Naturalism, pragmatism and historical epistemology[1]

David Hyder

Abstract: Historical Epistemology is a discipline that draws on quite distinct sources, straddling the analytic-continental divide within the history and philosophy of science. In this paper, I examine the analytic side of the equation, namely the tradition of empiricist naturalism, and the emergence, within the work of Goodman, Kuhn and Hacking, of naturalized transcendental structures resembling Wittgensteinian language-games, and the correlated multiplication of "worlds".

Keywords: Goodman; Hacking; Kuhn; naturalism; pragmatism; history and philosophy of science (HPS)

Historical Epistemology is a discipline essentially associated with the Max Planck Institute for the History of Science, having been developed as its *raison d'être* by Lorenz Krüger, the driving force behind the Institute's creation, in collaboration with Lorraine Daston and Ian Hacking. Krüger died in the year before the Institute opened, meaning that his legacy was assumed and developed by the first directors of the Institute, including Jürgen Renn and Hans-Jörg Rheinberger. The work of these authors, along with that of dozens of associated researchers and post-docs in the intervening years, has come to define the field, though often without a unified understanding of what the term should mean.

This is certainly no major shortcoming – there is no movement or school of thought that does not, on closer inspection, reveal considerable diversity among the approaches of its members. There is no reason to think that the lack of a consensus among the members of the Vienna Circle on a host of issues somehow indicates a methodological shortcoming, nor that the term "Logical Empiricism" thereby becomes superfluous or misleading. In both cases, the

proper way to respond to this diversity is to examine and compare these approaches and thereby develop a "cluster-concept" that covers adequately both the commonalities and the differences. Such an analysis presents special difficulties in the case of HE, because of the deliberately diverse sources on which its creators drew. Loosely speaking, the tradition has both "analytic" and "continental" origins, for instance Kuhn versus Foucault, and from the point of view of late 20th c. HPS, these authors were quite remote both in their methods and their objects of study. One positive consequence of HE has been a dramatically improved understanding of the pre-war context, and of authors such as Helene Metzger, Ludwig Fleck, Georges Canguilhem, and George Sarton, none of whom fits neatly on just one side of the cleavage. Extending the history of the discipline into the first half of the 20th century allows one to bridge this gap, without forcing any single author into one framework.

In this paper, I propose the second part of what might be called an historical epistemology of "Historical Epistemology". In the first part (2003), I have discussed some of the French and German antecedents to the programme, focussing on the normative transcendental residues we find in authors such as Husserl, Cavaillès, Canguilhem and Foucault. In the following, I examine the other side of the equation, namely the tradition of naturalist empiricism, and the emergence, within the work of Goodman, Kuhn and Hacking, of naturalized transcendental structures resembling Wittgensteinian language-games, and the correlated multiplication of "worlds". It can therefore be regarded as an historical epistemology of *analytic* HE, and it is executed following the method of that discipline itself, as I came to understand this while studying under both Krüger and Hacking in the early 1990s, and while working at the MPIWG in the Department of Hans-Jörg Rheinberger from 1997-2000.[2] Most of the views I ascribe to the above-mentioned authors I have learned less by reading their works, and more in conversation and debate, meaning in turn that their views may have changed, or, in some cases, were never published in the first place.

This accounts for what will strike many readers as an incongruity, namely the central position of the work of Nelson Goodman throughout the following discussion, even though there has been little discussion of his role in the HE literature.[3] This is, I believe, an important omission, since Goodman's *Fact,*

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[2]   This method is being employed in this paper primarily to *illustrate* what I believe Historical Epistemology *should* look like, if it is done at all.

[3]   The most notable exception is Hacking himself. The importance of Goodman for my own work derives from an intensive study of his *Fact, Fiction and Forecast*, which I began in 1993 under Hacking's direction in Toronto and pursued from 1993-1995 under Krüger at Göttingen. In the final stages of drafting this paper, I was made aware of Hacking's (1993), which provides a quite different view of many of the topics explored here.

Fiction and Forecast (*FFF*) not only drove the development of projects such as Kuhn's, but equally well made the topic of counterfactual conditionals a central concern of both philosophers and scientists. Both the "analytic constructivism" we find in Kuhn, and modern theories of counterfactual conditionals up to and including the work of Kripke and Lewis find their source in this book. But the argument presented is of such logical concision that few writers today appreciate the impact that it had.

Similar remarks apply to my discussion of pragmatism and its antecedents. Goodman's own solution to his "New Riddle of Induction" was essentially pragmatic, and the same can be said of the late Wittgenstein, of Kuhn, who drew on both sources, and, finally, of Hacking himself. The *nominalism* that creates the "New Riddle" and the *pragmatism* that solves it are the philosophical basis of the programme of HE in its analytic guise. But, as I will argue by examining the history of these doctrines, they come with certain costs. Most obviously, nominalists are, by definition, anti-realists, meaning that they have programmatic objections to strong ("metaphysical") theories of causality such as emerged late in the 20th century. And if that nominalism is applied just as well to our mental and linguistic representations, as it is in the works of both Hume and Goodman,[4] the result is a near total collapse of normativity. Since both outcomes are desired by the nominalist, we should hardly expect that he will acknowledge either as a shortcoming. He will say that the ultimate norm is always utility and that the ultimate argument for accepting his position must also be pragmatic – what else could it be? But, as I will suggest in conclusion, the empirical evidence speaks against the utility of pragmatism. If one reacts by saying that it is a *normative proposal*, it thereby acquires the same epistemological status as the aprioristic and metaphysical doctrines it seeks to eliminate.

1.   *Analytic constructivism: "we live in many worlds"*

Phrases like these are often heard around the HPS community, along with kindred constructivist claims along the following lines: "object X did not exist before Y", "natural kind W was constituted by experimental practice Z", and so on. The claims are deliberately provocative. When pressed, the speaker

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[4]   Both authors argue that general representations ("abstract ideas") are particulars attached to a word and projected by means of a similarity-relation onto their extensions (the "extension" of a predicate is the set of all objects to which it applies). One way of distinguishing the Humean tradition from the Kantian one is to examine the status of this relation: for transcendental philosophers, it is "internal", in Moore's and Wittgenstein's sense of the term, whereas in the empiricist tradition, it is external.

usually concedes that they are not referring to the Multiverse, or to other galaxies, when they speak of many worlds, but to something else. Or they will say that it was not the *existence* of, say, protons, that was called into question, but the *concept*. Yet to be told that we live in many worlds, but not literally so, or that scientists invent new *concepts* is hardly provocative – the first is merely a metaphor, while inventing new concepts is exactly what theoretical science is supposed to do, and indeed normally does.

