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SCIENTIFIC PERSPECTIVISM AND ITS FOES

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ABSTRACT

In this paper, I address a prominent realist challenge recently raised by Anjan Chakravartty (2010) against scientific perspectivism. I offer a response to the challenge, by rethinking scientific perspectivism as a view on *how* we form scientific knowledge, as opposed to a view about *what sort of objects* we have scientific knowledge of. My response follows Ernest Sosa's perspectivism in epistemology by drawing a distinction between truth and justification for our knowledge claims. With this distinction in place, I pledge to defend scientific perspectivism as a promising alternative to both objectivist realism and relativism.

Scientific perspectivism has emerged as a refreshingly new philosophical position in the ongoing debate between scientific realism and antirealism. The position has a distinguished philosophical pedigree back to Leibniz, Kant, Nietzsche, and even Wittgenstein.[1] The motivations for

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[1] There are several varieties of perspectivism available on the philosophical market. For example, Huw Price's (2007), pp. 250-292 causal perspectivalism as the view that the asymmetry of causation is ultimately rooted in the deliberative faculties of human agents, bears similarities with the anti-representationalist motivation behind scientific perspectivism. My focus here is with scientific

perspectivism in contemporary philosophy of science are various. Perspectivalist themes can be found in van Fraassen, especially his latest book on *Scientific Representation*, all dedicated to the perspectival nature of scientific measurement, in analogy with Albrecht Dürer's *Unterweysung der Messung*, and to the indexicality inherent our epistemic activities.[2] Alex Rueger[3] and Margie Morrison[4] have both discussed the prospects and challenges that perspectivism faces in dealing with inconsistent models in science, especially in the study of fluid dynamics. In recent years, Ron Giere[5] has championed a version of scientific perspectivism as a healthy *via media* between what he calls objectivist realism, on the one hand—namely, the view that science gives us a God's eye knowledge of nature—and the traps of silly relativism, on the other hand. As is to be expected with any middle ground, the position faces challenges both from the realists and the relativists. In what follows, I will not discuss the challenge coming from relativism, and I concentrate instead on the challenge coming from realism.

In a recent article,[6] Anjan Chakravartty has identified perspectivism as a view committed to either of these two theses:

(P1) We have knowledge of perspectival facts only, because non-perspectival facts are beyond our epistemic grasp.

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perspectivism itself, and I will not explore the wider philosophical context in which perspectivalist trends originate and flourish.

[2] van Fraassen (2008), pp. 75-86.

[3] Rueger (2005).

[4] Morrison (2011).

[5] Giere (2006a), (2006b), (2009), (2010).

[6] Chakravartty (2010), p. 407. For a reappraisal of perspectivism from the point of view of taxonomic pluralism and an account of natural kinds in terms of sociability of properties, see Chakravartty (2011).

(P2) We have knowledge of perspectival facts only, because there are no non-perspectival facts to be known.

The first is a weak claim of Kantian flavour: perspectivism would be compatible with the view that there are facts of the matter about the way nature is, but would insist that such facts of the matter are unknowable. The second thesis is stronger and amounts to a form of ontological relativism. Chakravartty discusses various arguments for perspectivism. One of them is the argument from detection, which from the selective range of input and the conditioned nature of the output concludes that knowledge afforded by detection procedures is always perspectival. But, he argues, from the fact that one's detectors are sensitive only to specific aspects or properties of target systems, "it does not follow that the facts they describe are perspectival in any philosophically controversial sense. It is a non-perspectival fact about charged bodies, for example, that they exert electrostatic forces on other charged bodies".[7]

In this paper, I analyse the realist's objection against the argument from detection. In particular, I focus on the realist view that knowledge afforded by scientific instruments is often knowledge of non-perspectival facts, and I conclude that the arguments usually provided in support of this claim tend to fall prey of an unwelcome form of epistemic bootstrapping. In this way, I hope to show that the prospects of defending scientific perspectivism (or—as will become apparent—some suitable variety of it) are not as unpromising as it might seem.

Most of the current debate has unfolded on the assumption that scientific perspectivism is a philosophical position about *what* we have scientific knowledge of, i.e. what kinds of *facts* (perspectival or non-perspectival) fall under the remit of our knowledge of nature. Here below, I am going to propose an alternative way of thinking about scientific

[7] Chakravartty (2010), p. 407.

perspectivism as a view primarily about *how* we gain scientific knowledge of nature. In so doing, I will echo Ernest Sosa's perspectival coherentism, as part of his early virtue perspectivism, whose aim was to accomplish a similar *via media* between foundationalism and coherentism about human knowledge.[8] I will draw some hopefully useful analogies with Sosa's program in epistemology and his distinction between apt beliefs *versus* justified beliefs, to make the point that although the truth-makers of our beliefs are non-perspectival facts about nature, yet the justification of our beliefs is intrinsically perspectival and rooted in our epistemic perspectives as human agents.

