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Scientific Ontology and Speculative Ontology

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A conflict has emerged in contemporary philosophy between two quite different ways of approaching ontology. Over the last few years a growing divide has emerged between the fields that are often called 'analytic metaphysics' and 'scientific metaphysics.' Analytic metaphysics is characterized by the importance given to a priori methods and to conceptual analysis. A posteriori scientific results are at best a peripheral part of its evidence base. In contrast, scientific metaphysics looks to the results of contemporary science for guidance to the correct ontology.[1]

This tension between scientific and analytic metaphysics has a long history. The logical empiricists tried to do away with metaphysics, failed, and metaphysics made a spectacular comeback. Its revival increased the potential for friction between the two areas, although the antipathy seems to be more visible to philosophers of science than it is to metaphysicians. Some philosophers of science have principled objections to metaphysics or to conceptual analysis, often for reasons stemming from a sympathy for empiricism or for naturalism.[2] Others object to the use of non-perceptual intuitions as a reliable method for arriving at truths.[3] Still others find the

[1] Although scientific metaphysics tends to draw its conclusions from fundamental physics, I do not presuppose the correctness of that approach here. One reason is the failure of various reductionist programs and the empirical evidence for emergent properties that are not fundamental in the sense that they fall outside the domain of high energy physics, digital physics, information-theoretic physics, or whatever is currently considered to be 'fundamental.'

[2] See e.g. van Fraassen (2004) for an example of the first orientation.

[3] See e.g. Williamson (2005).

pretensions of analytic metaphysics objectionable.[4] My paper is an attempt to lay out some of the reasons behind the tension and to suggest the form that appropriate ontological inquiries might take. There is a legitimate place for metaphysical reasoning and conceptual analysis in the philosophy of science. It is also true that parts of contemporary metaphysics are indefensible.[5]

Put in its simplest terms, the question is this: If one has reason to think that broadly aimed anti-metaphysical arguments have failed and that metaphysics can be pursued as a supplement to science, what methods should a scientifically informed metaphysics employ? As a starting point, I shall assume that some version of realism is acceptable, where by 'realism' I mean any ontological position that accepts the existence of at least some entities such that those entities and their intrinsic and relational properties do not depend on conscious intellectual activity.[6] This allows that some entities are so dependent, such as the property of fear, that some are culturally dependent, such as the existence of money, and that our own access to them may be mediated, perhaps unavoidably, by representational apparatus. The realism assumption is not unassailable, but there are few idealists nowadays, neo-Kantians can interpret the arguments given here as establishing choice criteria for the representational and evidential apparatus to be employed, and it allows many entities of traditional metaphysics, such as abstract objects, causal relations, haecceities, and others to be considered under the definition of realism.

This general characterization of realism is important for two reasons. First, more specific kinds of realism are defined in opposition to some other position, such as empiricism in the case of scientific realism, nominalism in the case of realism about universals, or constructivism in the case of realism about mathematical objects. One cannot ignore those oppositions entirely because they have to a large extent shaped the tradition of what counts as metaphysics, and it is the lack of clear success for the anti-realist member of each of those pairs that has left open the possibility for the

[4] See Ladyman and Ross (2007).

[5] In this article I shall discuss only selected examples of mainstream analytic metaphysics. There are more extreme forms but they are easier targets of criticism. In some cases the defense of a religious position appears to be the ultimate goal of the arguments.

[6] One thing that is not allowed to exist: conscious intellectual activity by a deity. This will be a restriction only if the existence of such a deity is used to transform some version of what is ordinarily considered to be idealism into a deity-dependent form of realism.

broader kind of realism considered here. But those oppositions are not directly relevant to my concerns. For example, the differences between scientific metaphysics and analytic metaphysics need not be due to differences about the status of abstract entities, as the older opposition between realism and nominalism suggested. Scientific metaphysics has to consider the possibility of abstract entities because first order logic is too weak to serve as the basis for mathematics that is adequate for science and at least some second-order mathematical properties such as 'is a random variable' are, if not purely formal, abstract.[7] Secondly, the kind of broad ontological categories that emerge from these oppositions—abstract versus concrete entities, observable versus non-observable entities, and so on—are too crude to be methodologically useful. The kinds of procedures that are relevant to establishing the existence of a set with the cardinality of the real numbers are radically different from those that would be needed to establish the existence of non-natural moral properties.

Although the tension between the philosophy of science and analytic metaphysics is prima facie about what exists, that is proxy for a deep difference about what counts as an appropriate philosophical method. This means that the epistemology of ontological claims will play a central role in the discussion. I thus have a second assumption. It is that the methods of the physical sciences have been successful in discovering the existence and properties of a number of generally accepted entities in the physical sciences.[8] These procedures include empirical, mathematical, and computational methods. This assumption should also be reasonably uncontroversial and it does not deny that other methods can and have been successful when applied to appropriate subject matter. The assumption is incompatible with versions of universal scepticism under which all methods of inquiry are equally unable to provide warrants for truth but on those views the basic dispute under discussion here has no content. Weaker positions such that specifiable scientific methods are less fallible than the methods of analytic metaphysics could be substituted for our second assumption.

[7] The nominalist program for scientific mathematics pursued by Field (1980), while revealing, is not widely regarded as successful.

[8] By 'physical sciences' I mean astrophysics (including cosmology and cosmogony), physics, and chemistry. I would be willing to extend this to some, but not all, biological sciences but this is not necessary for present purposes.

The two assumptions together provide us with an overall strategy. Realism suggests that because things are the way they are independently of how we know (of) them, and there is no prima facie reason to hold that a single, uniform set of epistemological methods will be successful in all domains, we should begin with the position that different domains of inquiry might require different epistemological approaches. Our second assumption suggests that we begin with those methods that have evidence in favor of their success in a given area and explore how far they can be extended before they break down and need supplementation. This suggestion does not preclude a priori methods and appeals to intuition being successful in areas such as mathematics and metaphysics. It relies on the inductive fact—and it is a fact—that those methods are unreliable when applied to the domain of the sciences. That is, we already have evidence that such methods fail when they are applied to the sciences mentioned above unless they are supplemented by empirical data. The project now is to see if incursions into metaphysics by scientific methods can be successful. It would be naive to simply assume that methods which have been successful in the physical sciences will also be successful for ontological purposes in other areas, but a good deal of sound epistemic practice is enshrined in the methods of the more rigorous sciences and it can be useful to see whether they can be adapted to philosophical applications. If and when these methods break down, their failures can provide clues as to what should replace them in the given domain.

