Perception and Computation*

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I was walking through the desert, and a ufo landed right in front of me. Three aliens got out, and they were one inch tall. I said, "Hey, are you guys really one inch tall?" And they said, "No, we're very far away."
— Stephen Wright

Students of perception have long puzzled over a range of cases in which perception seems to tell us distinct, and in some sense conflicting, things about the world. In the cases at issue, the perceptual system is capable of responding to a single stimulus — say, as manifested in the ways in which subjects sort that stimulus — in different ways. This paper is about these puzzling cases, and about how they should be characterized and accounted for within a general theory of perception.

After rehearsing the sort of case at issue (§1), I'll examine critically some of the strategies by which philosophers and perceptual psychologists have attempted to account for them (§2). Finally, I'll present an alternative computational account of the puzzle cases, argue that this view is superior to its competitors, and examine some of its implications (§3).

1 The Puzzle Cases: The Ambiguity of Perception

Let me begin by bringing to mind some (I hope) familiar cases in which our perceptual systems generate multiple reactions to a single stimulus.[1]

*In a companion to the present paper entitled "Computation and the Ambiguity of Perception" (in Gary Hatfield and Sarah Allred (ed.), *Visual Experience: Sensation, Cognition, and Constancy*, forthcoming), I take up the psychological issues raised by the view defended here; in the present paper I concentrate more directly on the philosophical motivations for, and consequences of, the view.

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[1]I prefer to bring out the ambiguity at issue by pointing to clearly bimodal experimental results in matching tasks rather than by the kinds of raw appeals to introspective phenomenology favored by such authors as Noë (2007); Kelly (2004). Ultimately, my view is that such psychophysical experiments are not alternatives to phenomenological description; rather, they are forms of phenomenological description, albeit forms that are (more than usually) systematic and properly controlled. One benefit of relying on phenomenological descriptions that are systematic and that involve more than reports from a single subject (indeed, a subject who might be thought to be

A first classic example is that of the non-uniformly illuminated but uniformly painted wall. Consider two contiguous and same-sized, same-shaped regions of the wall that are each (more or less) illuminated uniformly, but such that there is a difference in the illumination between the two — say, one is in shadow and one is in direct sunlight. Here is a fact. Subjects perceiving this stimulus condition can indicate about the differently illuminated regions (say, by their sorting behavior) that they are, in one way, alike in their color appearance and that they are, in another way, not alike in their color appearance. It seems that visual systems can pick up both the constancy/similarity or the inconstancy/dissimilarity between the regions, and subjects can respond (say, in the ways that they sort, report, or make matches) to either one. Moreover, famously, ordinary subjects can be made to switch between these different modes of response by manipulating the task instructions (Arend and Reeves, 1986; Blackwell and Buchsbaum, 1988; Valberg and Lange-Malecki, 1990; Arend *et al.*, 1991; Troost and deWeert, 1991; Cornelissen and Brenner, 1995; Bäuml, 1999). These familiar results give us powerful reason for believing that, in the kind of case at issue, perception is representing distinct things about the single distal stimulus. Assuming (standardly, though not uncontroversially) that perceptual states have representational contents, we can put this point by saying that the perceptual states caused by such stimuli have (at least) two different contents — one representing the aspect of similarity driving one kind of subject response, and one representing the aspect of dissimilarity driving the other kind of subject response.[2]

Here is another familiar example of the same sort of phenomenon. Viewing two telephone poles at different distances, subjects can judge of the different poles both that they are, in one way, alike in their size appearance and that they are, in another way, not alike in their size appearance. And, again, ordinary subjects can be made to report on (or respond in a quantitatively measurable way that is sensitive to) either the constancy/similarity or the inconstancy/dissimilarity simply by manipulating the task instructions (for a review of relevant literature, see Wagner, 2006, chapter 6). Here again, it is natural to regard subjects' distinct judgments about the single stimulus as reflecting different contents that perception represents. On the one hand, perception represents the aspect of similarity driving one kind of subject response; and, on the other hand, perception represents the aspect of dissimilarity driving the other kind of subject response.

A final, and equally familiar, example of the phenomenon I'm after involves the visual perception of a round dinner plate/penny held at two different angles: one head on (i.e., one's line of sight is perpendicular to the surface

prejudiced by a philosophical agenda) is that they are much less open to flat denial by interlocutors who claim to introspect differently.

[2]I'll be assuming in what follows that perception has the kind of representational content that would legitimate this way of talking (for defense of this assumption, see Byrne (2010); Pautz (2010); Siegel (2010); for criticism, see Travis (2004)). But I won't assume that such contents occur at the personal level. Given this last point, it is not a constraint on the attribution of a content to a perceptual state that the subject in whom the state occurs has conscious awareness of this content.

of the plate), and one tilted (i.e., one's line of sight forms an acute angle with the surface of the plate).[3] Yet again, we find that ordinary subjects can be made to report on (or respond in a quantitatively measurable way that is sensitive to) either a respect in which the apparent shape of the plate is constant/similar between the two presentations, or a respect in which the apparent shape of the plate is inconstant/dissimilar between the two presentations. And, yet again, this gives us reason to believe that visual perception can represent both an aspect of similarity and an aspect of dissimilarity between the two presentations of the plate.

It seems, then, that in these familiar cases (and many others that I won't bother to describe), subjects can behave in quite different ways as a result of perceiving a single stimulus. They have reaction that recognizes the simultaneously perceived wall regions/telephone poles/dinner plates as alike — as constant — in the relevant aspect of their appearance. And they have a reaction that recognizes the simultaneously perceived wall regions/telephone poles/dinner plates as unlike — as inconstant — in the relevant aspect of their appearance. We can call the former the *constancy reaction*, and the latter the *inconstancy reaction*. These two reactions are not simply different from one another. They are contrary, or opposed, to one another. Therefore, the fact that both are simultaneously present in a single perceptual system upon perceiving a single stimulus is quite puzzling. Thus, I'll label cases in which both of these sorts of reactions are available as *puzzle cases*. My central question in this paper will be how we should think about these puzzle cases.

While there is much that is unclear about the perception of puzzle cases, one feature I want to emphasize immediately is that the perceptual system does *not* respond to these cases by representing a contradiction. This can be seen by comparison with, for example, the perceptual representation of the spatial layouts in certain familiar Escher drawings containing inconsistent cues about the depth relationships obtaining between depicted objects. Similarly, although this is more controversial, some have treated the waterfall illusion as another case where the perceptual system attributes and withholds a single property (in this case, the property of moving with respect to other objects in the scene) to an object, resulting in a contradictory perceptual content. The right thing to say about the perception of such Escher drawings, and perhaps about the waterfall illusion as well, is that the stimulus brings about the result that the perceptual system attributes conflicting properties (or attributes and withholds a single property); and when this result obtains, there is an interesting and recognizable (if poorly understood) perceptual breakdown. The point I am stressing here is that the perceptual phenomena involving puzzle cases contrast with our perceptual reactions in the Escher cases: the former do *not* seem to involve the perceptual representation of contradiction that we undergo in the latter.