Within the Anglophone HPS community, such claims all go back to the work of Kuhn, who introduced the language of paradigm-shifts and semantic revolutions – changes in the conceptual scheme of a scientific community that are so deep-reaching that they may be compared to the acquisition of a new language. Kuhn's defence of this claim, developed in his *Structure of Scientific Revolutions*, bears some resemblance to Foucault's *Archaeology of Knowledge*. Both are works written by historians of science in which they retroactively identify a methodology in their earlier work; and both authors do so by modifying the view of a neo-Kantian predecessor – in Foucault's case, Husserl, and for Kuhn, Carnap. Whereas Foucault retained, if uncomfortably, the normative-transcendental component of this Kantian background, in Kuhn's work the constitutive framework is *naturalized*.

2. *Kuhn*

Kuhn is known well outside his field for two interrelated claims: mature scientific disciplines are governed by "paradigms" and "disciplinary matrices" that determine the methods and problems historical actors can consider; but these disciplines undergo punctuated evolution, marked by revolutionary "paradigm-shifts". *Structure* implements a dynamic version of Carnap's late conventionalism as empirical history, which, once one recalls the neo-Kantian background, leads naturally to the language of multiple worlds. For in that tradition, philosophy is concerned with *foundations* for the natural sciences, that is to say their logico-mathematical and inductive *principles*. As in Kant, these are first "constitutive" (Early Logicism), later they become "conventional" (Reichenbach and, earlier, Poincaré). If and when we change these principles, we change our "framework" or "scaffolding", and since the framework, for any neo-Kantian, plays the same foundational role as traditional metaphysics, it follows that changing the framework "changes the world".

In consequence, Kuhn claims that scientists living in different eras "live in different worlds". The worlds are *defined* by their fundamental normative commitments, which simultaneously *separate* them. These worlds are successive – in each historical phase of a science, terminology and methods

are shared, and so is ontology. After a revolution, however, there is a loss of translatability, which parallels exactly the same failure that – supposedly – accompanies a radical change in a category-system. We are, with respect to our distant scientific forebears, in the same position as a field-linguist encountering an historically isolated dialect within her own language-group.

Seen from this point of view, it is evident that Kuhn's theory is *historico-epistemological* in much the same sense as other authors in the French and German traditions, specifically Husserl's *Crisis of European Sciences*, Canguilhem's *Normal and the Pathological* and the earlier works of Foucault up to an including *The Order of Things* and *The Archaeology of Knowledge*. All of these authors appeal to *historical a prioris*, *epistémès*, *disciplinary matrices*, and the *ruptures* and *revolutions* that separate successive conceptual systems. Since, however, we are focused in this paper on the analytic side, I will turn immediately to the *difference* between the French and German approaches on the one hand, and the American one on the other. This difference derives from a commitment to "naturalist empiricism" which, as we shall see, could be more aptly called *nominalist inductivism*.

Nominalist inductivism is an ancient philosophical position with an equally long history, since it is canonically addressed and rejected in favour of what we now call "Platonism", "essentialism", or "natural-kind realism" in Aristotle's works on logic, specifically *Posterior Analytics* I.i (71a30f.). It is the philosophical thesis that all universal propositions are provisional, because (i) it is impossible to know the extensions of their predicates in advance, meaning that (ii) piecemeal induction on actual past observations is the only source of *credibility* for universally quantified propositions, and such credibility never amounts to *certainty*. At various points in history, (i), (ii), and their ancillae have been called "nominalism", "extensionalism", "empiricism", "naturalism", "pragmatism" etc. Thus the 20th c. version of this position, typified by the work of Quine and those around him, has classical, medieval, early modern and 19th c. antecedents. But it is still more extreme. Almost all earlier authors, even Hume, made exceptions for at least some of the propositions of mathematics and logic. Twentieth-century American nominalist inductivists went further, however. Not only was the entire project of synthetic a priori foundationalism to fall. Even *analytic a priori* principles, including constitutive conventions in the style of Carnap were to be rejected. But Quine's project failed, and the way in which it failed is, one might say, the condition of the possibility of 20th c. analytic historical epistemology.

3. *The condition of the possibility of analytic historical epistemology*

As we just saw, Kuhn's worlds are *successive.* But when we look at much contemporary Anglo-American HPS, we get the claim that we live in multiple worlds *at the same time* – the many worlds are now *simultaneous.* So, what changed? The key figure is Nelson Goodman, the author of *Ways of Worldmaking*, and a collaborator of Quine's in their earliest days. This collaboration began as the project just outlined: by nominalizing the new logics, one would dismantle the last *a priori* remnants in Russell and Whitehead's *Principia*, Wittgenstein's *Tractatus*, Carnap's *Aufbau* and his *Meaning and Necessity*, thereby destroying the analytic foundations of mathematics that were the principal goal of logicism. This forcibly undermined philosophy's *normative* status: since no universal propositions are certain, there are no rational foundations for logic, mathematics, or the physical sciences; there are also no certain universal principles in ethics, including universal human rights. The difficulties Goodman later highlighted in his *Fact, Fiction and Forecast* (FFF) emerged only when this radical nominalism was applied in empirical science, where the target was the types of necessary connection involved in *natural kinds* and *causation.*

Quine never abandoned his extensionalist project, but Goodman did quite early on, and he presented his reasons to Quine as a dilemma: abandon (i) set-theoretical extensionalism, or abandon (ii) induction. More precisely, he argued that there was no way of implementing a theory of inductive confirmation without appealing to one of three alternatives: Natural Kinds, Natural Laws, or Counterfactual Conditionals. A solid theoretical account of any one of these, Goodman argued, could serve as a basis for the other two; however, all of them were problem-ridden, because they all involved the concept of *possibility.*[5] Goodman offered his own, fourth solution, that would accord with Quine's and his scruples, because it appeals only to past regularities in the use of names – his theory of predicate-entrenchment. It follows that human and social factors are unavoidably involved in the practice of science at the level of induction itself. It is this last solution that motivates the Kuhnian and post-Kuhnian tradition we are discussing. But it is not the solution most philosophers opted for, at least among the younger generation, and this fact alone accounts for much of the gap between what historians of science today consider to be "philosophy", and what is actually going on in 21st c. philosophy departments.