Having set up the broad opposition in these terms, I shall immediately restrict the scope of my discussion. It is impossible to precisely capture the scope of analytic metaphysics, which allows some practitioners to deny that they contribute to the discipline. So rather than discussing the broader category of 'analytic metaphysics,' I shall consider what I call 'speculative ontology.'[9] Consider ontology to be the study of what exists, a domain that includes not only what there is and what there is not, but the intrinsic

[9] The term 'speculative metaphysics' is often used to designate a certain type of activity, including the kind of metaphysics to which Kant was opposed. I shall therefore avoid that term. The term 'naive ontology' is not quite right because the lack of appeal to scientific knowledge can be willful, although the effects are the same as would result from ignorance. The term 'speculative mathematics' was traditionally used to denote what is now known as pure mathematics (see Stewart et al., 1835), a tradition not to be confused with how speculative mathematics is now conceived (see Jaffe and Quinn, 1993).

properties of and relational structures between the entities, including second-order and higher properties and relations.

What restrictions does science place upon ontological results? I do not have a sharp criterion to distinguish scientific results from other kinds of conclusions. One reason is that considerable parts of contemporary cosmogony are so remote from direct empirical tests that they cannot be assessed primarily on grounds of empirical adequacy and are, in their own way, as speculative as are parts of metaphysics. But such activities are constrained by well established scientific results such as general relativistic accounts of gravity, conservation principles derived from high energy physics, and the Standard Model, together with widely accepted standards of scientific evidence such as consistency with empirical knowledge, use of the principle of total evidence, explicitness of the assumptions used, willingness to abandon a hypothesis in the face of counter-evidence, and so on. All of these constraints are defeasible but they must be respected by those wishing to take into account all of the relevant contemporary evidence. The relevant differences between scientific ontology and other kinds of ontologies thus tend to center on what are considered constraints on the truth of the basic assumptions and the evidence base and when the kinds of constraints just mentioned are applied, we have scientific ontology. When they are not, we have speculative ontology.

Scientific ontology goes beyond whatever ontology the current scientific community currently endorses because underdetermination considerations often suggest the exploration of alternative ontologies that are compatible with scientific principles and evidence and in which scientists display little interest.[10] Two examples are Bohm's interpretation of classical quantum mechanics (Bohm, 1952) and David Chalmers' conclusions about dualism (Chalmers, 1997). These are serious attempts to argue for an alternative to the mainstream ontology and both satisfy the conditions for a scientific ontology. I shall now present four principal reasons why speculative ontology should be viewed with deep suspicion. These are its widespread factual falsity, its appeal to intuitions, its informal use of conceptual analysis, and its assumption of scale invariance. These objections are not independent but because they do not apply uniformly to all activities within speculative ontology it is worth considering them separately.

[10] Thus the deferential attitude to science endorsed in the natural ontological attitude (Fine, 1984) is inadequate for an informed scientific ontology. I shall say more on this point in section 7.

1. The factual falsity of speculative ontology

Some claims of speculative ontology can be dismissed on the straightforward grounds that they are not even true, let alone necessarily true. The fault is not that these claims are false. Falsity is a ground for criticizing a claim, but not for dismissing it as irresponsible. What moves a claim from the first to the second category is the existence of an epistemic situation consisting of these components: i) the claim is incompatible with the results of a well-established knowledge base, ii) those results are widely known in the relevant epistemic community, and iii) a modest amount of work would lead to those results being understood by philosophers. A murkier realm looms when the fact that the claim is false is brought to the attention of those who argue for it and the fact is ignored.

Traditional metaphysics tended to concern itself with necessary truths and although they were truths of our world too, the claims were generally beyond the reach of empirical science and so any potential conflict with scientific results was muted. Two things have changed that situation. The increased sophistication of the physical sciences has led to a number of metaphysical theses that were widely held to be necessarily true being shown to be factually false by experimental evidence. Well known historical examples are the identity of indiscernibles, universal determinism, and universal causation.

Conversely, there has been a move by some metaphysicians towards taking certain metaphysical claims as contingent, rather than necessary. A much-discussed contemporary example of this kind of project is David Lewis's Humean supervenience program, the physicalist position within which the ontology consists only of local points of space-time and local properties instantiated at those points. Everything else globally supervenes on that. Here is what Lewis had to say about the modal status of his view: 'I have conceded that Humean supervenience is a contingent, therefore an empirical, issue. Then why should I, as a philosopher rather than a physics fan, care about it? . . . Really, what I uphold is not so much the truth of Humean supervenience as the *tenability* of it. If physics itself were to teach me that it is false, I wouldn't grieve' (Lewis, 1986: xi).

As an exercise in theorizing, Lewis's attitude would be unobjectionable were the position seriously put to an empirical test. But it has not in the sense that science long ago showed that Humean supervenience is factually false. The claim that the physical world has a form that fits the constraints of Humean supervenience is incompatible with well-known and well-confirmed theoretical knowledge about the non-separability of fermions. It was empirically established before Lewis's position was developed that entangled states in quantum mechanics exist and do not supervene on what would in classical cases be called the states of the components. This feature of our world is sufficiently well confirmed as to make Humean supervenience untenable.[11]

It would be unreasonable to object to an intellectual activity simply on the grounds that its products did not represent truths about the concrete world. Many areas of mathematics have their own intrinsic pleasures and there is virtue in understanding how the world might have been, but is not. Yet when reading many Lewisian disciples, they do little to dispel the impression that the apparatus under construction is a guide to the ontological structure of our world and one wonders why so much effort is expended on this apparatus when more promising ontological alternatives are waiting to be investigated.[12]

Speculative ontologists might object to this line of reasoning on the grounds that what I have called factual falsity is better described as an inconsistency between a sentence that is supported by empirical evidence and a sentence supported by a priori reasoning, that the truth value of the scientific sentence is, on inductive historical grounds, uncertain and liable to eventually be rejected and hence that we should not allow the empirical evidence for the scientific claim to take priority over the a priori reasons for the other claim.[13] We can reply to this concern in two ways. First, that worries stemming from the pessimistic meta-induction have been exaggerated; that raising the mere logical possibility that a scientific claim might be false adds nothing to what we already knew, which is that such claims are contingent; and that in the absence of specific evidence that is directly relevant to a particular scientific claim which suggests that the claim is false and the presence of specific evidence that it is true, the rational epistemic action is to accept the claim as true. Such worries are more pressing when claims about fundamental ontology are involved and this response does indeed gain purchase there. But many conflicts between scientific and speculative ontology are not about fundamentals.

