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# Natural Kinds and Naturalised Kantianism

MICHELA MASSIMI

University of Edinburgh

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## 1. Introduction

Metaphysical debates about natural kinds have never lost their appeal. What metaphysics of nature licenses the most promising account of kinds? How to reconcile natural kinds with the apparent historical contingency and interest-relative nature of our taxonomic classifications? And how to make room for contingency without jeopardising natural kinds' ability to support inductive inferences? It is this distinctive feature of natural kinds, namely their ability to support inductive inferences, the focus of the present paper.

That natural kinds support (or are expected to support) inductive inferences, is widely acknowledged among various philosophical quarters.<sup>1</sup> Inductive inferences are normally understood in this context as *projections* from examined to (past, present, and future) unexamined cases, following a distinguished pedigree that goes back to Goodman and Quine.<sup>2</sup> Realism has traditionally had the upper hand in the explanation of our epistemic achievements. If natural kinds are understood in a realist's sense as 'carving nature at its joints', an explanation is easily available for why our inductive inferences about them have an unfailing tendency to succeed. In turn, success in inductive projections is regarded as truth-conducive about the ontology of nature.

Unearthing the mechanism that can bridge the gap between what we *ought to believe* there is (to the best of our knowledge) and what there *is*, is the topic of the present paper. The strategy here adopted is to combine Quinean naturalism with a suitable version of Kantianism able to deliver a mild form of realism about kinds, which can resist the charge of constructivism whilst also bearing the epistemic weight of inductive projections.

Quine's naturalism set a new agenda for engaging with ontology: questions about what we ought to believe there is should be deferred to and ultimately answered from within the vantage point of our best scientific theories.<sup>3</sup> Natural kinds become the scientific, discipline-specific outcomes of our "innate subjective spacing of qualities".<sup>4</sup> In the name of naturalism, induction reduces to "animal expectation or habit formation", and the problem of induction becomes the problem of explaining "how we, as we now are (by our present scientific lights), in a world we never made, should stand better than random or coin-tossing chances of coming out right when we predict by inductions which are based on our innate, scientifically unjustified similarity standard."<sup>5</sup> The question remains as to how our innate, pre-scientific similarity standards could eventually evolve into the theoretical similarity standards that proved favourable to inductions, and became 'entrenched' in our kinds.

Naturalism is common currency in realist quarters, whereby the aforementioned question finds its answer and ultimately dissolves into the question of how science models reality so successfully. Among the many versions of realism, the brand aptly called by Boyd 'realist accommodationism' has provided the most robust naturalistic account of kinds and their inductive projectibility over the past two decades. It has also mounted a series of challenges against

alternative accounts of natural kinds and their inductive projectibility, of both empiricist and Kantian origins. In the case of Kantianism, my topic here, two main challenges have been raised.

The first sees the Kantian as illegitimately borrowing key tools from the realist's arsenal to explain inductive projectibility. Natural kinds support inductive projections only to the extent that some suitable version of realist accommodationism is met. Kantians ought to claim that *in some way* we do have epistemic access to the *causal mechanism* underpinning how natural kinds terms (and what is predicated of them within a disciplinary matrix) are *true* of things in a mind-independent world. For inductive projectibility to be retrievable, Kantians must allow for more realism than they are willing to concede.

The second prominent challenge turns on its head the aforementioned surreptitious appeal to a mind-independent ontology in retrieving inductive projectibility. For Kantianism seems to belong to a peculiar breed of anti-realism, namely 'constructivism', in assuming that our mind or conceptual capacities make *some* contribution to the causal structure of the objects under investigation.

In what follows, I propose a naturalised version of Kantianism that can meet both challenges, and deliver a mild form of realism about kinds and their inductive projectibility, equidistant from realist accommodationism and constructivism. Naturalised Kantianism becomes then an inquiry into naturalised ontology that does not take our theoretical framework (and its epistemic success) as a given, but questions instead how it was possible for our pre-scientific "animal habit formation" to evolve into the successful science we have. Naturalism will provide the rock-bottom ground to anchor Kantianism to, while Kantianism will dovetail Quinean naturalism by resorting to transcendental arguments to answer the question as to how our innate pre-scientific similarity standards could evolve into the theoretical kinds we know and love.

If transcendental arguments ultimately license the conclusion that we ought to believe there is a causal structure in nature underpinning the projectibility of our kinds, so be it. But at least a Kantian would have secured an explanation of our epistemic achievements that is neither parasitic upon realist accommodationism, nor does it land Kantianism in constructivist moorlands. Or so I shall argue.<sup>6</sup>

## 2. Natural kinds and Naturalised Kantianism

Debates about natural kinds are often regarded as belonging to the province of metaphysicians. The far-reaching appeal of Richard Boyd's homeostatic property cluster kinds over the past twenty years or so lies in its ability to defuse such prejudice by advancing a view of kinds that is unfailingly realist *and*, at the same time, sensitive to the interest-relative nature of our taxonomic classifications.<sup>7</sup> Boyd's view serendipitously combines what he calls the *accommodation thesis* or "realist accommodationism" with the idea that natural kinds are ultimately the "workmanship of women and men".

The view originates against the backdrop of an empiricist tradition with nominalist roots.<sup>8</sup> It was Locke's advocacy of nominal essences that opened the door to contemporary nominalist views about kinds. Yet, as Boyd notes, there is a deep tension between Locke's nominalist project in metaphysics and his empiricist project of identifying rational principles for induction. If Locke's nominalism were correct, if classification of things into kinds were solely the "the workmanship of the understanding", then any attempt to justify inductive practices would be doomed. Instead, inductive practices demand a realist presumption about natural kinds, without which they would not

be justified. Natural kinds must ‘carve nature at its joints’, for us to be able to identify projectible generalizations. Empiricists and realists would then agree on the necessity of natural kinds for the viability of successful inductive inferences, but they would disagree as to whether natural kinds pick out real causal connections in nature, or simply regular empirical patterns. On Boyd’s view then, natural kinds are licensed by our epistemic achievements: without them, our inductive inferences would stand no better than random guessing.

While our kinds must ultimately accommodate to the “causal structure of the world” for inductive practices to succeed, Boyd acknowledges that natural kinds are the products of our classificatory needs, as suited to the inductive and explanatory purposes of specific disciplines.<sup>9</sup> That natural kinds are *a posteriori* identifiable homeostatic clusters of imperfectly co-occurring properties has proved particularly fruitful to address vexed issues about the nature of species and higher taxa in philosophy of biology.<sup>10</sup>

Without denying the undoubted merits of homeostatic property cluster kinds (HPCK), the view comes under strain in the delicate balancing act between the realist rationale and the interest-relative nature of human classifications. If kinds are ultimately the “workmanship of women and men” and even “social constructions”<sup>11</sup> satisfying the accommodation demands of practitioners within a disciplinary matrix, a thin line seems to separate genuine natural kinds from artificial ones. Take the case of one of the most familiar dinosaurs in the collective imagination. *Brontosaurus* is the dinosaur made famous by the comedy *Bringing up Baby* (where Cary Grant plays the role of the palaeontologist David Huxley reconstructing the skeleton of a Brontosaurus), innumerable baby books and clothes, as well as US Post Office stamp in the October 1989 release in Orlando, Florida. The story goes that the palaeontologist O. C. Marsh gave the wrong name *Brontosaurus* to what is effectively the skeleton of *An Apatosaurus ajax* in 1877–9. The fictitious natural kind term *Brontosaurus* entered common language and people referred (and continue to do so) to *Brontosaurus* and *Apatosaurus* as if they were two distinct genera of the family of sauropods.<sup>12</sup> If homeostatic property cluster kinds are resources for achieving accommodation, *Brontosaurus* could be licensed alongside with *Apatosaurus* as satisfying the accommodation demands of a disciplinary matrix that includes cinematography as well as zoology. Yet brontified paleontology would not fare well on the score of inductive inferences.<sup>13</sup> The problem is not new. But while critics have flagged it to hark back to essentialist views of natural kinds,<sup>14</sup> I am here suggesting that HPCKs fail to deter the worrisome version of constructivism that realists of all stripes fear most, namely social constructivism.

Yet there is something obviously right about Boyd’s malleable, historically contingent, interest-relative HPCKs, as there is something intuitively right about the US Post Office decision not to withdraw the *Brontosaurus* stamp, despite the reaction of the scientific community. I offer here an alternative account of kinds that holds several points in common with Boyd’s, but tries to overcome the tension affecting Boyd’s account by mitigating the constructivist implications inherent HPCKs. The result is a naturalised version of Kantianism about kinds, which brings a humanly touch to the realist dimension of the debate, while also deflating the social constructivist threat.

Naturalised Kantianism takes its cue from the naturalistic intuition—shared also by realists and empiricists alike—that there are clusters of empirical properties, or to echo Quine “functionally relevant groupings in nature”,<sup>15</sup> occasionally manifesting themselves via robust experimental data (i.e., data that have been selected as genuine and not due to background noise or experimental error). There is no mind-dependence or contribution of our conceptual framework at this simple rock-bottom empirical level, if not in the innocuous form that any realist and empiricist would also

accept, namely that our scientific instruments are built according to some principles of the relevant theory in the relevant subject area. Nature takes its toll in the form of robust experimental data.<sup>16</sup>

But a naturalised Kantian would disagree with both realists and empiricists about the ground for the projectibility of natural kinds. Whilst realist accommodationism grounds the projectibility of, say, green emeralds in the *causally sustained* tendency of what is predicated of the natural kind term 'emerald' within a disciplinary matrix to be *true* of things that satisfy a homeostatic cluster of properties defining the kind; empiricists with nominalist roots ground projectibility on the deeply instilled conventionality of our taxonomic labels.<sup>17</sup>

The problem with the realist account is that homeostatic clusters of properties underdetermine the causal mechanism allegedly responsible for successfully predicating something true of natural kind terms (e.g., being 'green' for 'emeralds'). There might be more than one underlying causal structure compatible with the same cluster of empirical properties; nor does appeal to the success of science in identifying it warrant a presumption of natural kinds carving nature at its joints. Nominalism, on the other hand, leaves projectibility on shaky foundations: for if predicating a natural kind term of something hinges ultimately on how instilled our taxonomic conventions are, the wheels of inductive projections may well turn idly.

Naturalised Kantianism is equidistant from realist accommodationism and empiricism with nominalist roots in playing down the realist God's eye access to the causal structure of the world and giving a 'thicker' account of projectibility than empiricism. This 'thicker' account is to be found in the Kantian view that our knowledge concerns "objects of experience" intended as "conceptually determined appearances".<sup>18</sup> Out of Kant's old-fashioned terminology, a naturalised Kantian is committed to the view that natural kinds are clusters of fairly stable empirical properties (as evinced by experimental data) that have been conceptualised so as to make experience of nature possible.<sup>19</sup> Inductive projectibility becomes then the expression of natural kinds' survival-adaptive features, namely their resilience in surviving both changes in the empirical data *and* in the conceptual classifications involved. But, crucially, these conceptual classifications are neither human contributions to the causal structure of nature, nor mirror images of a ready-made world. Instead, they provide us with the conditions of possibility of having comprehensible experience of nature. As such, naturalised Kantianism commends natural kinds as carving nature at its joints without being parasitic upon realist accommodationism or falling back onto fact-constructivism.

But this may sound brisk and epistemologically dubious. The stereotype of the Kantian preaching the unknowability of noumena dangerously looms on the horizon. For the account to be a credible live option, rather than some infamous *Ding-an-sich* caricature, I must unpack the slogan and scrutinise the challenges facing the account.

### **3. Boyd's Realist Accommodationism and the Challenge of Parasitism**

Objections to the Kantian line arise from two distinct fronts, which can conveniently be clustered under Boyd's apt term *realist accommodationism* (RA).<sup>20</sup> This is the view that we accommodate the classificatory and conceptual resources of a disciplinary matrix *M* to the causal structure of the world. It serves two main purposes:

- (i) It gives an account of the reliability of our inductive practices;
- (ii) It supports the metaphysical-innocence of theory-dependent methods.

*Realist accommodationism* acts as a weapon against Kantianism about kinds by showing that

(i.a) Kantianism is ultimately parasitic upon RA to explain the reliability of inductive inferences;

and

(ii.b) Kantianism errs in taking metaphysically too seriously the theory-dependence of scientific methods.

In the rest of this paper, I consider these two charges in turn, starting first with Boyd's positive arguments for theses (i) and (ii).

Thesis (i) follows a well-trodden realist path in appealing to the success of our inductive inferences as truth-conducive about natural kinds. The view is known under various names and is at least as old as the scientific revolution. When in the seventeenth century, Francis Bacon devised his method of tables<sup>21</sup> to find out the nature of phenomena such as heat, he opened the door to the view that induction is the scientific method to investigate into the 'true forms' of phenomena, whose knowledge can in turn be used to foster mankind's progress. On a similar line, the success of Copernican theory in predicting novel phenomena, such as the phases of Venus, despite the Polish overcast sky, became emblematic of a new realist wave, which shook the foundations of religious authority. In more recent times, realism inspired by our epistemic achievements has found other incarnations in Fresnel's prediction of the white spot in optics,<sup>22</sup> and Maxwell's realism about atoms in statistical mechanics.<sup>23</sup> One could try to resist realism by rehearsing a similarly well-trodden antirealist line from the history of science.<sup>24</sup> But listing historical examples one way or another would ultimately prove inconclusive to defend any claim about science's success (or non-success) in tracking nature's kinds.