The paper is structured as follows. Section 1 gives a brief overview of Giere's scientific perspectivism. Section 2 considers the dispositional realist's view that perspectival knowledge reduces to knowledge of non-perspectival facts (more precisely, knowledge of nature's causal properties and dispositions). Section 3 questions the epistemic procedure on which such knowledge claims seem to be often made within dispositional realism. Section 4 sketches an alternative version of scientific perspectivism, which takes the lead from Sosa's perspectival coherentism in distinguishing matters of truth from matters of justification, and relocates scientific perspectivism in the latter camp.

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[8] See Sosa (1991), in particular the essays "The raft and the pyramid: coherence versus foundations in the theory of knowledge"; "The coherence of virtue and the virtue of coherence", and "Intellectual virtue in perspective". For a discussion of Sosa's work, see Greco (ed.) (2004), especially ch. 7 by Goldman, and Sosa's reply on pp. 312-313.

1. Ron Giere's Scientific Perspectivism

The secondary quality of scientific observation is Giere's start-up problem for scientific perspectivism. As our human visual system responds only to electromagnetic waves of a certain frequency, similarly scientific instruments are designed to respond only to a selected range of inputs. Moreover, just like human vision, the output of each scientific observation reflects the idiosyncratic nature of both the instrument that produced it and its interaction with the selected input. On this perspectivist view, we never have an observation of, say, the Trifid Nebula in and of itself, but instead an observation of the Trifid "*from the perspective provided by Malin's three-color process*".[9] We do not have an image of the brain, but an image "*as produced by CT scanning or fMRI*".[10] Giere uses these remarks to embark on a thoroughgoing perspectivist journey through scientific models and scientific theories, which I will not discuss in this paper. Instead I want to concentrate my attention on the very start-up problem for scientific perspectivism. How should we understand these perspectival claims about scientific observation and detection?

There is something intuitively right, and even appealing, about them. But for these remarks to constitute the argumentative platform for a new philosophical position sufficiently distinct from traditional realism, they must be construed as claims to the effect that there is no specific way the observed objects are *in and of themselves*, independently of the particular perspective from which they are observed or detected. For scientific realists would certainly agree with Giere that observation and detection are always from a specific vantage point afforded by the scientific instrument or set-up in question. But they would also resist the

[9] Giere (2006a), p. 43.
[10] Ibid. p. 56.

conclusion that the perspectival nature of scientific observation *affects* somehow the nature of the facts observed.

On the other hand, as soon as the prefix "From where we stand…" is added, and truth claims are made relative to a perspective, the ghost of relativism comes back to haunt the perspectivist. One may indeed legitimately ask what is the difference between scientific perspectivism and the fact-constructivism that some philosophers see at work in Hanson and Kuhn? Or what is the difference between scientific perspectivism and Putnam's conceptual relativism (recall Putnam's mereological conclusion about the Polish mathematician),[11] or Goodman's ways of world-making?[12]

Giere replies that being relative to a perspective does not imply that there is no fact of the matter about the object under investigation. Think of Brunelleschi perspectival experiment, for example. Brunelleschi painted the Battisterio in Florence and then made a hole in the painting and by looking through the hole to the real Battisterio exactly from the vantage point in which he painted it, he could compare his painting with the image of the Battisterio in the mirror and the two were identical. The Battisterio would still be there, no matter from which vantage point we look at it. Yet there is no 'objectivist' way of looking at the Battisterio, independently of any vantage point.[13]

The problem with this answer is that if all there is to scientific perspectivism is the view that our scientific observation and detection is always from a vantage point, critics are right in complaining that the position does not have a genuine philosophical bite. After all, scientific realists and anti-realists alike may well agree with the view that our observation and detection is always from a specific vantage point. Let us then analyse in more detail the challenge coming from the realist camp.

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[11] Putnam (1990), pp. 96-103.

[12] Goodman (1978).

[13] For remarks along these lines, see Giere (2006a), pp. 81-82.

2. Dispositional Realism and the Argument from Detection

Objectivist realism comes in many varieties. A prominent one in contemporary philosophy of science takes the form of dispositional realism, according to which nature is populated with genuinely occurring dispositions, conferred by causal properties, which may (or may not) manifest themselves in the presence of suitable stimuli. In a version originally due to Shoemaker and recently defended by Chakravartty,[14] dispositional realism captures a powerful intuition: namely, that causal properties are identified by the dispositions they confer on objects—hence the name 'dispositional identity thesis', or DIT. If DIT is correct, no philosophically interesting perspectivalist claim is afforded by scientific observation and detection procedures for three main reasons:

i. The selected range of inputs does not by itself license any perspectivalist conclusion about the outputs; e.g. even if a device may be selectively sensitive only to the electric charge of a body, it does not follow that the measured electrostatic force is itself perspectival.
ii. The conditioned nature of the output does not by itself make it perspectival in any genuine sense. For example, both electron microscopes and light microscopes can offer different vantage points on a target system, and yet corroborate certain causal properties of it.
iii. Perspectival facts are often explained away by the multi-faceted dispositional nature of the causal properties of the target system. For example, despite salt being ordinarily soluble in water, it

[14] See Shoemaker (1980), and Chakravartty (2007), pp. 123ff.