The contrast between perceptual contradiction and the puzzle cases makes for a further constraint on our treatment of the latter. For it is not so obvious

[3]See, for example, Broad (1923, 235), Price (1964), Russell (1912).

how we can account for the dual contents that seem to be present in the puzzle cases without treating them as cases of perceptual contradiction. It is curious that, for example, subjects can both sort the tilted dinner plate with circles seen head on and sort the same tilted dinner plate with ellipses seen head on, given that *being circular* and *being elliptical* are incompatible determinates of a common determinable. Similarly, it is curious that, subjects can both sort the two telephone poles as similar in size and sort the same telephone poles as dissimilar in size, given that two objects cannot be of the same size and different size. But it is yet more curious that they can do these things without representing a contradiction!

What should we make of this situation?

2 Some False Starts

I'll begin be considering some responses to our puzzle cases that, it seems to me, are ultimately unsuccessful.

2.1 Denial

The puzzle cases are puzzling because the perceptual system responds to the stimuli in distinct and what seem to be opposite or contrary ways, but do so without falling into the representation of contradiction. Some theorists have responded to the puzzle cases by downplaying or dismissing one of their component reactions, and so dissolving the threat of contradiction by fiat. Typically, these theorists have offered accounts of perception that emphasize constancy reactions and the kinds of features they reflect at the expense of inconstancy reactions and the kinds of features they reflect. It seems clear that our puzzle, which involves accounting for the relationship between distinct perceptual reactions/contents, would dissolve if we could explain away one of the troublesome reactions/contents. Unfortunately, it seems to me that both reactions/contents are genuine; consequently, I believe that the strategy of denial will inevitably result in an (at best) incomplete conception of perception.

One example of the tendency toward denial comes out in a passage that is unrepresentative only for its explicitness on the point:

> I am not even inclined, the tiniest bit, to take the [penny seen at an angle] to be elliptical, or to react to it as to an elliptical — one can even say elliptical *looking* — object. If set to perform discrimination tests, I should naturally and unthinkingly class together, on the basis of their visual appearances, what I see when I look at the titled penny with *round* objects seen full on. Animals react the same way. Indeed, the relatively difficult identification in this area is trying to identify objects that [result in type-identical perceptual states]. That kind of painterly, or so-called innocent, attitude to what we are presented with visually is an unnatural and sophisticated one that is difficult to attain (Smith, 2002, 182; cf. 178).

Smith is dismissive of dual contents, and explicitly discounts inconstancy reactions: "...that of which I am most fundamentally and immediately aware ...does not appear to change at all in such a situation. This is a plain phenomenological fact" (178).[4]

I suggest that Smith's reaction is inappropriate. Like it or not, inconstancy reactions are part of the observed data; they show that inconstancy (e.g., along the dimensions of size, shape, color) *is* part of subjects' phenomenal experience in perceiving the cases of interest. This, too, is a plain phenomenal fact.

Now, Smith is surely right that subjects are "not inclined, the tiniest bit to take" the tilted penny to be elliptical, if by this he means that their net perceptually informed belief about the penny's shape is that it is not elliptical (cf. Austin (1962, ch. 3)). But this does not show that subjects fail to perceptually represent the penny as being elliptical (or elliptical-looking, or in some perceptually available way relevantly similar to ellipses, etc.). What it shows is, rather, that this representation (a representation whose presence is motivated by the psychophysical data) is not the only factor contributing to subjects' overall belief about the penny's shape. In any case, the persistence of familiar illusions even after learning about how they work gives us independent evidence that the content of our perceptually informed beliefs goes beyond and sometimes conflicts with the content of perception. Indeed, in the remainder of the first passage quoted above, Smith seems to soften his position substantially by admitting that there *is* a second, discriminatory reaction to the tilted penny that classifies the stimulus with ellipses rather than circles. Although he claims (without evidence, as far as I can see) that this second reaction is slower, more demanding, not present in (non-human?) animals, "unnatural," and "sophisticated," he allows that it is present.[5] But if that is right (as I think it is), then our puzzle arises once again: how does the perceptual system maintain representations of both these properties without falling into contradiction?

[4]Smith's dismissiveness is echoed in Heidegger's assertion that, "When things appear, we never...originally and really perceive a throng of sensations — tones and noises, for example; rather, we hear the storm whistling in the chimney, we hear the three-engine aeroplane, we hear the Mercedes in immediate distinction from the Volkswagen" (Heidegger, 1977, 156). Despite their significant differences, in this passage Heidegger allies himself with Smith's views by claiming both that (i) perceptually-informed recovery of inconstant features is derivative on perceptual recovery of constant features, and that (ii) inconstant features are no part of perceptual content ("*we never*...originally and *really perceive*..."). My complaint is with (ii), not with (i).

[5]In fairness, Smith (2002, 183–184) does accept at the end of the day the existence of a property over and above the distal shape/size of the object that is responsible for the second sorts of reactions — he calls this property "extensivity," presumably as a way of distinguishing it from distal shape/size. But he denies that such properties are perceptually represented; he holds that such a property is "not a real feature of the two-dimensional visual array, but an abstraction from the three-dimensional field with which one is phenomenally presented" (184). One respect in which this view is unsatisfactory is that we are left without an adequate understanding of what "extensivity" amounts to and how it is related to distal shape/size. A second is that, because it enforces a categorical distinction between the two properties, the view makes it mysterious why, in making matching judgments, subjects balance differences in extensivity against corresponding differences in size/shape.

The preference for constancy reactions at the expense of inconstancy reactions exhibited by Smith (in at least part of what he writes) is, of course, shared much more widely. Indeed, one area in which this preference is frequently encountered — and with respect to which the dual content thesis might therefore represent a useful corrective — concerns what has come to be called perceptual constancy. Theories of perceptual constancy are typically conceived as theories of how perceptual systems extract constant features across a diverse range of perceptual conditions. In addressing this problem, it is only natural that authors have wanted to focus on constancy reactions rather than inconstancy reactions; the former, rather than the latter, comprise the subject matter that is under study. This, by itself, is appropriate and entirely unproblematic. Surely there is a perfectly good question of how perceptual systems extract constant features. What is worrisome is only that some treatments of this question tend to treat perceptual systems as if the extraction of constant features were the only thing they do. We know this must be false, since the operation of perceptual systems in the very same settings can also do a different job — namely, perceptual systems also extract inconstant features that result in inconstancy reactions.