A more promising line of response is available in philosophical quarters. Nelson Goodman devised it, back in 1947, with what became known as the new riddle of induction.<sup>25</sup> Goodman showed that if we take positive instances (say,  $n$  green emeralds) of a generalization (e.g., "All emeralds are green") as a measure of the success of our inductive inferences (under Nicod's principle), we are vulnerable to an unwelcome branching scenario, whereby the same positive instances, up to a specified time  $t$ , equally support alternative generalizations ("All emeralds are green" and "All emeralds are grue"), licensing in turn incompatible predictions after time  $t$  about the next unobserved instances (e.g., green versus blue emeralds). As Goodman saw the problem, we need a theory of kinds that can explain the difference between 'green' and 'grue' in terms of their respective projectibility and nonprojectibility. Goodman's famous answer to this problem was entrenchment. 'Grue' is not well entrenched as 'green' because it has not been successfully projected as often as 'green', despite being perfectly compatible with the same data. Goodman thought that his theory of projectibility could be used to distinguish more genuine from less genuine kinds, since the entrenchment of a predicate like 'green' involves the entrenchment of the very class of objects captured by it, and hence could be used as a measure of how akin a group of things are.<sup>26</sup>

Following up on Goodman, Quine believed that projectibility is ultimately due to similarity standards, i.e., two green emeralds are more similar than two grue ones if only one of the grue ones were green. But defining similarity proved elusive from a logical point of view, and Quine took it as innate and "part of our animal birthright".<sup>27</sup> Quine's answer to Goodman's problem was a form of Darwinian natural selection, whereby new hypothetical groupings, emerging from a growing theory, prove favourable to induction and become 'entrenched'.

Realists have never been too impressed by the Goodman-Quine challenge. In fact, Boyd's RA seems to be the right antidote against the Goodmanian temptation to concoct non-projectible 'grue'-like predicates. Our inductive practices are reliable to the extent that they allow us to identify projectible generalizations, whereby projectible generalizations are nothing but *causally sustained* generalizations, i.e., generalizations that latch our conceptual resources onto the causal structure of the phenomena at issue.<sup>28</sup> RA supports projectible judgments, and hence the reliability of our inductive inferences, via a two-pronged tool, namely:

1. *the epistemic access condition*

And

2. *the accommodation condition.*

The *epistemic access condition* says that there is a systematic, causally sustained tendency for what is predicated of a natural kind term  $t$  (within a disciplinary matrix  $M$ ) to be approximately true of things that satisfy a cluster of properties  $F_i, i = 1, \dots, n$  defining the kind referred to by  $t$ . The *accommodation condition* adds that this fact (captured by the former condition) causally explains how the use of the term  $t$  in  $M$  contributes to the accommodation of the inferential practices of  $M$  to relevant causal structure.<sup>29</sup>

Equipped with these two conditions, a defender of RA can mount her attack to Kantianism about kinds<sup>30</sup> on the ground that

(i.a) Kantianism is ultimately parasitic upon RA to explain the reliability of inductive inferences.

The parasitism argument runs as follows:

1. If the epistemic access condition (call it EAC) holds, it would causally explain how the use of a natural kind term  $t$  within a disciplinary matrix  $M$  contributes to accommodate the inferential practices of  $M$  to causal structure (*accommodation condition*, call it AC).
2. EAC and AC are jointly necessary and sufficient conditions for *realist accommodationism* (RA).
3. Any philosophical view that aims to give an account of the reliability of our inductive inferences must endorse RA.
4. Hence any philosophical view that aims to give an account of the reliability of our inductive inferences must jointly endorse EAC and AC.
5. Kantianism aims to give an account of the reliability of our inductive inferences.

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Kantianism must jointly endorse EAC and AC

It would seem that for a Kantian to explain the reliability of our inductive inferences, she must commit herself to the view that we accommodate our conceptual resources (as deployed in inferential practices within a disciplinary matrix  $M$ ) to the causal structure of the world. Since AC ultimately depends on EAC holding, let us pause for a moment on EAC. This is a re-enactment of the realist view that we can access the properties of mind-independent natural kinds. For it seems possible to have epistemic access to mind-independent natural kinds via the

successful deployment of the corresponding natural kind terms within a disciplinary matrix. The argument for EAC takes the form of an inference to the best explanation (IBE):

- (I) If a natural kind term  $t_j$  picks out a genuine (i.e., mind-independent) natural kind  $K_j$ ,  $t_j$  can be successfully deployed within a disciplinary matrix  $M$  to refer to a homeostatically stable cluster of properties  $F_j$  defining the kind  $K_j$ .
  - (II) Natural kind terms are usually successfully deployed within a disciplinary matrix  $M$  to refer to homeostatically stable clusters of properties  $F_s$  defining kinds  $K_s$  (with  $s = a, \dots, z$ ).
- 

Therefore, natural kind terms pick out genuine (i.e., mind-independent) natural kinds  $K_s$ , and things, which terms  $t_s$  are predicated of, have (most of) the properties in  $F_s$

Premise (II) captures a powerful semantic assumption, namely that a theory of reference for natural kind terms in science must be a component in the explanation of our epistemic success in induction. This premise is in turn supported by the following argument:

- (A) If there were unobservable structures causally underpinning homeostatic clusters of properties  $F_s$ , this would explain why those properties tend to co-occur in nature.
  - (B) Such unobservable structures are the objects of scientific theories within a disciplinary matrix  $M$ .
  - (C) Successful scientific theorising about unobservable structures gives us reasons for thinking that homeostatically stable clusters of properties  $F_s$  identify genuine (i.e., mind-independent) natural kinds  $K_s$  (with  $s = a, \dots, z$ ).
  - (D) Homeostatically stable clusters of properties  $F_s$  causally fix the reference of the corresponding natural kind terms  $t_s$ .<sup>31</sup>
- 

Natural kind terms are usually successfully deployed within a disciplinary matrix  $M$  to refer to homeostatically stable clusters of properties  $F_s$  defining kinds  $K_s$ .

The successful deployment of natural kind terms to refer to homeostatically stable clusters of properties is then ultimately warranted by successful scientific theorising about their underlying unobservable structures.<sup>32</sup> The charge of parasitism against Kantianism amounts then to the following: for a Kantian to give an account of why inductive inferences are reliable, she must fall back on RA; in particular, she must fall back on EAC, which explains how our successful deployment of natural kind terms within a disciplinary matrix  $M$  is ultimately the product of successful scientific theorising about unobservable causal structures, *pace* any Kantian claim about the epistemic inaccessibility of reality.

#### 4. A Kantian Response to the Challenge of Parasitism

A Kantian may reply to the charge of parasitism (i.a) by pointing out some ambiguities in the



steps (C)–(D) in the argument for the semantic assumption (II) behind EAC. Recall the powerful realist intuition captured by (II): namely, that the accommodation of our inferential practices to the causal structure of the world is explained and warranted by the *successful use* of natural kind terms within a disciplinary matrix  $M$  to refer to homeostatically stable clusters of properties defining mind-independent natural kinds.

One may wonder to what extent this semantic assumption justifies the realist metaphysics of natural kinds, as opposed to the epistemology. Two distinct theses seem to be interwoven in steps (C)–(D) of the aforementioned argument. The first, captured by premise (D), might be called the *semantic realist* thesis: namely, that the reference of natural kind terms  $t_S$  is causally fixed by (and tracks) homeostatically stable clusters of properties  $F_S$ . This thesis is distinct from, nor does it necessarily bring along with it what might be called the *epistemic realist* thesis; namely, that we ought to believe in, say, natural kind  $K_A$  because our scientific theorising about  $K_A$  within a disciplinary matrix  $M$  is supposedly true. In the aforementioned inference-to-the-best-explanation argument for EAC, the semantic assumption (II) is functional to defending the view that we do have epistemic access to mind-independent natural kinds, ultimately secured via our successful scientific theorising about the causal structure underpinning the relevant homeostatic clusters of properties  $F_S$  (as per premise (C))

A Kantian could happily endorse the semantic realist thesis (D), while questioning the epistemic realist thesis (C). For holding a literal construal of the language of science does not entail the further *epistemic* claim that we ought to believe, say, green emeralds as a mind-independent natural kind, because what we predicate of the natural kind term  $t_i$  (e.g., ‘emeralds are green’) within a disciplinary matrix  $M$  is *true* of the *things* that satisfy the cluster of properties  $F_i$ . A Kantian would then hold the semantic realist thesis in common with RA, but would resist the further epistemic realist conclusion that we ought to believe there is a natural kind  $K_A$  because our successful scientific theory about  $K_A$  (including generalizations such as ‘all emeralds are green’) is true.<sup>33</sup>

Suppose  $t_i$  is the term ‘ether’. Consider a scientist working in the early nineteenth century on optical phenomena and noting the existence of a stable pattern of properties  $F_i$ , with  $i = 1, \dots, n$ . For example, given a beam of light going through a diaphragm, the homeostatically stable cluster of properties  $F_i$  might look like the following list:

- (1) When only one slit of the diaphragm is open, a white band appears on the screen behind the diaphragm;
- (2) When two slits are open, a sequence of white and black bands appears on the screen;
  
- (3) When a disk is placed in the direction of the beam, a white spot appears in the center of the dark shadow;
- .....
- ( $n$ .) When lenses are used, the outgoing beam gets polarised so that longitudinal waves cancel out and only transverse waves remain.

The scientist forms the belief that the term ‘ether’ refers to this homeostatically stable cluster of properties  $F_i$  satisfied by a material medium that propagates transverse optical waves at work in diffraction and polarization phenomena. She then predicates  $t_i$  of being ‘luminiferous’, or light-

bearing. Although there seems to be (and it did seem to be) a causally sustained tendency of what is predicated of  $t_j$  to be *true* of the *thing* that satisfies the property cluster  $F_j$ , that *thing* may well be a fictitious entity like the ether. Unless we *know* already that  $t_j$  is a natural kind term, we are in no position of knowing that what we predicate of  $t_j$  is *true of some unobservable thing* within a disciplinary matrix  $M$ . Thus, step (C) of the argument above can only be accepted if one has already endorsed scientific realism; *per se*, it cuts no ice for what we ought to believe there is. The semantic assumption (II) underwrites the realist metaphysics of natural kinds, but not the epistemology. Hence, it cannot warrant our success in inductive inferences concerning  $t_j$  in a disciplinary matrix  $M$ .

This may sound quick. After all, realists would insist that it is our *successful* scientific theorising about unobservable causal structure that gives us reasons for thinking that homeostatically stable clusters of properties  $F_S$  identify genuine (mind-independent) natural kinds  $K_S$ . The burden of the proof lies with step (C) above. It is the success of our scientific theorising about, say, green emeralds, as opposed to the luminiferous ether, which ultimately explains why we take some property clusters as identifying genuine natural kinds, while others do not. One is reminded here of familiar realist strategies for defending this point (from Worrall's structural realism and Kitcher's "working posits" to Leplin's criterion of novelty), which I won't rehearse.<sup>34</sup> Quite reasonably, realists also argue that an induction on the history of science will produce an overwhelmingly positive picture than the over-exploited Fresnel's story seems to suggest.

A worry remains nonetheless. It is a worry about the sweeping adjective 'successful' applied to scientific theorising in premise (C), no matter if it is theorising that distinguishes working posits from idle wheels, or structures from entities. When we say it is our successful scientific theorising about green emeralds that gives us reasons for thinking that homeostatically stable clusters of properties  $F_S$  identify genuine natural kinds  $K_S$ , what do we mean by 'successful'?

We can possibly mean two distinct things. Either we mean theorising about unobservable causal structures that can account for all the available data and seem to be inductively confirmed by all positive instances we have available as of today (let us call this minimal definition 'successful'<sub>MIN</sub>—it captures the successful past track record of scientific theorising about unobservable structures). Or, we mean scientific theorising that *not only* is compatible with all the available data *but can also* be used to make novel predictions about future unobserved cases (let us call this maximal definition ('successful'<sub>MAX</sub>—it captures the expected successful future performance of scientific theorising). The minimal definition runs into Goodman's paradox; the maximal definition begs the question against it.