[11] See e.g. Maudlin (2007), Chapter 2.

[12] For a defence of Lewis's tenability claim, see Weatherson (2010).

[13] I am grateful to Anjan Chakravartty for raising this objection.

Despite initial appearances, Lewis' metaphysics is as much about preserving common sense as it is about establishing esoterica.[14]

The second reply is to accept the response and to note that what science can do is to provide us with descriptions of possible situations that, even if they are not true of our world, expand our set of known metaphysical possibilities and can also show that certain metaphysical generalizations are not necessarily true. It is often as important to be aware of error as it is to know the truth and science is capable of informing us about both, within the limits of fallibility that are inescapable in both science and ontology.

2. Whose intuitions?

A second source of discontent with speculative ontology is its appeal to intuitions as evidence. Although this suspicion is well-founded in many cases, arguments against the use of intuitions are not straightforward. Empirical evidence has shown that intuitions are highly fallible about both factual matters and reasoning, violating our principle of least epistemic risk (see section 6), but that evidence usually comes from studies on agents with skills below the expert level and we should be wary of too hasty conclusions about the inappropriateness of all appeals to intuition.[15] I take an intuition to be an unreflective and non-inferential judgment and I shall be concerned primarily, although not exclusively, with non-perceptual intuitions.[16] It is common to add that intuitions are immediate, but insisting on immediacy qua temporal immediacy is unnecessary, for what is important is the unreflective aspect. Were I to be asked for my judgment on some issue, then immediately fell into a prolonged state of unconsciousness within which no subconscious or unconscious reasoning processes occurred, and I finally

[14] For a defense of this claim, see Symons (2008).

[15] In mathematics, views are divided about the use of intuitions. There is a stark contrast between the position of the logician J. Barkley Rosser: 'The average mathematician should not forget that intuition is the final authority' (quoted in De Millo, Lipton, and Perlis, 1979) and that of Frege: 'To prevent anything intuitive from penetrating [the realm of arithmetical reasoning] unnoticed, I had to bend every effort to keep the chain of inferences free from gaps' (Frege, *Begriffsschrift* in van Heijernoort, 1967).

[16] One use of the term 'intuition' ruled out by this definition is its use in the expression 'Here's the intuition', often said by mathematicians and other practitioners of formal methods after presenting some technical item. What is being conveyed is an informal understanding, stripped of necessary but secondary details, and that understanding is the result of significant reflection on the content of the formal apparatus.

rendered my judgment upon awakening, or the intervening time was spent mentally rerunning the last six miles of a recent marathon, my response would be as much an intuition as any instantaneous judgment. There are other uses of the term 'intuition' in contemporary philosophy. In addition to the sense just given, it is common to use the term to refer to a psychological entity, a propositional attitude accompanied by a felt sense of certainty.[17] Brief reflection on the proposition involved is also allowed. Sometimes an intuition can be the starting point for a process of reflective equilibrium, but more often it is a non-negotiable item.

Two obvious problems with intuitions are that they tend to differ, often considerably, between philosophers and they are often wrong when they are not about everyday experiences because we have no prior knowledge base on which to draw. These are familiar objections but I want to draw attention to a further reason to doubt many appeals to intuition. In traditions in which logical analysis and explicit definitions are central, it is often taken for granted that conceptual analysis and the use of intuition are subject matter independent activities and are largely agent-independent as befits their foundational status. But there are good reasons to doubt both of these claims and to hold that the reliability of intuitions and the use of conceptual analysis is domain specific and varies between agents. That is, a given agent's intuitions can be a reliable source of knowledge when applied to one domain and unreliable when applied to another while another agent's intuitions have the inverse degrees of reliability.[18]

This claim is clearly true for perceptual intuitions. Certain qualia are epistemically accessible by the visual modality but not others, such as flavours which must be accessed by the faculty of human taste. Other domains, such as those of mathematics and of modal truths, are assumed to

[17] For this use, see Bealer (1999: 247). Bealer argues that one can have an intuition that A and not believe that A because certain mathematical falsehoods can seem to be true yet one knows that they are not. This is arguable—if you do not believe A, you usually do not have the full force of a traditional intuition. It is not enough just to 'seem' that A is true otherwise a guess will count as an intuition. I doubt that there is a uniform answer here, in part because different philosophers use the term 'intuition' differently. Note that the modifier 'rational' can be applied to intuitions, for example when extrinsic constraints such as consistency with other intuitions or Bayesian coherence criteria are imposed. For further discussions of intuitions, see DePaul and Ramsey (1998).

[18] Reliability is also agent-specific in that different agents have different degrees of reliability in a given domain, a fact that is often ignored in the exchange of intuitions in philosophical arguments.

be accessible by rational intuition or spatial intuition but are beyond the reach of olfactory intuitions.[19] Different agents tend to have different degrees of acuity, and so an idealization is made to ideally competent agents. In the perceptual realm, most humans were considered to have capacities sufficiently close to the ideal standard to enable them to come to know most observational truths. This was also thought to be true in the realm of a priori truths for ideally rational agents, and in that case the vast majority of humans were considered able, if not willing, to attain the standards needed for simple cases of a priori knowledge. Yet this level of generality is implausible.

