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Perspectivism, inconsistent models, and contrastive explanation

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ABSTRACT

It is widely recognized that scientific theories are often associated with strictly inconsistent models, but there is little agreement concerning the epistemic consequences. Some argue that model inconsistency supports a strong perspectivism, according to which claims serving as interpretations of models are inevitably and irreducibly perspectival. Others argue that in at least some cases, inconsistent models can be unified as approximations to a theory with which they are associated, thus undermining this kind of perspectivism. I examine the arguments for perspectivism, and contend that its strong form is defeasible in principle, not merely in special cases. The argument rests on the plausibility of scientific knowledge concerning non-perspectival, dispositional facts about modelled systems. This forms the basis of a novel suggestion regarding how to understand the knowledge these models afford, in terms of a contrastive theory of *what*-questions.

> 'The notion of a physical world that emerges from the interaction of the objective and the subjective is difficult to grasp, even if you are a philosopher.'
>
> – Lipton, 2007, p. 834

1. Perspectivism and relativism

Over the past two decades, the terms 'abstraction' and 'idealization' have become widespread in discussions of scientific modelling and representation. As one might expect, these are terms of art: there is no strictly uniform use of them in the philosophical literature; their various uses are closely related, but serve somewhat different ends. What these discussions have in common is the idea that talking about abstraction and idealization may explicate some of the ways in which models characterize their target systems in something other than "perfectly" accurate' terms, whatever it might mean to achieve such a lofty ambition. For instance, abstraction is often described as a process in which only some of the features of a given target system are represented in a model of that system. Here, one excludes other factors that are potentially relevant to the nature or behaviour of the system under consideration. Idealization is often described as a process in which features of a given target system are represented in a distorted way—a way that they simply could not be, for example, given the laws of nature.

It is natural to think that the reasons we abstract and idealize in the sciences are broadly pragmatic. We abstract, naturally, because the numbers of factors that are relevant to the nature or behaviour of a system are often very numerous, making the construction of an equally refined model impractical and often impossible. Often, the relative importance of many and sometimes most potentially relevant factors is negligible given the explanatory or predictive purposes relevant to the context. We idealize, again naturally, because often undistorted representations of target systems are too complex or mathematically intractable to formulate. And again, even when undistorted representations are possible, they often go well beyond what is required for explanatory or predictive purposes, in terms of complexity or mathematical sophistication. Clearly, then, pragmatic constraints and tendencies go a long way toward explaining why one might be tempted to deviate from the truth by means of abstraction and idealization.

In this paper, I want to consider the idea that, quite apart from the pragmatic reasons one might have for deviating from the truth, there are *principled* reasons to expect that one *must* do so. More specifically, I want to consider the idea that because our

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observations, detections, measurements, theories, and models are in some sense unavoidably *perspectival*, this rules out the possibility of our uncovering non-perspectival facts—"the truth"—about target systems in the world. Variations on this theme have become popular in recent work in the philosophy of science, and although the variations I will examine here are possible interpretations of these accounts, it is also important to note that they differ in significant ways.[1] Thus, I will make no pretence of engaging a group of authors with a univocal view, but rather seek to engage the notion of perspectivism as a philosophical thesis in its own right. While it is surely correct to say that there are some perfectly uncontroversial ways in which one may regard the knowledge associated with observations, detections, measurements, theories, and models as perspectival, the term 'perspective' also has misleading connotations in this context—some of which, I believe, are propounded by this recent literature. My aim here is to offer a corrective and an alternative to what I consider to be these misleading connotations.

I will begin by examining the notion of perspective and what, more precisely, it means in the present context. I will then elaborate the forms of relativism this perspectivism may connote, and consider whether they give us good reason to reject the prospect of non-perspectival knowledge. My ultimate contention is that even though there are thoroughly reasonable senses in which scientific models—and in particular, inconsistent models, which will be my focus here—are perspectival, this does not entail that we do not or cannot learn non-perspectival facts relating to the things these models model. Furthermore, I will suggest that scepticism regarding non-perspectival facts rests on a hidden and unmotivated premise concerning the nature of scientific properties and relations represented by models. Once this premise is replaced with a more compelling view of scientific properties as dispositional, it turns out that perspectivism does not entail any potentially worrying sort of relativism after all; neither does it rule out the prospect of non-perspectival knowledge.[2] In closing, I will propose this suggestion as a contribution toward a novel understanding of knowledge and explanation in connection with modelled systems, by means of a contrastive theory of *what*-questions, inspired by Peter Lipton's work on contrastive why-questions.

So, to begin, what is meant by 'perspectivism' here? The idea of perspective is formally defined in the realm of art, referring to the practice wherein three-dimensional entities are represented on a two-dimensional surface, in such a way as to give the viewer the same sort of impression of certain features, such as relative positions and magnitudes, as they would have if viewing the original (that is, if directly viewing whatever is depicted). In the process, however, some features of the original are inevitably represented in ways that they are not. Indeed, part of the process of being properly acculturated with or "trained into" a particular perspectival convention is learning how to ignore these deviances.