All we can legitimately mean when we say that we have been successfully theorising about green emeralds is that current mineralogy has been inductively confirmed by all positive instances available as of today 'successful'<sub>MIN</sub>). We cannot legitimately mean that it is successful because it can be used to make reliable predictions about future unobserved cases ('successful'<sub>MAX</sub>), *unless* we know already that the instantiation of the antecedent 'emerald' *causes* the instantiation of the consequent 'green', but not the instantiation of the consequent 'blue' (as for 'grue'). But this is exactly the sort of causal knowledge that—following Goodman's new riddle of induction—is at stake in inductive generalizations. Knowing the cause-effect relation is precisely what is required to guarantee that our inductive inference "All emeralds are green" is successful to make reliable

predictions about future unobserved cases ('successful' MAX).<sup>35</sup>

Although realists may be right in inferring from a homeostatically stable property cluster to an unobservable causal structure, the latter is neither God-given nor hard-wired in our brain. In a Goodmanian hypothetical scenario, we might have developed a gruified mineralogy that would still have been 'successful' MIN and licensed an inference from the same homeostatically stable property cluster to an alternative unobservable causal structure.<sup>36</sup> The success of current mineralogy in licensing the reality of green emeralds has to be understood as a reflection on the successful past track record of our mineralogy so far. In sum, appeal to successful scientific theorising about unobservable causal structure does not license a realist presumption of natural kinds 'carving nature at its joints' in a Goodman-non-question-begging way, *pace* premise (C).

## 5. Naturalised Kantianism and the Reliability of Inductive Inferences

Let us take stock. Kantianism is levelled with the charge of being ultimately parasitic on realist accommodationism (RA) to explain the reliability of inductive inferences. I have foreshadowed two possible responses, which question the soundness of the parasitism argument. The burden of the proof lies with the epistemic access condition (EAC), whereby our epistemic access to genuine (mind-independent) natural kinds is chaperoned by the successful deployment of natural kind terms within a disciplinary matrix *M*. First, I questioned the extent to which the semantic realist thesis (D) *per se* licenses realist epistemological conclusions about what we ought to believe there is. Second, I raised doubts about the appeal to successful scientific theorising on causal structure as a way of delivering a Goodman-non-question-begging realist presumption about natural kinds.

In this Section, I show that there is a defensible way for a Kantian to explain the reliability of inductive inferences without being parasitic upon RA. At the heart of the Kantian strategy is the idea that we cannot fathom properties of mind-independent natural kinds. But this epistemic inaccessibility that Kantians share with constructive empiricists alike does not prevent the former, anymore than the latter, from having an account of our epistemic achievements. Moreover, this account proves to be compatible with Quinean naturalism as the view that ontological questions should be answered from within natural science, and in continuity with it. Hence the strategy that gives this paper its title: *naturalised Kantianism*.

Epistemic achievements, first. That our inductive inferences prove on average correct, our generalizations projectible, and our natural kind terms successfully deployed within a disciplinary matrix *M* should not come as a surprise. They are, after all, the product of a long natural selection process, where many of their non-projectible competitors were entertained, and discarded.<sup>37</sup> Success in inductive projections is a matter of trial-and-error. Our extant inductive projections have proved survival-adaptive. No pre-determined, carvable nature's joints are responsible for our epistemic achievements. The projectibility of our natural kinds is ultimately the product of their survival-adaptive features over millennia.

Fallibilism is not excluded, however. As new kinds come to existence, old ones become extinct.<sup>38</sup> Successful inductive projections of yesterday may become obsolete, or prove favourable to novel kinds. Fresnel's successful projections about optical diffraction proved in the end favourable to Maxwell's electromagnetic waves, rather than the luminiferous ether. A Kantian can thus be true to historical records about innumerable examples of discarded kinds, without being either revisionist about our epistemic achievements or unpalatably Whiggish all along.<sup>39</sup>

A classical objection to the Darwinian account comes to the fore. What makes our projectible kinds survival-adaptive, while the non-projectible ones undergo extinction? It is one thing to assert that projectible kinds get selected. It is quite another thing to explain why kind  $K_b$  instead of kind  $K_d$  has what it gets to be selected as projectible. Realists have an easy answer to this question: unobservable causal structures.<sup>40</sup> If homeostatically stable clusters of properties latch onto causal structures of the world, it is no wonder that they prove resilient to natural selection and become our projectible kinds. But a Kantian seems to be at loss in explaining what makes some kinds projectible over others. If epistemic access to unobservable causal structures via successful scientific theorising is not an option, what underpins the projectibility of our survival-adaptive kinds?

I suggest a twofold strategy for a defence of the Darwinian argument about the projectibility of our natural kinds. Their survival-adaptive features are ultimately down to stable clusters of *empirical* properties that (a) have proved experimentally robust, and (b) have survived the historical evolution of our conceptual taxonomies to make comprehensible experience of nature possible. Clusters that prove experimentally robust *and* conceptually resilient become “entrenched”. Our projectible kinds latch onto stable empirical clusters evinced by robust experimental data, i.e., observable records of occurrences that cannot be ascribed to error or background noise.<sup>41</sup> From the pre-scientific ability of children to cluster objects with same empirical properties (pears with pears, apples with apples), to the mineralogist’s ability to cluster minerals, it is our human ability to identify and track recognisable patterns of empirical properties in nature that gave us the upper hand in the evolutionary gamble. Peaks in magnetometers, sparks in scintillation counters, bubble trails in cloud chambers that have proved genuine (i.e., not due to background noise or experimental error) are the sophisticated scientific counterpart of children and laymen’s pre-scientific clustering ability.

How stable clusters of empirical properties could have become our natural kinds, especially the most exotic kinds envisaged by contemporary physics, biochemistry and genetics, is a question ultimately for scientific practitioners. I suspect one would need to tell a very detailed, discipline-specific and context-specific story about how stable clusters evinced by robust data became part of data models, and how new kinds of objects were identified in the process of producing such data models, and saved by devising suitable theoretical models.<sup>42</sup>

What matters for our purpose here is that an explanation of our epistemic achievements needs not fall back onto realist accommodationism. Natural kinds need not be accommodated to causal structures of the world, for them to be projectible. An explanation of our kinds’ projectibility can instead be given within the modest remit of a Kantian stance on stable clusters of empirical properties that get selected for their experimental robustness and their resilience to conceptual changes within a given theoretical framework. Hence, a Kantian can avail herself of this view to answer the question as to why ‘green emeralds’ have proved survival-adaptive over ‘gruified’ ones.

Of course, there are important analogies with Boyd’s realist accommodationism here: first, in the idea that kinds are stable clusters of properties, and second, in the key intuition that our kinds reflect the historical evolution of our conceptual classifications. But there are also significant disanalogies. First and foremost, from the perspective here canvassed, no appeal is made to accommodation to causal structures of the world, which instead plays a central role in realist accommodationism. The Kantian adage that we cannot fathom properties of a mind-independent world is thus vindicated, without any *Ding-an-sich*-mongering.

I promised to address two points in this Section: namely, to give an account of our epistemic achievements non-parasitic upon RA, and to show that such an account is compatible with Quine's naturalism. Back to Quinean naturalism now. For Quine, the problem of induction reduced to the problem of explaining how "our innate subjective spacing of qualities accord so well with the functionally relevant groupings in nature".<sup>43</sup> His answer to this question was that we revise our innate similarity standards on the strength of second-order induction. More importantly, Quine held that the innate, pre-scientific similarity standards would eventually dissolve in fragmentary discipline-specific theoretical similarity standards (be they the classification of chemical elements in terms of atomic number, or the classification of animals in clades) to finally accomplish "the evolution of unreason into science".<sup>44</sup>

In what respect is the Kantian position here canvassed in line with Quine's naturalism? The answer lies in the naturalised ontology of kinds emerging from it. What Quine portrayed as innate "subjective spacing of qualities" finds its counterpart in Kant's pre-conditions of possibility of experience, namely space and time.<sup>45</sup> Without harking back to discarded modes of thought about space and time as a priori forms of intuition, the burden is on contemporary cognitive neuroscience to elucidate the modalities through which we, as higher vertebrates, successfully adapted to the environment and came to develop a distinctive spatiotemporal cognitive ability to find our way around nature and identify functionally relevant clusters of properties in it. On a positive note, important work has been done over the past thirty years in cognitive neuroscience suggesting the validity of a loosely Kantian view of spatial representation in vertebrates as an efficient survival mechanism in the evolutionary gamble.<sup>46</sup>

Functionally relevant clusters of empirical properties have survived natural selection in allowing higher vertebrates to encounter a goal object (say, food, water, prey, predator, burrow, etc.) and be able to store the location in an incentive location store, which can be activated by the animal motivation system<sup>47</sup> next time it found itself hungry, thirsty, hunting, hunted, sick, and so on. Few millennia later in the evolutionary tree of life, our kinds have survived selection in empowering us with a sophisticated knowledge of nature. *How* stable clusters of empirical properties have proved resilient to the historical evolution of our discipline-specific conceptual taxonomies is, ultimately, a question for historians of science and historical epistemologists to address.<sup>48</sup> *That* they have proved so resilient is a fact, for which a Kantian explanation is available, without the need of resurrecting either a priori forms of intuition or categories of the understanding, as I shall clarify in Section 7.<sup>49</sup> Projectibility is overall explainable from within a metaphysically deflationist view that does not resort to causal accommodation between the structures of the world and our kind terms and concepts.

Yet a more serious threat looms at large. After all, realists too can live with the historical contingency and interest-relative nature of our kinds. By contrast with Kantians, though, realists would insist that the presence of a causally sustained tendency anchoring our natural kind terms to causal structures in the world prevents kinds from being dependent on *us*. No wonder Quinean naturalism has traditionally served the purpose of realist mind-independence: namely, to explain how we "in a world we never made, should stand better than random or coin-tossing chances of coming out right when we predict by induction". It is this worrisome threat of mind-dependence that we must address next.

## 6. Boyd's 2N2C Thesis and the Challenge of Constructivism

The heart of the debate between realists and Kantians verges on the mind- independence or dependence of natural kinds. Recall that one of the functions of realist accommodationism was to

(ii) support the metaphysical-innocence of theory-dependent methods,

and hence to accuse

(ii.b) Kantianism of erring in taking metaphysically too seriously theory-dependence of scientific methods.

That Kantianism is tantamount to a form of constructivism is usually assumed in this literature without further question. Part of the confusion surrounding Kantianism as a form of constructivism is due to some of its proponents and advocates. The late Kuhn was primarily responsible for some persistent confusion on this delicate issue, because he described his view as a form of post-Darwinian Kantianism.<sup>50</sup> Boyd sees the association with constructivism justified by a key neo-Kantian epistemological argument, which from the theory-dependence of scientific methods concludes that the reality investigated by science is partly constituted by the theoretical tradition within which scientific research occurs.<sup>51</sup> While acknowledging that our scientific methods are infected by the theoretical framework scientists happen to work with, realists see theory-dependent methods as metaphysically innocuous, and if anything, as guarantors of, rather than obstacles to knowledge of a theory-independent reality.<sup>52</sup> Theory-dependent methods would guarantee epistemically relevant contact between our inferential practices and the causal structures of the phenomena under study.

Hence, realist accommodationists and Kantian constructivists diverge as to the metaphysical import of theory-dependent methods. The former affirm, whereas the latter deny the *No Noncausal Contribution Thesis* (2N2C): the thesis that human social practices make no noncausal contribution to the causal structures of the phenomena under study.<sup>53</sup> 2N2C captures point (ii) above, namely the metaphysical-innocence of theory-dependent methods supported by RA. Let us take a closer look at it.

The 2N2C thesis summarises a bundle of powerful realist assumptions. This bundle of assumptions, which includes the previously discussed epistemic access condition (EAC) and accommodation condition (AC), jointly reinforces the metaphysical conclusion about the mind-independence of natural kinds:

- (a) There is a causally sustained tendency of what is predicated of a natural kind term  $t_j$  within a disciplinary matrix  $M$  to be true of things that satisfy a cluster of properties defining the kind  $K_j$  (EAC).
- (b) This fact causally explains how the use of  $t_j$  in  $M$  contributes to accommodating inferential practices to causal structure (AC).
- (c) The relevant epistemic contact between inferential practices of  $M$  concerning  $t_j$  and causal structure is warranted by scientific methods.
- (d) Scientific methods are theory-dependent.

(e) Given (a) and (b), the object  $t_j$  refers to, and the kind  $K_j$  the object belongs to, are part of the causal structure of the world and they would exist independently of the theory governing the methodology of the disciplinary matrix  $M$ .

(f) Given (b), (c), and (d), accommodating inferential practices concerning  $t_j$  to causal structure—via theory-dependent methods—preserves causal structure.

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#### RA licenses mind-independent natural kinds

A clarification is in order. Realist accommodationism is in fact committed to the view that in a sense, natural kinds are ‘social constructions’ so long as they are the kinds suitable to the inductive and explanatory demands of practitioners within a disciplinary matrix  $M$ . Yet, the metaphysical-innocence of theory-dependent methods captured by 2N2C implies that accommodation is one-way street. We accommodate inferential practices to causal structure, *not vice versa*. Hence, the mind-independence of natural kinds.

Building up on the aforementioned charge of parasitism concerning points (a) and (b) above, a realist accommodationist can mount a further attack on Kantianism, this time equated with a form of constructivism. Kantians are accused of going astray in some metaphysical considerations surrounding points (d)–(f) above. From the theory-dependence of methods (d), a Kantian would seem to deduce the mind-dependence of natural kinds by rejecting (e), i.e., that the object the term  $t_j$  refers to, and the kind  $K_j$  the object belongs to would exist independently of the theory governing scientific methodology, and by rejecting also (f), i.e., that accommodation is one-way street.