> won't dissolve if either the water is already saturated or is in the presence of a strong electromagnetic field. Yet in neither case would the solubility of salt be called into question.[15]

In what follows, I suggest that although dispositional realists are correct in complaining that neither the selective range of inputs nor the conditioned nature of the outputs per se license any perspectival claim about the target system, there are ways of reconciling the realist metaphysics (dear to DIT) with a *bona fide* perspectivalist position.

My argumentative strategy is the following: I envisage a problem standing on the way of living up to the dispositional realist's metaphysical promise of unveiling the dispositional nature of the target system. This problem is an instantiation of a more general problem well-known in epistemological quarters: epistemic bootstrapping. I contend that DIT defenders tend to leave open the question as to *how* our knowledge of the dispositional nature of the target system is *justified* (e.g. how are we justified in holding the belief that salt is indeed soluble?). One possible (albeit not exclusive) way of answering the justificatory question within the resources of DIT is to appeal to reliabilism. After all, reliabilism as an externalist epistemological position is congenial to DIT metaphysical realism: for example, one could reply that we are justified to believe in the solubility of the salt (even if there may be contexts in which this causal property is not manifested) because we have overall a successful past track record of observing salt dissolving in water, from which we generate the reliable belief that salt is soluble. But, I argue, if one attempts to answer the justificatory question along reliabilist lines, a compelling problem arises. In Section 3, I present the problem. In Section 4, I canvas a possible way out by appealing to a new version of scientific perspectivism, which can retain (and is indeed compatible with) the

[15] The three points are raised by Chakravartty (2010), pp. 407-409, in his criticism of the argument from detection.

realist rationale behind DIT, while also doing full justice to perspectivism in answering the justificatory question.

3. Epistemic Bootstrapping and Belief Justification

Consider the question of *how* we gain scientific knowledge of nature. The dispositional realist tends to reply that measurement devices are successfully deployed to detect entities' dispositions and hence causal properties (since causal properties are identified with the dispositions they confer on objects, according to DIT). This reply may take a more or less sophisticated form. For example, she may insist that the serendipitous coincidence of measurement outcomes in different experimental contexts is a clear indication that the causal property at issue is real and not an artefact of our measurement procedures. Or, she may insist, echoing Hacking, that insofar as we can intervene on these causal properties and manipulate them to do things in a lab, we are justified to believe that they are real.[16] A common strand in these different replies is the following: even if our causal knowledge is incomplete and our causal laws do not afford us an exhaustive knowledge of the causal mechanisms at work in each instance, still one is justified in ascribing causal properties to entities in the light of their downstream effects on the perceptual states of the observer (when confronted with meter readings and other measurement devices).[17] More precisely:

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[16] Hacking (1982).

[17] For an epistemic objection against DIT along these lines, see Rosenberg (1984), with a reply by Chakravartty (2007), pp. 134-36. By 'downstream' effects I mean the effects produced on the perceptual states of the observer at the

1. Dispositional realists seem to believe that we form reliable beliefs about causal properties as displayed by the dispositions they confer on objects via scientific instruments and detection procedures;
2. They also seem to believe that what justifies our beliefs about causal properties is an inference-to-the-best-explanation: believing in those causal properties is the best explanation for the success of our scientific instruments and detection procedures in delivering reliable beliefs (i.e. beliefs that have a preponderant tendency to be true, incomplete causal knowledge notwithstanding).

I want to stress the verb "seem" in 1. and 2. above, because while DIT has a full-blown metaphysical story about causal properties and their manifestations, DIT does not necessarily give us a clear indication about *how* our knowledge of these causal properties (and their manifestations) is in turn *justified*.[18] Thus, despite different ways of understanding 1.

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end of a potentially very long chain (which may or may not involve computer-aided detection procedures).

[18] One may, for example, try to endorse DIT while eschewing reliabilism (I thank Anjan Chakravartty for drawing my attention to this point). With or without reliabilism in prominent position, some form of IBE seems to be at work anyway in answering the justificatory question within DIT. My point in what follows is that such an IBE inference is often an inference from the success of our scientific instruments in delivering reliable beliefs about data and measurement outcomes (i.e. beliefs reliably generated and hence likely to be true) to more general beliefs about the causal ontology of nature. Hence, I take reliabilism to enter into the IBE inference that goes from (beliefs about) reliably generated experimental data (say, the displacement of fluorescence in cathode rays, where such displacement cannot be ascribed to experimental error and it is

(e.g., convergent measurement outcomes, or Hacking-style manipulability criterion, and so forth), our belief in, say, electrons having the causal property electric charge (let us call it EC) is: (1.) likely to be true because reliably generated via a suitable detection procedure; and (2.) justified because believing that electrons have electric charge is the best explanation for the success of our detection procedure in producing reliable beliefs (i.e. beliefs about electrons that have a preponderant tendency to be true, even if we may not know all the details of the causal mechanism at work in the detection procedure that delivers such beliefs).