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[5]   Thus it is worth reemphasising that any "solution" to Goodman's paradox that appeals to one of these factors is, from Goodman's point of view, a concession that he is right.

4. *Why does nominalism matter to constructivist HPS?*

It is not hard to see why some form of nominalism is essential to those who believe in "made up worlds" or "made up people". Nominalism is the position that denies universal forms and asserts instead that all categories are human creations. A fortiori, it justifies the sort of *ontological pluralism* we have been discussing: if the world is a box of sand, consisting of indefinitely many x's, none of which is possessed of real properties, then all ways of classifying the grains have the same ontological standing. Since nothing has real, let alone essential properties, and all predicates are derived from human thought or language, it follows that the fundamental metaphysical categories, and the constitutive principles of the sciences that mention them, are either inductive generalizations or conventions. Thus, not only is a *succession* of incompatible worlds possible, but such worlds are *simultaneously compossible.*

In the early work of Quine and Goodman, nominalism is a means of deconstructing logical and mathematical foundationalism, which they attempted by completing the "no-classes" theory of *Principia Mathematica*. Russell and Whitehead had argued that, in order to block the set-theoretical paradoxes, we first had to reduce set-theory to logic, and then, second, introduce a hierarchy of functions and logical forms, thereby blocking the formation of the *pseudo-statements or -judgments* that apparently asserted the existence of these absurd sets. But Russell's theory of propositional judgment contained "forms", which were the inevitable residue of the classes he had eliminated, and which reappeared in the definite descriptions that Russell had used to handle non-denoting signs, such as propositions, class-terms and proper-names. So a principal aim of Quine's and Goodman's (1947) "Steps towards a Constructive Nominalism" was to eliminate this residue, which they achieved by means of linguistic behaviourism. This was a natural fit, since the latter doctrine replaces cognitive meaning-bearers (concepts, ideas, intentions) with *dispositions*, which are in turn interpreted as empirical hypotheticals. Concretely, linguistic behaviourism allows one to replace "mental forms" with sequences of tokenings. Instead of presuming the existence of a sensible property such as *red*, which, when wedded to the word "red", determines its extension, we introduce a definition such as: "Set of objects in whose presence English-speaker Q utters 'red'". Property-ascriptions are now language-relative, and, more importantly, they are essentially unbounded: no fact in the world determines in advance the extension of "red", and any claim to know that extension is a *prediction*, that is to say a "projection" of that term onto future linguistic behaviour. The effect is to turn every universally quantified universal proposition into an empirical prediction, including, as intended, the

"logical propositions" at the heart of Frege's *Foundations*, Russell and White-
head's *Principia*, and Wittgenstein's *Tractatus*.

The premises for this conclusion were: first, that extensions are determined
by tokenings, and only past tokenings are known, meaning that there are no
future extensions beyond those anticipated by our dispositional "projections";
second, that universal propositions acquire whatever credibility they possess
only by induction on past observations, which means, for both Hume and the
behaviourist, through the formation of *habits* or *dispositions*. Goodman's para-
dox then implements the following dilemma: accept a principled distinction
between coextensive terms or abandon induction. He does this by arguing
that, for any inductive context in which we may find ourselves, there is a pro-
jection-ambiguity that cannot be resolved in extensionalist terms. Concretely,
we *must* choose between "green" and "grue", and, furthermore, we *do* choose
"green". But everything that differentiates them lies in the future or has never
been observed. Therefore, our inductive practice is based on convictions that
are essentially non-extensional – the nominalist inductivist must choose be-
tween the two.[6]

5. *Goodman's rejection of extensionalism*

Given the enormous literature on Goodman's paradox, we will dispense with
a statement of it,[7] and will try to avoid entering into disputes regarding its correct
formulation. What interests us is the dilemma just outlined, and it does not de-
pend on these finer points, for Goodman's target is very specific. His argument
shows that Quine's and his youthful nominalism,[8] however successful it might be

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[6]   The simplest way to drive home the point is to consider a world like Goodman's which, for
whatever reason, is destroyed immediately after time *t*. In this world, the actual (or "manifest") exten-
sions of "green emerald" and "grue emerald" are strictly identical, therefore any property, including
causal ones, that is ascribed to the one must be ascribed to the other. That "they will differ after *t*" is
a belief that speakers in this world may well hold (prior to *t*); however, nothing "corresponds to" or
"verifies" this psychological state (similar remarks apply to unobserved emeralds prior to *t* – the fu-
ture and the unobserved past are symmetrical with respect to the logical point). For this very reason,
it can do no work in parrying Goodman's paradox in the world he considers.

[7]   On Goodman's original definition, an object is *grue* if-and-only-if it was examined before some
time *t*, and was observed to be *green*, *or* it is *blue*. *Grue* and similar predicates are often called "dis-
junctive", because they fuse, by means of the *or*-connective, or "disjunction", two apparently "natu-
ral" classes of objects such as *green* and *blue*, to generate an absurd class. The New Riddle of Induc-
tion challenges us to explain why, at time *t*, we prefer to induce on "green emerald" rather than "grue
emerald", given that their actually observed extensions are, by design, identical prior to *t*, but diverge
thereafter, and thereby generate incompatible predictions.

[8]   As indicated earlier, Goodman's allegiance to this position was always limited. Both of them
soon abandoned the extreme position of their (1947), Quine adopting classes, but no natural kinds,

in undermining the claims of *mathematics* to a priori certainty, cannot be reconciled with the needs of *empirical science*. Since the naturalistic conclusion of the nominalist argument was to be that *all* science is fallible empirical science, the naturalist must now pick either (i) his nominalism or (ii) his inductivism.

This point can be brought out by considering our natural responses to Goodman's problem: we could appeal to the fact that "green" refers to a real, as opposed to an artificial kind; when pressed, we could appeal to counterfactuals in order to demonstrate that "grue" is in some sense absurd; finally, if asked how we know that these counterfactuals are true, we could invoke the laws of chemistry and optics, which can be distinguished from "mere regularities" by appealing to a difference between natural and artificial kinds. These options resemble – from Goodman's point of view – a closed curve in space. For each projects beyond an *actual* extension (of *past* tokenings) to a *possible* one. When we say – in the simplest case – that the concept "green emerald" *differs* from "grue emerald", we anchor the difference in something that either *has not yet* happened (an observation of a green emerald after *t*), or that *could have* happened but didn't (a counterfactual observation of a green emerald before *t*). But that something is not part of the actual, or "manifest", extensions of "green emerald" and "grue emerald". Indeed, "grue" has been defined in such a way that these sets are *necessarily* identical, so that no fact of the matter could ever distinguish them before time *t*. Any appeal to supplementary criteria, for instance laws of nature, will also involve general propositions whose terms have open extensions, and the Goodmanian will simply disjunctivize those as well.