Interestingly, the mathematical conventions according to which perspective is rendered can be varied, resulting in different sorts of veracity with respect to the original. The different projections available for mapping the three-dimensional surface of the earth onto the two-dimensional maps with which we are more familiar are a good example of this. The Mercator projection, for instance, gives better approximations of the shapes of land masses on the earth's surface, but at the cost of a relatively poor representation of their relative sizes. The Peters projection gives better approximations of relative sizes, but at the cost of shapes, and so on. Taking a perspective, it seems, has interesting epistemic consequences. Moving from the case of art to more generic usage, the idea of "taking a perspective" on something entails precisely the same sorts of consequences. We commonly speak of how something "looks", figuratively speaking, from one perspective, and how this can differ from the way it "appears" from another. Different perspectives, then, may yield different and apparently conflicting descriptions of their subject matter.

By itself, the idea that different representations may offer different and conflicting perspectives is uncontroversial. The idea of multiple perspectives does not by itself rule out the possibility that, quite independently of any given perspective on something, there are non-perspectival facts of the matter about it; neither does it rule out, by itself, the possibility that one might come to know what those facts are. It was tacit in my description of the Mercator and Peters projections, for example, that there are non-perspectival facts of the matter relating to the shapes and surface areas of the land masses on the surface of the earth. After all, I described these projections as furnishing better or worse representations of these features, the tacit assumption being that "better" and "worse" are judged with respect to the way these things are, non-perspectivally. From the perspective I had of Peter over lunch in the Senior Common Room, he seemed a fairly tall man, but as I saw him in the distance some time after parting, he seemed rather small. This sort of perspectivism is uncontroversial because there are non-perspectival facts of the matter about the dimensions of Peter in our inertial reference frame that, in conjunction with facts about optics and my visual sensory apparatus, underwrite the differences in the appearance of his size. There is a height that he *is*, and then many ways he may appear to be from different perspectives.[3] In cases in which non-perspectival facts underwrite perspectival ones, perspectivism is commonplace, and not philosophically controversial.

Perspectivism becomes a philosophically controversial thesis, however, when one adds to the notion of perspective the notion that perspectival facts are *all that can be known*. On this view, truths concerning target systems of interest and, more specifically, scientific truths such as those afforded by models, are not underwritten in the way the apparent shapes and surface areas of land masses or apparent heights of friends are. As Ronald Giere (2006, p. 81) puts it: 'For a perspectivist, truth claims are always relative to a perspective'. And, regarding multiple perspectives on the same thing (2006, p. 92): 'The knowledge that we get comes from one perspective or another, not from no perspective at all'. Perspectivism, thus understood, is controversial because it engenders one or another form of relativism, and the prospect of relativism raises alarm among those, including most (but by no means only) scientific realists, who are attracted to the idea that there are non-perspectival facts about things, and that at their best, the sciences succeed in telling us what these non-perspectival facts are. A philosophically interesting perspectivism would appear to do away with these sorts of facts, and any sort of epistemic position defined in terms of them.

I have just claimed that the philosophically controversial version of perspectivism in the present context (I will reserve the term 'perspectivism' *simpliciter* for this variety henceforth) engenders relativism 'of one form or another'. Let me now be more precise.

[1] For example, see Teller (2001) and Giere (2006). Van Fraassen (2008) also explores perspectivist themes (see especially Chapter 3), but with a different emphasis. All three hold that perspective *qua* human action and purpose is central to scientific representation, and van Fraassen agrees that observation and measurement are in a sense perspectival, but only Giere and Teller suggest that scientific theories and models yield perspectival descriptions (compare van Fraassen, 2008, p. 86).

[2] As I will emphasize again later, I adopt a realist idiom, here, with respect to dispositions. That is, I will speak as though dispositions are genuinely occurrent properties. Those who worry about dispositions may substitute their preferred paraphrases—in terms of causal structures or empiricist-friendly conditionals—as they go.

[3] If one is sceptical of the idea that there is any fact of the matter regarding a person's height, because of variations due to spinal compression and extension or the possible vagueness of the predicate, replace 'height' with 'height ± δ' for a reasonably chosen height and δ.

I will use the term 'facts' to denote true propositions, whatever analysis one may wish to give of the latter. A non-perspectival fact about a target system is thus a proposition that is true, independently of any particular perspective one may take with respect to it; it is true across perspectives. A perspectival fact is a proposition that is true only from, or within, or relative to, a given perspective (or limited set thereof). As a philosophically controversial thesis, then, perspectivism would seem to take the form of either one or possibly both of the following claims:

(In the sciences, in connection with representations such as theories and models, ...)

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

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

If P1 is true, it should come as no surprise that scientific models contain abstractions and idealizations, which, in addition to their pragmatic character, also reflect the perspectives we have on target systems in specific contexts of investigation. If P2 is true, the very idea of truths from which abstractions and idealizations are deviations is illusory. P1 is a thoroughly epistemological thesis, concerning the bounds of scientific knowledge—it explains these bounds by means of our epistemic limitations. P2 combines an epistemological thesis with an ontological thesis—it explains the asserted bounds of scientific knowledge by means of an assertion concerning the world. The relativism engendered by P1 may thus be thought of in terms of conceptual relativism, and that engendered by P2 in terms of conceptual relativism borne of ontological relativism. The truth of P2 would entail the truth of P1 (but not *vice versa*), since the non-existence of non-perspectival facts would of course entail that we have no epistemic access to such things (but not *vice versa*).[4]

The motivation for resisting perspectivism in either of these forms is to uphold the possibility and indeed the likelihood of scientific knowledge that is epistemically sound across perspectives, thereby resisting the relativistic thesis that different perspectives inevitably yield irreducibly incompatible claims to knowledge.[5] In the next three sections, I examine the foremost considerations in support of perspectivism, presented by its advocates and further elaborated as necessary, and argue that none of them establishes P1 or P2.