But if we attempt to complete DIT along these lines (in order to answer the justificatory question), we become vulnerable to the same bootstrapping objection that critics like Jonathan Vogel have levelled against reliablism: namely, that it sanctions its own legitimacy. The problem has significant consequences for this possible extended version of DIT. Our scientific instruments reliably pick out a causal property such as EC to the extent that a bootstrapping mechanism of belief justification has taken place.

Let us take stock. We can see this battleground between perspectivists and dispositional realists clearly displayed in one historical example. Consider J. J. Thomson's first series of experiments on cathode rays in 1897.[19] Thomson's working hypothesis was that cathode rays consisted of negatively charged particles, which he called "corpuscles".[20] The

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a genuine feature of the target system), to (beliefs about) the causal properties that these data provide evidence for, and are the dispositional manifestations of (say, electrically charged particles).

[19] For a historical analysis of this episode, see Jed Z. Buchwald and Andrew Warwick (eds.) (2001), in particular ch. 1 by George Smith on "J. J. Thomson and the electron, 1897–1899", and T. Arabatzis (2006), ch. 4.

[20] As is well known, George Johnstone Stoney coined the term "electron" in the previous decade to refer to a fundamental unit of positive and negative

experimental set-up of cathode ray tube with an electrometer and a coil magnet, revealed that rays were bent in the presence of a magnetic field. Thomson was able to measure the mass-to-charge ratio of the "corpuscles" by inferring (in addition to the electric charge measured by the electrometer) the strength of the magnetic field *H* by the electric current in the coil, and by inferring the angle of deflection from the displaced fluorescence in the glass tube. Thus, the scientific perspectivist may argue that the ascription of the causal property electric charge is perspectival. Had either (a.) J. J. Thomson's perceptual system been impaired; or (b.) had the magnetic field not been strong enough to bend the rays away from the collector, or had the point of fluorescence not been well displaced; or (c.) had the electrometer, the anod or the magnetic coil been faulty, J. J. Thomson would not have concluded that cathode rays have negative electric charge. But is electric charge *itself* perspectival in any philosophically interesting sense?

The dispositional realist has a point when she complains that scientific perspectivism trades on an ambiguity. For surely the *ascription* of electric charge to cathode rays might well be perspectival; but it does not make the electric charge itself perspectival. Yet the dispositional realist trades herself on an ambiguity when in replying to the question of *how* we gain scientific knowledge of electric charge, she replies that we are justified to believe in this causal property because this is the best explanation for the success of J. J. Thomson's detection procedure in licensing reliable beliefs about cathode rays and their behaviour.

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electric charge. But the term had subsequently been adopted by Joseph Larmor in the early 1890s to refer to structural units of the ether and in the same sense adopted also by FitzGerald, to the point that Thomson resisted the adoption of the term "electron" for his "corpuscles" as late as 1906. See George Smith, op. cit.; and Peter Achinstein (2001).

Out of the historical context, on the dispositional realist's account, when confronted with the readings of an instrument like an electrometer, *assuming* that the experimenter's perceptual system functions well *and* the electrometer is indeed accurate, the experimenter concludes:[21]

(A) On this occasion, the electrometer reads '$EC = -1.602 \times 10^{-19}$ C' and $EC = -1.602 \times 10^{-19}$ C.

Now, according to our IBE inference, we are justified to believe in electrically charged particles as the best explanation for the success of our scientific instrument (i.e. for the reliability of our electrometer in reading EC and delivering beliefs about electrons' causal properties that have a preponderant tendency to be true). But, should this be the case, we would be vulnerable to a bootstrapping mechanism of belief justification that—in the absence of an independent justification for believing that the electrometer is indeed accurate in reading EC, or the experimenter's perceptual system not deceptive in reading the electrometer's reading, the electromagnetic field strong enough to bend rays, etc.—goes from (A) to

(A*) In general, the electrometer is reliable in reading EC.

(A*) is, in turn, applied to justify beliefs about similar cases that may warrant sufficiently similar conclusions. But for our belief that electrons have the causal property electric charge to be justified, and hence to amount to knowledge of the causal property at issue, more is required than a reliabilist bootstrapping process of belief-justification.

For physicists to *know* the causal property electric charge as identified by the disposition it confers on electrons to be deflected by a magnetic

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[21] I call 'EC' the causal property electric charge, while C is the unit of electric charge, the Coulomb.

field, for example, the following procedure seems to be taking place (let us use '*K*' to stand for 'Physicists know that…' following Vogel):[22]

(1) *K* (particles carry electric charge *EC*) RELIABLE PROCESS

(2) *K* (*if* (causal property EC is identical to the disposition it confers on objects to get deflected by a magnetic field) $\rightarrow$ *then* electrically charged particles get deflected by a magnetic field) DIT INFERENCE

(3) *K* (electrometer reads 'EC = -1.602×10^{-19} C' at time t_1) PERCEPTION

(4) *K* (electrically charged particles are deflected by a magnetic field in a cathode rays tube) PERCEPTION OF DISPLACED POINT OF FLUORESCENCE ON THE TUBE

(5) *K* (electrically charged particles are deflected by a magnetic field & electrometer reads 'EC = -1.602×10^{-19} C') LOGICAL INFERENCE FROM (3) AND (4)