Let us separate two claims. The first is that for a given agent, appeals to a priori intuitions have equal validity across all domains in which non-empirical knowledge might be available. This is demonstrably false. Intuitions about probability are unreliable for most people, one famous example being the Monty Hall problem.[20] There is a correct answer to the problem but most people arrive at a wrong answer when they approach the problem intuitively and their intuitions must be corrected either by arguments or by real or simulated frequency data.[21] In contrast, intuitions about the transitivity of preferences or the correctness of modus ponens are, outside a few problem cases, generally correct.[22] The second claim is that most agents are sufficiently close to ideally competent across all domains when using intuitions. This is also demonstrably false. When considering geometrical intuitions, number theoretic intuitions, probabilistic intuitions, moral intuitions, logical intuitions, and so on, a given individual often has strengths in one area and not in another. So just as there are different perceptual modalities for different observable properties, and different scientific instruments for different detectable properties, the evidence seems to suggest that there are different levels of success for

[19] This surely is not necessarily true—there could be an arithmetic of smells—but I know of no mathematician who has reported working in this way.

[20] For an extensive discussion of this problem see Rosenhouse (2009).

[21] Paul Erdös was initially certain that the accepted solution was incorrect and was convinced only after seeing the results of a computer simulation.

[22] Anyone who has taught logic to enough students will have encountered the curious phenomenon of an occasional student who seems to lack the ability to understand some primitive logical inferences. Sometimes they function using concrete inferences; in other cases one suspects that associations between categorical statements substitute for hypothetical reasoning, for example substituting the sequence 'A customer complained. Call the supervisor' for inferences based on the rule 'If a customer complains, call the supervisor.'

different kinds of intuitions, and that we must specify a domain of reliability for a given type of intuition and a given agent.

Of course, there have been attempts to reduce expertise in these disparate domains to a common basis. But in cases in which intuitions involve concepts, the burden of proof is on those who claim that all mature agents have equal reliability when appealing to intuitions, regardless of the concepts involved. This is at odds with what we know from practice. Some philosophers have better moral intuitions or logical intuitions than others, where the basis for evaluating reliability is long-term consistency between an individual's intuitive judgments and evidence gained from non-intuitive sources. This conforms to the widely held view in science and mathematics that physical, biological, mathematical, and other types of intuition come in degrees and there is no obvious reason why this should be different in philosophy. Furthermore, because in scientific areas the expert 'intuitions' are usually, although not invariantly, shaped by considerable knowledge of the relevant science, the non-inferential characteristic of intuitions will hold only at the level of conscious processing and this will also be characteristic of philosophical intuitions.

Behind the tacit assumption that the use of intuition is the basis of a general method often lies an appeal, inherited from the tradition of linguistic analysis, to competent users of a language. But semantic externalism and the division of linguistic labor entail that this competence, and the use of linguistic intuitions in conceptual analysis, has severe limitations.[23] If the semantic content of some part of language depends upon the way the world is, then knowledge of the world, often quite detailed knowledge of the world, is required to know what constitutes that content. Perhaps this is a minor difficulty since the use of intuitions is often restricted to core examples of the correct use of the expression.[24] Even so, there is a related and more serious problem that occurs independently of whether one subscribes to externalism and it again requires us to decide whose intuitions should prevail. Consider the extension of the predicate 'dangerous'. Applied to other humans, many of us have some reasonably reliable intuitions about whether a given individual has the associated property or not and can identify some core examples of

[23] Arguments for semantic externalism can be found in Putnam (1974).

[24] Although not always because considerable philosophical discussion occurs about borderline cases of concepts.

dangerous humans. Yet we would, or should, defer to those who have better intuitions, such as members of the fire department, war veterans, or members of mountain rescue teams when circumstances demand it. What are the analogous circumstances in ontology and who are those with superior intuitions? I place little credence in appeals to intuitions and so I pose this challenge to the ontologists who use them. How do you train philosophers to improve their intuitions and how can we recognize when you have been successful? Who granted the Doctor of Intuition diploma on the metaphysician's mental wall?

We have arrived at the following principle: All methods have their domains of successful application and associated probabilities of error. There is not a uniform method of 'appeal to intuition' that has the same success rate for all rational agents across all domains. In the presence of conflicts between intuitions and in the absence of criteria establishing who are the expert practitioners in a given domain, we should remain agnostic about any appeals to intuition and reject them as a source of evidence.

3. Conceptual analysis

Conceptual analysis has a legitimate role to play in scientific ontology. Providing explicit or implicit definitions for concepts is an essential part of scientific understanding and should be encouraged but concepts drawn from everyday experience are often the wrong ones to analyze, whether in scientific or metaphysical contexts. One reason is that everyday, psychologically grounded, concepts usually do not have sharp, necessary and sufficient conditions, so that when an explicit definition is set up, it will not fit all intuitive examples of the concept. This is often the basis for the kind of unproductive exchange well-known to those who attend philosophy colloquia. In scientific contexts, conceptual analysis is complicated by the use of approximations and idealizations and a great deal of care is needed to draw the distinction between an idealized theoretical concept and the concept that is used in applications. Despite these reasons for maintaining a clear distinction between refined, theoretically based, concepts and concepts drawn from less considered sources, appeals to intuition have begun to serve as a replacement for traditional conceptual analysis in some areas of philosophy and even sophisticated philosophers with high standards for argumentation have suggested that their use is acceptable.

Take Frank Jackson's characterization of conceptual analysis: 'conceptual analysis is the very business of addressing when and whether a story told in one vocabulary is made true by one told in some allegedly more fundamental vocabulary' (Jackson, 2000: 28). This characterization covers not only familiar cases that lie in the vicinity of analytic truths and falsehoods, but the kinds of traditional reductive procedures in the philosophy of science that considered whether condensed matter physics is simply re-describing complex combinations of phenomena for which high energy physics has its own language.[25] Presupposed in this account is the view that we can tell when we are describing the same things in different ways. When this decision procedure relies solely on our understanding of some language, appeals to a priori knowledge are reasonably unproblematical. But the situation is different in discussions of reduction because the higher-level concepts are often presented to us through a theory at the higher level and not through explicit definitions or a quasi-reductive compositional account of the ontology. The identification of the referents of the different descriptions then often requires empirical knowledge and cannot be carried out a priori, a fact that is reflected in necessity of identity claims resting on the contingent truth of the identity. Furthermore, the evidence for the existence of the higher-level phenomenon is empirical, not a priori. For example, purely theoretical, *ab initio*, derivations of high temperature superconductivity are infeasible and the approximations used to arrive at the higher-level theory are justified on experimental grounds, not on a priori reasoning and definitions.