6. *Three possible solutions*

The addressee of Goodman's argument is therefore forced to choose between extensionalism and inductivism. Quine stuck to the former and never did, to my knowledge, offer a substantive response to Goodman. Most philosophers and historians, however, made the opposite choice, and the specific *intensionalist* solutions they chose define the field of methods arising within analytic HPS in the second half of the century. The options were: metaphysical realism, counterfactual definiteness, and natural laws, all of which involve some form of realism about universals, and the normative force these have carried since Plato. I will first say a few words about each.[9]

Goodman favouring qualia much like our "tropes" or Wittgensteinian "objects", while rejecting classes (for a discussion of this period, see Cohnitz & Rossberg 2006: 86ff.). It is easy to see how the grue-paradox works in favour of Goodman's choice, and against Quine's.

[9]   These options are sequentially examined in the first chapter of *FFF*, "The Problem of Counterfactual Conditionals".

(1) Natural Kinds ("metaphysical realism")

This solution responds to Goodman's paradox by pointing out that green objects form a natural kind, whereas grue objects do not. This is the simplest response provoked by *FFF*, which Goodman no doubt intended to elicit in order to drive home his fundamental point. For not even the scientific realist believes that colours are real, in the sense that they might hold a spatiotemporal distance to be. The reality of colours long yielded its place to such scientific properties, but Goodman's argument applies just as well to them: if the meaning of a predicate simply *is* the set of its instances, then there exist, for every such predicate and at each time *t*, many disjunctive correlates[10] which will recreate the original dilemma. Furthermore, since every appeal to future or counterfactual observations is a projection, there are no *causal* properties that can be ascribed to the "real" properties which do not automatically apply to their coextensive doubles.

(2) Counterfactuals

Counterfactuals seem to have been an early candidate for solving the problems that led to *FFF*, since it begins with a lengthy analysis of what were, in fact, Goodman's own earlier failures to make them work to his satisfaction. But if we had a theory of counterfactuals – for instance that of David Lewis – it might not be difficult to decide the question in favour of *green*. As many authors have pointed out, given an entirely plausible claim concerning some green object G that I did *not examine* before *t*, such as "Had I examined G, it would have been found to be green," I can infer with certainty[11] that, "Had I examined G, it would have been found to be grue." And if objects don't change their properties for no reason, then it seems reasonable to assert that, since it *would have been found to be* grue, it *is still* grue. But that entails that, *were* I to examine it *now*, after *t*, it would be found to be blue, contradicting our original assumption that it is green. Thus either (i) objects change their properties for no reason, (ii) the predicate *grue* is absurd, or (iii) some of the relevant counterfactuals have no truth-values. If we hold to (i) on grounds of simplicity and economy, then either (ii) *grue* is an absurd predicate, or (iii), the negation of Counterfactual Definiteness[12] (CD), must hold.

As already suggested, Goodman appears to have rejected this approach

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[10]   See footnote 7.

[11]   Because this inference follows from the definition of "grue".

[12]   That is, we must reject the supposition that statements such as: "If an observation of E had been made, result G would have been obtained" always have a truth-value. See Skyrms 1982: 43 and Stapp 1971 for discussion.

even before formulating the New Riddle, because it involved either possibilia, or an appeal to Natural Kinds. Rejecting the first, Natural Kinds become the obvious option, but then we recur to (1). And, in fact, things have grown still more problematic for this option since Goodman's work, for CD is a variant of Einstein, Podolsky and Rosen's "Criterion of Reality" (1935: 777), and it is only by removing this same realist premise that one can neutralize their argument. In consequence, anyone who goes this route[13] will eventually have to confront the role of counterfactuals in EPR.

(3) Natural Laws

The notion of a Natural Law is stronger than that of an empirical generalization. As Hume complained, the notion of a Law adds something to the latter that goes beyond the prior instances observed, and indeed beyond the future instances as well. The difference corresponds exactly to the Medieval distinction between "sempiternal" (always true) and "essential" (always true by necessity). If we are pushed back, by recursive application of arguments in the style of (1), to our fundamental categories and laws, and if we are able to reject their disjunctivization, then it is an easy matter to show that *green* is legitimate and *grue* is not. But to do so is to claim that one has some way of knowing, once and for all, that one has arrived at these fundamental laws, and the property-concepts they deploy. And on this point, Goodman is intransigent: any appeal to metaphysical properties that *causally necessitate* observable regularities is unscientific (*FFF*, 20). What of, one may therefore ask, the disposition that forms in us when we resolve to project in one direction in preference to another?

7. *Constructivism (back to HE)*

Thus we are left with Goodman's own, fourth option, which is the philosophical foundation of the analytic constructivism which followed. On this approach, I reject realism, counterfactual definiteness and the notion of natural laws, and restrict myself to what has actually been observed. The problem is that the latter does not, by design, offer any facts that could break the symmetry.

Yet all is not lost, Goodman argues, because we have overlooked the fact that the *use of names* falls within what has actually been observed. And, quite clearly, this leads to a form of *intensionalism*, in that it allows us to ascribe

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[13]   Including this author. For background, see Dickson 2002: 657. Note that there are many versions of EPR in the literature that avoid this premise; however, most involve, for reasons that are too complex to discuss here, Absolute Time.

properties to "green" and "grue" that distinguish them,[14] given that, once again, grue has been so defined that no observation of its *referents* could ever yield such a criterion. But if I am allowed to appeal not only to what my words refer to (extensions), but also to the words themselves, a simple response to the dilemma presents itself: one of the words has been used a lot, the other hasn't. This is a fact about names in their past application to things, and not a fact about the things themselves. It is, therefore, a *nominalist,* but *non-extensional* solution.[15]

Suppose now that I am a nominalist who wishes to explain the difference between green and grue, without appealing to real properties or counterfactuals. I find myself obliged to do this, because there is no science without induction and, given that I have sacrificed the reality of extensions in order to undermine necessary truth, I must offer a substitute. This substitute turns out to be the *past usage of scientific terms.* For, since everything that is not a particular referent (=X), is a human creation, and these "intensional" factors are necessary to science, I also believe that natural-kind concepts of human creation are ineliminable. There is no empiricism free of a human-created foundation, and that foundation is (1) neither a free choice, nor is it, (2) derived from the *nature of things,* for (1a) it precedes me, and (2a) I remain a nominalist. Thus, I must conclude that scientific practice is essentially dependent on an historically contingent conceptual frame – a paradigm, a disciplinary matrix, a style. Put otherwise, Goodman's argument leads unavoidably to the view that concepts have memories.