As one prominent example of the worrying tendency, consider one of Land's articulations of his justly-famous Retinex Theory. According to Land, the theory can be understood as the conjunction of the following central claims:

> I. The composition of the light from an area in an image does not specify the color of that area.
> ...
> II. The color of a unit area is determined by a trio of numbers each computed on a single waveband to give the relationship for that waveband between the unit area and the rest of the unit areas in that scene (Land, 1986, 144–145)

Principle I tells us what does *not* determine our constancy reactions with respect to apparent color: the total composition of light from the area in an image. And Principle II tells us what (according to Land) *does* determine our constancy reactions with respect to apparent color: a certain triple of ratios of waveband-restricted light from a unit area to light from the remaining areas in the scene. To be fair, Land nowhere says that the total composition of light from an area — what, in his system, would presumably be called on to account for inconstancy reactions — is utterly without perceptual significance. But he does tell us that, as far as color perception is concerned, the latter quantity is not what we're after. Thus, Land's picture encourages us to think of color perception exclusively in terms of constancy reactions, and the computations that underpin these reactions.

Later theorists have often disagreed with Land about just exactly what constant features are extracted by color vision, or about how such features are extracted; still, many have followed Land in relegating inconstancy reactions (and the computational processes that define them) to an at best incidental role. This focus is often reflected in the description of color perception as

"discounting" or "discarding" the illuminant by from the total perceptual signal by some (deterministic or statistical/Bayesian) computation to arrive at what really matters: constant object features (e.g. Maloney, 1986; Maloney and Wandell, 1986; Wandell, 1989; D'Zmura *et al.*, 1995; Brainard and Freeman, 1992).[6] Thus, in an entirely typical expression, Poggio claims that "the goal of colour vision is to recover the invariant spectral reflectance of objects (surfaces)" (Poggio, 1990, 147).

On the view I am defending, this picture is not so much wrong as misleadingly incomplete. I am not claiming that constant features or constancy reactions are unimportant, or that they play no role in perception, or that perceptual systems fail to compute them. Rather, I am suggesting that, while constancy reactions are indeed important, the normal operation of perceptual systems also results in inconstancy reactions. To ignore this is to ignore that part of perception that is responsible for our performance on some occasions, and thereby to arrive at a partial conception.

The problem of incompleteness that I have been highlighting in these writers has sometimes led to a further problem in the writings of philosophers who have appealed to perceptual constancy as a way of arguing for views about the metaphysics of color.[7] For example, writers including Tye (2000, 147–148), Hilbert (1987, 65), and Byrne and Hilbert (2003, 9) explicitly appeal to constancy reactions in color perception as cases where the very same feature can be extracted despite variation in the ambient illumination, and infer from this claim that color (which we may assume is indeed represented by color perception) is itself a constant feature — viz., that it is an illumination-independent feature of objects. Against the backdrop of what we've said in this section, I hope it is clear that this inference fails by depending on a partial account of what it is that perception delivers. For, while it is reasonable to take constancy reactions to reveal that perception represents constant features, it is no less (and no more) reasonable to take inconstancy reactions to reveal that perception represents inconstant features. Given that perception represents both constant and inconstant features, there is no sound inference from the fact that color is represented by perception to the conclusion that color is a constant (here, illumination-independent) feature. Consequently, the sort of appeal to perceptual constancy made by these authors does not successfully motivate the claim that colors are illumination-independent features of objects.

2.2 Ontological Inflation

There is an alternative approach to our puzzle that (whatever its other flaws) deserves credit for taking the problem more seriously than the denial-based strategies considered in §2.1. This alternative solution rests in a kind of ontological inflation — in solving the problem by adding to the ontology of individuals represented by perception. Roughly, the thought is that we

[6] I believe the expression 'discounting the illuminant' originates with von Helmholtz (1962).

[7] I discuss such arguments at greater length in Cohen (2008).

could account for the Janus-faced behavior of the perceptual system in puzzle cases without threat of inconsistency by positing new (theoretically-motivated) individuals and treating the perceptual system as representing two distinct properties holding of two different individuals — one individual of the familiar, distal sort, and a second of the new, theoretically-motivated sort.

(By way of analogy: while the conjunction $\ulcorner Fa\&\neg Fa\urcorner$ contradicts itself by affirming and denying that a certain property holds of one individual, there is no contradiction in the conjunction $\ulcorner Fa\&\neg Fb\urcorner$, which affirms a property of one individual and denies that property of another individual. So by introducing into our ontology the individual b distinct from a, we gain the ability to both apply and forebear $\ulcorner F\urcorner$ without risking contradiction.)

One classic instance of this ontologically inflationary approach to the puzzle cases can be discerned in philosophical attempts to motivate the (in)famous view that perception relates us only indirectly to distal items through the intermediation of immaterial entities — sense-data — that are themselves both caused by the distal stimuli and immediately accessible to subjects. Indeed, it seems to me that considerations about the bimodality of perceptual responses to our puzzle cases have been a — perhaps *the* — central motivation for classic articulations of such views by Russell (1912); Ayer (1963, 1967); Broad (1925).

That said, the idea can be seen especially clearly in the relatively recent defense of a sense-datum-like theory by Peacocke (1983).[8] In arguing for his position, Peacocke describes a case very similar to the telephone poles example discussed above, and explicitly recognizes both the constancy and inconstancy reactions subjects have when confronted with the case:

> Your experience represents these objects [trees] as being of the same physical height and other dimensions; that is, taking your experience at face value you would judge that the trees are roughly the same physical size .... Yet there is also some sense in which the nearer tree occupies more of your visual field than the more distant tree. This is as much a feature of your experience itself as its representing the trees as being the same height...(Peacocke, 1983, 12).

And he ends up concluding that this case, and others with the same structure, can only be described adequately by appeal to something over and above the

[8] Arguably Rock (1983, 253–256) has in mind something like the view I am attributing to Peacocke as well (see also Rock, 1977). He does, at any rate, hold that the visual system represents both "proximal" properties such as those Peacocke attributes to visual field regions (in the present case, *different size*) and "distal" properties such as those Peacocke attributes to distal items (in the present case, *same size*). Moreover, he sometimes attributes the proximal and distal properties to different entities (like Peacocke). However, Rock is inconsistent in this policy: while he sometimes agrees in attributing the proximal properties to something distinct from the distal objects of perception (Rock prefers the retinal projection over Peacocke's visual field regions), he claims at other points that proximal properties are exemplified by distal items (e.g., trees). Consequently, I'm ultimately unsure how to understand his view.

constant features of distal objects.[9] This is just to say that, for Peacocke, there are two different ways in which perception classifies the trees' size — that perception presents two different contents with respect to their size.[10]

Given that Peacocke accepts these dual contents, he needs to say something to stave off the worry about contradiction raised above: how does the perceptual system represent both contents without devolving into inconsistency? How can it simultaneously represent an instance of *same size* and an instance of *different size* without contradiction? And he has a solution to this problem: ontological inflation. That is, he proposes to solve the problem by introducing new entities — entities distinct from any of the trees or other objects in the distal scene, and holding that the two different properties mentioned are represented by perception as holding of different entities. In particular, his view is that *same size* holds of the trees, whereas *different size* holds (not of the trees, but) of his new, distinct entities: viz., regions of the visual field (14ff).[11] Thus, for Peacocke, our dual reactions to the stimulus reflects the exemplification of two different properties by two different individuals. When we judge/respond that the trees are the same size, we are responding to the exemplification of constant object features (objective sizes) by trees. But when we judge/respond that the nearer tree occupies more of the visual field than the more distant tree, this is best understood as a reaction to the exemplification of sensational features by portions of the visual field. Contradiction averted.