Not all contemporary conceptual analysis takes the traditional form of definitions. For example, David Chalmers and Frank Jackson have argued that conceptual analysis based on explicit or implicit definitions is unavailable and unnecessary in many epistemological contexts. 'It is sometimes claimed that for A ⊃ B to be a priori, the terms in B must be definable using the terms of A. On this view, a priori entailment requires definitions, or explicit conceptual analyses: that is, finite expressions in the relevant language that are a priori equivalent to the original terms, yielding

[25] The question of whether the Nagelian bridge laws used in that tradition are empirical or definitional is obviously relevant to whether conceptual analysis in this sense is sufficient for this example. The fact that neither the concepts of condensed matter physics nor its ontology are reducible to those of high energy physics is but one reason why many mereological claims fall into the category of speculative ontology.

counterexample-free analyses of those terms. This is not our view. . . . If anything, the moral of the Gettier discussion is that . . . explicit analyses are themselves dependent on a priori intuitions concerning specific cases, or equivalently, on a priori intuitions about certain conditionals. The Gettier literature shows repeatedly that explicit analyses are hostage to specific counterexamples, where these counterexamples involve a priori intuitions about hypothetical cases' (Chalmers and Jackson, 2001: 320–2). On this view, intuition plays a central role but since far more than a mastery of language is needed to bridge the levels in realistic reductionist examples, this position is less than convincing.

Goldman (2007: 18) argues that 'Philosophical analysis is mainly interested in common concepts, ones that underpin our folk metaphysics, our folk epistemology, our folk ethics, and so forth.' That would be fine, and indeed it may be the best approach for many issues in ethics, for ethics cannot move too far from what seems instinctively correct to most people without encountering overwhelming resistance. The situation is different in ontology because metaphysical arguments have led to highly counter-intuitive positions. The fact of being counter-intuitive is not itself an objection, for science frequently uses counter-intuitive representations too, but these are usually supported by empirical data. The problems arise when metaphysicians venture judgments about domains for which the appropriate concepts are far removed from, and often alien to, our human intuitions. Humans are epistemic experts in certain limited domains of inquiry, those that are best suited to our naturally evolved cognitive apparatus, and this includes many ordinary moral judgments. Had we evolved in a different environment, it is likely that our concepts would have been different, probably very different. Bees are the product of evolution, but there is little reason to think that they have similar concepts to us.[26] This suggests that when considering ontological issues, we should also consider cognitive agents who are not subject to our own contingent limitations and are different from or superior to us in cognitive abilities.

An example from computational science may illustrate why this appeal to extended cognitive abilities is useful in certain situations. We are delegating significant parts of computationally based science to non-human executors

[26] There is empirical evidence that bees perceive the world differently from us and thus would be likely to have a bee ontology that is different from human ontology. See Chittka and Walker (2006).

in computational neuroscience, complexity theory, condensed matter physics, and in many other domains, a trend that is destined to accelerate. We shall then with increasing frequency require novel conceptual frameworks to first, employ those techniques in the most effective possible ways and secondly, to understand the results emerging from their deployment. This is because what makes an effective representation for a computer is frequently different from what we humans find transparent in the conceptual realm.

Consider how computerized tomography represents data. An X-ray beam is directed through an object and impinges on a detector which measures the intensity of the received X-rays. If f(x,y) represents the intensity of the X-rays at the point <x,y>, then the line integral along the direction of the beam L, which is represented by the Radon transform of f along L, sums the intensities at all points along the line. Rotating the source around the object and plotting the values of the Radon transform for each of these angles gives a sinogram, which is what the detectors 'see'. It is rarely possible to know what the irradiated object is by visually inspecting the sinogram. Yet computers, using the inverse Radon transform, can easily produce data that, when turned into a graphic, 'directly' represent the object, such as a human skull, in a form accessible to the human visual system.[27]

The sinogram image has no compact representation in human languages connecting it with the ordinary perceptual concept of a human skull and since the machines operate on purely extensional representations, this example directly raises the problem that intensional characterizations of properties in natural languages are likely to be too sparse to capture the kinds of extensionally characterized properties used by computational science. What constitutes a pattern for a human is more restricted than (or is just different from) what constitutes a pattern for a computer. This suggests that philosophers need to do one of three things; expand their repertoire of representations to include those used by computational devices and instruments, despite the fact that those representations do not conform to any that are intuitively accessible to humans; concede that certain current and future scientific activities lie beyond human understanding, assuming that understanding requires possessing the relevant intensional representations, a position that is at odds with the fact that

[27] For examples of sinograms see <http://demonstrations.wolfram.com/ComputedTomographySimulationUsingTheRadonTransform/> accessed 23 May 2012.

we can understand at least some of these activities; or push their explorations of sub-conceptual, non-representational, and non-conceptual content beyond the realms currently explored in artificial intelligence, such as the use of dynamical systems theory or neural net representations. The second and third options entail that there are parts of ontology that lie beyond what is currently intuitively accessible, while the first option is unlikely to be successful without a considerable amount of conceptual retraining.

4. Philosophical idealizations

Consider the following claim. Having insisted that a collective, long term cognitive effort by humans allows an approximation to the ideal cognitive conditions required for a strong modal tie of intuitions to the truth, the author goes on to write that:

> Some people might accept that the strong modal tie thesis about intuition . . . [is] non-empirical but hold that [it does] nothing to clarify the relation between science and philosophy as practiced by human beings. After all, these theses yield only the possibility of autonomous, authoritative philosophical knowledge on the part of creatures whose cognitive conditions are suitably good. What could this possibly have to do with the question of the relation between science and philosophy as actually practiced by us?
>
> The answer is this: The investigation of the key concepts—intuition, evidence, concept possession—establish the possibility of autonomous, authoritative philosophical knowledge on the part of creatures in those ideal cognitive conditions. The same concepts, however, are essential to characterizing our own psychological and epistemic situation (and indeed those of any epistemic agent). (Bealer, 1998: 202–3)

So what are these idealized cognitive conditions? In the article by Chalmers and Jackson cited in section 3, the authors write: 'A priority concerns what is knowable in principle, not in practice and in assessing a priority, we idealize away from contingent cognitive limitations concerning memory, attention, reasoning, and the like' (Chalmers and Jackson, 2001: 334). But this view quickly leads to idealizations that are questionable and commit us to epistemic abilities that can trivialize philosophical conclusions. In the realm of idealizing human abilities, if we were allowed to sufficiently idealize our limited abilities, an appeal to supernatural agents would always be available. Moreover, since it has been remarked that the correct metaphysics will be revealed at the limit of idealized epistemology, some, although not all, epistemological idealizations of the 'in principle' kind will render certain claims of analytic metaphysics unassailable by default.