Kantianism is ultimately accused of denying that the relationship between terms and objects, inductive inferences and kinds, is causally sustained, and, hence that in some important sense natural kinds suitable for induction are mind-independent. But from the RA standpoint, the mind-dependence Kantianism is charged with should not be conflated with some form of Berkeleyan idealism. What is at stake is *not* the claim that the objects terms refer to, and the kinds they belong to, would not exist unless someone were around to observe or interact with them.<sup>54</sup> Instead, at stake is the more subtle claim that the objects terms refer to, and the kinds they belong to, are *causally influenced* by the theory governing scientific methodology within a disciplinary matrix  $M$ .

How should we understand the latter claim? The simplest way of understanding it is as a sheer methodological claim: natural kinds  $K_S$  are dependent upon the scientific theory that enters in the methods employed to empirically test and eventually confirm inductive projections about  $K_S$ . Theory-dependence of kinds would then amount to a methodological claim about how scientific hypotheses about  $K_S$  are introduced and inductive projections tested in the light of theory-laden evidence.<sup>55</sup>

But understood this way, theory-dependence is a fairly innocuous claim, shared by realists and empiricists alike.<sup>56</sup> Indeed, it sums up Boyd’s metaphysical innocence of theory-dependent methods, with its emphasis on the role of background theories in inductive projections.<sup>57</sup> For the charge of constructivism to have a bite on Kantianism, premise (d) on theory-dependent methods must be construed as a *semantic claim*. Two options are available:

- (d.1) The theory-dependence of scientific methods implies description-dependence of kinds.
- (d.2) The theory-dependence of scientific methods implies paradigm-dependence of kinds.

Both are semantic claims about how kinds hook up to our scientific language and the latter in turn shapes the ontology of nature. Let us consider how each, in turn, can be used to argue for Kantianism as a form of constructivism.

Under (d.1), we find a family of views, in increasing order of strength. In its weakest form, (d.1) says that natural kinds  $K_S$  are dependent upon a particular *description* given by a scientific language. Hanson, for example, defended the view that facts are “somehow moulded by the logical forms of the fact-stating language”.<sup>58</sup> He gave the example of Galileo, who in 1638 in *Two New Sciences* introduced the concept of constant acceleration for free falling bodies in the absence of a proper language to express this concept.<sup>59</sup> Next in order of strength under (d.1), we find Putnam’s conceptual relativity as the view that there is no fact of the matter that can decide which one of alternative conceptual schemes is true.<sup>60</sup> The most radical version of (d.1) is Goodman’s, whereby the incompatibility of, say, description  $P$  and not- $P$  (e.g., the geocentric and the heliocentric system) is resolved by assuming radical relativism and a plurality of ways of world-making.<sup>61</sup>

Regardless of which of these three variants is chosen, (d.1) serves the function of a hidden lemma in the charge of constructivism levelled against Kantianism. Kantians would be committed to the following argument from the theory-dependence of scientific methods:

- (d) Scientific methods are theory-dependent.
  - (d.1) The theory-dependence of scientific methods implies description-dependence of kinds.
- (e) The object  $t_j$  refers to, and the kind  $K_j$  the object belongs to, although part of the causal structure of the world, do not exist independently of the description proffered by the theory governing the methodology of the disciplinary matrix  $M$ .
- (f) Accommodating inferential practices concerning  $t_j$  to causal structure—via theory-dependent methods—implies cutting the worldly dough according to different, and even incompatible, ‘cookie-cutter’ descriptions.

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Kantianism licenses mind-dependent<sub>1</sub> natural kinds

Turning to (d.2), this is the stronger claim that natural kinds  $K_S$  are dependent upon the scientific paradigm endorsed by a given community at a given time, whereby a paradigm goes beyond the mere language of a scientific theory in including a system of values, the experimental set-ups, and technological devices relevant to the theory. This view was famously championed by Thomas Kuhn, with the contentious claim that “though the world does not change with a change of paradigm, the scientist afterward works in a different world”.<sup>62</sup> Experimental data cannot provide a hook to mind-independent reality because operations and measurements are themselves paradigm-dependent. Moreover, different paradigms display different conceptual resources that make possible for scientists (before and after a scientific



revolution) to see the world differently.<sup>63</sup> Thus, under the Kuhnian account, kinds are dependent on the broader scientific paradigm of a given community at a given time. Also in this case, (d.2) functions as a hidden lemma in the argument that from the theory-dependence of scientific methods would lead Kantians to embrace a Kuhnian version of constructivism:

(d) Scientific methods are theory-dependent.

(d.2) The theory-dependence of scientific methods implies paradigm-dependence of kinds.

(e) The object  $t_j$  refers to, and the kind  $K_j$  the object belongs to, although part of the causal structure of the world, do not exist independently of the paradigm, which the theory governing scientific methods belong to.

(f) Accommodating inferential practices concerning  $t_j$  to causal structure—via theory-dependent methods—implies casting the worldly dough into different incommensurable paradigms.

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Kantianism licenses mind-dependent<sub>2</sub> natural kinds

These are the considerations that have led realists such as Boyd to identify Kantianism with versions of constructivism, variously associated with the names of Hanson, Putnam, Goodman or Kuhn. That our kinds are “constructed” or “constituted” by the theoretical tradition to which we belong, that different conceptual schemes bring along with them alternative “worlds”, and similar claims, have all become familiar in the philosophical literature and among science studies.<sup>64</sup> The burden is on the Kantian to prove that she can defend theory-dependence of methods without falling prey of constructivism.

## 7. A Kantian Response to the Challenge of Constructivism

Can a Kantian eschew the Charybdis of description-dependence and the Scylla of paradigm-dependence? Some Kantians might happily endorse (d.1) or (d.2), and the ensuing mind-dependence<sub>1or2</sub> they respectively license. But I endeavour to show that there is a better way of understanding theory-dependence of methods that whilst still licensing mind-dependent kinds, it would do so more in line with the Kantian doctrine, and without conflating Kantianism with constructivism *tout court*. This alternative way of thinking about theory-dependence of methods is not tantamount to “constructing” kinds or conceptually cookie-cutting the worldly dough. The core strategy beneath it is, once again, a form of naturalised Kantianism.<sup>65</sup>

As we saw earlier, naturalised Kantianism encompasses the Kantian insight about our knowledge being confined to objects of experience intended as conceptualised appearances<sup>66</sup> with the Quinean stance about kinds as functionally relevant grouping in nature adopted on the basis of their survival-adaptive features. Whilst the Quinean stance guarantees that our kinds are not free-standing but latch onto stable empirical patterns in nature, the Kantian transcendental stance, on the other hand, secures a distinctive role for concepts as neither logical forms of fact-stating language, nor conceptual schemes, or Kuhnian paradigms. What is this distinctive role for concepts? On a genuinely Kantian account, premise (d) on theory-dependent methods must be construed as an *epistemic (as opposed to semantic) claim*:

(d.3) The theory-dependence of scientific methods implies experience-dependence of kinds.

Under this account, natural kinds are mind-dependent<sub>3</sub> in an epistemic sense: namely, they are dependent on our conditions of possibility of having a comprehensible experience of nature. Mind-dependence<sub>3</sub> is not a claim about how natural kinds hook up to our scientific language (hence Kantianism should not be confused with Hanson–Putnam conceptual relativity, or with Kuhn’s incommensurability). Instead, mind-dependence<sub>3</sub> is a claim about how natural kinds ought to be for them to be experienceable for us. For natural kinds to be experienceable, appearances (loosely intended in the aforementioned Kantian sense as unconceptualised spatio-temporal objects—or, to use a different terminology, as the one suggested in Section 2, stable clusters of empirical properties evinced by experimental data) must be subsumed under scientific concepts (e.g., force, mass, momentum, etc.).<sup>67</sup> Crucially, these concepts should neither be taken in the sense of (a) logical forms of fact-stating language (à la Hanson), nor as (b) semi-Davidsonian<sup>68</sup> conceptual schemes (à la Putnam), or as (c) paradigm-defined Kuhnian concepts. They must instead be understood as providing the epistemic conditions under which we can form knowledge of the natural world. In a genuine Kantian sense, we form knowledge of the natural world via transcendental arguments<sup>69</sup> taking the following form:

- (i) Natural kinds are experienceable
- (ii) A necessary condition for natural kinds being experienceable is that they exhibit, say, feature A.
- (iii) Therefore, natural kinds exhibit A.<sup>70</sup>

This involves only the minimal Kantian claim that for us to have comprehensible experience of natural kinds, certain conditions must be met. But this minimal Kantian claim does not imply that the *way in which natural kinds meet these conditions* is through any constructive activity of our mind, as the 2N2C thesis would suggest. For example, one such condition might be ‘being causally structured’, and it might feature in a transcendental argument to the effect that natural kinds ought to be causally structured for them to be experienceable.<sup>71</sup> We can then run the argument from theory-dependent methods to mind-dependent<sub>3</sub> natural kinds as follows:

- (d) Scientific methods are theory-dependent.
  - (d.3) the theory-dependence of scientific methods implies experience-dependence of kinds.
    - (d.3.i) for kinds to be experienceable they must be causally structured
- (e) Therefore the object  $t_j$  refers to, and the kind  $K_j$  the object belongs to, are part of a causally structured nature, which we can have experience of.
- (f) Accommodating inferential practices concerning  $t_j$  to causal structure—via theory-dependent methods—preserves causal structure.

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Kantianism licenses mind-dependent<sub>3</sub> natural kinds

Note here the crucial steps between (d.3) and (f). Premise (d.3), jointly with (d.3.i), captures the transcendental argument to the effect that kinds have to be causally structured for them to be experienceable at all. Premise (f) is the usual realist accommodation condition, which a Kantian *can* indeed maintain, by contrast with constructivists of (d.1)- and (d.2)-type, without yet bestowing on it the role of explaining our inductive success (as we saw in Section 5). Thus, there is a sense in which under a Kantian account, natural kinds are *epistemically* mind-dependent<sub>3</sub> (i.e., dependent on our conditions of possibility of experience), whilst preserving the realist intuition that our conditions of possibility of experience do not fabricate kinds, nor do our inferential practices *causally* contribute to their causal structure.

Thus, while Boyd's epistemological argument from theory-dependence of methods to the 2N2C thesis rightly targets some versions of constructivism (namely, (d.1) and (d.2)), which have occasionally been associated with Kantianism (especially, (d.2) with Kuhn's *soi-disant* post-Darwinian Kantianism), there is an alternative way of thinking about theory-dependent methods, which licenses mind-dependent kinds more in line with the Kantian view *and* at a distance from constructivism. This alternative way of thinking about mind-dependent kinds is captured by what I call naturalized Kantianism, whereby the Kantian process of subsuming spatio-temporal appearances under concepts is compatible (and indeed continuous) with Quine's naturalistic project. Natural kinds are ultimately experience-dependent because the concepts, under which we subsume appearances, are what transform our ancestors' "subjective spacing of qualities" into the theoretical kinds specific of each discipline. These same concepts that have proved to accord so well with the pre-scientific "functionally relevant groupings" in nature have empowered our species with a formidable knowledge of the natural world over millennia: we identify them a posteriori as the conditions of possibility of natural kinds being experienceable for us.<sup>72</sup>

Yet a defender of the 2N2C thesis might rejoin that this epistemic sense of mind-dependence<sub>3</sub> is not water-tight against the threat of constructivism. Constructivism may still threaten naturalised Kantianism, if a weakening substitution occurs in the transcendental argument above:

- (i\*) Natural kinds are experienceable.
- (ii\*) A necessary condition for natural kinds being experienceable is that they *appear* to exhibit feature A (e.g., causal structure).
- (iii\*) Therefore natural kinds *as they appear* to us exhibit feature A (e.g., causal structure).
- (iv\*) Our concepts ultimately constitute the way natural kinds appear to us.

Note here the weakening substitution occurring in (ii\*) with the verb *appear*.<sup>73</sup> If all is required of natural kinds is to *look as if* they were causally structured (in the discipline-specific way indicated above), the prospects of mounting even a mild realist defence of natural kinds via transcendental arguments would be unpromising. If we can have comprehensible experience of natural kinds as long as they *appear to us* in a certain way, we might never be able to bridge the gap between what we *ought to believe* there is and what there *is*. For if our epistemic achievements in inductive projections might well be explained by *apparent features* that do not track nature's properties, then not only would transcendental arguments for those features be idle wheels in the epistemic machinery. More worryingly, constructivism would creep into the picture again via (iv\*), making (d.3) fall back into (d.1) or (d.2).