As noted above, Peacocke's solution to the problem posed by the puzzle cases is reminiscent of classical arguments for sense-data from illusion and hallucination. For proponents of these arguments, the problem to which sense-data are the solution is the finding that none of the local physical objects bear the properties falsely represented by perception when we suffer from illusion or hallucination.[12] Indeed, in the usual setup, these falsely

[9] Peacocke (1983, 12–13) draws similar conclusions from, among others, a case involving blurred vs. unblurred visual representations of the same objects, and from a version of the case of the uniformly painted but non-uniformly illuminated wall described above.

[10] Terminological caution: on Peacocke's more restrictive usage (roughly, restricted to cases of "personal-level" representation), the phenomenal difference between the trees does not count as being represented. Similarly, Peacocke would deny the existence of dual *contents*. As far as I can tell nothing I'll be concerned about hangs on the choice of terminology — the issues I shall raise for Peacocke below come up whether the states in question are genuine representational contents or some sort of proto-contents.

[11] More accurately, the property/relation that he says holds of visual field regions is not *different size* (that property/relation that holds of certain distal items in the world), but the corresponding property/relation *different size*′, that holds of visual field elements when the distal items connected with those elements bear *different size* and are presented under favorable conditions for the discrimination of sizes. I won't worry about this nicety.

[12] Jackson (1977) develops alternative arguments for sense-data that do not depend on the sorts of motivations considered in the main text. While he thinks there are sense-data, he does not think the latter are required in order to account for illusion or hallucination. That said, he does want to recognize that there are two different perceptual reactions to stimuli such as the round plate held at an angle. His way of recognizing this point is to hold, unusually among fans of sense-data, that sense-data exist in depth and at angles with respect to the perceiver:

> the sense-datum belonging to the round plate held at an angle is round *and at an angle*. Hence, it differs from the sense-datum belonging to the round plate seen

represented properties are metaphysically incompatible with the properties of the quotidian, distal items to which subjects are perceptually related: the straight, half-immersed stick *can't* be bent, because it is straight; the round dinner plate *can't* be elliptical, since it is round, etc. Sense-data are then introduced as alternative bearers of the properties that their proponents think are exemplified in the relevant instances of perceptual illusion or hallucination, but which cannot be exemplified by the quotidian, distal items. For these writers, then, as for Peacocke, the solution to the puzzle we have been discussing lies in the recognition of extra entities that can share with quotidian items the job of bearing whatever properties are perceptually represented.[13]

I hope the foregoing has brought to light one important benefit of such ontologically inflationary views: their postulation of extra entities as potential bearers of perceptually represented properties makes them well-suited to accommodate the distinct contents that, I have emphasized, we have reason to take perception to represent. The bad news for such views is that, for many, this kind of ontological inflation is unacceptable on familiar ontological grounds. Thus, critics have argued that proponents of sense-data have no acceptable of where sense-data are located, how they are individuated, whether they can exist unsensed, whether a given sense-datum can be sensed by distinct observers or by one observer at different times, how they are structured from

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straight on in not being at right-angles to the line of vision, and differs from the sense-datum belonging to an elliptical plate in being round, not elliptical (104; cf.Smith (2002, 182)).

From the point of view of the present paper, Jackson's account holds the attraction that it at least makes room for two different respects of perceived difference corresponding to the two different perceptual responses of visual systems to a single stimulus. Unfortunately, it seems to me that Jackson's account falls short: while it arguably makes room for the differences that perception can represent, it doesn't allow for the samenesses that perception can represent. The perceptual state of a subject viewing a plate at an angle is, as Jackson says, different from that of a subject viewing a round plate straight on and from that of a subject viewing an elliptical plate seen at an angle. However, what subject reactions suggest is that the state of seeing a round plate at an angle is also similar to the state of the subject viewing an ellipse straight on. Jackson's account predicts that these two states differ in the two distinct respects that were present in the intermediate cases he discusses (a difference corresponding to shape and a difference corresponding to angle). But Jackson seems to lack the resources to account for the similarity between these cases to which perception can be responsive.

[13]This strategy is, of course, only available to sense-datum theorists who take perception to represent *both* quotidian items (and their properties) and sense-data (and their properties) — this strategy for accounting for dual contents only works for sense-datum theorists who have dual systems of entities and dual systems of properties. As I read them, many classical sense-datum theorists took this position. Indeed, they held that there is a theoretically interesting in-virtue-of relation that obtains between the two sorts of content: namely, that the perceptual relation one bears to the exemplification of sensational properties by mental items is partly constitutive of the perceptual relation one bears (in veridical perception, at any rate) to the exemplification of ordinary properties by quotidian physical objects. And it seems that they could not have held this last position without recognizing dual contents. On the other hand, some sense-datum theorists, such as Ayer (1973), seems to hold that perception represents *only* the exemplification of sensational properties by sense-data, and therefore to reject dual contents. Unfortunately, I take it that such single-content forms of sense-datum theory are implausible because, (among other problems) like the single-content views of §2.1, they lack the resources to address part of what it is that perception does (as reflected in the duality of perceptual responses we have been considering).

(or fail to be structured from) entities whose ontological credentials are less in doubt (e.g., tables and chairs, physical particles), and so on. For better or worse, most readers have thought that these problems with the entities are unsolvable or not worth solving. Moreover, similar worries can be raised against non-sense-data forms of the ontologically inflationary response to our puzzle.[14]

If this is the right verdict, then we need to find an alternative way of endorsing the dual contents that seem to be represented in the perception of puzzle cases — one that does not commit us to a sense-datum conception of perception.

2.3 Ontological Deflation

Given that ontological inflation seems to give out as an answer to our puzzle, it is worth considering an alternative that works by reducing, rather than increasing, the number of individuals represented by perception. The ontologically deflationary account I have in mind is the adverbial theory of perception championed (often specifically as an ontologically preferable alternative to sense-data views) by such writers as Ducasse (1942); Chisholm (1957); Sellars (1963, 1975). On the adverbial theory, perceptual states should be thought of simply as manners of affecting perceivers, rather than as episodes in which perceivers are related to extramental particulars. Thus, the adverbial account of what it is for me to perceive a red object (as it might be) is just that I undergo a certain kind of state — I am "sensing red-ly". Significantly, adverbialists urged that we should understand the modifier in this and similar analyses (here, "red-ly") as modifying the *experiential episode* in the perceiver, rather than modifying some object external to the perceiver (a "perceived object," or "object of perception"). Indeed, one of the key respects in which adverbialism seemed to many to be an advance over sense-datum accounts of perception is just that it avoids the hypostatizion of objects of perception, and, in so doing, sidesteps the worries about the ontology of such entities that were thought to be so damaging to sense-datum theories.