Although these approaches often go by the name of 'in principle' approaches, they are more accurately seen as forms of idealization and this requires us to answer the question: What counts as a legitimate philosophical idealization? The analogous question for scientific domains has been much discussed, but there is little in the way of sharp answers to the philosophical question.[28] Just as it is appropriate to require of scientific idealizations that a given idealization maintains some contact with properties of real systems, we should similarly require that we have some criteria for how to relax philosophical idealizations to bring them into contact with human abilities. One kind of epistemic idealization involves the extrapolation of human abilities. We can perform arithmetical operations on integers of a certain size and we then extrapolate that ability to much larger integers that human memory capacity is incapable of storing. That kind of idealization seems to be philosophically legitimate for some purposes because we know the algorithm for generating integers, we are familiar with memorizing small collections of them, and extrapolating that familiar experience to larger collections is just 'more of the same'.[29] A different kind of epistemic extension involves augmentation. Examples of this are easy to give for sensory modalities. We are not naturally equipped to detect the spins of elementary particles and we require instruments the output of which must be converted into a form that we are equipped to detect. Here it is unreasonable to suggest that detecting spins involves an in-principle idealization of human abilities, for there is nothing like that ability in our perceptual repertoire.

The epistemology of speculative ontology relies heavily on cognitive extrapolations and augmentations; the appeal to the perfections of God in the ontological argument, but against the standard theological position that, lacking the full complement of those perfections themselves, it is blasphemous for humans to suggest that they can fully understand the concept of God; the appeal to truths at the limit of scientific inquiry, when

[28] The literature on the differences between those who appeal to ideally rational agents and those who require bounded rationality is relevant here.

[29] This argument does not apply when we are accounting for how much of science is applied in practice.

we have no conception of what limit science will be like; oracles, or Platonists, who can inexplicably access mathematical truths, and so on.[30] Whether these are legitimate extrapolations or augmentations of human intellectual powers is an open question in the absence of criteria for acceptable philosophical idealizations.

5. Scale variance

Here is another principle: *Whether the world is scale-invariant is a contingent fact.* There is evidence that it is in certain ways and that it is not in others. Humans are all inescapably middle-sized objects with limited cognitive capacities that developed in the course of dealing with properties associated with similarly sized objects. One of the great scientific shifts in perspective was the twentieth-century realization that physical phenomena were not universally scale-invariant, that classical mechanics did not extend unchanged to the realms of the very small and the very large (nor, as a result, was it exactly correct in the realm of the middle-sized).[31] Once we had arrived at that realization, the status of the human a priori and of human experiences as sources of knowledge should have changed dramatically. Yet much work in epistemology and metaphysics proceeds as if that scientific shift had never occurred.

What properties, relations, objects, laws, and other parts of our ontology are like at scales radically different from those with which we are natively equipped to deal cannot be inferred from the evidence of direct experience. Consider this simplistic argument: ordinary experience tells us that a magnet has two opposite poles. If one cuts a bar magnet in two, each half has both a north and south pole. Therefore, by induction on common experience, one concludes that magnetic monopoles should not exist. And indeed, magnetic monopoles have not to this point been detected. But the scientific arguments for and against the existence of magnetic monopoles are of a very different kind than the simplistic argument just given and

[30] For clarification: the ontology of limit science here is included in the category of speculative ontology because there is no currently available way of inductively inferring from the present state of science to its limit state.

[31] I exclude here renormalization theories that focus on scale-invariant phenomena. Ladyman and Ross (2007) have discussed similar issues under the idea of 'scale-relative ontology'. Their discussion of Dennett (1991) on which their scale-relative position is based is very helpful in understanding the consequences of Dennett's paper.

current versions of quantum field theory suggest the existence of dyons, of which magnetic monopoles are a special case. For a less naive inference, take the limit of zero resistance in a suitable conducting material (usually achieved by lowering the temperature) and you have moved into a distinctively different physical realm, one in which not just Ohm's Law is false but the ontology changes as the conductive carriers, which originally are electrons, are replaced by a Cooper pair superfluid.

So what morals should we draw from the lack of scale invariance? First, the distinctions between the observable and the unobservable, between the non-theoretical and the theoretical, and between entities at the human scale and those outside that scale are different distinctions. The fact that the first two draw on different categories, objects, and properties in the first case, terms in the second, has often been noted. The logical independence of the elements of the second and the third distinctions can be shown by the fact that money is a classically human scale construct but there exist multiple different theoretical measures of what falls under its scope—M0, M1, M2, and M3 are common measures. Also, the description 'a sphere twice the size of the largest sphere considered to be at the human scale' is non-theoretical, whatever non-trivial sense of 'theoretical' you use, but describes an entity beyond the human scale. The other two cases are easy. The fact that the third and the first distinctions are incommensurable becomes evident if we focus on properties rather than objects. Properties can be observable or not, but size scales do not apply to properties, including metric properties such as 'is one foot long,' only to regions of space possessing them.

Now consider the standard definition that induction involves inferences from the observed to the unobserved. Stock examples of inductive inference, such as generalizations from sub-populations to the whole population, which involve claims that the same property possessed by members of the sub-population will be possessed by all members of the population, can be misleading because usually all instances of the generalization exist at the same scale. But inferences from the observed to the unobserved across differences of scale introduce an additional inductive risk. In addition to the usual assumptions such as that the future resembles the past and that properties are projectable, we must make the assumption that the part of the world under investigation is scale-invariant. This kind of inference is often classified as extrapolation, and extrapolation is, at root, a particular kind of inductive inference and is hence not a priori. Thus what might seem to be a result of a priori reasoning within speculative ontology, and this is especially true of various forms of mereology when put forward as a comprehensive ontological position, actually contains a hidden a posteriori element that is, moreover, likely to be false. This argument applies independently of what particular perceptual abilities an agent has, as long as they are not universal, and the concepts involved in the ontology require empirical access to be acquired.