8. *The Normative vs. the Descriptive*

The argument I have just given is the philosophically interesting and important basis of HE – the one that convinced its philosophical creators. But it's not, from what I can tell, what people understand by this term today. What we get much of the time is *just history*, without a genuine *epistemological* component. This is due to a contingent accident: Lorenz Krüger died just before the Max Planck Institute he worked so hard to establish was founded. Historical Epistemology became the province of Anglo-American historians *only*, many of whom have contempt for philosophy, or are, at best, "naturalized epistemologists" à la Quine. That's the sociological situation. But the problem is system-

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[14] Trivially, *green* is longer than *grue*, but that is a property of the *names*, and not of what they refer to. Goodman did not regard this as "intensionalism", but it does agree to our current understanding of, for instance, an "intensional" context. Those who object to the term can substitute "non-extensional".

[15] See Declos 2019 for a discussion of the nominalism involved here.

atic and theoretical, because to *solve* Goodman's problem, we need a definition of "good" concepts (green over grue). And "good" is a normative term.[16] If you try to define it in terms an empiricist would accept, you get *pragmatism.*

9. *Pragmatism: a potted history*

In its modern form, pragmatism is the view that whatever maximizes utility is better than whatever does not. Given a market that accurately prices utility, pragmatism in epistemology yields the view that *what sells is true.* But most contemporary pragmatists resist this natural connection to economics, preferring to leave open the nature of the interests in question, and the measure of utility. Thus, when philosophers in this tradition tell us that "It's real if you can spray it," they mean "if you can *do* [Gr. *prattein*] something with it", where the nature of this "doing" is at first left dangling. But whatever it is, it is going to be something in the human life-world, something connected to human interests and desires, without which the notion of utility in question draws a blank. It might seem at first glance as if pragmatism in the philosophy of science is a special case, since today we have pragmatist theories of ethics, epistemology, etc. But if we engage in a little history, we discover that it emerged hand in hand with the Early Modern version of nominalist inductivism that Kant had named "Empiricism", specifically within the collaboration between John Locke and Thomas Sydenham on the theory and practice of medicine. Already in these early authors, pragmatism plays the role of metaphysics. For the empiricist, having rejected appeals to natural kinds and hidden mechanisms, owes us an explanation of our realist convictions, and this explanation must give account of their epistemological role.

Kant's choice of the term was not friendly, and the view he ascribed to "empiricists" was closer to that of Berkeley, and indeed to 20th c. sense-data verificationism, than it was to Locke's, or even Hume's views.[17] Locke did not deny the existence of a mind-independent world, nor even our ability to learn things about the Cartesian sea of matter we inhabit. But, through his collaboration with the physician Thomas Sydenham, he came to argue against the possibility of knowing anything concerning the true causes of disease, eventually denying that the study of anatomy could tell us anything about illnesses and how to cure them.[18]

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[16]   The *realist* does not think that the difference is between good and bad predicates, but between real (natural-kind) predicates and artificial ones. Normativity comes in, as it did in Plato and Aristotle, with the intensional structure that such a distinction engenders.

[17]   See Specht 2009.

[18]   See Walmsley 2008 for an excellent treatment of the relation between the two thinkers.

This radical rejection of causal explanations and scientific theorizing was an outlying view; indeed, it seemed to deny the tremendous success that Harvey's work had enjoyed all over Europe. Thus Locke was obliged to state clearly his reasons for holding it, and it is in these writings that the interconnection of pragmatism and nominalism that interests us took its characteristic modern form. Since it is impossible for us to know the inner causes of nature, it is impossible to establish a correspondence theory of truth, and the role of truth is taken over by something else, as Locke explains in his "De Arte Medica":

…all speculations in this subject [the knowledg of natural bodys] however curious or refined or seeming profound and solid, if they teach not their followers to doe something either better or in a shorter and easier way than otherwise they could, or else lead them to the discovery of some new and usefull invention, deserve not the name of knowledg, or soe much as the wast time of our idle howers to be throwne away upon such empty idle phylosophy.[19]

That is to say, knowledge is to be called "true" not because it corresponds to the inner workings of things, whether these be souls or mechanisms, but only to the degree it allows human beings to flourish. As Locke's own career as an amateur physician flourished, so did his commitment to Sydenham's pious anti-realism, and they doubled down on this view in their collaboration on Locke's "Anatomia":

Others of them have more pompously and speciously prosecuted the promoting of this art by searching into the bowels of dead and living creatures…to find out the seeds of discharging them, but with how little success such endeavours have been and are like to be attended, I shall here in some measure make appear.[20]

All that anatomy can do is only to show us the gross and sensible parts of the body, or the vapid and dead juices, all which, after the most diligent search, will be no more able to direct a physician how to cure a disease than how to make a man; for, to remedy the defects of a part whose organical constitution, and that texture whereby it operates, he cannot possibly know, is alike hard as to make a part he knows not how is made.[21]

Locke was in fact what Kant later called a "transcendent realist" – his empiricism did not compel him to deny all structure to the mind-independent world, and he accepted much of Descartes's mechanical physics. But, like many

[19]   In Dewhurst 1966: 83.
[20]   Sydenham, handwritten remark on Locke's "Anatomia", in Dewhurst 1966: 85.
[21]   Locke, introduction to "Anatomia", in Dewhurst 1966: 85.

Protestant fundamentalists up to the present day, he did not assign much importance to such a theory of stuff. Mechanical physics is useful to human beings who wish to manipulate lifeless Cartesian matter. But this is a pale shadow of the Aristotelian universe, with its natures and causes. Locke and Sydenham warn us above not to confuse such useful investigations of the material universe with an explanation of the true natures of things. On the contrary, all such explanations "do work" and "do not idle" only under the direction of our pragmatic goals.