Since I don't have the space to engage in a full-scale defense (or even proper exposition) of adverbialism, I want here to address the far more limited question of how adverbialism might fare with respect to the dual contents that seem to be present in the puzzle cases. Viewed from this admittedly limited perspective, adverbialism can look initially promising. This is because adverbial ways of appearing/sensing seem not to put substantive

[14]For example, one of the crucial elements in the famous criticism of sense data by Austin (1962) involves rejecting extra entities as the bearers of apparent properties; rather, Austin urges, we should analyze the situation in a way that does not require the exemplification of such apparent properties to any entity at all.

Peacocke (2008) offers responses to some of the standard ontological objections against sense-data; for example, he holds that sensational features are located in ordinary physical space (specifically, in a curved plane that is the location of an imaginary retina the subject would have were she seeing from a single "Cyclopean" eye), and literally exemplify ordinary spatial properties such as distance, size, and shape. I won't attempt to assess Peacocke's responses here.

constraints on one another: such ways of appearing/sensing are typically taken by adverbialists to be more or less without structure, and therefore not to participate in relations of mutual exclusion. That is to say, adverbialism, at least unless supplemented by further apparatus, gives no reason that a subject who is sensing F-ly could not also be sensing G-ly. Consequently, the adverbialist can, in principle, accommodate the dual contents I have been emphasizing by regarding these as multiple, independent ways of sensing.[15] For example, the subject who perceives the tilted penny could be described by the adverbialist as both sensing circularly and sensing elliptically; and the adverbialist might hope to account for the plurality of perceptual reactions to a stimulus by appealing to this plurality of sensory modes. So far, then, so good.

Alas, the news is not all good for adverbialism; for the very means by which adverbialists solve the current problems (viz., their refusal to recognize objects of perception) famously causes deep trouble elsewhere in their theory of perception. The most serious manifestation of this deep trouble, to my mind, is the Many Properties Problem of Jackson (1977). This problem stems from the observation that the inference from (1) to (2) seems to be valid:

(1) S perceives a red round object.

(1a) S represents x as red and S represents x as round.

(1b) S senses redly and S senses roundly.

(2) S perceives a red object.

(2a) S represents x as red.

(2b) S senses redly.

The usual explanation of this inference rests in the thought that (1) is made true by S's perceptual attribution of redness and roundness to the very same object, as per (1a), and that we can validly infer from (1a) to (2a) (which paraphrases (2)) by an application of conjunction elimination. But, of course, this explanation is unavailable to adverbialists, who deny that perception represents the exemplification of properties by individuals. The natural response for an adverbialist is to account for the inference in terms of conjunction elimination on (object-free) modes of sensing, as per the inference from (1b) to (2b). Unfortunately, as Jackson (1977) points out, this suggested conjunctive treatment of the sensing of multiple properties is unable to distinguish between what are obviously distinct cases, e.g., those described

[15]The success of this maneuver depends on the idea that the ways of sensing in question are distinct. As Johnston (2004, fn. 23) points out, it is not so easy to see how the adverbialist can account for cases of perceptual contradiction such as those (arguably) induced in the waterfall illusion. Just what does it mean to say that the subject is sensing *moving-and-not-moving-ly*? What kind of a mode of sensing is that? The present point, however, is that adverbialists are not forced to think of the cases we are discussing as involving a single, curious and apparently contradictory mode of sensing: rather, they can treat the cases in terms of two distinct, logically unrelated modes of sensing.

by (3) and (4). For the adverbialist paraphrases (3b) and (4b) are truth-conditionally equivalent:

(3) S perceives a red round object and a green square object.

(3b) S senses redly and S senses roundly and S senses greenly and S senses squarely.

(4) S perceives a green round object and a red square object.

(4b) S senses greenly and S senses roundly and S senses redly and S senses squarely.

The Many Properties Problem, then, is that the adverbialist is unable to distinguish (3) from (4) without accepting objects of perception (viz., without surrendering her account of perception).

I think it is generally conceded that this is a very serious problem for adverbialism. Partly as a way of showing just how recalcitrant the trouble is, I want to criticize, briefly, two adverbialist responses to the Many Properties Problem.

The first, due to Tye (1984), involves the postulation of a "coincidence" adverb modifier ('Coin') that maps, as it might be, the two adverbial modes of sensing redly and circularly onto the adverbial mode of sensing redly-coincidental-with-circularly. On the intended interpretation, this operator denotes a function "mapping any two given sensory modes or functions F-ly and G-ly onto a function which, in turn, maps the property of sensing onto a further sensing property which is usually instantiated in normal perceivers by virtue of their viewing a physical object, which is both F and G, in standard circumstances" (218).

While this represents a valiant effort to solve with an operator the problems created by doing without objects of perception, I am at a loss to understand the meaning of this and other of Tye's proposed operators. There appear to be a plurality of sensing properties "usually instantiated in normal perceivers by virtue of their viewing a physical object, which is both F and G, in standard circumstances." For example, there is the sensing property that adverbialists would describe as sensing F-ly; and there is the sensing property that adverbialists would describe as sensing G-ly; and there is the sensing property that non-adverbialists would describe as sensing something that is represented as both F and G. I don't see how the adverbialist can pick out just the third of these (which is what Tye needs) without recognizing represented perceptual objects and thereby giving up adverbialism. Consequently, I do not see that this response is adequate to save adverbialism from the Many Properties Problem.

The other defense of adverbialism from the Many Properties Problem I want to mention comes from Kriegel (2008, 88–89), who relies on metaphysical rather than semantic resources to account for Jackson's inferences. Kriegel would represent (3) by (3c) and (4) by (4c):

(3c) S senses redly-and-roundly and greenly-and-squarely.

(4c) S senses greenly-and-roundly and redly-and-squarely.

He insists that the hyphenated names for the sensory modes in these paraphrases lack semantically significant constituents, *a fortiori* that they lack constituents that can be freely commuted, so that (3) and (4) are not equivalent after all. But this appears to leave an awkward question: if the correct paraphrase of (3) lacks a constituent for sensing redly, how could (3) entail (2), for example? Kriegel's answer turns on finding a determinate-determinable relation between modes of sensing rather than on finding semantic structure in the contents of sensory acts. That is, he holds that the property of sensing redly is (as a matter of metaphysical fact) a determinable of which the property of sensing redly-and-roundly is a determinate. Hence, for Kriegel, any act of sensing redly-and-roundly is also an act of sensing redly.