(6) *K* (electrometer reads accurately at time t_1) LOGICAL INFERENCE FROM (3) AND (5) (under the assumptions that the electrometer functions well and the experimenter's perceptual system is not deceptive)

(7) REPEAT THE OPERATION SEVERAL TIMES

(8) *K* (electrometer is reliable) INDUCTION

But of course, physicists cannot claim to *know* that the electrometer is reliable in this way. Instead, they would have to test the electrometer, check that it is properly wired, that its meter reading is not faulty, calibrate it, and so on. This has consequences for the envisaged version of DIT that attempts to answer the justificatory question via reliabilism. Consider what Vogel calls "rollback": if physicists do *not* after all know that the electrometer is reliable, i.e. –(8), it follows that –(6) and –(5).

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[22] See Vogel (2000), and (2008), p. 519, on which I draw here.

Since (5) follows from (3) and (4), which are not open to dispute (we are not assuming any evil demon hypothesis about the perceptual system of physicists), we should conclude –(2), namely the denial of the DIT inference, whence –(1). Thus, for us to *know* the causal property electric charge, more is required than the process reliabilism that seems to be at work in the envisaged version of DIT. This is the opening wedge of a perspectivist rejoinder.

In what follows, I want to suggest an alternative way of thinking about scientific perspectivism. Perspectivists need not deny that there can be some causal property of body *x* in nature ultimately making the experimenter's belief about cathode rays having negative electric charge true. But they would also insist that what *justifies* such belief is ultimately a perspectival fact about how—to borrow Ernest Sosa's expression—that belief fits into the experimenter's epistemic perspective,[23] including *beliefs about*: (1) her unimpaired perceptual state, (2) the electrometer reading not being faulty, (3) tests to check that the electrometer reading is not faulty, (4) the body's trajectory being sufficiently deflected by the magnetic field, (5) the angle of deflection being deducible from the displacement of fluorescence in cathode rays, (6) electric current in the coil inducing a magnetic field, and so on.[24]

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[23] Sosa introduced the notion of epistemic perspective to block the classical objections against coherentism in epistemology, whereby for any body of beliefs that seems coherent and comprehensive, there could be another system of beliefs equally coherent and comprehensive, which nonetheless does not confer any justification to its members beliefs. Sosa concludes: "to block this refutation … a body of beliefs need include an epistemic perspective, an account … of the ways in which member beliefs in various categories acquire epistemic justification … That amounts to a form of coherentism aptly labeled 'perspectival' for requiring an epistemic perspective in any world view adequate to induce knowledge-making justification in member beliefs" (1991), p. 97.

[24] One may reply that such net of beliefs, forming what I called the experimenter's epistemic perspective, is entirely consistent with the

In Sosa's words, "A belief is justified only if it fits coherently within the epistemic perspective of the believer … Animal knowledge … needs only belief that is apt and derives from an intellectual virtue or faculty. … reflective knowledge always requires belief which is not only apt but also has a kind of justification, since it must be belief that fits coherently within the epistemic perspective of the believer".[25] In Sosa's view, the perspectivist can agree with the reliabilist in appealing to perception, memory, induction and the like when it comes to explain how we know nature. Yet the perspectivist would consider perception, memory, induction and the like reliable sources of truth or true belief, but not fundamental sources of justification.

This alternative way of looking at the perspectival nature of property ascription cashes out a new epistemological reading of scientific perspectivism, which in line with Sosa's "perspectival coherentism", claims that the *justification* of any of our beliefs takes always place within an epistemic perspective, including not only first-order beliefs about body x, but also beliefs we have about our perceptual system,

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aforementioned IBE inference, via which one may attempt to complete the DIT account so as to answer the justificatory question (I thank Anjan Chakravartty for raising this point). In reply, I think that a DIT defender, who is happy to embrace such perspectivist twist has already gone a long way from the received view towards the kind of perspectivism that I want to defend here, namely one that is ultimately compatible with realism, while also doing full justice to perspectival considerations in belief-justification. We are justified to believe in electrons having electric charge not because our detection procedures are ultimately reliable (although, this may explain why our beliefs about electrons are *true*); but instead we are justified in holding such belief about electrons because—in addition to being *reliably* generated—it fits into an epistemic perspective including various other first- and second-order beliefs we have about ourselves and nature.

[25] Ibid., p. 145.

cognitive faculties, measurement devices, and their reliability as sources of beliefs.[26]

Here below I can only sketch such an epistemological version of scientific perspectivism. The start-up problem is not whether or not electrons have electric charge, but *under what conditions* we are justified to believe that electrons have electric charge; in other words, under what conditions we can claim to *know* that electrons have electric charge. The notion of epistemic perspective helps cash out precisely the conditions under which such knowledge-claims can be made and arguably defended.