2. The argument from detection

A first argument for perspectivism is what I will call the 'argument from detection'. There are in fact two distinct arguments here. The first begins by noting that in our observations and detections of target systems, whether one employs unaided human senses or scientific instruments, one is only ever in causal contact with certain features of these systems. Whether one is using one's eyes or a scanning tunnelling electron microscope, only certain aspects of the system one investigates are investigated, because one's detectors are only ever configured in such a way as to be sensitive to certain kinds of inputs—signals originating from specific aspects or properties of the things investigated. Thus, scientific observation and detection is generally limited or partial in scope, and this is one reason that even our best models are generally abstractions, incorporating representations of only some of the many features that constitute their target systems.

The second argument from detection has a Kantian flavour: one's means of detection themselves make a contribution to one's representations, over and above the natures of the things one represents. (One might take these objects of representation to be things in themselves, or in a more strictly Kantian spirit, phenomenal things.) We see the world around us as coloured, for example, and that is in part a function of the way our visual apparatus works. Scanning tunnelling electron microscopes yield images of surfaces up to a resolution of approximately 0.1 nm laterally and 0.01 nm in depth. As a consequence, pictures generated from the outputs of these microscopes represent their subject matter within these bounds of resolution; anything finer appears smudged. This is one reason for which even our best models are generally idealizations, representing aspects of their target systems in variously distorted ways. As van Fraassen (2008, p. 9) notes in the context of measurement (a form of detection): 'what measurement shows is not directly what the measured is like but how it appears in that particular measurement set-up'; more generally, it is a mistake to think that 'what is represented is simply *like* what is presented in the representation'.

Thus, the argument from detection has two faces: one concerned with the partial nature of detection; and the other concerned with the conditioned nature of detection. Let us consider, in turn, whether either of these faces presents a reason to uphold either one or both of the perspectivist theses P1 or P2, beginning with the case of partial detection. Some authors have maintained that, quite generally, partial knowledge is perspectival knowledge (see footnote 1), but it is difficult to imagine why this should be considered tantamount to perspectivism. When giving sworn testimony in many jurisdictions, one is enjoined to speak 'the truth, the whole truth, and nothing but the truth'. Presumably the second condition is present here not merely for the sake of redundancy, but precisely because one may speak the truth (thereby satisfying the first condition) without thereby speaking the whole truth (thereby satisfying the second). But this is not tantamount to perspectivism, because there is no presumption that telling part of the truth is in any way incompatible with telling the whole truth, and both may be viewed as non-perspectival. That is to say, one may speak the truth, even if not the whole truth, without any implication that it is perspectival in the philosophically controversial sense—incompatible with the notion of having non-perspectival knowledge. This is a homely truism with countless instances. One might correctly describe the front of one's house, in a way no doubt compatible with descriptions of its other sides. Et cetera.

Does this homely practice of illuminating just part of a larger possible concatenation of non-perspectival facts extend, *mutatis mutandis*, to the context of scientific detection? Surely it does. 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. After all, knowledge of a proper subset of the properties of a target system may be perfectly non-perspectival. It is a non-perspectival fact about charged bodies, for example, that they exert electrostatic forces on other charged bodies. This is something that can be learned by means of experiments using detectors that are sensitive to only a very limited number of features of such bodies, such as their electric charge and their motions. The partiality of detection, here, has no perspectivist consequences. The moral is a general one: the fact that detectors generally yield information relating to limited aspects of target systems does not by itself imply any philosophically interesting sort of perspectivism.

[4] Although arguably, some passages of their work might be read as suggesting P2, in correspondence, Giere and Teller both confirm a preference for something like P1.

[5] Brown (2009, pp. 214–215) suggests that different perspectives may be compatible because the assessment of a perspectival claim can only occur within the context of the perspective within which it is generated. It is unclear how this promotes compatibility, however, given that one cannot generally adopt multiple perspectives simultaneously, since they are themselves incompatible. I offer a proposal for compatibility in what follows.

Giere (2006, p. 66) advances the concern about partiality in one further direction, as follows: 'the only way any particular model could exhibit an exact fit to the world is if it were a complete model that fits the world exactly in every respect'. In the absence of completeness, according to this line of thought, such a model inevitably takes a perspective on the system by representing only certain aspects of it. Giere contends that incomplete models exclude aspects of their target systems that may be causally connected to the aspects they describe. Including those excluded aspects would yield, he maintains, a different perspective on the system.