Unfortunately, this solution seems unsatisfactory as well. For one thing, Kriegel fails to explain why he finds the particular sensory modes in (3) and (4) that he does. Why does redly-and-roundly occur in his paraphrase for (3) rather than, say, redly-and-squarely or (worse) redly-and-greenly? I don't see how he can answer this question — viz., how he can put the hyphens in exactly the right places to get the inferences he needs and forbid the rest — without adverting to objects of perception, which would mean giving up adverbialism. For another, since the problem generalizes productively, Kriegel's solution depends on accepting infinitely many (apparently brute) determinate-determinable relations holding among modes of sensing. This problem does not arise for those who treat perception in terms of the representation of property exemplifications by individuals (as per (1a), (2a), etc.). For these theorists, the inferences at issue fall out of the compositional semantic structure of perceptual representations — structure which, can be understood in terms of a finite stock of primitive vocabulary and the application of a finite number of recombination rules. Since Kriegel and other adverbialists forswear structure in favor of atomic modes of sensing, they are left having to account for what appears to be a completely productive (infinitely large) set of inferences on a case by case basis. To my mind, these costs make Kriegel's defense of adverbialism untenable.

I conclude, then, that the Many Properties Problem remains a serious obstacle for adverbialism. And since adverbialism is the best worked-out version of an ontologically deflationary explanation of the puzzle cases, it would seem that we should look elsewhere for an adequate treatment of the phenomena.

3 A Computational Alternative

In my view, the failure of the views considered above give us reason to go back to the initial idea, bruited in §1, that the distinct behaviors exhibited in our puzzle cases arise because here perceptual systems represent concrete physical

individuals (walls, telephone poles, pennies) exemplifying multiple properties. This idea (some version of which is accepted by Tye (1996, 2002); Byrne (2002); Noë (2004); Schellenberg (2008), among others) is intended to account for the bimodal behavior of subjects by the explicit recognition of distinct contents, and in this way it is superior to the views criticized in §2.1. Moreover, in treating the cases as involving the attribution of multiple properties to one and the same external, ordinary individual, the strategy does not run the risks of ontological inflation or deflation urged against the views criticized in §2.2 and §2.3).[16]

However, there remains the outstanding question of how a view of this sort can avoid treating the puzzle cases at issue as involving perceptual contradiction. While proponents of the dual representation view have not always faced up to this problem explicitly, their choice of terminology suggests the strategy of drawing some sort of distinction between the distinct perceptually represented properties — e.g., the penny's roundness is sometimes described as an "object" or "distal" property, while its ellipticality is an "apparent," "proximal,""perspectival," or "situation-dependent" property. But of course the mere labels do not amount to a substantive answer to our question so much as an invitation to explain the difference. (I do not mean to suggest that purveyors of such labels thought otherwise.) How, then, should someone sympathetic to the dual representation account explain the distinction between the properties represented?

In what follows I want to propose an answer to this question, and, ultimately, an account of the puzzle cases, in terms of computation. In particular, I'll suggest that we should supplement the appeal to dual representations with a computational conception of how they are related to one another. I hope that the broad outlines of this computational treatment (if not its specific

[16]Tye and Byrne, in the works cited, propose versions of the current proposal as a way of defending the representationalist/intentionalist thesis that (roughly) perceptual phenomenology supervenes on the representational content of perception. This thesis is threatened by puzzle cases since, on the one hand, there seems to be a phenomenological difference between, e.g., the perception of a tilted penny and the perception of a penny seen straight on, while on the other hand it might seem that in both cases there is identical representational content ascribing a certain shape to a particular penny. The dual content proposal responds to this threat by finding a difference between the representational contents of the two perceptual episodes to go with the phenomenal difference, thereby preserving the supervenience thesis. However, my official aims in this paper are more limited. I am proposing to accept dual contents only so as to offer an explanation for the observed bimodal behavior that we have discussed; in doing so I don't want to take sides about the supervenience thesis (or any other claim about the metaphysics of perceptual phenomenology).

I should also note that, despite adverting to representational contents of states of the visual system, my proposal is intended to be compatible with (at least many versions of) disjunctivism about perception (Hinton, 1973; McDowell, 1982). While disjunctivists deny that the relation between subjects and objects that is constitutive of veridical perception involves epistemic intermediation by representational contents, they do not deny that this relation involves causally intermediate states in the subpersonal visual system (*inter alia*), and there is nothing to prevent them from accepting that such subpersonal causally intermediate states have representational contents. The current proposal *is* in conflict with claims to the effect that subpersonal states of the visual system lack representational contents (e.g., Gibson, 1979; Brooks, 1991; O'Regan and Noë, 2002); but I take these claims to be highly implausible (Cohen, 2001), and so will set them aside.

details) will strike many readers as uncontroversial or even obvious. Still, I believe that there are several reasons for thinking through the computational proposal. Among other benefits, the computational outlook suggests a natural explanation of the sense in which the target properties are treated differently by the perceptual system. Namely, they are treated differently by being assigned different roles in a certain functional/computational relationship that perceptual systems compute. More specifically, I suggest that one of our properties is the input to a computation carried out by perceptual systems, and the other property is the output of that computation. This, in turn, will allow us to understand the bimodal pattern of subject responses that we have noted without wrongly predicting that the puzzle cases will lead to the perceptual representation of contradiction, and without falling prey to the problems raised above for alternative proposals. Ultimately, I think the computational outlook will put us in a better position to understand just which properties are perceived in the puzzle cases, just which properties are represented by the perceptual system, and how they are related to one another.

3.1 Perception and Computation

One reason to pursue a computational account of the puzzle cases comes from the observation that, if we are looking for a difference between represented properties in order to avoid perceptual contradiction, it won't suffice merely to find a metaphysical difference between our properties — say, a difference in extension, or the observation that they are determinables of different determinates. For that won't help the perceptual/visual system avoid representational conflict unless the properties are *treated as* different in kind by those systems. This is not to say that there is not a difference between the two properties that can be characterized metaphysically. It is, rather, to say that a successful answer to the puzzle we are considering will need, additionally, to say how the target properties are treated differently by perceptual systems.

Let us, then, begin to consider our puzzle not from the point of view of just which properties of things are represented, but from the point of view of the perceptual system and the computations it carries out.

For concreteness, consider the tilted penny once again. Suppose it is right that perception attributes to the penny one property that comes out in our constancy reaction (call it *round*) and a different property that comes out in our inconstancy reaction (call it *elliptical*).[17] We know these properties can't both be treated as determinates of a common determinable (say, *shape*) on pain of the kind of reaction to perceptual contradictions that is simply not present in the case. So our question is: how does perception treat the two properties distinctly?

The answer I want to suggest is that perception treats the two properties as playing different roles in a certain computational relationship.

[17] Below I'll deny that the second of these properties is best thought of as *elliptical*; but I'll stick by the current choice of labels for present purposes just to get the computational view on the table.