4. An Epistemic Version of Scientific Perspectivism

Consider again J. J. Thomson's experimental work on the electrons. Can we say that J. J. Thomson *knew* the electron? Philosophers and historians have asked the question of whether he *discovered* the electron,[27] given

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[26] See ibid. p. 210: "that thought experiment yielded the need for coherentism to require not only the coherence and comprehensiveness of a world view but also that the subject who holds that view places himself within it at the time in question with awareness both of his own beliefs at the time and of his possible means of intellectual access to himself and the world around him at that time and in the past. … A good label for coherentism modified to include these requirements is perspectival coherentism, for it is coherentism requiring of an epistemically effectual world view that it makes essential provision for a subjective and epistemic perspective by including both a view of the object-level beliefs held by the subject and a view of the sorts of reliable beliefs—about himself, his world, and his past—open to him".

[27] For the historiographical debate on this point, see Falconer (1987), and Achinstein (2001).

that he refused to use the term "electron" even in his Nobel Prize speech, and a series of people can be legitimately regarded as contributing to the discovery of the electron at different stages (from Stoney to Crook, from Larmor to Lorentz). But asking whether Thomson really discovered the electron presupposes the DIT assumption that causal properties are up for grabs to be 'read off' via the deployment of suitable detection procedures.

I want to ask instead a different type of question: namely, whether J. J. Thomson *knew* the electron, namely given the epistemic environment he worked in, what *epistemic conditions* allowed him to gain knowledge of nature's fundamental properties. I take this to be the central question that an epistemic version of scientific perspectivism should be concerned with and address. This way of thinking about scientific perspectivism as an epistemic position (rather than a metaphysical view about whether or not there are genuine perspectival facts) helps us revisit important issues, from scientific progress to incommensurability. One can indeed ask whether the epistemic conditions under which we have knowledge of the electron today are the same conditions under which J. J. Thomson operated, and hence to what extent there has been progress in our scientific knowledge of electrons since Thomson's time, and whether we can legitimately claim to be referring to the same entity despite epistemic changes.

Consider for example, J. J. Thomson's *belief* (Y.), i.e. the belief that cathode rays consisted of negatively charged particles and that those particles (whose *m/e* ratio he measured with accuracy) were *not* electrons but instead what he called 'corpuscles'. One can ask to what extent entertaining belief (Y.) amounts to *knowing* the electron and its fundamental properties (such as charge). I take that answering this question requires answering the following two sub-questions (following Sosa):[28]

[28] Sosa distinguishes between apt belief and justified belief as follows (see Sosa 1991, p. 289): "the 'justification' of a belief B requires that B has a basis in

1. Is belief (Y.) *apt?* i.e. relative to environment E, is the belief derived from what Sosa would call an 'intellectual virtue' (V (C, F)), which yields a preponderance of truth over error? (for propositions P in field F, given contextual conditions C). In this case, belief (Y.) would be apt because generated from J. J. Thomson's intellectual virtue, as an experimentalist, to identify true propositions about cathode rays, given his theoretical and experimental environment E (say, Victorian Cambridge physics), and specific contextual conditions C (i.e., his apparatus and methodology).
2. Is belief (Y.) *justified*? i.e. is the belief safely grounded in a coherent body of beliefs in, say, J. J. Thomson's epistemic perspective?

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its inference or coherence relations to other beliefs in the believer's mind—as in the justification of a belief derived from deeper principles and thus 'justified' …; the 'aptness' of a belief B relative to an environment E requires that B derives from what relative to E is an intellectual virtue, i.e. a way of arriving at belief that yields an appropriate preponderance of truth over error (in the field of propositions in question, in the sort of context defined by C)". In particular, Sosa defines how a subject is internally apt in believing something as follows: "(IA') S believes proposition P out of sufficient virtue relative to epistemic group G iff (a) S believes P out of intellectual virtue V (C, F) and (b) the likelihood that S believes correctly when S believes out of intellectual virtue V (C, F) is at least up near the average for group G." Animal knowledge consists primarily of apt, yet rarely justified beliefs. Reflective knowledge, on the other hand, requires beliefs, which are not only apt but also justified: our best reflective knowledge consists of apt and justified beliefs, where aptness has to do with intellectual virtue as a way of expressing how reliable the source of the belief is in producing a preponderance of truth over error; whereas justification is ultimately a matter of perspectival coherence.

The two sub-questions are distinct: a positive answer to the first question secures that the belief (Y.) is likely to be true. A positive answer to the second question guarantees that in addition to being likely to be true, the belief is also justified. Justification presupposes aptness, but not vice versa. A belief can be apt without being thus justified; but justified beliefs cannot in general be inapt.[29] Apt beliefs are reliably generated, whereas justified beliefs are apt beliefs, which in addition are born of perspectival coherence.

A case can easily be made for belief (Y.) being apt: the belief was reliably generated from experimental processes and techniques (e.g. J. J. Thomson 1897 cathode rays experiments as well as Lenard's evidence for the small mass of the particles at work in cathode rays absorption). Given the experimental and theoretical environment E in which Thomson worked (i.e., cathode rays experimental tradition back to Crooks and Faraday), and given specific contextual conditions C (for example, Thomson's two distinct methods for measuring *m/e*),[30] the belief that cathode rays consisted of negatively charged material particles was very likely to be true, and likely to be embraced as such by the scientific community, as the timely Nobel Prize in 1906 testifies to. But was (Y.) also justified?