No doubt these observations are correct, but it remains the case, I submit, that nothing philosophically interesting or controversial is labelled by the term 'perspective' in connection with these more or less complete descriptions. It is certainly correct to say that a model that excludes potentially causally relevant features of a system gives a different description of it than one that includes more or fewer. But, as the example of charges and electrostatic forces demonstrates, nothing about excluding potentially causally relevant aspects of a system rules out the apprehension of non-perspectival facts regarding how those features *described* may be related, causally or otherwise, and there is no obvious reason to think that such facts should be incompatible with facts given by more detailed descriptions incorporating larger numbers of features. As such, the application of 'perspective' here lends no support to P1 or P2. Non-perspectival facts relating to what systems are like and how they may behave in the absence of other potentially causally relevant features may happily co-exist with other non-perspectival facts regarding the natures and behaviours of these systems, were other features present. As Lipton (2007, p. 834), who associates non-perspectival facts with 'objectivity', observes: 'Scientific descriptions surely are incomplete and affected by interest, but these are features the objectivist can take on board. Completeness and objectivity are orthogonal'.

So much for the argument from detection based on partiality, but what of the appeal to conditioning? This second consideration—the idea that detectors condition their output—contributes more initial plausibility, I believe, to P1, though no obvious support to P2. If the detectors one employs to investigate systems of scientific interest systematically condition their outputs in such a way as to render them dissimilar to the features they detect, this lends *prima facie* support to the notion that our resulting knowledge of these systems is limited in just the way described by P1. I say *prima facie* support, because the fact that detectors condition their output, and the fact that different detectors may yield different sorts of output in connection with the same object of detection, do not by themselves entail that no non-perspectival facts are illuminated. Light microscopes and electron microscopes yield very different sorts of output in detecting the contents of cells, for example, but both sorts might be thought to confirm the non-perspectival facts that certain organelles are present, that they have certain structures, and so on.[6] Even so, perhaps there are cases in which the outputs of detections cannot be so reconciled—let us grant this, for the sake of argument. Such a case would more strongly suggest that we are epistemically limited to the perspectives contributed by our detectors, but would not thereby demonstrate that there are no non-perspectival facts to be known, hence my suggestion that there is no obvious support here for P2.

It will be my contention in what follows that even if one grants the possibility that there are cases in which detections produce descriptions of target systems that (apparently) cannot be reconciled with those produced by alternate forms of detection, this does not support P1 (let alone P2). The possible case of irreconcilably perspectival detections bears a great deal of similarity to the case of inconsistent models: both are cases in which one's descriptions of something in the world, generated in different contexts—whether these are contexts of detection or model construction—are in apparent conflict. My argument in favour of non-perspectival knowledge is the same in response to both of these challenges. Before describing this response, having outlined the argument from conditioned detection, let me now outline the argument from inconsistency.

3. The argument from inconsistency

What appear to be mutually incompatible collections of models are often associated with one and the same scientific theory or target system. A nice example of this phenomenon is constituted by the different models of fluids that are brought to bear in thinking about different aspects of fluid flow.[7] If one is interested in explaining how water flows, for instance, or how water waves propagate, one models water as a continuous, incompressible medium. If one is interested in explaining the diffusion of a chemical compound in water, one models it as a collection of discrete particles in thermal motion. Even from this cursory description it should be clear that these models attribute what appear to be mutually incompatible properties to water. Even in the context of thinking about one particular sort of behaviour of a system, scientific models may vary considerably. In the treatment of fluid flow, for instance, one models different types flow—around immersed solids, along solid walls, and so on—by applying the relevant mathematical description (the Navier-Stokes equations) in different ways. The equations are adapted and applied differently in these subcontexts. And, importantly, just as in the case of models of different fluidic phenomena, these different models of fluid flow behaviour appear to attribute different and incompatible properties to fluids.

Noting that such apparently incompatible collections of models are commonplace in the sciences, an argument for perspectivism is born. These different models, it is suggested, yield a perspectival knowledge of the behaviours of fluids. Models applied to different fluidic contexts or phenomena offer different perspectives on the nature of fluids themselves. From one perspective, water is a continuous medium; from another, it is made up of discrete particles. Given that this is often the best that one can do, there is arguably little reason to expect yet further access to a realm of non-perspectival facts that would underwrite these apparent differences. Scientific knowledge, so the argument concludes, is thus exhausted by incompatible perspectives, which are distinguished by the different kinds of phenomena at issue, as well as the explanatory, predictive, and other purposes one brings to bear in constructing scientific models of them. Thus stated, the argument from inconsistency, much like the argument from conditioned detection, is most plausibly interpreted as an argument for P1. For, while the *de facto* state of scientific practice described here lends an air of initial plausibility to the idea that we are epistemically limited to perspectival facts, it does not by itself suggest anything about the ontology of the world that might explain this limitation by means of an absence of non-perspectival facts in reality, thus failing to motivate P2.

My goal here is to resist the sort of perspectivist pessimism endorsed by the argument from inconsistency, and a first clue as to how one might do this comes from recent work by Alex Rueger (2005) on perspectival models of fluid flow. Rueger suggests that, while different models of flow *appear* to attribute different and

[6] The idea that using different instruments and forms of detection can yield inductive support for non-perspectival knowledge is a familiar theme in discussions of scientific realism, coming under the heading of 'corroboration'. I believe that there is something to this idea, but will not rely on it in what follows.

