permits us to formalize the intuition that a progressive theory furnishes closer theoretic interpretations to the range of phenomena within its domain of application. The basic interpretation is the intended model. Thus, theories have epistemic virtue when all models are substantially interpretable in terms of the intended model, or are getting closer to the intended model over time. We say 'most' since we cannot assume that theoretic advances are uniformly progressive. Frequently, theories move backwards without being, thereby, rejected. We are looking for a preponderance of evidence or perhaps, where possible, a statistic. We do not define this a priori. What counts as an acceptable rate of advance is a judgment in respect of a particular enterprise over time. This is another instance of the pragmatic turn.

A related, but distinguishable notion, a theory being model progressive, begins with the intuition that theories transcend their initial domain of applications as they move from limited conjectures to effective explanatory theories. This notion defines a sequence of models that capture increasingly many aspects of the theory.

3.2. Let T´ be a subtheory of T in the sense that T´ is the restriction of the relational symbols of T to some sub-set of these. Let f´ be subset of some f in F, in some realization of TT. Let $<T´_1,...,T´_n>$ be an ordered n-tuple such that for each i,j, $i \leq j \leq n$, T´j reflects a subset of T modeled under f´ at some time later than $T´_i$. We say the T is *model progressive under* f´ if:

   a) T´k is identical to T for all indices k, or
   b) the ordered n-tuple $<T´_1,...,T’_n>$ is well ordered in time by the
      subset relation.

3.3. Let $<C_1,...,C_n>$ be a well ordering of the progressive model chains of TT, such that for all i,j, $i \leq j \leq n$, C_j is a later model chain than C_i. TT is *model chain progressive* if the n-tuple $<C_1,...,C_n>$ is well ordered in time by the subset relation.

The intuition should be clear. A theory's models in the sense of the sets of phenomena to which it is applied must confront the logical expectations the theory provides. That is to say, as the range of application of a theory moves forward in time and across a range of phenomena, the fit between the actual models and the ideal theoretic model defined by the intended model is getting better or is as good as it can get in terms of its articulation. The model history of a theory T, enable us to evaluate the theory as it stands. By examining T under RR we add the dimension of theoretic reduction. The key intuition here is that, under RR, models are donated from higher-order theories. Theories under RR form a strict partial order (transitive, irreflexive and asymmetric) but with constraints on transitivity since we are dealing with approximations. The models (or near models) of T donated under functions in R are differentiated from models of T under functions in F by their derivational history and by the particulars of the members of RR. Similar constructions offer a precise sense of progressiveness under RR. This will enable us to offer essential definitions resulting in a principled ontological commitment in terms of the history of the theory and its relations to other essential theories with which it comports.

We can distinguish particular models and their history across the field, giving us criteria for preference among them. The *ex post facto* selection of an ontologically significant model from among the intended models in light of their history will be seen to ultimately yield a truth predicate in a Tarskian sense. More importantly, it yields an image of how judgments of epistemic adequacy are made before such a truth predicate is defined. It elucidates the criteria for model choice in terms of the history of the scientific structure, TT, within which a theory sits. That is, plausible desiderata are defined, not only upon the theory and its consequences (its models under functions in F), but also in terms of the history of related theories that donate models to the theory under appropriately selected reduction relations (sets of functions in R). It is the structure of the field under these reduction relations, and in particular the breadth and depth of the model chains donated by interlocking reducing theories, that determines the epistemic power of the theory.

4. We now turn our attention to the members of RR. Recall that the members of R represent T in T* in respect of some non-empty subset of T, k(T). Let $<k_1(T),...,k_n(T)>$ be an n-tuple of representations of T over time, that is, for i < j, $k_j(T)$ is a representation of T in T* at a time later that $k_i(T)$. We say that TT is *reduction progressive* if,

a) k(T) is identical to Con(T) for all indices, or

b) the n-tuple is well-ordered by the subset relation.

4.1. We call an n-tuple of theories, $RC = <T_1,...,T_n>$ a *reduction chain,* if for all i,j there is a r_i in R_i such that r_i represents T_i in T_j in respect of k(T)for all i<j≤ n. $RC = <T_1,...,T_n>$ a *deeper reduction chain* than $RC´ = <T´_1,...,T´_j>$, if T_i is identical to $T´_j$ for all i≤ j and j< n.

4.2. We call a theory *reduction chain progressive* if T is a member of a series of reduction chains, $<RC_1,…,RC_n>$ and for each RC_{i+1}, RC_{i+1} is a deeper reduction chain than T_1.

This leads to an even more profound extension under RR.

4.3. T# is a *branching reducer* if there is a pair (at least) T´ and T* such that there is some r´ and r* in R´ and R*, respectively, such that r´ represents T´ in T# and r* represents T* in T# and neither T´ is represented in T* nor conversely.