One natural option to avoid this constructivist rejoinder, is to relax the original Kantian demand for *necessary* conditions as featuring in premise (ii) and (ii\*).<sup>74</sup> The constructivist challenge arises when we take at face value Kant's original demand for *necessary* conditions of experience. Understood as necessary, conditions of possibility of experience would *dictate* the way we *ought* to think of natural kinds, and since those conditions reside in our cognitive faculties, our concepts (say, the concept of 'being causally structured') would function once more as cookie-cutters in the worldly dough. Once we relax the demand for *necessary* conditions, and allow those conditions of experience to be *historically contingent*, the dubious constructivist rejoinder can be eschewed. Natural kinds would still be mind-dependent<sub>3</sub>, i.e., dependent on our conditions of possibility of experience, without being conceptual fabrications of our mind. All is required is to modify premise (d.3.i) to allow *historically contingent, sufficient but not necessary* epistemic conditions in:

- (d) Scientific methods are theory-dependent.
  - (d.3) The theory-dependence of scientific methods implies experience-dependence of kinds.
    - (d.3.i\*) For kinds to be experienceable, it is sufficient that they (contingently) exhibit feature A (e.g., being causally structured)
- (e) Therefore the object  $t_i$  refers to, and the kind  $K_j$  the object belongs to, are part of a causally structured nature, which we can have experience of.
- (f) Accommodating inferential practices concerning  $t_i$  to causal structure—via theory-dependent methods—preserves causal structure.

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Kantianism licenses mind-dependent<sub>3</sub> natural kinds

Replacing (d.3.i) with (d.3.i\*) undercuts the dubious constructivist rejoinder of affirming that nature must be thus if it is to satisfy our conditions of possibility of experience. Moreover, substituting necessary conditions for sufficient, historically contingent ones is to be expected in a post-Kantian world, which has long abandoned Kant's project of grounding the apodeictic certainty of Euclidean geometry and Newtonian mechanics.<sup>75</sup> Our conditions of possibility of experience evolve, and have an internal history of their own, often a terribly complicated one, which follows the fate and fortune of our best scientific theories. A few-century-old journey separates the pre-scientific condition of 'being causally structured', from the way this condition is understood and implemented in contemporary physics, in the case of motion of material bodies, for example, or in evolutionary taxonomy. Hence, to the extent that they depend on our historically contingent conditions of possibility of experience, our natural kinds should be expected to depend on the internal evolution of our scientific conceptual system (such as, for example, the evolution that goes from the laws of Medieval impetus theory and Archimedean hydrostatics to Galileo's science of mechanics; from Galileo's new sciences to Newton's mechanics; and from Newtonian mechanics to classical continuum mechanics, in turn).<sup>76</sup>

Yet all this still leaves room to a further, more worrisome rejoinder. Whilst introducing a tolerable level of contingency may help Kantianism escape the charge of fabricating kinds that *must* conform to our conditions of possibility of experience, Kantianism does not seem to be able

to retrieve modal features of natural kinds. Making kinds historically contingent does not help towards the realist intuition that unless the world was *really* causally structured and kinds *really* carved nature at its joints, we could not have comprehensible experience. If anything, historical contingency aggravates the situation. For if the conditions of possibility of having comprehensible experience are the historically contingent conceptual resources displayed by our best scientific theories in their historical evolution, why is it that we can confidently utter truths about, say, the solubility of salt in water, the attractive power of loadstone on iron filings, and the unfailingly green colour of emeralds? Aren't our historically contingent kinds free-floating, so to speak, in our conceptual sea? And would not the prospect of explaining the success of our inductive projections about salt, loadstone, and emeralds, be forever lost?

Naturalised Kantianism should not feel intimidated by this daunting prospect. The whole point of wedding Kantianism with Quinean naturalism about kinds was to anchor the transcendental enterprise about conditions of possibility of experience to a rock-bottom naturalistic base, while at the same time constraining the naturalistic project in a direction that could serve the purpose of explaining how our innate, pre-scientific similarity standards could turn into the theoretical kinds we know and love. If the conceptual resources delivered by transcendental arguments serve the latter purpose, naturalism in turn latches the conceptual features we ascribe (via transcendental arguments) to "functionally relevant groupings" onto genuine causal patterns in nature. To echo both Quine<sup>77</sup> and Harrison,<sup>78</sup> creatures who believe and act as if the world were not causally structured (i.e., as if emeralds were not green, or salt not soluble in water, and so on), would not stand much chance of surviving.

## 8. Conclusion

Where does all this leave us? Can naturalised Kantianism provide a viable account of natural kinds' projectibility without being either parasitic on realist accommodationism or falling prey of constructivism? At the end of Section 5, we envisaged an objection to the use of Quine's naturalism within the context of a broadly mind-dependent conception of kinds. In the past two Sections, I endeavored to distinguish the notion of mind-dependence at work in constructivist quarters, from what I take to be the distinctively Kantian notion of mind-dependence, which is compatible with a Quinean stance on kinds. I hope I have made the case for a serious reappraisal of Kantianism that does not conflate it *tout court* with a variety of constructivism, nor makes it parasitic on realist accommodationism in the explanation of our epistemic achievements. Naturalised Kantianism licenses the belief in a causally structured nature, whose joints are carved and carvable. But such belief is not ushered in via any God's eye epistemic access claim, but instead via the more modest strategy of transcendental arguments coupled with Quinean naturalism.

Yet a major problem still stands on our way. We are still not in a position to rule out Goodman's scenario. Past experience cannot give inductive support to green emeralds any more than to grue ones. Nor can naturalised Kantianism select between the evolutionary adequacy of 'green emerald' over grued ones. For all we know, the survival-adaptive feature of the kind *green emerald* shows how congenial our conceptual resources have proved so far in giving us comprehensible experience of a functionally relevant cluster of empirical properties in nature. But we cannot project from its survival-adaptive feature up to now to its future survival. As with any evolutionary account, naturalised Kantianism can account for our epistemic achievements thus

far, but does not secure them for the future. The main point of transcendental arguments is that *as long as* we can have experience of emeralds, they exhibit the feature of being green as a causally relevant feature. This is all naturalised Kantianism can explain: our success in inductive projections up to the present time.

A realist is not going to be impressed. Realist accommodationism fares better on this score by explaining the future projectibility of green emeralds over grueified ones in terms of the former latching onto *real causal stuff* in nature. But, as I hope to have argued for in Section 4, no easy Goodman- non-question-begging answer to this problem is available in the realist quarter either.

Perhaps, we simply have to live with Goodman's new riddle of induction, or bypass it somehow with entrenchment or survival-adaptive measures. It is not a God-given metaphysics of natural kinds that ultimately supports our inductive inferences but rather how well-entrenched our conceptual resources are in our cultural history. The resilience and historical evolution of our natural kinds testifies to how entrenched our scientific taxonomy must be to grant us comprehensible experience of nature.

The goal of this paper was not to develop an account of natural kinds that could solve Goodman's riddle. Instead, its more modest goal was to make the case for naturalised Kantianism as a live option on a par with realist accommodationism in explaining our success in inductive projections. As I hope to have shown, our natural kinds are not God-given any more than they are social constructs. Yet they are no less real than realist's kinds, which are nothing over and above our historically contingent kinds but reified as 'carving nature's joints'.

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## Notes

1 See, for example, (Boyd, 1991, 2010; Kornblith, 1993; Hacking, 1991a, 1991b, 1993, 2007; Kuhn, 1991, 1993).

2 See (Goodman, 1973; Quine, 1969).

3 Quine famously portrayed this inherited vantage point using Neurath's metaphor, see (Quine, 1975. Reprinted in Quine 1981, p. 72).

4 Quine (1969), p. 126.

5 *Ibid.*, p. 127.

6 A ground-clearing remark is in order. The version of naturalised Kantianism here proposed is not meant to implement Kant's own view either in general, or in particular on the subject matter of what was much later termed 'kinds'. Nor is it engaged with the even more

ambitious project of repackaging all or part of Kant's view into a Quinean version of it with all the obvious problems of how to reconcile Quine's rejection of the analytic/synthetic distinction—following the path of Wilfrid Sellars (1968). The more modest strategy here adopted consists instead in being true to two crucial insights due to Kant and Quine, respectively: namely, (a) that an explanation of our epistemic achievements has to be searched for in the way *we can* acquire knowledge, as opposed to in the way in which science allegedly mirrors nature from a God's eye point of view; (b) that our natural kinds are the evolution of pre-scientific unjustified similarity standards, part of our animal birthright. These are the two key insights, which the present version of naturalised Kantianism will rely on. Hence the view here expounded is not committed to endorse Kant's full-fledged view as displayed, for example, in the *Metaphysical Foundations of Natural Science*, whereby Kant endeavoured to provide the conditions of possibility of physical science (in particular Newtonian mechanics) by determining the empirical concept of matter according to the a priori categories of the understanding (quantity, quality, relation and modality). Nor is the present paper committed to buy into Kant's view of a priori conceptual resources and the transcendental idealism that in places Kant suggested as an important component of his position (which elsewhere he termed instead as 'empirical realism' to the point that in the second edition of the *Critique of Pure Reason* he added the 'Refutation of Idealism'). Instead, the only Kantian working posit of the present paper is the insight that any inquiry into our epistemic achievements is ultimately an inquiry into our conditions of possibility of experience, and that transcendental arguments can deliver conclusions about what we ought to believe there is, which are compatible with Quinean naturalism about kinds.

7 See (Boyd, 1990, 1991, 1992, 1999a, 2010).

8 See (Boyd, 1991). The best known contemporary advocate of this nominalist tradition about kinds is Ian Hacking (1991a, 1993, 2007).

9 In this respect, Boyd's view shares important points of similarity with Kitcher's (1984) pluralistic realism, and Dupré's promiscuous realism (1981). However, by contrast with pluralistic stances, which insist on the existence of partially overlapping taxonomies (e.g., for the term *lily*, the layman one, and the botanist one, which includes garlic and onions under *Lili-aceae*), homeostatic property cluster kinds are said to satisfy the accommodation demands of a disciplinary matrix that involves gardening, landscaping, and decorating as well as botany; see (Boyd, 1999b, p. 162).

10 See (Griffiths, 1999; Wilson, 2005; Keller, Boyd and Wheeler, 2003; and Wilson, Barker and Brigandt, 2009).

11 The terminology is due to Boyd (2010, p. 219).

12 The story goes that the skeleton Marsch was referring to was itself a paleontological pastiche including the skull of a third distinct genus, namely *Camarosaurus*, while the *Apatosaurus* would have a skull more similar to that of the genus *Diplodocus*. In 1903 the palaeontologist Riggs realised Marsch's mistake and announced that the real name should be *Apatosaurus*, while *Brontosaurus* should be dismissed. But the name *Brontosaurus* continued to be used widely, despite its non-scientific character. See (Gould, 1991).

13 One might reply that this could be an example of what Boyd calls partial denotation in Field's sense: there can be a term  $t$  that "partially denotes different kinds  $k_1$  and  $k_2$  in a disciplinary matrix  $M$  when the epistemic connection between the uses of  $t$  in  $M$  and  $k_1$  explains very nearly the same achievements in  $M$  as does the connection between  $t$  and  $k_2$  . . . [and] practitioners in  $M$  do not distinguish between  $k_1$  and  $k_2$  " (Boyd 2010, p. 216). These situations

compromise the reliability of our inferential practices, and, as Boyd points out, “an improvement in reliability could be achieved by drawing the  $k_1 - k_2$  distinction and by replacing the existing use of  $t$  with the use of two terms ... one referring to  $k_1$  and the other to  $k_2$ . This is *denotational refinement* in Field’s sense” (ibid.). Something along these lines might have happened in the case of *Brontosaurus* when Riggs discovered that  $t$  (*Brontosaurus*) referred to  $k_2$  (*Apatosaurus*) instead of  $k_1$  (Marsh’s alleged specimen of *Brontosaurus*). But this answer in terms of *denotational refinement* does not address the issue at stake here, namely that there seems to be a tension between the *social dimension* of Boyd’s kinds and the success of inferential practices they license (see Boyd 2010, pp. 217–8): the lone, unfunded researcher, who gets it right, does not make any contribution to the reliability of our scientific practices. One is reminded here of Stephen Jay Gould’s (1991, p. 90) observation about *Brontosaurus*: “No one has ever seriously challenged Riggs’s conclusion, and professionals have always accepted his synonymy [with *Apatosaurus*]. But Publication 82 of the ‘Geological Series of the Field Columbian Museum’ for 1903—the reference for Riggs’s article—never gained much popular currency. The name *Brontosaurus* ... never lost its luster, despite its technical limbo”.

14 See (Devitt 2010).

15 Quine (1969, p. 126).

16 A social constructivist may rejoin at this point that there is a substantial causal story to be told about experimental data themselves, the construction of scientific instruments, their use in producing data and the statistical techniques of data collection and data analysis (I thank Melinda Fagan for drawing my attention to this point). In reply, I want to draw attention to the difference between the theory-dependence of scientific methods (involved in data collection and selection) and the metaphysical assumptions they license. In this respect, I diverge from social constructivists and agree with Boyd about what he calls the metaphysical innocence of theory-dependent methods. I only beg to differ from Boyd when he classifies Kantianism under the same umbrella of social constructivism and identifies the theory-dependence of scientific methods as the main epistemological argument for a form of “neo-Kantian social constructivism”, as I shall argue in more detail in Sections 6 and 7.

17 In this category we find John Stuart Mill’s ‘real Kinds’, for example. Hacking’s nominalism (1993 and 2007) can also be regarded as falling into this category.