To see what I have in mind, we can begin by thinking about the gross state of the perceptual system at a time — henceforth, the perceptual state. The perceptual state is obviously a property of the perceptual system, as opposed to distal, worldly items. On the other hand, distal, worldly items that we perceive have dispositions to cause those perceptual states in us under certain circumstances; and these dispositional properties — henceforth, perceptual state dispositions — are properties of distal, worldly items as opposed to perceptual systems.

Consider, in particular, the perceptual state resulting from the subject's visually attending to the tilted penny. The system begins by transducing, and then representing, particular property instances. This transduction step can be understood as being caused to enter into a certain perceptual state — namely, the very perceptual state caused in us by visually attending to an ellipse head on. But of course what the system attributes to the worldly, distal penny is not a property of perceptual systems. Rather, it represents (and is ordinarily is warranted in so representing) the worldly, distal item as having the disposition to cause that type of perceptual state. That is to say, it represents the distal item as bearing this perceptual state disposition: *disposed to generate in us an instance of the type of perceptual state we undergo when perceiving an ellipse straight on*. That perceptual state disposition, I claim, is the property we were earlier (and, we can now see, misleadingly) labeling as *elliptical*. Significantly, given the representation of this perceptual state disposition, together with other represented information about the scene, the perceptual system can do something else. Namely, it can carry out a computation whose output is a representation with the content that there is a distal instance of *round*. Crucially, the two properties *disposed to generate in us an instance of the type of perceptual state we undergo when perceiving an ellipse straight on* and *round* play entirely different roles in this computation: the former is input, and the latter is output.

Thinking of perception in such computational terms provides a ready explanation of the distinct behaviors of subjects in puzzle cases. The current proposal accounts for the inconstancy reactions of perceivers — the reaction that distinguishes between the tilted penny and the penny seen straight on, and that assimilates the tilted penny to an oval seen straight on — by appeal to representations of perceptual state dispositions. For the tilted penny and the oval seen straight on share a perceptual state disposition that the penny seen straight on lacks (viz., *disposed to generate in us an instance of the type of perceptual state we undergo when perceiving an ellipse straight on*). On the other hand, we have the resources to account for the constancy reaction that is also present in subjects in terms of their representation of object feature. For the tilted penny and the penny seen straight on share an object feature that the oval seen straight on lacks (viz., *round*). In this case, the geometric shape of the penny (it is round) is one of the factors that determines the subject's total

perceptual state, and so is something that the perceptual system can compute given sufficient information about the perceptual perspective.[18]

Accepting the foregoing also puts us in a position to explain the difference between ordinary puzzle cases and cases involving the perceptual representation of a contradiction. When we perceive the perceptually contradictory Escher drawings, we attribute incompatible properties to one and the same object. When, in contrast, we perceive the tilted penny, we attribute *compatible* properties. There is no inconsistency in a thing's being simultaneously *round* and *disposed to generate in us an instance of the type of perceptual state we undergo when perceiving an ellipse straight on*. And, to repeat, the perceptual system can distinguish the two properties — and can associate each with the appropriate determinable — by assigning them different roles in the computational process it carries out.

3.2 Computation and The Perspectival Character of Perception

Why do perceptual systems carry out these computations? They do so because such computations are inevitable for the recovery of object features (which is, as it happens, one of the important roles that perception fills) given the perspectival perceptual relation to the world that we happen to enjoy.

In saying that our perceptual relation to the world is perspectival, I mean, among other things, that we always perceive objects and their properties from a particular angle and distance, under particular lighting conditions, in the context of a particular cognitive and perceptual history and future that affects the particular state of adaptation of our transducers, our perceptual expectations, and on and on. That perception is perspectival in these, and other, ways is a permanent, mandatory fact of our condition. While it may be that there is a species of the kind perception — perhaps a species available to God — that is not perspectival in this sense, it seems to be true and necessary that perception in creatures like us (as we are) always occurs under a perspective. Moreover, it turns out that a difference in perspective is (very often) a difference that makes a discriminable difference to perceptual systems.

For this reason, the perceptual state is an interaction effect resulting from the (typically independent) contributions of two different classes of features: *object features*, which qualify perceived objects, and *perspectival features* which constitute the perceptual circumstances under which we perceive objects.[19] Although it is difficult to characterize the contrast between perspectival and object features in more precise terms, I take it that the basic idea is familiar

[18]This last qualification is important. As Jameson and Hurvich (1989) observe eloquently, there are in ecologically realistic settings a wide range of perceptually relevant features of the perceptual perspective. Hence there are typically far too many unknowns for the perceptual system to compute closed form solutions for the assignment of values to object features. Consequently, the perceptual system must rely on default value assumptions about at least many perspectival features.

[19]Terminological caution: Some writers, such as Noë (2004), use 'perspectival feature' not for features of the perceptual perspective (as on my usage), but for something closer to what I am calling the perceptual state dispositions of objects.

enough as a principle of experimental design in perception science. In crude terms, the idea is that our perceptual responses depend systematically on both the way the world is (object features) and how we as perceivers are situated within that world (perspectival features), and that, consequently, any attempt to account for our perceptual responses has to control for these features separately.

That things are so arranged in the world explains why perceptual systems do the computational things I am claiming they do. Since the perceptual state is a joint product of perspectival features and object features, computation on the basis of the perceptual state (the input) is needed to recover representations of object features or perspectival features as output. Luckily, the perceptual state (hence the perceptual state disposition) will be fixed by causal interaction with the world, and so will be available for use as a computational input. Hence the perceptual system is in a position to carry out the needed computations: given either perspectival or object features, the system can compute the other.

3.3 What Is Represented?

In the foregoing we have focused mainly on two perceptual reactions: the constancy reaction (which we have explained in terms of the stability of object features) and the inconstancy reaction (which we have explained in terms of the instability of perceptual states/perceptual state dispositions). The behavioral evidence, then, gives us reason for believing that the two sorts of variables enlisted to explain the behavior (viz., object features and perceptual state dispositions) are in fact represented by perceptual systems. But the computational framework set out above makes use of not two but three sorts of variables — in addition to variables corresponding to object features and perceptual states, it appeals to variables corresponding to perspectival features. Thus, it would be nice to see some independent empirical confirmation of the existence of representations of the latter. In particular, if it is true that perspectival features are represented by the perceptual system, as I am claiming, it would be nice to see some examples of cases where subjects' reactions tracked those features rather than object features or perceptual state dispositions. Luckily, there appear to be such examples.