Much of metaphysical argumentation has deep similarities with the arguments that accompany thought experiments and when constructing a hypothetical scenario, we need to know the laws and specific facts that apply at the scale at which the scenario is described. The only source of that knowledge is science; our intuitions and a priori imagination and reasoning are not equipped to provide it. At least some of the problematical examples of speculative ontology arise from simply assuming scale invariance when the system does not exhibit it. For example, the telegraphic identity 'water = H_2O' is false as stated since the left hand side refers to the usual macroscopic fluid and so the right hand side should read 'a macroscopic collection of H_2O molecules interacting in such a way that the properties of liquidity, transparency, ability to undergo phase transitions, and so forth are present.'[32]

Here then is a central problem of using intuitions in speculative ontology. The apparently a priori methods mask a tacit appeal to an inductive inference when making the scale-invariance assumption. Because human intuitions about ontology are obtained by experience with human-sized entities, any inference to regions beyond that domain involves an inference from the empirically known to the empirically unknown and that contains an inductive risk. Because there is considerable evidence that this inductive risk is high and that the conclusions of similar inferences have turned out to be false, generalization from intuitions in speculative ontology should be avoided.

6. The principle of least epistemic risk

One feature that traditional metaphysics and traditional empiricism had in common was a commitment to risk aversion. It can be captured in this principle: When competing ontological claims are made, determine the

[32] For a related point, see Johnson (1997).

degree of epistemic risk associated with the methods used to establish or deny the existence of the entity in question and make the ontological choice based on the method with the lowest risk. The risk need not be zero—certainty may not be obtainable—but in their different ways, the foundational enterprises embedded in traditional metaphysics and traditional empiricism both relied on this principle, together with a second principle that inferences from the foundations never decrease the degree of risk, making the foundations the most secure of all claims.[33]

This epistemic principle has important consequences for ontological claims. For example, it makes the opposition to scientific realism by traditional empiricism inappropriate because traditional empiricism takes observables to constitute a fixed category tied to human perceptual abilities and it takes beliefs about observables to be uniformly less risky than beliefs based on what are considered to be unobservables.[34] I criticized the first assumption in Humphreys (2004), Chapter 2; here I focus on the second assumption. Suppose we take the human perceptual apparatus as the foundation for all beliefs about concrete entities. In this role, the human perceptual apparatus plays the same function as calibration devices in the sciences. If we believe that a room measured with a laser rangefinder has a length of 22 feet, this is based on the user's belief that were he to use a tape measure instead, he would directly see the coincidence between the 22 feet mark on the tape and the wall of the room. Assessments of systematic and random errors for an empirical quantity are always made with respect to a calibration standard for the 'true' value. But the device used for the calibration standard is rarely the one used to collect data in most experiments because the conditions under which data from a particular system must be collected are not those under which the calibrating system has optimal functionality. To illustrate the different domains of applicability of traditional empiricism and scientific empiricism, at the time of its painting a portrait by Vermeer could have been authenticated by his wife who witnessed him painting it but now, X-ray fluorescence and wavelet decomposition techniques would supercede any human judgment. Differently, although the correctness of individual steps in a long

[33] Of course inferences together with additional evidence might result in a decrease.

[34] I have couched the discussion here in terms of beliefs to accommodate traditional empiricist positions although my own view is that this anthropocentric apparatus should be abandoned.

computation can be determined a priori by humans, the balancing of foreign exchange trading by Deutsche Bank AG is made by automated methods, and unavoidably so. The philosophical moral is this: the fact that there exist agents who act as a ground for beliefs about a given epistemic task does not entail that those agents can act as a foundation for comparative judgments about risk for that task under all conditions. As science gains greater access to what exists, the judgments of humans, whether empiricists or speculative ontologists, become increasingly risky and so will be replaced by conclusions drawn from scientific sources.

7. Why philosophers of science cannot avoid doing metaphysics

Some of the problems of speculative ontology have been described. Does this mean that we should avoid ontological or metaphysical arguments entirely? This is not possible and to see why consider the following question. How did we get to the point where it is necessary to once again eliminate certain types of metaphysical reasoning? Here is one broad historical thread that gives at least part of the reason. By its very nature, much of metaphysical activity involves decisions about issues that are under-determined by science. In particular, for decisions about ontology, this route was signaled by Carnap's characterization of external questions as having conventionally chosen answers and by Quine's relativized ontology. (See Carnap, 1956 and Quine, 1969.) Wanting such choices to be based on less vague grounds than the pragmatic criteria offered by those two philosophers, some metaphysicians, understandably, have tried to provide convincing arguments for the choice of one ontology over another.

This is a legitimate role for philosophy. Ordinary scientific practice is not oriented towards establishing claims of realism or anti-realism. For the most part, when scientists try to do philosophy, they do it as amateurs, with noticeably poor results.[35] Science is designed to obtain results from complex experimental apparatuses, to run effective computer simulations,

[35] There are exceptions. Richard Feynman, despite his often caustic comments about the philosophy of science, had a number of important philosophical insights, some contained in Feynman (1967). Other scientists, equally critical of the philosophy of science, are simply naive, which is what one would expect of those with no training in the field. For one example, see Hawking and Mlodinow (2010).

to derive predictions from models, along with other tasks unrelated to ontology. In arguing for his Natural Ontological Attitude in which one leaves the choice of ontology to the relevant scientific community, Arthur Fine suggested, in analogy with Hilbert's programme in metamathematics, that 'to argue for realism one must employ methods more stringent than those in ordinary scientific practice' (Fine, 1984: 85–6). This analogy with consistency proofs is misplaced. The justification procedures involved in using observational or experimental techniques to assert the existence of some entity or type of entity are not stronger than the theoretical representations involved in making the realist claims, merely different.[36] Moreover, even in formal sciences, philosophical arguments about existence are relevant. Here is an example. Using a consistency proof, Herzberg (2010) has shown that infinite regresses of probabilistic justification do not render justification of the end-state proposition impossible but he notes that the value of the justificatory probability may not be expressible in the form of a closed form solution. Because there is no precise, universally accepted, definition of a closed form solution, reasons for and against the acceptability of probability values that cannot be estimated are not mathematical but recognizably philosophical, whether presented by philosophers or by mathematicians.