18 At the outset of the Transcendental Aesthetic Kant defined an appearance as ‘the undetermined object of an empirical intuition’ (Kant 1781/1787, A20/B34). Appearance refers then to an object as merely given in sensibility and conceptually still ‘undetermined’, not brought yet under the categories of the faculty of understanding. A phenomenon or object of experience, on the other hand, is a *conceptually determined appearance*, namely an appearance that has been brought under the categories of the understanding. Thus, while appearances are the spatio-temporal objects of empirical intuitions, the *data for possible experience*, phenomena or objects of experience are appearances brought under the concepts of the faculty of understanding so as to make experience finally possible (see Kant 1781/1787, B298/A239 and A249). On this distinction, see (Massimi 2008, 2010).

19 In this loose contemporary sense, one can retain the Kantian original rationale for going beyond empiricism and realism without committing oneself to the long discarded view of space and time as a priori forms of sensibility or to a priori categories of the understanding. For more details, see below Sections 5, 6, and 7.

20 See (Boyd, 1999b, p. 147; and 2010).



21 See (Bacon, 2000).

22 This episode has famously provided the rationale for Worrall's epistemological structural realism (1994).

23 See (Achinstein, 2002).

24 The *locus classicus* is Laudan (1981). On a more recent note, see (Stanford, 2006; and Chang, 2005).

25 The riddle was first published in (Goodman 1947) and reprinted in (Goodman 1973).

26 "For surely the entrenchment of classes is some measure of their genuineness as kinds; roughly speaking, two things are the most akin according as there is a more specific and better entrenched predicate that applies to both", (Goodman 1973, p. 123).

27 See (Quine 1969, p. 123).

28 See on this point (Boyd 1999b, p. 147): "anyone who has read Goodman can come up with indefinitely many unprojectable generalizations about such matters that fit all past data equally well, but that are profoundly false. You were able to discern the true one because your inductive practices allowed you to identify a generalization appropriately related to the causal structure of the phenomena in question ... what distinguished the generalization you accepted from the unprojectable generalizations (which also fit the extant data) was that for any instantiation of it that makes the antecedent true, the state of affairs described by the antecedent will (in the relevant environment) cause the effect described by the consequent. Your deployment of projectable categories and generalizations allowed you to identify a *causally sustained* generalization". In more recent time, (Boyd 2010, p. 213), has expressed the same point about projectibility judgments.

29 See (Boyd 2010, p. 215).

30 See (Boyd, 1999a; 1992, p. 140), distinguishes between classical Kantian constructivism and sophisticated neo-Kantian constructivism. The former is associated with the names of Kuhn (1962) and Hanson (1958), and Boyd describes it as an attempt to restore some form of foundationalism in the light of potentially embarrassing facts about the history of science. He identifies a main neo-Kantian epistemological argument for it, to which I turn in Section 6. Boyd does not mention any specific example of a sophisticated neo-Kantian constructivist but makes the case for what he sees as the most plausible version of constructivism that needs be taken in serious philosophical consideration. He concludes that neo-Kantian constructivism is successful in grounding the reliability of inductive methods in science, only insofar as it shares with realism a *quasi-naturalistic* version of the *accommodation thesis* (Boyd 1992, p. 171). Whence the accusation of parasitism on RA, which I consider in this Section and the next one.

31 As Boyd clarifies (2010, p. 224), RA is coupled with a causal theory of reference, whereby natural kind terms *ts* track families of properties *Fs* and the descriptive and intentional factors involved in the accommodationist conception of reference must be understood as playing a causal role themselves in our practices (as opposed to some hybrid causal-descriptive theory of reference).

32 See on this point also (Kornblith 1993, p. 43).

33 In this respect, a naturalized Kantian shares important points in common with constructive empiricism in resisting the God's eye view on reality (the *locus classicus* is van Fraassen, 1980). For a more recent re-assessment of this theme, and its analogy with Kantianism, see (van Fraassen, 2008; and Massimi, 2009).

34 See (Worrall, 1994; Kitcher, 1993, pp. 145–8; and Leplin, 1997).

35 Goodman was adamant in detaching projectibility from truth; it is not the case that the right or true predicates have become well-entrenched in our language, but instead the other way around: “If our critic is asking, rather, why projections of predicates that have become entrenched happen to be those projections that will turn out to be *true*, the answer is that we do not by any means know that they will turn out to be true. When the time comes, the hypothesis that all emeralds are green may prove to be false, and the hypothesis that all are grue prove to be true. We have no guarantees. The criterion for the legitimacy of projections cannot be truth that is as yet undetermined. Failure to recognise this was responsible, as we saw, for some of the worst misconceptions of the problem of induction” (1973), pp. 98–99.

36 On the basis of this alternative unobservable causal structure in a hypothetical Goodmanian world, we would proceed to infer reliably other empirical properties (e.g., being blue) for emeralds:

(A\*) homeostatically stable cluster of properties (e.g., gem, vitreous luster, 7.5 hardness...) → unobservable chemical structure (‘gruified’ beryl with gruified traces of chromium and vanadium) → empirical property of being blue after time  $t$ .

Both the usual inference

(A) homeostatically stable cluster of properties (e.g., gem, vitreous luster, 7.5 hardness, ...) → unobservable chemical structure (e.g., beryl with traces of chromium and vanadium) → empirical property of being green

and the gruified inference (A\*) are successful<sub>MIN</sub>. Claiming that (A) has to be preferred over (A\*) because in addition to being successful<sub>MIN</sub> is also successful<sub>MAX</sub> begs the question against Goodman. For all we know, after time  $t$ , a gruified beryl may give rise to a blue emerald which we could then identify with a new kind of emerald (for example, a change in cosmic rays after time  $t$  might result in emeralds being exposed to light to change their colour from green to blue, following the example of Barker and Achinstein (1960).

37 One is reminded here of van Fraassen’s Darwinian reformulation of the no miracle argument (1980, pp. 34–40). Van Fraassen uses the argument against the realist’s demand for truth; I use the Darwinian argument against the realist’s plea for natural kinds ‘carving nature at its joints’.

38 Think, for example, of zoology where old kinds, such as the Linnean order of Bruta is no longer in use, and others such as Mammalia was refined to include Monotremes (egg-laying mammals such as the platypus).

39 For a recent re-evaluation of the epistemic importance of alternative historical competitors in assessing our currently accepted scientific theories, see (Stanford, 2006; Chang, 2005).

40 For a criticism along these lines of van Fraassen’s Darwinian reformulation of the no miracle argument, see (Kitcher, 1993, and Lipton, 1991).

41 One is here reminded of Bogen and Woodward’s definition of ‘data’ as idiosyncratic to specific experimental contexts and providing the evidence for inferring the existence of entities or phenomena, such as the melting point of lead and weak neutral currents (I have discussed Bogen and Woodward’s notion of data, the realist rationale behind it and suggested a Kantian twist to it, in Massimi 2011). Of course, the idea of data is borrowed from the empiricist

tradition. But, after all, historically, Kantianism took the lead from Hume's empiricism; believing in stable patterns of empirical regularities in nature or stable clusters of empirical properties is compatible with maintaining that we cannot fathom properties of mind-independent kinds.

42 One example, taken from the history of particle physics and concerning the identification of a new *kind* of particle, composed by a new *kind* of quark, is discussed in (Massimi, 2007).

43 See (Quine, 1969, p. 126).

44 *Ibid.*, p. 138

45 Recall that for Kant, appearances as spatio-temporal objects of empirical intuition are "objects of a possible experience" (see footnote 18 above). They provide the pre-conditions for a possible experience of nature, which can only take place when concepts are applied to them and suitably schematized according to the principles of the understanding, so that appearances can be transformed into phenomena or objects of experience.

46 See (O'Keefe and Nadel, 1978; O'Keefe, 1990, 1993). O'Keefe's work on experimental neurology of higher vertebrates has identified in the hippocampus the innate spatial representation map, whereby movements in an environment are coded as vectors representing distances and directions with respect to a centroid. Animals would learn how to move around the environment by comparing the internal navigation representation provided by the hippocampus with the representation deriving from sensory stimuli. This method of learning would not depend on biological drives or bodily needs: "it assumes that there has been an evolutionary gamble that the acquisition of a particular type of knowledge for its own sake will prove to be an efficient survival mechanism for the individual, since information acquired at a time when biological needs such as hunger and thirst are absent might be useful at some subsequent time when those needs arise" (O'Keefe 1993, p. 53).

47 See O'Keefe 1993, op.cit.

48 In recent time, historical epistemology has emerged as a new trend that purports to address and answer justificatory questions about human knowledge by appealing to the history of the relevant scientific concepts. For example, the question as to how scientific knowledge can advance claims of objectivity is addressed from within a historical dimension that tracks the origin of the same concept of objectivity (see Galison and Dalston, 2007). Or the question as to why a cluster of well-defined empirical properties (say, charge-to-mass ratio, discharge rate, etc.) came to be identified as the 'electron', despite J.J. Thomson's analysis in terms of 'corpuscles', and Larmor's treatment in terms of ether, is similarly addressed by digging into the history of the concept; see (Arabatzis, 2006). See also (Feest and Sturm, 2011). Regardless of what one might think of this new trend, my point here is that questions concerning the evolution and sedimentation, so to speak, of our existing kinds are better addressed in their discipline-specific, historical context.

49 The view that a contemporary Kantian position is compatible with there being no a priori categories of the understanding, and that our concepts change with the evolution of our cultural and scientific history to become 'relativised a priori' has been defended by Friedman (2000 and 2001). Although I am not committing myself to it here, the gist of the discussion in this Section goes in a similar direction in thinking that there are important Kantian insights that can be reconciled with the historical contingency of our kinds.

50 See Kuhn (1990): "like the Kantian categories, the [scientific] lexicon supplies preconditions of possible experience. But lexical categories, unlike their Kantian forebears, can and do change, both with time and with the passage from one community to another". Kuhn's *soi-*

*disant* Kantianism has captured the philosophical imagination and entered the philosophical literature see (Hoyningen-Huene, 1993), so that it has become common to associate Kantian constructivism with Kuhn's view itself.

51 See (Boyd, 1990; 1992, p. 136; 1999a, p. 63). Boyd (2010, p. 221) calls Kuhn's view a sort of "neo-Kantian social constructivism".

52 See Boyd (1992, p. 143).

53 *Ibid.*, p. 173.

54 This version of mind-dependence implies an *existential* claim about kinds and is remote from a Kantian viewpoint (after all, Kant was at pain to avoid any association with Berkeley's idealism in his Refutation of Idealism, second edition of the *Critique of Pure Reason*). Other realists have criticised this notion of mind-dependence, which they see as relevant to their particular brand of realism. See (Kitcher, 2001, p. 182ff).

55 See (Hanson 1958, ch.1), building up on works in Gestalt psychology by Köhler (1929), and Popper (1959).

56 van Fraassen, for example, accepts theory-dependence of methods without endorsing truth about scientific theories (1980, pp. 80–83): "The working scientist is totally immersed in the scientific world-picture ... But immersion in the theoretical world-picture does not preclude 'bracketing' its ontological implications ... For to say that someone is immersed in theory ... is not to describe his epistemic commitment".

57 See (Boyd, 1991, pp. 137–8): "Projectability judgments are almost always judgments of *theoretical plausibility*. A theory is projectable just to the extent that what it says about both observable and unobservable phenomena coheres appropriately with the best confirmed background theories: it is projectable just in case it is supported by plausible inductive inferences from the 'observational' and 'theoretical' claims embodied in previously well established theories ... Therefore the best account of projectability judgments is the realist one according to which those judgments reflect inductive inferences from previously acquired approximate knowledge of unobservable as well as observable phenomena".

58 Hanson (1958), ed. used (1972, p. 36). Although Hanson is usually credited for his defense of theory-ladenness of observation (see footnote 55), it is possible to distinguish a more substantial claim he made in ch. 2 of the same book about 'facts' and their dependence on our scientific language. The claim here is that "the formation of a concept  $x$  in a language not rich enough to express  $x$  (or in a language which explicitly rules out the expression of  $x$ ), is always very difficult" (*ibid.*, p. 36).

59 The geometrical notation dominant at Galileo's time led people to think of velocities as proportional to spaces traversed as opposed to times (which were regarded as a trivial function of velocities). Only after Newton's fluxions, did it become possible to symbolise constant acceleration as  $ds/dt$ . Hanson's moral is that although it might be possible to think of a concept  $x$  (e.g., constant acceleration) in the absence of a proper mathematical language to express it, significant conceptual difficulties stand on the way.

60 Putnam's example is that of a world of three objects  $x_1, x_2, x_3$  à la Carnap, and how this same world would count as a world of seven objects for the Polish logician Lesniewski (namely,  $x_1, x_2, x_3, x_1 + x_2, x_1 + x_3, x_2 + x_3, x_1 + x_2 + x_3$ ). Putnam uses the example against the metaphysical realist's view, according to which there is only one world that we can slice in different ways, to use the 'cookie cutter' metaphor: this way of posing the problem would leave wide open the mereological question as to what the 'parts' of the worldly dough are (Putnam, 1990, p. 98). For

a recent discussion of Putnam's view, see (Boghossian 2006, p. 36), from which the expression 'cookie-cutting the worldly dough' is borrowed.