[7] For more detailed discussions of the physics of this case, see Morrison (1999, pp. 53–60), Teller (2001, pp. 401–402, 408–409), and Rueger (2005, pp. 581–587).

incompatible properties to water, this simply masks more subtle facts about what these properties are, more precisely. The argument from inconsistency presents the incompatibility of different models as a consequence of their attributions of incompatible *intrinsic* properties to the relevant target systems. This leads irresistibly to the impression of incompatibility—a fluid cannot both comprise a continuous medium and a collection of discrete particles, for example. Conversely, Rueger maintains, the correct way to understand the attribution of such properties is not in terms of intrinsic properties at all, but rather in terms of *relational* properties:

> These models describe the system relationally: from *this* perspective, the system looks as if it has intrinsic property *x*, from *that* perspective it looks like it has property *y*. (Rueger, 2005, p. 581)
> [...]
> This interpretation makes the models' assignments of intrinsic properties to a system relational: what appears as an intrinsic property of the system is actually a perspectival view of the intrinsic property, hence relational. (Ibid., p. 592)

On this view, in connection with what may appear superficially to be incompatible models, different perspectives generate non-perspectival facts after all, regarding the manner in which the intrinsic properties of the relevant target system "appear" in different contexts. This, I think, is a valuable step in the right direction. It is also admittedly somewhat vague as a general formula. Let me develop it now in my own idiosyncratic way, in the hope of clarifying how a knowledge of non-perspectival facts about the properties of target systems may underwrite their different appearances.

To begin, let us consider what it could mean to say that different and apparently conflicting descriptions of properties may be interpreted as perfectly consistent descriptions of the relational features of those properties in different contexts, or from different perspectives. I submit that the requisite insight stems from a reflection on what it is, precisely, that scientific knowledge is knowledge of—a reflection on the nature of the properties and relations described by scientific theories and represented by models. Here, I take inspiration from the work of number of contemporary authors in the philosophy of science and metaphysics interested in the nature of natural properties.[8] The common theme to emerge from this work is that, more often than not, the properties of interest to scientific investigation are dispositional properties. They dispose the systems that have them to behave in particular ways in specific circumstances.

Why and how do various parts of target systems interact with one another and with our instruments of detection? Their properties—masses, charges, spins, densities, concentrations, acidities, osmotic pressures, fitnesses, and so on—confer on the entities that have them certain abilities. Nancy Cartwright refers to these properties as 'capacities'; overlooking fine-grained distinctions that are inconsequential for present purposes, I will use the more common term 'dispositions'. The basic, shared idea is that what one learns via scientific investigation into target systems in the world are their modal features: how having certain properties dispose them to be or to behave in different contexts. To emphasize the generality of the point I intend here, it is not even essential to the argument that one be a realist about dispositions, though I myself consider this to be a defensible position. It is sufficient that one merely accept the modal character of much of what is learned by means of scientific investigation and represented by theories and models, whether this takes the form of a realist analysis of dispositions, a realism about causal structures, or even a deflationary analysis of modal talk in terms of conditional statements. That there must be *some* account of the modal features of scientific discourse is universally accepted, and this is all that is required for present purposes. For ease of exposition, I will continue to employ the realist idiom, and ask the reader to translate as (s)he sees fit.

With this view of properties in mind, we are now in a position to unpack the inspiration inherent in Rueger's response to perspectivism. Consider first the argument from conditioned detection. The perspectivist is right to claim that detectors often contribute to the outputs of scientific observations and measurements, and thus it should come as no surprise that these outputs yield different perspectives on their target systems, and that models constructed on the basis of such information sometimes yield different and apparently incompatible descriptions of those systems. But this, I suggest, is simply a reflection of the dispositional nature of the properties of those systems. Dispositions are often manifested differently depending on the ambient circumstances, and while such manifestations can vary, they may be manifestations of one and the same property nonetheless. Crucially, facts about how a property of some system disposes a detector to behave are non-perspectival facts: they are true whatever perspective one takes. One must take a perspective in order to investigate it, of course; that is, one must view the phenomena from a particular vantage point, or use a particular sort of instrument, or perform a particular kind of experiment, in order to determine how a disposition manifests itself in that particular interaction. But the facts produced by these investigations are perfectly non-perspectival ones, regarding the interactions of certain properties in specific circumstances.

These considerations point to one respect in which the response I wish to give to the arguments from conditioned detection and inconsistency depart slightly from the initial inspiration provided by Rueger. While it is correct to say that apparently incompatible models yield non-perspectival information about the relational features of the properties of their target systems, I regard these properties generally as intrinsic properties. Descriptions of dispositions are usually given in terms of their manifestations—in other words, in terms of relations. This does not by itself, however, render such properties relational. The dispositions of target systems studied by the sciences are often intrinsic properties, and this is so quite independently of the fact that our epistemic purchase on them comes by way of their relations to other properties, including those of our instruments of detection.