[29] Sosa allows for the conceivability of inapt justified beliefs (ibid., p. 292), while also stressing that "there is no aptness without coherence, or at least our potential for coherence".

[30] The first method relied on measuring the charge Q at the collector via an electrometer, the kinetic energy W inferred from the increase of temperature at the collector (via a thermocouple), the magnetic field H inferred from the current in the coil, and the radius of curvature (ρ) inferred from the displaced fluorescence. The second method calculated m/e only from macroscopic observables such as the angle of deflection (θ) in the presence of superimposed electric F and magnetic fields H. See Smith, op. cit., pp. 40-41.

Among the coherent body of beliefs available to Thomson at the time, and forming part of his ‘epistemic perspective’, as it were, the following ones seemed to have played a prominent role in shaping his belief (Y.) about cathode rays:

(a.) Cathode rays are associated with negative charge;
(b.) Cathode rays are identical to negatively charged particles;
(c.) Negatively charged particles are material;
(d.) Electrons are immaterial structural features of a fluid elastic ether (with a vacuous core);

(Y.) Therefore, cathode rays consist of negatively charged particles, which are not electrons (call them instead ‘corpuscles’).

Thus, for (Y.) to be justified from a perspectival viewpoint, we should ask whether (Y.) fitted coherently with the rest of these beliefs, *and* reflect as to whether the sources of these first-order beliefs about cathode rays were themselves reliable (forming as it were second-order beliefs about the origin of first-order beliefs). As it appears, the subset of beliefs (a.)–(d.) from which (Y.) is inferred within J. J. Thomson’s epistemic perspective, does form a coherent, self-standing sub-set: it is coherent to think that the negatively charged particles at work in cathode rays are not electrons, if electrons were by default identified with structural features of an all-pervasive immaterial ether. But how about the sources of beliefs (a.)–(d.)? were these beliefs in turn reliably generated?

Thomson’s first experiments in May 1897 revealed that cathode rays were associated with negative charge (as per belief a.). A subsequent set of experiments, whose results were announced in October 1897, demonstrated that cathode rays were ‘invariably accompanied’ by negatively charged particles, supporting then belief (b).[31] In both cases, Thomson was able to measure with accuracy the mass-to-charge ratio of the particles and found to his dismay that it was much smaller than the mass-to-charge ratio measured in electrolysis. He resorted to the experiments of Lenard on the absorption of cathode rays[32] to support the conclusion that the negatively charged particles were material corpuscles (as per (c.)) with a very small mass (compared to ordinary atoms and molecules such as those at work in electrolysis) and high velocity. The term "electron" had been introduced in 1891 by George Stoney to indicate the smallest unit of electric charge at work in electrolysis and within the context of the ether theory. Stoney's use of the term was further expanded by Joseph Larmor in 1894. Working within the vortex theory of the atom (dating back to the work of Lord Kelvin and James Clerk Maxwell in the 1860s),[33] Larmor regarded the electrons as structural features of the elastic ether, with an empty core, radial vibration (with a certain phase and amplitude), and electric charge. Thus, J. J. Thomson (despite some speculative work he himself did on the vortex theory of the atom, whence belief (d.)) could not accept the conclusion that the negatively charged particles cathode rays consisted of, were one

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[31] See for details George Smith, op. cit.

[32] From 1892 to 1896, a year before Thomson's experiments, Lenard run a series of experiments on cathode rays outside the tube, which became known as "Lenard rays". He studied the absorption properties of those rays in gases and thick metal foil, and concluded that the rays must consist of particles much smaller than ordinary molecules or atoms, which would normally be blocked by the thick metals. Some historians have suggested that these experiments must have inspired Thomson a year later in his conclusion about the very small mass of the corpuscles at work in cathode rays (see on this point Helge Kragh (2001), p. 220, ft 25; and also Peter Achinstein, op. cit., p. 404.

[33] On the vortex theory of the atom and its role for J. J. Thomson's work on the electron, see Jaume Navarro (2005) and Helge Kragh (2002).

and the same with the immaterial structural features of the ether, i.e. the electrons. Hence, his belief (Y.).[34]

Going back to perspectivism, was J. J. Thomson justified to believe (Y.)? There is a sense in which he was justified to believe (Y.), insofar as (Y.) was part of a coherent system of beliefs he (and the majority of people at his time) accepted. But there is another sense in which, if deeply reflecting on the sources of each of the beliefs involved in Thomson's epistemic perspective, he was not justified in believing (Y.) because some of the beliefs involved in the logical inference for (Y.) were not born of reliable sources (for example, belief (d.) was born of a respectable, yet rather speculative theoretical tradition such as the vortex theory of the atom, entangled as it was with esoteric Victorian Cambridge practices of spiritualism, for example).[35] This explains why J. J. Thomson was justified to believe (Y.) from *his own* epistemic perspective as much as we are justified in not believing (Y.) from *our own* perspective (from which belief (d.) has been expunged),[36] although we share with Thomson

[34] Navarro has told a more nuanced story of Thomson's relation to the ether theory, whereby Thomson refused the term 'electron', because in the vortex theory of the atom, electrons were structural features of the ether, but he was himself happy to accept the ether theory and subscribed to the view that electrons were somehow supervenient features of the elastic ether. For details, see Navarro (2005). This more nuanced historical reading of Thomson's reaction to the ether theory is still in line with my suggestion that although beliefs about the ether may enter in the justification of Thomson's belief (Y.), such theory (and beliefs about the ether) were not likely to be true, and, hence, *per se* would not be sufficient to justify Thomson's belief (Y.).