61 "Consider, to begin with, the statements 'The sun always move' and 'The sun never moves' which, though equally true, are at odds with each other. Shall we say, then, that they describe different worlds as there are such mutually exclusive truths? Rather, we are inclined to regard the two strings of words not as complete statements with truth-values of their own but as elliptical for some such statements as 'Under frame of reference A, the sun always move' and 'Under frame of reference B, the sun never moves' –statements that may both be true of the same world. Frames of reference, though, seem to belong less to what is described than to systems of description: and each of the two statements relates what is described to such a system. If I ask about the world, you can offer to tell me how it is under one or more frames of reference; but if I insist that you tell me how it is apart from all frames, what can you say? *We are confined to ways of describing whatever is described*. Our universe, so to speak, consists of these ways rather than of a world or of worlds". See (Goodman 1978, pp. 2–3, emphasis added).

62 See (Kuhn 1962, third ed., p. 121).

63 Kuhn contented that Galileo saw the swinging stone differently from Aristotle because "he measured only weight, radius, angular displacement, and time per swing, which were precisely the data that could be interpreted to yield Galileo's laws for the pendulums ... Given Galileo's paradigms, pendulum-like regularities were very nearly accessible to inspection ... Regularities that could not have existed for an Aristotelian (and that are, in fact, nowhere precisely exemplified by nature) were consequences of immediate experience for the man who saw the swinging stone as Galileo did" (*ibid.* p. 124). It is the conceptual switch from motion as the distance *to* a final end point, to motion as the distance *from* the origin that "underlies and gives sense to most of his well-known 'laws of motion'" (*ibid.* .). These jointly (paradigm-dependent) regularities *and* conceptual parameters were in turn made possible by a series of crises and intellectual changes that had occurred in the Medieval impetus theory and Neoplatonism, among others.

64 Indeed, many more versions of constructivism could be identified than the two aforementioned ones, to which I intend to confine my attention in this paper. Under the social constructivist account for example, kinds *Ks* depend upon a community of scientists, *C*, that—via laboratory life—*constructs* them. This form of social constructivism is most prominently advocated by Bruno Latour. For example, Latour's (1999, ch. 2) analyses how via laboratory life scientists construct pedological claims (where pedology is the science of soil) about whether or not the Amazon Forest is advancing or retreating with respect to the savanna. At the very beginning of the book (p. 6), Latour gives the following caricature of the Kantian project and how it was superseded by science studies: "Kant had invented a form of constructivism in which the mind-in-the-vat built everything by itself but not entirely without constraints: what it learned from itself had to be universal and could be elicited only by the experiential contact with a reality out there, a reality reduced to its barest minimum, but there nonetheless. For Kant, there was still something that revolved around the crippled despot, a green planet around this pathetic sun. It would not be long before people realized that this 'Transcendental Ego', as Kant named it, was a fiction, a line in the sand (...). It was soon replaced by a more reasonable candidate, *society*". It is beyond the aim and scope of this paper to engage with this form of constructivism, and I prefer to concentrate my attention to the philosophically more subtle versions captured by (d.1) and (d.2) above. For an insightful discussion, see (Knorr Cetina, 1993; and Sismondo, 1993).

65 A clarification is in order here. That some suitable version of naturalism is compatible with

Kantianism is not new. Most notably, Strawson (1985) argued for a Humean version of naturalism in combination with transcendental arguments directed to the existence of external objects. On Strawson's 'naturalistic' view, the question as to whether there are or are not external objects is futile and has to be granted in all our reasoning (for a discussion and dismissal of Strawson's strategy, see (Stern, 1999, pp. 63–65). As it should be clear from the discussion so far, the naturalism I am wedding Kantianism to, is of a different, Quinean variety. Its key role is to anchor a loosely Kantian transcendental strategy about our conceptualization of appearances to reality itself, via Quine's 'Darwinian' take on the evolution of our pre-scientific 'spacing of qualities' into natural kinds (see footnote 72).

66 I am here assuming the one-world interpretation of Kant defended by Bird (1962) and Allison (1983), and not the two-world view, under which there would effectively be an ontological dimension in the Kantian view that our knowledge is confined to phenomena, as per Bennett (1966), Guyer (1987) and van Cleve (1999). According to Allison's one-world interpretation, Kant's view is not a metaphysical theory that affirms the unknowability of the 'real' and relegates knowledge to the realm of representations (appearances). Against the two-world view, which effectively interprets the Kantian doctrine as a phenomenalist account of what is knowable (hence the two worlds of mental representations and physical entities), Allison has argued that the Kantian distinction between appearances and things in themselves should be understood instead in its transcendental (as opposed to empirical sense) as follows: (1) appearances are spatio-temporal entities, i.e., things insofar as they are viewed as subject to the conditions of human sensibility; (2) things in themselves are instead things insofar as they are viewed as independent of these conditions. So, there is only one world but two ways of looking at the objects in it as either independent of the conditions of human experience (*qua noumena*) or as dependent on them (*qua phenomena*).

67 In Kant's own doctrine, of course, the process of subsuming appearances under concepts required a rather complex architectonic involving the categories of the understanding, transcendently deduced to account for the various forms of judgments available, and the system of the principles of the understanding, namely the schematization of the categories according to time. Hence, the resultant Axioms of Intuitions (for the category of quantity), Anticipations of Perception (for the category of quality), Analogies of Experience (for the category of relation), and Postulates of Empirical Thinking in General (for the category of modality). In the *Metaphysical Foundations of Natural Science*, Kant addressed the issue of how to characterize the empirical concept of "matter" according to the categories; hence, the four chapters on Phoronomy (matter as motion), Dynamics (matter as the seat of moving forces), Mechanics (communication of motion between parts of matter), and Phenomenology (matter as "the moveable insofar as it, as such a thing, can be an object of experience" MFNS 554). Thus, in Kant's own account, scientific concepts such as 'force', 'momentum', what he called 'quantity of matter' (or inertial mass) and so on were introduced as further specifications of the more general, albeit still empirical, concept of matter, schematized according to the four categories of the understanding. Out of Kant's complex architectonic, the key insight remains that 'objects of experience', or what Kant also called 'phenomena', are conceptualized appearances, and this becomes the relevant working notion in my discussion (I have discussed the relevance of Kant's notion of phenomena for contemporary debates on realism, in Massimi 2008 and 2011).

68 I say 'semi-Davidsonian' because although in the relevant aforementioned section of *Realism with a Human Face*, Putnam refers to Davidson's meaning theory in claiming that

although Carnap and the Polish logician descriptions may be ‘mathematically equivalent’, still the Polish logician’s sentence would not count as a truth-condition for the Carnap sentence that there are only three objects. Putnam takes the distance from Davidson’s ‘radical translator’ thesis, according to which for the sentence of the Polish logician to be meaningful in Carnap’s language it must be possible to offer truth-conditions for it within Carnap’s language. See (Putnam, 1990, p. 104).

69 Transcendental arguments are at the center of an important literature that discusses their relevance and effectiveness in addressing scepticism. See (Strawson, 1966; Stroud, 1968; Cassam, 1987; Harrison, 1982; Pereboom, 1990, 2006) and Stern’s (1999) edited volume.

70 Transcendental arguments are famously used by Kant in his Refutation of Idealism (added to the second edition of the *Critique of Pure Reason*, B275) as a way of going from our conscious experience to the conclusion that there must be spatio-temporal objects in nature. Taking the lead from Kant, but going beyond Kant himself, some Kantian scholars have interpreted the use of transcendental arguments in the Refutation of Idealism as a causal inference to a mind-independent ontology (most notably, Guyer, 1987, and Dicker, 2008); for a criticism of this causal reading of Kant’s argument, see (Chignell 2010, 2011). My concern here is not with Kant’s own Refutation of Idealism, nor with the use of transcendental arguments in addressing skepticism about the external world as such. Instead, I envisage a contemporary different role for transcendental arguments in addressing the charge of constructivism leveled against a Kantian reading of natural kinds. Yet, *mutatis mutandis*, the strategy here adopted bears important similarities with some of the issues concerning the ‘causal inference to reality’ typical of the aforementioned readings of Kant’s Refutation of Idealism.

71 ‘Being causally structured’ can in turn be understood in a variety of discipline-specific ways: e.g., as having a certain acceleration in response to an impressed force (for physical kinds described by Newtonian mechanics); or as having a certain ability to combine with some chemical substances but not others (for chemical kinds); or as bearing evolutionary links with other species (when dealing with biological taxa).

72 A similar in spirit endeavour to naturalise Kantianism (although not directly functional to the issue of natural kinds) can be found in Harrison (1982, p. 223): “Just as the harmony between the nature of an animal’s organs and the environment which it inhabits can be explained by natural selection, so also can the harmony between a human’s general forms of judgment and the world. In both cases it depends neither upon a designer nor upon pure luck, but is the result of normal causal processes. Any individual who thinks (or acts as if) that there is no causation in the world, or that the future does not resemble the past, is an unsuccessful mutation, ill-adapted to survive or breed.” Along similar lines, Westphal (1997, p. 153): “our cognitive apparatus is such that we are only receptive, sensitive, or cognitively competent with regard to certain kinds of objects, although these objects would have the properties (whatever they may be) that enable us to experience them, whether or not we existed or experienced them. This naturalistic alternative is of course much more obvious after Darwin”.

73 Weakening substitutions of this sort have famously been introduced by Barry Stroud in his now classic treatment of transcendental arguments (1968). For a discussion of Stroud’s position and the charge of idealism that seems to arise from weakening substitutions, see (Stern 2000, ch. 2). Stroud’s challenge to transcendental arguments has prompted some philosophers to switch from truth-directed to belief-directed transcendental arguments. For example, Stern himself (1999) subscribes to the latter, whereby the more modest use of transcendental arguments is

functional to justify our *beliefs* about what there is, as opposed to justifying claims about what there is, *tout court*. The result is a coherentist theory of epistemic justification, which would explain how holding a particular belief that *p* is a necessary condition of having experience insofar as the belief that *p* coheres with a broader system of beliefs providing the necessary conditions of possibility of our experience (a similar position is advocated by Stroud himself, see (Stroud 1994); for a discussion of this literature see (Pereboom 2009). Belief-directed transcendental arguments and coherentist theory of justification are the target of Sacks (1999). Sacks mounts a compelling criticism of the modest coherentist justificatory strategy as being incompatible with the correspondence theory of truth, among other pitfalls. Once more, my concern here is not with the idealist threat that arises from Stroud's weakening substitution; instead, I am interested in looking at possible ways of using transcendental arguments to make the case for a form of Kantianism about kinds that can escape the charge of constructivist mind-dependence. Hence, in this context, I use the weakening substitution for a possible constructivist's rejoinder to the mild realism licensed by naturalised Kantianism. Moreover, since my goal is to argue for a mild form of realism about natural kinds, I see transcendental arguments as truth-directed rather than belief-directed, following Harrison (1982) (see footnote 72). One may wonder how one can reasonably uphold truth-directed transcendental arguments despite Stroud's challenge. In response, wedding transcendental arguments with Quinean naturalism secures causal inference to reality. For, although apparent features that do not track nature's properties (because, say, due to a collective hallucination or other) could well feature in weakening substitutions of transcendental arguments as indicated above, they could not explain the survival-adaptive nature of our kinds. If emeralds were not green, salt not soluble in water, and so forth; i.e., if these were just apparent features of our *beliefs* about emeralds, salt, etc., we, as *Homo Sapiens*, would not stand much chance of finding our way around nature.

74 This suggestion follows a similar one by Quassim Cassam in a different context, namely his discussion of the fate of transcendental arguments on the score of transcendental idealism, see (Cassam 1987, p. 370). Once more, my concern here is not with idealism, but with a constructivist's reply that *mutatis mutandis* bears enough similarity to the idealist threat to justify an analogous use of argumentative resources in response.

75 In this sense, my proposal is in line with similar ones that in recent decades have pledged to go back to Kant without trying to retrieve Kant's notion of *necessity*. Friedman (2001), for example, has reinterpreted Kant's a priori as consisting of two components: namely, (1) being a *necessary* and unchangeable condition of possibility of experience, and (2) being *constitutive* of the object of experience, whereby only the latter maintains its relevance for contemporary debates in philosophy of physics (in particular, in assessing the nature of the light principle and the equivalence principle in special and general relativity). The *relativised a priori* is designed to retain Kantian insights for twentieth century science, despite the challenge posed by Kuhn's view of scientific revolutions. The version of naturalised Kantianism here expounded shares the spirit of Friedman's proposal, without yet endorsing its defence of the constitutive *a priori*.

76 Here I have in mind the sort of complex historical transformations that for example Mark Wilson has so aptly described as far as the evolution of Newtonian classical mechanics is concerned, see (Wilson, 2006). The dynamical, patchy, and localized evolution of the concept of force in the treatment of classical continuum mechanics and the indispensable need to introduce additional concepts alien to mechanics and belonging to chemistry and thermodynamics justifies Wilson's claim that Newtonian mechanics is only a *theory façade*. Interestingly enough, Michael



Friedman, in a recent exchange with Wilson, has appealed to the same case study to draw analogies with his Kantian *dynamics of reason*. See (Friedman, 2010; Wilson, 2010). I thank Mark Wilson for sharing with me manuscript correspondence.