Thus far, the discussion of dispositions, manifestations, and perspectival contexts of investigation has been rather abstract, so let us make matters more concrete with a couple of examples, beginning with a simple, everyday case. Is salt soluble? Solubility is the ability of a substance to dissolve when placed in a solvent; and thus, clearly, salt is. At the risk of pedantry, however, one might wonder whether this seemingly mundane fact is quite as banal as it seems. For, as the pedant may insist, salt does not always dissolve when placed in water. If the water concerned is already saturated at a given temperature and pressure, or if it is in the presence of a strong enough electromagnetic field, the salt will not dissolve. These observations might be marshaled in support of a misleading, sophistical claim: it appears that salt is both soluble and insoluble. Is this a contradiction, to be diagnosed in terms of perspectival models? In making this claim, is one thereby attributing incompatible properties to salt? Surely not. One might more plausibly say that everyday observations of the behaviour of salt in water support a more innocuous claim: salt sometimes dissolves in water, and other times does not, depending on the circumstances. The ability to dissolve is a property of salt that is manifested in

[8] For merely the tip of the iceberg, see Cartwright (1999), Mumford (2003), Bird (2007), and Chakravartty (2007).

some circumstances and not in others. This is a simple illustration of how putatively perspectival facts may be straightforwardly understood as non-perspectival facts regarding how behavioural dispositions are manifested under different stimulus conditions. Let us label these 'dispositional facts'.

In addition to dispositional facts, it would seem that in many branches of the sciences, non-perspectival knowledge extends significantly further. In these areas, scientific investigation has proceeded so far as to describe, in some detail, non-perspectival facts that underwrite well-established dispositional facts. The chemistry of solubility is a case in point, for here we have a theory of inter- and intra-molecular forces that can be employed to explain how and why these different manifestations occur under the relevant stimulus conditions. These explanatory facts, concerning the molecular and atomic constitutions of salt and water, their electromagnetic properties, the types of bonds and bond angles they form and so on, underlie the dispositions of solubility and insolubility that are manifested by salt. For lack of a better term, let us call these 'categorical facts'. This example provides a simple illustration of how talk of perspectival facts is reducible in principle to talk of non-perspectival dispositional facts, which may in turn be explicated in terms of categorical facts, themselves non-perspectival.

Lest the moral of the preceding paragraph be overextended, let me stress here immediately that the sort of explanatory grounding of the dispositional on the categorical one finds in the case of solubility and insolubility should not be regarded as a gold standard, or a necessary condition, for non-perspectival knowledge. Consider another example. Nineteenth-century wave theories of the nature and behaviour of light explicated their subject matter in terms of the oscillations of ordinary or classical waves, on the model of various and better understood wave-like phenomena such as water waves, sound propagation, and so on. Later, James Clerk Maxwell's theory of electromagnetic radiation subsumed these earlier theories of light. Skipping forward to modern-day field theory, one finds light represented as quanta (photons), modelled as excitation states of a field, and not anything resembling a classical waveform. One possible diagnosis of this epistemic transition is to think of the nature of light as something that is revealed perspectivally, through the lenses of different theories and their associated models. The picture of light as a classical wave and the picture of it as an excitation of a field are perspectives, one might suggest, well established in their own domains and described appropriately by different theoretical tools.[9]

Note that in this case, the inconsistent models at issue are models of two different theories, as opposed to models of one and the same theory, but the dispositionalist response is applicable in either case. Do the preceding observations regarding different models of light suggest that its wave-like nature is a perspectival property of it, facts about which are confined to the perspective of classical physics? Surely not. Certain wave-like features of light are dispositions of luminous systems, quite independently of the perspective offered by any particular theory. When light is subjected to certain kinds of detection, wave-like effects are registered in our instruments. Different models of light allow one to see how its properties are manifested in different circumstances. And note: the fact that we do not have an underlying explanation available with which to account for why and how these different manifestations occur (as we do in the case of solubility and insolubility) does not alter the fact that light is disposed to behave in different ways in different circumstances; these are well-established experimental facts. What one has here are not perspectival facts about light—claims that are true only from the vantage point of some perspective. Rather, scientific investigation has revealed perspective-transcendent facts about how light *behaves* in different conditions.

Understanding scientific modelling in terms of descriptions of the dispositional properties of target systems, I believe, answers both the argument from conditioned detection and the argument from inconsistency. In the case of detection, contributions made by measuring and other instrumental procedures to their outputs have led some to suggest that these investigations yield only perspectival facts about the intrinsic properties of the entities and processes detected. On the dispositionalist view, however, what are described are non-perspectival facts about how the properties of these systems are manifested when subjected to various forms of detection. Naturally, different kinds of detection and measurement may elicit different manifestations of the properties of the systems investigated. Different contexts of investigation—such as observing the flow of water around an immersed body, or along a solid wall—may elicit different manifestations of the properties of water. In just the same way, different and apparently inconsistent models of a system, whether they are models of one and the same theory, or of different theories in a domain, reveal non-perspectival facts about dispositions and manifestations. Many apparent incompatibilities are dissolved when models are understood to reveal dispositional facts about target systems in the world.

4. The argument from meaning and reference

When first introducing the arguments from detection and inconsistency earlier, I suggested that any initial plausibility these arguments afford perspectivism must concern P1 (the thesis that we have knowledge of perspectival facts only, because non-perspectival facts are beyond our epistemic grasp), and not P2 (the thesis that we have knowledge of perspectival facts only, because there are no non-perspectival facts to be known). This was because, while both arguments promote the idea that one's epistemic access to target systems is limited to perspectival facts, neither give any motive for suspecting that the reason for this epistemic limitation has its roots in ontology—that is, in the non-existence of states of affairs about which there could be non-perspectival facts. If one did have good reason to suppose, however, that the ontology of the world is such that non-perspectival knowledge is ruled out for this reason and not merely as a consequence of our epistemic foibles, one would have the beginnings of an argument for P2. Let us now consider the possibility of just such an argument.