Some scientific activities, such as the search for the Higgs boson or the earlier search for the conjectured planet Vulcan, also have the aim of establishing the existence or non-existence of certain features of the world and philosophers can learn much from the procedures used. There is a strong tradition in arguments for and against realism that criteria for what exists must be general. Yet one moral that can be drawn from claims of existence made within science is that the evidence for existence claims is often domain-specific. This suggests that a position of selective realism is the kind of realism appropriate for scientific realism, rather than the uniform commitment to realism that is characteristic of, to take one example, Quine's criterion for ontological commitment.[37] Coupled with

[36] 'Observational' is used here in the liberal scientific sense, not in the philosophical sense.

[37] The 'realism' that results from the appearance of existential quantifiers in a theory is only a genuine form of realism when objectual quantification over domains of real objects is used. Quantification over domains of models, or other kinds of weaker interpretations of quantification are insufficient to establish genuine realism. Of course, using domains of real objects is, without clarification, blatantly circular. For an account of selective realism see Humphreys (2004), section 3.8.

Quine's resistance to second-order logic, the legacy of this criterion has distorted discussions of ontology. We can also be misled by too strong an emphasis on entity realism or statement realism, where entities are identified with objects, when an important part of the realism issue involves the existence of properties.

These are considerations relating to scientific realism and although empiricists and anti-realists have attempted to label specifically philosophical reasoning about such matters as illegitimate, such reasoning is to specifically ontological conclusions. Here is one further example that is indisputably metaphysical. Universal determinism can seem puzzling because it is committed to the view that the present state of the universe was fixed millions of years ago. The puzzlement can be made to go away, but there is a related puzzle that is less easy to resolve: How can all of the relevant information needed to fix future states of the universe be encoded into a single instantaneous state? This puzzle becomes more pressing when we consider the state at the first instant of the universe. How can everything needed to guide the development of the universe for evermore be right there in a single time slice which has no history and no law-like regularities to guide its subsequent development? This is a serious difficulty for any view that insists that there can be no causal properties without an associated law, and that regularities are a necessary condition of having a law. There are no non-trivial regularities at the start of the universe, hence no laws, and hence, on these views, no causes.

There is no difficulty for systems that can refer to rules. Computational systems are such that their dynamical development is driven by rules of the form: if the system is in such and such a state, then execute action thus and so. If we assume analogously that the laws of nature were there at the beginning, as part of the program for the universe, this answer immediately gives us an important realist conclusion, that the early stages of the universe contained laws that existed independently of specific states and of what we can know about them.

There are other approaches to addressing this puzzle. One says simply that there is no answer to our question, that there are just successive states of the universe, one after another, and parts of the first time slice can be attributed a causal role only if and when regularities appear. I note that this answer can be, and is, couched in realist terms rather than in the epistemic way that Humeans favor. If you feel that there are deep and probably unanswerable mysteries about the origin of the universe, then you should feel that this first approach attributes those mysteries to every successive instant in the universe's evolution until a satisfactory regularity had been established. This is Hume's Problem dramatized, and it leaves the early and subsequent development of the universe a complete mystery. It is consistent but lacking in explanatory content.

A second approach denies the implicit assumption of the puzzle, which is that at the first instant there are no later instants yet in existence, and adopts the block universe model with its assumption that all states are eternally coexistent. This second approach has a curious feature, for if in such worlds laws supervene upon regularities and at least some different subsequent histories of the universe would give rise to different laws, and explanations of why later states of the universe have the features that they do depend upon both the initial state and the laws, then it is not true that the initial state of the universe determined (by itself) what was to come. Nor indeed does any initial segment of the universe, but only its entire subsequent development. This involves both the dependence of earlier states on later states and action at a temporal distance. A high price to pay and one that can be avoided by a third approach, which is to reject the idea that laws play a role in the development of the universe, and to assert that it is present property instances and their interactions that alone give rise to future developments. This is a metaphysical argument and one to which science itself has little if anything to contribute beyond providing constraints on the possible solutions.

8. Conclusions

The source of many of the problems associated with speculative ontology is that science, and physics in particular, long ago outran the conceptual abilities of most speculative ontologists. Contemporary science has revealed a much more subtle and interesting world than the often simple worlds of speculative ontologists, one example being the overuse of mereology by many contemporary metaphysicians.[38] The solution to these inadequacies is to pursue scientific ontology, an activity that is primarily interested in the

[38] There are scientifically sensitive advocates of more sophisticated forms of mereology. For one example, see Arntzenius and Hawthorne (2005) and for a balanced assessment of the mereological project see Varzi (2011).

contingent ontology of our world but one that can also provide a guide to unactualized possibilities. We can extract six morals from our discussion.

First, metaphysicians could, with a modest amount of effort, identify which contemporary metaphysical claims have been shown by science to be either contingently, rather than necessarily, true or simply false, thus preventing a considerable amount of wasted effort. It is true that advocates of speculative ontology can point to the pessimistic induction from the history of science as evidence that all scientific knowledge is eventually overthrown and argue that appeals to scientific authority are therefore too temporary and flimsy a basis for metaphysical truth. This would be an acceptable response if appropriate controls are placed on the methods used in metaphysics. A scientific ontologist must concede that fallibilism is the only acceptable epistemological position but our second conclusion, that different methods are appropriate for different domains of investigation, should be implemented. Thirdly, appeals to intuition are to be viewed with suspicion and it must at least be recognized that such appeals are both domain sensitive and differ in reliability between philosophers. Fourthly, conceptual analysis needs to rely less on ordinary concepts and draw more heavily on the extensive conceptual resources of science and, where appropriate, mathematics. Fifthly, philosophers collectively need to develop criteria for what counts as a legitimate philosophical idealization, criteria that are currently conspicuous by their absence. Finally, ontologists must recognize that our world is not scale-invariant and that as a result, a number of inferences that are taken to be a priori have a hidden inductive element.[39]

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