[35] For an intriguing account of the broader intellectual context in which the vortex theory of the atom flourished and became popular in Victorian Cambridge, see Kragh (2002).

[36] Perspectival/contextual considerations resonate in Chakravartty (2010), p. 411, in relation to how different experimental contexts may select different dispositions of scientific entities. What I suggest here is sympathetic with this

and his contemporaries the true belief that cathode rays consist of negatively charged material particles, whose mass-to-charge ratio was accurately measured by Thomson's experiments.[37]

Justified-belief-*attribution* is always perspectival and contextual: it has to do with the way each belief fits into the agent's epistemic perspective. But the perspectival nature of justified-belief-attribution does not open the door to epistemic relativism of Rortian type or to Kuhnian incommensurability. What makes belief (Y.) non-accidentally true is not only the reliable experimental methods followed by Thomson in grounding beliefs (a.)–(c.), but also the way (Y.), in a suitably revised form, ended up interlocking a coherent system of beliefs, from which the inapt belief (d.) was eventually expunged. It took another generation of scientists of Einstein's calibre, and a deep conceptual revision of some central issues in electrodynamics to get rid of (d.), or at least to make evident its inapt character.

Thus, the epistemic version of scientific perspectivism here sketched shares with reliabilism the view that whether something is a reliable source of truth or true belief is not context-dependent or perspective-dependent. There are facts of the matter that make our beliefs about nature either true or false, and these facts of the matter are not

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line, and goes further in claiming that what *we are justified* to believe about scientific entities and their causal properties depends ultimately on our epistemic perspective.

[37] This shows once more the delicate relation between aptness and justification of beliefs, to borrow Sosa's expression. For (Y.) to be *apt*, it has to be generated via reliable methods, and Thomson's accurate experimental methods for measuring the *m/e* of cathode rays particles count as such. But for this same belief to be *justified*, it must be non-accidentally true because of the reliable way in which it has been generated, *and also* because it fits coherently into an interlocking system of beliefs (forming the epistemic perspective).

perspectival or context-dependent. Reliable methods and procedures ultimately tell us whether or not the electrons really have the mass-to-charge ratio that Thomson found, and whether or not electrons are structural features of an elastic ether. Yet the process through which we come to know these facts of the matter has an important perspectival component: our beliefs about mass-to-charge ratio or about electrons being structural features of the elastic ether may or may not be justified, depending on whether they fit coherently within a system of apt beliefs. By occupying an epistemic perspective, the agent is able to self-reflect on her beliefs, on the sources of her beliefs, the way beliefs cohere with one another, no less than the way in which they, individually and jointly, are anchored to the empirical ground via reliable methods. Although there may be several ways of world-knowing (as there are many perspectives conferring justification to member beliefs), there is only one natural world they all ultimately respond to. Yet nature legislates on our ways of knowing within the bounds of our historically contingent and interest-relative epistemic perspectives.

5. Conclusion

Looking back at Giere's scientific perspectivism and some of the criticisms coming from realist quarters, in this paper I have tried to show two main things. First, I have attempted to deflate the realist challenge by showing how knowledge of the dispositional nature of target systems needs a more complex story to be told about how we come to know nature's dispositions. The DIT account at best leaves this question open. If we attempt to answer the justificatory question within the resources of DIT via inference to the best explanation from the success of our experimental practices in delivering reliable beliefs, the position may become vulnerable to a form of epistemic bootstrapping.

Second, and related to the first point, I have suggested that perspectival knowledge needs not and does not reduce to knowledge of non-perspectival, dispositional facts about the target system, if we interpret ‘reduce’ in the philosophically interesting, epistemic sense, i.e. in the sense of *how we come to know* those facts. That there are genuinely occurring properties in nature that our scientific theories latch on is a fact. That they are the truth-makers of our beliefs is also a fact. But so is also the complex perspectival process through which such properties become the objects of our scientific knowledge.

Needless to say, what I have offered here is only a sketch of how a possible epistemic version of scientific perspectivism may look like. A lot more work needs be done to clarify the details of the position, and how the issue of truth and justification are inter-related within the approach I am suggesting. Important resources and tools are available for this work within the epistemological tradition of Ernest Sosa, to which I have latched on, and I leave the exploration of these resources for my future research. But what I hope to have shown in this paper is that the prospects of scientific perspectivism are not as unpromising as they might seem. Perspectivism does not have to threaten realist metaphysics, anymore than uncovering such metaphysics would necessarily undercut the legitimacy of epistemic perspectivism.

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