The result is a peculiar inverted ontology, but one which now makes perfect sense: the *further* an object is from the network of human needs, the *less* we can know about its real properties. Spirits, including the Cartesian souls of other people, are out there, but are so infinitesimally *small* as to escape observation:

…it is certainly some thing more subtile & fine then what our senses can take cognisance of that is the cause of the disease, they are the invisible & insensible spirits that governe preserve & disorder the aeconomie of the body.[22]

But this aperture on the mind-independent world shrinks to a vanishing point in later authors such as Hume. The latter does occasionally qualify his skepticism by observing, for instance, that necessary causal relations in things might well exist, but this does not change the fact that, even if they are out there, we still have no means of discovering them. At the limit, the theory of matter deserves the name of knowledge *only* insofar as it helps us achieve our practical goals.

By contrast, it is much easier to identify real kinds within humanity than it is to identify the real kinds of matter. Hume and his contemporaries remain realists concerning *human kinds*, a topic actively discussed throughout 17th and 18th c. Europe, which conviction becomes explicit when Hume discusses slavery:

I am apt to suspect the negroes and in general all other species of men…to be naturally inferior to the whites. There never was a civilized nation of any other complexion than white, nor even any individual eminent either in action or speculation. …. Such a uniform and constant difference could not happen, in so many countries and ages, if nature had not made an original distinction betwixt these breeds of men.[23]

Like Locke, Hume also believes that regularities in comportment and ability point to real differences between kinds of human beings, that these differences are intrinsic and were implanted by God. But in his works on the foundations

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[22] Locke, "Anatomia", in Dewhurst 1966: 91.
[23] Hume's "Of National Characters" as quoted in Immerwahr 1992: 481-482.

of natural science this realism is entirely offset by Locke's and Sydenham's arguments concerning the unknowability of the actual causal structure of these natures, meaning that, on those rare occasions where Hume does oppose slavery, he does so on purely *economic* grounds. These philosophies contain, and not by accident, both the materials for denying human rights to subjugated peoples, and those required to shed doubt any scientific claim that does not lead to greater riches, including the results of intelligence tests. The suspicion of essential inferiority can never be removed, since it is based on metaphysical convictions which are, on methodological grounds, beyond the reach of any experiment.

So in these authors, nominalist inductivism in its epistemological form makes all universal knowledge, and all universal laws, provisional and subject to doubt; however, in contrast to Berkeley, Kant and 20th c. empiricists, this does not mean that there are no real kinds in nature. Furthermore, neither Locke nor Hume denied that there were certain sciences, for instance arithmetic and algebra, whose clarity and distinctness made them impervious to such doubt. It was only in the case of geometry that the same worries occur as in the case of natural kinds, for geometry also required abstract ideas, or "transcendental forms" to mediate its inferences. Nineteenth-century nominalism, such as that found in the work of F.A. Lange,[24] and those influenced by him, such as Quine's teacher Peirce, results once the transcendental forms are again stripped out. This became the position of "naturalized Kantianism" that feeds into many of the authors discussed in the first sections of this paper.

10. *20th century pragmatism and HPS*

Quite obviously, one could object to this entire project on political grounds, arguing that this is simply the ontology you would expect from fundamentalist slave-traders, and that this explains its ongoing popularity in those part of the English-speaking world that were actively involved in that trade. For, realism about human kinds justifies our *not* extending full political rights to all human beings – merely to those capable of full rationality – and this barrier is absolute, grounded in essence; while realism concerning fundamental physics is either rejected or subject to endless skeptical doubt, because it threatens to produce a theory of the world that undermines the revealed truths of religion. But this is not a paper in practical philosophy, nor is it helpful to attack the doctrine on that field. These political consequences are seamlessly derivable

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[24]   I am deeply indebted here to Samuel Descarreaux, whose work on Lange has made clear the enormous impact he had on authors as diverse as Cohen, Peirce and Nietzsche.

from what appears to be "epistemology", even if, as we have just seen, that epistemology was always dependent on a radical nominalist metaphysics. Philosophers of biology working in this tradition have recently been forcibly reacquainted with that history. Since empiricism, including the logical empiricism of the Vienna Circle, endorsed Humean causality in this tradition, and defined the latter in terms of universalized material conditionals, it has found itself increasingly unable to find any explanatory value in Darwin's theory. To do so requires translating the extensional definition of "more fit" into some kind of causal explanation. Jerry Fodor's explicitly Goodmanian arguments lead to the usual result: causal explanations either fall prey to their disjunctivized twins, or they are tautological. The conclusion – that Darwin's theory is empty – was programmed already in the 18th c., by the ancestors of those who attack biological science today.[25]

11. *Goodmanian entrenchment*

Let us now turn to Goodman's own, nominalist solution to his paradox. Few pragmatists or Quinean naturalists have followed in his footsteps, because the task is enormous: a pragmatic reconstruction of a foundational science doubles the work. For, if the pragmatists are to provide a genuine alternative, they must embed the science in question in some larger utilitarian frame, in order to define concepts such as "truth", "consequence", "real predicate" in terms of utility. But then they must return to the original system to show the genuine theoretical consequences of the reconstruction. Goodman, to his credit, tried to do this, and the way his project ran aground is instructive precisely because it highlights the enormous task every pragmatist faces.

Goodman concludes his discussion of his New Riddle by *naming* what can count as an acceptable solution. The two coextensive predicates are distinguished by the fact that one is – in fact – *projected* by us, whereas the other is not. Thus what we are looking for is a theory of *projectability*. Since *projected* is a predicate that itself applies to *words*, statements about past projections are lists of observations, and *are* empirically verifiable. By contrast, a *projectable* predicate is one that *could*, and perhaps *should*, be used to make predictions concerning events which have not yet been observed, but which *will be* empirically verifiable. Thus, the task confronting us is to give criteria, referring only to actual past usage, which select "good" predicates for future use. This is the

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[25]   By contrast, parrying this attack inevitably involves invoking counterfactuals (Sober 2010: 606; Rosenberg 2013; Dubé 2019) and thus, if these are to be interpreted *objectively*, some form of causal realism.

problem of *projecting "projected"*, that is to say of defining a criterion, in terms of past events, which selects the "right" predicate to apply to future events.