4.31. $B = <TT_1,TT_2,...,TT_n> = < <T_1, F_1, R_1>, <T_2, F_2, R_2>,..., <T_n, F_n,R_n>>$ is a *reduction branch* of TTn if Tn is a branching reducer in respect of T_i and T_j, i, j ≥ 2; j ≤ n

4.4. We say that a branching reducer, T is a *progressively branching reducer* if the n-tuple of reduction branches $<B_1,...,B_n>$ is well ordered in time by the subset relation.

5. Let $TT# = <TT_1,...,TT_n>$ be an ordering of scientific structures seriously proposed at a time. Let $<<T_1,F_1,R_1>,...,<T_n,F_n,R_n>>$ be their respective realizations at a time. We say that a set of models M, $M = <m_1, m_2,...,m_n>$ is a *persistent model set* if for domains, d,

a) $M = <<m_1=<d_1,f_1>, m_2= <d_2,f_2>,..., m_n = <d_n,f_n>>$ and for all i, j $d_i = d_j$, or

b) M is a persistent model set in a set of ordered subsets of TT#, such that the sequence is well ordered in time by the subset relation.

Intuitively, M contains the ordered models that define what the theory can be seen to *really* be about. At each level in the ordering a model of what the theory is about has shown itself to be adequate over time and available for reinterpretation and integration with other adequate models. Physical chemistry tells the tale. We live in a world of substances, which are indicative of chemical processes, which are indicative of molecular structure, which are indicative of atomic structure, which is what chemistry may be seen to be about in reality. If particle physic ever gets truly sorted out, there will be another layer. I stop with the Periodic Table of Elements as the most coherent and pragmatically effective picture of the 'architecture of matter' that we have. That is, I take the Periodic Table of Elements to be true, in the sense elaborated below (6-6.33) even though changing and evolving.

5. Let TT# = $<TT_1,...,TT_n>$ be an ordering of scientific structures seriously proposed at a time. Let $<<T_1,F_1,R_1>,...,<T_n,F_n,R_n>>$ be their respective realizations at a time. We say that a set of models M, $M = <m_1, m_2,...,m_n>$ is a *persistent model set* if for domains, d, if,

a) $M = <<m_1=<d_1,f_1>, m_2= <d_2,f_2>,..., m_n = <d_n,f_n>>$ and for all i, j $d_i = d_j$, or

b) M is a persistent model set in a set of ordered subsets of TT#, such that the sequence is well ordered in time by the subset relation.

5.1. M is an ontic set for TT#.

5.2. We say that a ontic set, O, is a *favored ontic set* if:

a) O is the set of intended models of a theory, T, standing at the head of a progressive reduction chain. (Notice, O is thus the ontic set of all
`   of the theories in the chain.)

b) the members of the reduction chain are themselves reduction progressive.

c) T is a progressively branching reducer.

Notice that the set consisting of an ontic set and the sets that it generates (the set of sets under the reduction relation) form a persistent model set. An interesting yield of the notion of persistent model set is that it explains instrumentalism in theoretically primitive or dubious contexts. Without a theory that donates models the most persistent models are models of the data, whence instrumentalism or other brands of positivism. Of course, working with mature physical science our concern is with theoretic coherence. Which, although requiring that functions map onto models of data or other empirical models, takes its ontology from the deeper theoretic commitments as a function of reduction. For the scientifically informed the world is really made up of atoms and molecules, even though exactly what atoms and molecules will come to be seen as waits on the progress of science.

We now define the ideal of truth emergent.

6. TT is *progressive* if:

   a) TT is model progressive (3.2).

   b) TT is model chain progressive (3.3).

   c) TT is reduction progressive. (4).

6.1. We call T a *progressive reducer* if:

   a) T is reduction chain progressive (4.2).

   b) T is a progressively branching reducer (4.4).

6.2. We say T is a *favored reducer,* if:

   a) TT is progressive (6).

   b) T is a progressive reducer (6.1).

6.3. T is a *most favored reducer* if T is a maximally progressive reducer, that is, T is the nth member of a reduction chain such that for all Ti, $<Ti…,Tn>$ $i<n$, T is a favored reducer. (Notice, Tn is not reduction progressive, since it stands at the head of the longest reduction chain.)

6.31. The set, O, of ontic models of Tn, is thus, a favored ontic set in respect of every Ti in the reduction chain.

6.32. If Tn is a most favored reducer, and O is its favored ontic set than O is the ontology of scientific structure TT.

6.33. An ideal truth predicate for TT can then be constructed in fairly standard Tarskian as 's is true' for s in Tn in TT, iff O‖-s where O is the ontology of TT and Tn is the most basic theory of all.

Notes

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