Perhaps the most celebrated challenge, historically speaking, to the idea of non-perspectival facts arises from worries about the meaning and reference of scientific terms. Contextualists such as Thomas Kuhn argued that the meanings of theoretical terms are locked into the paradigmatic frameworks in which they are used, and one may read the discussion of the role of linguistic frameworks in logical empiricism in a similar manner. The meaning holism required to generate this thesis is, of course, controversial, as are the opposed approaches to meaning associated with Saul Kripke's and Hilary Putnam's developments of the causal theory of meaning and reference. These controversies are important and endlessly fascinating, but I will not revisit them here. In order to generate an argument for P2, it is necessary to go beyond semantics, to ontology.

Not all who are sympathetic to the holist picture are so inclined to go beyond semantics, but those who are may draw perspectivist-friendly implications from the ontological dimensions of hol-

[9] I take this case to be analogous in the relevant respects to the case of models of fluids introduced earlier. For comments regarding apparent model incompatibility in the latter domain, see Teller (2001, pp. 408–409), Rueger (2005), and Giere (2009, p. 222).

ism. The later Kuhn, for instance, endorsed an interpretation of how paradigms or frameworks shape the world that is explicitly neo-Kantian. Lipton (2001, p. 30, 2007, p. 834) labels this sort of approach with the apposite expression 'Kant on wheels': it is an account of how conceptual principles shape the *world*—not merely making certain propositions candidates for truth or falsity, but in some more profound sense constituting empirical reality itself. Unlike in Kant, however, these principles are changeable over time. Hence the infamous passages concerning world change in *The Structure of Scientific Revolutions*: there is an important sense, Kuhn said, in which, after a scientific revolution, scientists live in a different world (1970/1962, pp. 111, 121, 150). This is grist to the perspectivist mill. For, if one interprets Kuhn's slogan literally, one might then argue on this basis that the different perspectives afforded by different and apparently incompatible theories and models—embedded as appropriate in different paradigmatic or linguistic frameworks—literally create conflicting ontologies of things in the world. As a result, even under ideal epistemic conditions, an epistemic limitation would follow, in the manner described by P2.

How persuasive is this neo-Kantian, perspectivist analysis? The consequences of following the neo-Kantian down this particular rabbit hole are severe. For, when perspectivism is extended into the domain of ontology, it is challenging to see how it can be made coherent at all. Recall that for Kant, the world investigated by the sciences is not merely transcendentally ideal, but empirically real. The categories of the understanding that shape empirical reality are fixed for the Kantian—they are part and parcel of human cognition. The perspectivist who puts Kant on wheels in the manner described here, however, proposes something significantly more radical: it would seem that on this view, scientists interact with a fundamentally conflicted reality. It is not merely that there is an empirically accessible world, about which one has only perspectival beliefs. It is furthermore that this world comprises a tortured assembly of Frankenstein facts or states of affairs. Water would, on this view, be both a continuous medium *and* a collection of discrete particles. Light would be both a classical wave entity *and* an excitation state of a field. Every apparent inconsistency between rival theories and models in a domain would be realized in empirical reality, so long as these theories and models are employed. On such a view, there are no non-perspectival facts because empirical reality itself consists of a hodgepodge of contradictory states of affairs, created (in part) by the human act of theory use and model construction.

Many and perhaps most, I suspect, will doubt the very coherence of the idea of a world in which such contradictions are ontologically realized.[10] In the absence of an intelligible account of what it could mean for a target system in the world to instantiate (at the same time) strictly incompatible properties, there is no argument here for P2. Some dissolution of the metaphysical consternation resulting from the argument from meaning and reference is owed, but it is very difficult indeed to imagine how this debt could be paid.

5. Contrastive *what*-questions

With P1 and P2 on the ropes, both advocates and critics of the idea of non-perspectival knowledge may nonetheless harbour, understandably, some degree of unease regarding the account of it that I have proposed. Though I have characterized instrumental detections and inconsistent models as capable, in principle, of yielding non-perspectival facts about target systems in the world, there is nevertheless an important role played here by the notion of context or circumstance. Though a system may have a stable cluster of dispositions whatever its prevailing circumstances—dispositions one may have non-perspectival knowledge of—it remains the case that which of these dispositions are manifested is determined by the particular circumstances that are in play. The question of whether one is considering the behaviour of a fluid in the context of one experimental set-up or another, for example, is relevant to the question of which dispositions of fluids one will find manifested there (whether it will behave, for example, like a continuous medium or a collection of discrete particles). Similarly, one's epistemic and pragmatic goals in using models, regarding such things as the degrees of accuracy and precision required in making predictions and giving explanations, likewise constitute contexts of use. These contexts determine which descriptions of systems are most apt for particular purposes. In both these ways, context is important, even in the specification of non-perspectival facts.