Goodman's solution is to use induction on the past use of names: what distinguishes "grue" from "green" is their *history.* A term that has been successfully used in many inductions in the past is *entrenched*, such that, for any two predicates, the one with the higher degree of entrenchment is more projectable. If we endorse this definition, we make an empirical claim: the predicates on which we should induce are the ones that have been found, in the past, to have been repeatedly involved in successful, non-trivial inductions – these *will work better* in the future. It is in this sense very close to earlier definitions of "natural kind" in the work of philosophers such as Whewell and Mill. The classical metaphysician would have argued that, by means of experiments under varying conditions, we determine causal properties, thereby identifying species of objects with essential natures – horses, hydrogen atoms, top quarks, etc. But this relation can be inverted. We argue instead that we *call* those classes of things "natural kinds" whose predicates have often been used in describing successful experiments that we took to have confirmed universally quantified propositions. The proposal is that, faced with a deadlock, we select the one that worked well in the past.

Goodman should be commended for attempting what most others in this tradition only gesture towards. He truly does reconstruct the notion of a natural kind within a larger formal system that meets the scruples of the radical inductivist, quantifying only over past events that actually occurred. But he nevertheless failed in his attempt, and these failures are instructive because they point at the core weakness of the entire nominalist-inductivist tradition. So I will conclude this discussion by briefly summarizing the key difficulty, after which we will return to the constitutive role of this work in late-20th c. HPS, in the work of historical epistemologists such as Kuhn and Hacking.

12. *Entrenchment of kinds and laws*

On Goodman's approach, higher "entrenchment" accrues to predicates that have been used a lot – *green* has history, *grue* does not. But "use" is *too weak* for this definition to do any work. For instance, "delivered by Santa Claus" is used a lot, but is not predictively successful. So "use" must be restricted, and the definition strengthened: "used" shall mean "mentioned in many universally quantified propositions that were successfully used to make predictions in the past".

But now the definition is *too strong.* Consider, for instance, the periodic table of the elements. The projectability of the names that appear in it is not

just a function of the fact that they're used a lot. Some, like "Seaborgium", refer to substances which have rarely existed in the history of the universe, and have equally rarely, if ever, been used to make predictions. Goodman tries to solve this problem by bootstrapping. Entrenchment of low-level predicates, e.g. *Carbon*, confers projectability on some higher-level ones, e.g. the periodic table itself, and this then "trickles down" to *Seaborgium*. Put otherwise, Goodman must construct nominalised higher-level genera (replacing *natural genera)*, in order to handle species-concepts with short entrenchment-histories. And this recurs across all concept-types, since new scientific concepts are typically introduced in the vocabulary of some prior science, which in the mature physical sciences will generally involve some "laws" that must be interpreted nominalistically as well.

At this point, Goodman's theory collapses under its own weight, as he tries to introduce principles to disseminate entrenchment within the conceptual network. Roughly, *Carbon* is a scientific concept that inherited the deep entrenchment of words such as *coal*, and, perhaps still earlier, *wood* and *burn*. This entrenchment should contribute to that of higher-level species-concepts such as "element of the periodic table", which will then percolate to Seaborgium and other such problematic concepts. While *FFF* does not treat of mathematics, the nominalist-inductivist position here is of long standing: mathematical propositions are highly purified empirical propositions, whose pragmatic value derives from their use in the empirical sciences. Considered on their own, they have the status of dictionary definitions (conventionalism) or are simply imprecise, because oversimplified, physical sciences.

We can diagnose the problem with reference to its historical origin, and the entrenchment of that view. When Sydenham and Locke denied explanatory value to anatomy, they committed themselves to diagnoses based on correlations between observables on the *surface* of the organism, while denying any importance to its internal mechanisms. That same conviction, applied in physics, leads to the doctrine that one should not speculate concerning the nature of *forces*, for these are fully describable with reference to their kinematic effects. But each time causes, microstructure and mathematics are called into doubt, something must be introduced into the nominalist theory to replace them, in the same way that utility replaced truth. At the limit, one attempts to explain the economy and utility of laws of nature by claiming that *systematization* allows us "to doe something either better or in a shorter and easier way".

But no one actually *believes* that this is why we have a periodic table, or that atoms are fictions, except of course the pragmatists themselves. Since the pragmatist holds that "real" means at best "entrenched", he must respond to this fact: Doesn't the entrenchment of this realist conviction, or for that matter the

Platonist conviction of mathematicians that their abstract objects exist, have equal claim to validity as does the proposal of the pragmatist himself? That is to say, once it is conceded, on pragmatic grounds, that realism and Platonism are heuristically useful fictions, and that utility is the only criterion of reality that matters, why not *prefer* them to the nominalist's story, which makes no stronger claim for *itself* than to be a useful fiction?

Goodman's failure is, from this point of view, the formal correlate of a systematic problem. Utility *can't* provide the criteria we need to understand theoretical science, because the problem with Seaborgium is general. Our economic interests are much less finely-grained than our theoretical knowledge. It is therefore not possible to explain the surplus detail of mathematical and natural scientific reasoning without either trivializing the latter, or suggesting that mathematicians and scientists are gravely deluded concerning their own ontological and methodological commitments. We see this failure in much recent pragmatically driven HPS, when it is suggested that the emergence of Einstein's theories can and should be explained with reference to railroad time in the 19th c. No one seriously attempts this with mathematics any longer, which is one reason that Anglo-American history of mathematics is dying out.

The worry is that, in the case of mathematics, pragmatism has been *empirically* falsified – it is simply not the case that the grounds of mathematical justification lie in empirical science, not even in the case of applied mathematics. When we visit their department, we find mathematicians justifying by means of apodictic proof. It does no good to respond that (some of) this mathematics may eventually be applied by empirical scientists, nor even that mathematicians now make use of computer assistance in generating some of their proofs. For in neither case is the standard of validity the practitioners observe empirical and inductive. Should the pragmatist concede this, all while arguing that the mathematicians will enjoy more "success" if they adopt such standards instead of the ones they use in fact, then that is a *normative proposal*, and not an induction on past observations,[26] for the history of the field suggests the exact opposite.[27]

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[26] One should carefully distinguish between the claim that *mathematicians would enjoy greater success if they collaborated with empirical scientists* and the far stronger claim being rejected: that *they would enjoy greater success if they followed empirical and inductive methods within mathematics itself*. It is characteristic of the tradition being discussed to fall back on the first sort of claim, which most people would accept, when challenged on the second, radical claim that is the real content of their theory.