77 In Quine's words, "Creatures inveterately wrong in their inductions have a pathetic but praiseworthy tendency to die before reproducing their kind" (1969), p. 126).

78 See footnote 72 for quote from Harrison (1982).

## Bibliography

- Achinstein, P. (2002) 'Is there a valid experimental argument for scientific realism?'. *Journal of Philosophy* 99: 470–495.
- Allison, H. E. (1983) *Kant's Transcendental Idealism: An Interpretation and Defense*. Revised edition 2004. New Haven and London: Yale University Press.
- Arabatzis, T. (2006) *Representing electrons. A biographical approach to theoretical entities*. Chicago: The University of Chicago Press.
- Bacon, F. (2000) *The New Organon*, edited by L. Jardine. Cambridge: Cambridge University Press.
- Barker, S. F. and Achinstein, P. (1960) 'On the new riddle of induction'. *Philosophical Review* 69: 511–22.
- Bennett, J. (1966) *Kant's Analytic*. Cambridge: Cambridge University Press.
- Bird, G. (1962) *Kant's theory of knowledge*. London: Routledge and Kegan.
- Boghossian, P. (2006) *Fear of knowledge. Against relativism and constructivism*. Oxford: Clarendon Press.
- Boyd, R. (1990) 'Realism, conventionality, and "realism about"'. In G. Boolos (ed.) *Meaning and Method*. Cambridge: Cambridge University Press.
- Boyd, R. (1991) 'Realism, anti-foundationalism, and the enthusiasm for natural kinds'. *Philosophical Studies* 61: 127–48.
- Boyd, R. (1992) 'Constructivism, realism, and philosophical method'. In J. Earman (ed.) *Inference, Explanation, and Other Frustrations*. Berkeley: University of California Press.
- Boyd, R. (1999a) 'Kinds as the "workmanship of men": realism, constructivism, and natural kinds'. In J. Nida-Rümelin (ed.) *Rationalität, Realismus, Revision: Proceedings of the Third International Congress, Gesellschaft für Analytische Philosophie*. Berlin: de Gruyter.
- Boyd, R. (1999b) 'Homeostasis, species, and higher taxa'. In R. Wilson (ed.) *Species. New Interdisciplinary Essays*. Cambridge: MIT Press.
- Boyd, R. (2010) 'Realism, natural kinds, and Philosophical Method'. In H. Beebe and N. Sabbarton-Leary (eds.) *The Semantics and Metaphysics of Natural Kinds*. London: Routledge.
- Cassam, Q. (1987) 'Transcendental arguments, Transcendental Synthesis, and Transcendental Idealism'. *Philosophical Quarterly* 37: 355–78
- Chang, H. (2005) *Inventing Temperature*. New York: Oxford University Press.
- Chignell, A. (2010) 'Causal refutations of idealism'. *Philosophical Quarterly* 60: 487–507. Chignell, A. (2011) 'Causal refutations of idealism revisited'. *Philosophical Quarterly* 61: 184–86. Devitt, M. (2010) 'Species have (partly) intrinsic essences'. *Philosophy of Science* 77: 648–661.
- Dicker, G. (2008) 'Kant's Refutation of Idealism'. *Nou's* 42: 80–108.
- Dupré, J. (1981) 'Natural kinds and biological taxa'. *Philosophical Review* 90: 66–90.
- Feest, U. and Sturm, T. (eds.) (2011) 'What (good) is historical epistemology?', *Erkenntnis* 75: 285–302.
- Friedman, M. (2000) 'Transcendental Philosophy and A Priori Knowledge: a Neo-Kantian Perspective'. In P. Boghossian and C. Peacocke (eds.) *New Essays on the A Priori*. Oxford: Clarendon Press.
- Friedman, M. (2001) *The dynamics of reason. Stanford Kant Lectures*. Stanford: CSLI Publications.
- Friedman (2010) 'Logic, Mathematical Science and the Twentieth Century Philosophy: Mark Wilson and the Analytic Tradition'. *Nou's* 44: 530–544

- Galison, P. and Dalston, L. (2007) *Objectivity*. New York: MIT Press.
- Griffiths, P. (1999) 'Squaring the circle: natural kinds with historical essences'. In R. Wilson (ed.) *Species: New Interdisciplinary Essays*. Cambridge, Mass.: MIT Press.
- Goodman, N. (1947) 'The problem of counterfactual conditionals'. *Journal of Philosophy* 44: 113–128.
- Goodman, N. (1973) *Fact, Fiction, and Forecast*, 3rd ed. Indianapolis: Bobbs-Merrill.
- Goodman, N. (1978) *Ways of Worldmaking*. Indianapolis: Hackett.
- Gould, S. J. (1991) *Bully for Brontosaurus. Reflections in Natural History*. Norton: New York.
- Guyer, P. (1987) *Kant and the claims of knowledge*. Cambridge: Cambridge University Press.
- Hacking, I. (1991a) 'A Tradition of Natural Kinds'. *Philosophical Studies* 61: 109–126. Hacking, I. (1991b) 'On Boyd'. *Philosophical Studies* 61: 149–54.
- Hacking, I. (1993) 'Working in a New World: the Taxonomic Solution'. In P. Horwich (ed.) *World Changes: Thomas Kuhn and the Nature of Science*. Cambridge, Mass.: MIT Press.
- Hacking, I. (2007) 'Natural Kinds: Rosy Dawn, Scholastic Twilight'. In A. O'Hear *Philosophy of Science*, Royal Institute of Philosophy Supplement 61, Cambridge: Cambridge University Press, pp. 203–240.
- Hanson, N. R. (1958) *Patterns of discovery*. New York: Cambridge University Press.
- Harrison, R. (1982) 'Transcendental Arguments and Idealism'. In G. Vesey (ed.) *Idealism Past and Present*. Cambridge: Cambridge University Press.
- Hoyningen-Huene, P. (1993) *Reconstructing scientific revolutions. Thomas S. Kuhn's philosophy of science*. Chicago: University of Chicago Press.
- Kant, I. (1781/1787) *Critik der reinen Vernunft*. Riga: Johann Hartknoch. Engl. transl. in P. Guyer and A. W. Wood (eds.) (1997) *Critique of Pure Reason*. Cambridge: Cambridge University Press.
- Keller, R., Boyd, R. and Wheeler, Q. (2003) 'The illogical basis of phylogenetic nomenclature'. *Botanical Review* 69: 93–110.
- Kitcher, P. (1984) 'Species'. *Philosophy of Science* 51: 308–333.
- Kitcher, P. (1993) *The Advancement of Science*. Oxford: Oxford University Press.
- Kitcher, P. (2001) 'Real Realism: the Galilean strategy'. *Philosophical Review* 110: 151–197.
- Knorr Cetina, K. (1993) 'Strong constructivism: from a sociologist's point of view'. *Social Studies of Science* 23: 555–63.
- Köhler, W. (1929) *Gestalt Psychology*. London.
- Kornblith, H. (1993) *Inductive inference and its natural ground: An essay in naturalistic epistemology*. Cambridge, Mass.: MIT Press.
- Kuhn, T. S. (1962) *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
- Kuhn, T. S. (1990) 'Dubbing and Redubbing: the Vulnerability of Rigid Designation'. In C. Wade Savage (ed.) 'Scientific Theories', *Minnesota Studies in the Philosophy of Science* 14 Minneapolis: University of Minnesota Press. Pp. 298–318.
- Kuhn, T. S. (1991) 'The Road Since Structure'. In A. Fine, M. Forbes, and L. Wessels (eds.) *PSA 1990: Proceedings of the 1990 Biennial Meeting of the Philosophy of Science Association*, vol. 2. East Lansing, MI: Philosophy of Science Association. Pp. 3–13.
- Kuhn, T. S. (1993) 'Afterwards'. In P. Horwich (ed.) *World Changes: Thomas Kuhn and the Nature of Science*. Cambridge, Mass.: MIT Press. Pp. 311–39.
- Latour, B. (1999) *Pandora's hope: Essays on the reality of science studies*. Cambridge, Mass.: Harvard University Press.

- Laudan, L. (1981) 'A confutation of convergent realism'. *Philosophy of Science* 48: 19–49. Leplin, J. (1997) *A novel defence of scientific realism*. New York: Oxford University Press. Lipton, P. (1991) *Inference to the Best Explanation*. London: Routledge.
- Massimi, M. (2007) 'Saving unobservable phenomena'. *British Journal for the Philosophy of Science* 58: 235–262
- Massimi, M. (2008) 'Why there are no ready-made phenomena: what philosophers of science should learn from Kant'. In Massimi, M. (ed.) *Kant and Philosophy of Science Today*, Royal Institute of Philosophy Supplement 63. Cambridge: Cambridge University Press. Pp. 1–35.
- Massimi, M. (2009) 'Review of Bas van Fraassen *Scientific representation: paradoxes of perspective*'. *International Studies in Philosophy of Science* 23: 323–337
- Massimi, M. (2010) 'Galileo's mathematization of nature at the crossroad between the empiricist tradition and the Kantian one'. *Perspectives on Science* 18: 152–188.
- Massimi, M. (2011) 'From data to phenomena: a Kantian stance'. *Synthese* 182: 101–116.
- O'Keefe, J. (1990) 'A computational theory of the hippocampal cognitive map'. *Progress in Brain Research* 83: 287–300.
- O'Keefe, J. (1993) 'Kant and the sea-horse: an essay in the neurophilosophy of space'. In N. Eilan, R. McCarthy, and B. Brewer *Spatial representation. Problems in Philosophy and Psychology*. Oxford: Blackwell.
- O'Keefe, J. and Nadel, L. (1978) *The Hippocampus as Cognitive Map*. Oxford: Clarendon Press.
- Pereboom, D. (1990) 'Kant on Justification in Transcendental Philosophy'. *Synthese* 85: 25–54.
- Pereboom, D. (2006) 'Kant's metaphysical and transcendental deductions'. In G. Bird (ed.) *The Blackwell Guide to Kant*. Oxford: Blackwell.
- Pereboom, D. (2009) 'Kant's Transcendental Arguments'. *Stanford Encyclopaedia of Philosophy*, accessed online 10/07/2011.
- Popper, K. (1959) *The Logic of Scientific Discovery*. London: Hutchinson&Co.
- Putnam, H. (1990) *Realism with a Human Face*. Cambridge, Mass.: Harvard University Press.
- Quine, W. V. (1969) 'Natural kinds'. In *Ontological Relativity and Other Essays*. New York and London: Columbia University Press. Pp. 114–138.
- Quine, W. V. (1975) 'Five milestones of empiricism'. Reprinted in Quine (1981), *Theories and Things*. Cambridge, Mass.: Harvard University Press.
- Sacks, M. (1999) 'Transcendental Arguments and the Inference to Reality: A reply to Stern'. In R. Stern *Transcendental Arguments. Problems and Prospects*. Oxford: Clarendon Press.
- Sellars, W. (1968) *Science and Metaphysics: Variations on Kantian Themes*. London: Routledge.
- Sismondo, S. (1993) 'Response to Knorr Cetina'. *Social Studies of Science* 23: 563–69.
- Stanford, K. (2006) *Exceeding our grasp*. Oxford: Oxford University Press.
- Stern, R. (1999) 'On Kant's response to Hume: the Second Analogy as Transcendental Argument'. In R. Stern *Transcendental Arguments. Problems and Prospects*. Oxford: Clarendon Press.
- Stern, R. (2000) *Transcendental arguments and Scepticism*. Oxford: Clarendon Press.
- Strawson, P. F. (1966) *The Bounds of Sense*. London: Methuen.
- Strawson, P. F. (1985) *Skepticism and Naturalism: Some Varieties*. London: Methuen.
- Stroud, B. (1968) 'Transcendental arguments'. *Journal of Philosophy* 65: 241–56.
- Stroud, B. (1994) 'Kantian Argument, Conceptual Capacities, and Invulnerability'. In P. Parrini (ed.) *Kant and Contemporary Epistemology*, Dordrecht: Kluwer. van Cleve, J. (1999) *Problems*

- from Kant*. NY: Oxford University Press
- van Fraassen, B. (1980) *The Scientific Image*. Oxford: Clarendon Press.
- van Fraassen, B. (2008) *Scientific representation: Paradoxes of Perspective*. Oxford: Clarendon Press.
- Westphal, K. (1997) 'Affinity, Idealism, and Naturalism: the Stability of Cinnabar and the Possibility of Experience'. *Kant-Studien* 88:139–189.
- Wilson, M. (2006) *Wandering significance*. Oxford: Clarendon Press.
- Wilson, M. (2010) 'What can contemporary philosophy learn from our "scientific philosophy" heritage?'. *Noûs* 44: 545–70
- Wilson, R. (2005) *Genes and the Agents of Life: The Individual in the Fragile Sciences*. New York: Cambridge University Press.
- Wilson, R., Barker, M. and Brigandt, I. (2009) 'When traditional essentialism fails: biological natural kinds'. *Philosophical Topics* 35: 189–215.
- Worrall, J. (1994) 'How to remain (reasonably) optimistic: scientific realism and the "luminiferous ether"'. *PSA 1994*, vol. 1: 334–342.