Given the importance of context here, is the non-perspectival approach (constituted by the dispositional analysis of scientific properties) a sleight of hand? Has non-perspectival knowledge about dispositions and manifestations been purchased at the cost of a different sort of perspectivism, which binds scientific knowledge irreducibly to contexts and circumstances in other ways? I do not think so. The significance of context to dispositional facts is undeniable, but this does not court either of the philosophically controversial perspectivist theses expressed by P1 and P2. Rather, what the significance of context reveals is that, while questions regarding the natures and behaviours of systems of scientific interest are appropriately answered in different ways, depending on the circumstances, different answers appropriate to different circumstances are nonetheless *compatible* with one another. It is this compatibility that distinguishes the account I have described here from the forms of perspectivism it is intended to contest. In closing, I will attempt to illustrate this by analogy to some recent work on the nature of explanation.

A number of authors have explicated the phenomenon of successful explanation in terms of the idea of contrast classes.[11] The paradigmatic question introducing a demand for explanation is taken to be something of the form 'why *p*?', and the analytical insight central to this literature is that a successful or genuinely explanatory answer to a why-question can be elicited by considering an implicit contrast inherent in the question. One may wonder, for example, why Willie Sutton—the infamously accomplished and well-dressed bank robber of 1920s and 1930s America—robbed banks. In this, as in many examples of why-questions, there are many possible answers, and any number of different answers may be true. The determination of which answer is appropriate in the circumstances will depend on the context of the request for information. That context, it is maintained, can be revealed by considering the implicit contrast the question contains. On this picture, every request for an explanation of *p* has the implicit form: why *p* rather than *q*? It is by making the contrastive nature of the question explicit that one determines which answer is appropriate in the circumstances.

Consider the question of why Willie Sutton robbed banks. Does one mean, why did he rob banks rather than live an honest life? Perhaps the answer here has something to do (say, for the sake of argument) with an unfortunate childhood. Or does one mean, why did he rob banks rather than convenience stores? The answer here, allegedly Sutton's own, is that 'that's where the money is'. The facts pertaining to Sutton's childhood and the presence of large

[10] An exception may be Colyvan (2008), who contends (without arguing that the world is in fact this way) that scientific realists should accept the notion of inconsistent objects. The argument depends crucially on implausibly strong assumptions, however, including the thesis that realism requires a belief in the truth of idealized descriptions of objects, furnished by theories and models.

[11] See van Fraassen (1980), Garfinkel (1981), and Lipton (2004/1991).

sums of money in banks are, of course, perfectly compatible with one another. They are different but compatible facts. Successful answers to why-questions may depend on the context of the request for information, but that does not make the answers perspectival in any philosophically interesting sense, because all such answers can be true, without fear of contradiction, no matter which perspective one takes. What counts as explanatory in any given case depends on the question being asked, and this in turn depends on the context in which the question is posed—something which is generally implicit. The point of the contrastive theory of why-questions is that by making the relevant contrast explicit, one can illuminate clearly which question is being asked, and thereby, which answer is required.

Let us turn now from the analogy to the case in point. In the case of instrumental detections and inconsistent models, one is not so much interested in why-questions, I suggest; rather, one is interested in *what*-questions. One is interested in what the systems modelled are like; namely, what properties and relations they have, and what behaviours they display. Just as in the case of why-questions, there are generally many true answers to what-questions. The appropriate answer in a given context depends on the question being asked, and this in turn depends on the circumstances in which the question is posed, because it is these circumstances that determine which answer is not merely correct but also *explanatory there*. By making the context explicit—which behaviour of fluids is one modelling?; what degree of accuracy is required?—one can illuminate clearly the question, and thereby select an appropriate answer.

A paradigmatic question placing a demand for explanation here thus has the form 'what is *p*?', and according to the dispositional view of natural properties articulated earlier, this paradigmatic form is equivalent to 'what are the dispositions of *p*?'. Just as in the case of why-questions, there are generally many possible answers to what-questions, and any number of these answers may be true. Determining which answer is appropriate in the circumstances will depend on the context in which the question is posed, and that context, I suggest, is revealed by considering an appropriate contrast inherent in the question. A successful or genuinely explanatory answer to a what-question is thus elicited by considering an implicit contrast of the form: what dispositions of *p* are relevant to circumstances *x* as opposed to *y*? Circumstances *x* and *y* will include details of the instrument–experiment–model–target set up, in addition to the explanatory or predictive goals of the scientist. By making such contrasts explicit, the relevant dispositions can be selected, and an answer given to the corresponding what-question that is appropriate in the circumstances.

What is water? It is something that dissolves salt in some circumstances and not in others; that behaves like a continuous medium in some circumstances and not in others; that is nourishing in some circumstances and not in others. The perspectivist claims that answers to what-questions are irreducibly perspectival, but if what I have suggested here is compelling, they are not. One may or may not have an underlying theory of categorical facts with which to underwrite the dispositions of water, but quite independently of whether one does, one may have genuinely non-perspectival knowledge of their manifestations, nonetheless. What may appear on the surface to be inconsistent observations, detections, measurements, and models teach us things about the non-perspectival dispositions of the systems we study, and about how these dispositions are manifested in different circumstances. And so, there are no grounds here for anything resembling a strong perspectivism about scientific knowledge. "Objectivity", in Lipton's parlance—non-perspectival knowledge—rides again.

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