[27] To take just two examples among many: the long and intricate development of Riemannian geometry took place in the absence of any pragmatic need from the physical side; mathematicians such as Hilbert, who laid enormous emphasis on connecting work in mathematics to the needs and aims of physical science, always viewed their contribution as *foundational*. In axiomatizing scientific

In the case of the philosophy of the empirical sciences, the original connection between pragmatism and religious faith has reasserted itself: nominalist arguments such as those of Fodor are now being used to undermine the foundations of evolutionary biology. Our short historical epistemology of "historical epistemology" show us why and how this is possible. The first use to which Locke and Sydenham put their empiricist philosophy – the rejection of physiological and anatomical *explanations* of disease – was, from the beginning, a rejection of causal explanations in biology. It should not come as a surprise that it has exactly the same consequences today.

13. *Projecting "historical epistemology"*

The successful, because formally irrefutable, part of *FFF* is a demonstration that unconstrained nominalism leads to the result that all (non-falsified) hypotheses are equally credible, in other words that an extensionalist theory of induction is impossible. Since induction was to be the *only* means of generating general knowledge for Quine, including mathematical knowledge, this result is terminal. But Goodman also does not succeed in answering his New Riddle, at least not on terms that he can accept. Since he has strong reasons for doubting that causal relations and natural kinds, should they in fact exist, could be *known* otherwise than by induction on actual past observations, he agrees with Quine in rejecting all realist solutions as non-responsive, and extends this ban to *possibilia*. In consequence, the indisputable scientific role of such concepts and forms of reasoning requires a substitute, and this must be constructed within linguistics. If we set aside the significant obstacles to carrying out this programme positively, we get an influential *negative* doctrine. There is no such thing as *neutral* inductive verification: in every induction, thus in all empirical science, historical factors intervene in the form of our inherited conceptual scheme. In studying the history of these schemes, we do "historical" epistemology.

Goodman himself acknowledges that this result is in part a Kantian one, and we can now see why. Like others in this tradition, such as Husserl, he ascribes an essential cognitive role to a *prior* scheme, and since he is an empiricist epistemologist, this priority is temporal *only*. The epistemologists who follow in this tradition – above all Kuhn and Hacking – are therefore *historical* epistemologists. By identifying the paradigms, disciplinary matrices and

theories, we aim to isolate and clearly distinguish the empirical and "synthetic" parts of a theory from its logico-mathematical presuppositions. Maybe Hilbert was wrong to think that way, but it is a matter of fact that he did, and it can scarcely be denied that his "programme" was one of the most fruitful projects of our recent mathematical past.

styles of past scientists, we are not *merely* telling factual history; rather, we are inquiring into the conceptual presuppositions of our present, and therefore also sketching in our future. In opposition to thinkers in the French and German traditions, the "conceptual schemes" of pragmatists and naturalists are historical facts, but this difference is less than it might appear. For while thinkers such as Canguilhem roundly criticized Kuhn on just this point, he could not articulate his objection in terms that anyone working in that tradition would accept or understand. While Goodman had himself already put his finger on the key problem: counterfactual conditionals and *possibilia*, which, like a bump in the rug, stubbornly resist being smoothed away. This is why, slowly but surely, younger philosophers have moved towards variants of metaphysical realism.

For, as should now be clear, the *function* of conceptual schemes within the nominalist-empiricist tradition is much the same as it is in transcendental versions, and indeed within metaphysical realism. As the nominalist reconstructs the concepts of the sciences, he embeds them within a socio-linguistic structure – we saw how Goodman replaced the concept of a natural kind with that of linguistic entrenchment, which can now function as the *explanans* of statements such as "this stone would have been green even if I hadn't examined it." Given that entrenched predicates have a good – which simply means "long and successful" – epistemological history of projection, it is natural that speakers would say things like this, for a *habit* has formed in them, or in their ancestors. Nor should we be worried if they express this fact poetically, in terms of realism, claiming that "green is a property, and no mere predicate, and things have their properties whether or not we examine them." For this is just a complex way of expressing the deep entrenchment of the term. If one objects that this entrenchment itself is better explained with reference to the causal powers of natural kinds, the nominalist will respond with a *fact*: those natural kind concepts have worked well in the past, and this history has left a trace in us, or in our ancestors. This habit, which is perhaps by now entrenched in our neurology, is all we need to explain our current preference for them. Such an explanation is supposed to be *natural-scientific*, uncontaminated by metaphysical, or foundationalist superstitions. But is it be "epistemology"?

I think that we must answer in the negative. For, little has changed since Chomsky's devastating critique of linguistic behaviourism. Concepts such as "logical inference", "true", "justified" and "belief" are unquestionably part of the justificatory practice of empirical scientists, and the disciplines that study them have long been called "epistemology". It is entirely possible to study the users of that framework empirically, just as it is possible to observe

the brain of a logician who is executing a proof. But there are bad scientists, and poor logicians – choices will have to be made by the researchers regarding whose brains, and which neural processes are to count as good ones.[28] The psychologist does not have to make that distinction, until he claims that he is doing epistemology – then he owes us such a definition. And here it does no good to be told that the good ones are the ones that lead to more utility. For this is, when all is said and done, exactly as helpful as being told that the best investment strategies are the ones that lead to the highest returns, or that the best shoes are the ones that are most durable and comfortable. The craftsman knows this already, and still it tells him next to nothing about *how to make good shoes.*

When it comes to *historical* epistemology, the situation is fundamentally no different. The normative versions all involve a transcendental residue: *epistémès*, historical a prioris. Their naturalized cousins contain naturalized copies of these: disciplinary matrices, paradigms, language-games, styles. The first type of theory is vulnerable because it cannot explain the ontological status of these transcendental residues. The second avoids that problem precisely because the structures in question are naturalized; however, for that very reason, they have no normative force. The nominalist-inductivists themselves have already clearly shown us why. On their own account, such investigations say nothing definite about what *should* happen after time *t*. And while it remains true that now, at *t*, we do have certain *inclinations* about how to proceed, that was also never in doubt. The problem is that different people have different inclinations, just as methods that have worked well in the past often do not do so going forward. In consequence, while our history has much to teach us here, we can project its lessons on the future only to the extent that we have analyzed it normatively to begin with.

David Hyder
dhyder@uottawa.ca
University of Ottawa

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[28]   Put simply, the question whether the logician's proof is *valid* cannot be answered by studying her brain, nor by examining the history of logic. This does not mean that such examinations are without interest or utility, merely that they do not and cannot on their own provide an answer to the *logician's* question. See Kim 1988: 391ff., as well as footnote 26 of this paper.

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