For example, there is strong evidence that subjects represent the perspectival feature of illumination in color matching tasks. For one thing, subjects can, when asked, make matches of perspectival features, such as ambient illumination, as opposed to object features, such as surface lightness (Katz, 1935; Gilchrist, 1988; Hurlbert, 1989; Jameson and Hurvich, 1989; Zaidi, 1998). Indeed, subjects can even characterize the different incident illumination in the two regions of a scene — say, between a swath of forest in a scene illuminated by direct sunlight and the swath of forest in the same scene illuminated by partially could-obscured sunlight (Arend, 1993; Zaidi, 2001, 1998). These facts give us reasonably direct reasons for believing that subjects represent perspectival features at least some of the time.

A second sort of (less direct) evidence for the same conclusion comes from the "tissue-contrast" effect discussed by von Helmholtz (1962, 547). Mausfeld (2003) describes the effect this way:

> If a small piece of grey paper, to which we can refer as a test spot, is placed on the centre of a large piece of coloured paper and a piece of tissue paper is then placed over these pieces of paper, the test spot has a colour appearance roughly complementary to the colour of the surrounding piece of paper (while an induced colour is absent or much weaker without the tissue paper). Often, as was also noticed by Helmholtz, the complementary colour of the test spot is much more vivid than the weak colour of the surrounding piece of paper.... The tissue paper phenomenon behaves as if the chromatic content of the surround is captured by the spatial layer of the tissue and then interpreted as a chromatic illumination (415; cf. Mausfeld (1998)).

Again, it is hard to see why the properties of the surround should influence subjects' representation of the illumination, as they appear to, without supposing that subjects are representing the perspectival feature of illumination.

Another piece of support for the same conclusion is the finding that subjects' achromatic point settings for infields inside chromatic surrounds are systematically skewed toward the chromaticity of the surround (Walraven, 1976; Shevell, 1978); again, this result is hard to interpret without supposing that subjects are representing illumination information (and that the properties of the surround influence this representation).

A final and related result is that, in cases involving the perception of infields in chromatic surrounds, the point in chromaticity space on which constant hue lines converge is not the achromatic point but the chromaticity of the surround (Ekroll *et al.*, 2002). Yet again, this finding suggests that the perceptual system is parsing out a feature of the artificial stimuli (viz., the chromatic content of the surround) as reflecting a perspectival feature (presumably something like illumination, or perhaps a quality of an intervening mist) rather than an object feature of the test spot/infield. Therefore, these cases strongly suggest that perceptual systems do (at least in many cases) represent perspectival features.

Thus, there is evidence that perceptual systems can represent object features, perspectival features, and perceptual state dispositions. That is, the evidence shows that perceptual systems can be, in particular situations, responsive to any of the three. But what the evidence does not show is whether all of these sorts of features are in fact represented in every perceptual episode. Of course, the perceptual system always has a gross state at a time; consequently, whenever there is an object of perception, there is a good sense in which the perceptual system, just by being in such a gross state, is representing a perceptual state disposition of its object. But it is not obvious that perceptual systems always represent object features and perspectival features — it is not

obvious that they always carry out the computations need to arrive at an explicit representation of object or perspectival features.[20]

Now, one might think that perceptual systems must, at the very least, represent object features whenever they track and reidentify objects in a changing world. The thought would be that object features are a much more reliable clue for tracking and reidentification than perceptual state dispositions, since the latter can be shared by a variety of qualitatively distinct objects perceived under different perceptual conditions. But I think this line of thought is too quick. I believe we have good reasons for thinking that, in certain conditions, perceptual systems can track and reidentify on the basis of perceptual state dispositions and perspectival features — without ever representing object features. For example, with respect to color perception, Zaidi (1998, 2001); Foster and Nascimento (1994); Dannemiller (1993) have suggested that we might track objects perceived at different times not by comparing their object features, but by comparing their perceptual state dispositions in light of what we can estimate about the illumination. Crudely, the idea is that we can ask whether the two perceptual state dispositions lie in the graph of transformations that correspond to ecologically realistic changes in perspectival features (here, illumination). In other words, on these proposals, the perceptual system answers the question about object identity by asking whether perceptual state dispositions vary systematically in a way that could be accounted for by a known change in illumination. It does so on the basis of qualitatively distinct perceptual state dispositions, and without requiring the computation of object features. If something like this proposal is accurate, then we have further reason for denying that the perceptual system must routinely compute object features — even in situations where it must track or reidentify objects over time.

3.4 Computation, Epistemology, and Asymmetry

On the computational account offered here, perceptual systems start with perceptual states (/perceptual state dispositions), and on this basis arrive computationally at a representation of object or perspectival features. How should we understand the computational relation between these representations?

Schellenberg (2008), who endorses a structurally similar view to that offered above, thinks of the relation between such properties in distinctively

[20]One consideration that might be thought to suggest that such computations are not always carried out is that, while subjects can be made to switch between responding to perceptual state dispositions (inconstancy reactions) and responding to object features (constancy reactions), there is no evidence of wavering, confusing, or averaging, in subject responses as one might expect were both properties always represented and available for report. The difficulty with this line of thought is that, while there is no evidence of wavering, confusing, or averaging in the responses tracking perceptual state dispositions (which I'm claiming can be represented in the absence of representation of object features), there is also no such evidence in the responses tracking object features (which, if I'm right, should only be represented when perceptual state dispositions are represented as well, since they are the computational input on the basis of which object features are derived). So I don't think this line of argument can establish the point.

epistemic terms. Schellenberg's conclusion (expressed in my terminology) is that the representation of perceptual state dispositions has a kind of epistemic priority over the representation of object features (cf. Noë, 2004, 165). She argues for this conclusion by pointing to an asymmetry between the evidence/warrant for the representations of these two different kinds of properties. Thus, she claims that anything that constitutes a defeater for the subject's evidence for the representation of a perceptual state disposition *ipso facto* defeats the subject's evidence for the representation of an object feature, but not *vice versa*:

> It is because the evidence of the [perceptual state disposition] is in the line of evidence of the [object feature] that defeat of the former entails defeat of the latter. And it is because the evidence for the [object feature] is not in the line of evidence for the [perceptual state disposition] that defeat of the former does not entail defeat of the latter. Thus, evidence for [object features] is dependent on evidence for [perceptual state dispositions] both with regard to defeat and warrant (77).[21]

But Schellenberg explicitly avoids committing to the idea that there is a causal (or phenomenal) priority to representations of perceptual state dispositions.

While I think that Schellenberg is on to something extremely important here, it seems to me that, by failing to emphasize the specifically computational nature of the relationship between perceptual state dispositions and object features, she locates the source of the asymmetry in the wrong place. It is indeed deeply plausible that, in ordinary situations, the asymmetry of warrant and defeat works in exactly the way that Schellenberg says its does. Indeed, we can even explain the asymmetry further: we can say that the reason that evidence about perceptual state dispositions is "in the line of" evidence about object features but not *vice versa* is simply that the perceptual system computes representations of the latter from those of the former. In saying this I take myself to be agreeing with Schellenberg.

But I think we can go beyond what Schellenberg says in two respects. First, I think it is reasonable to claim that there is not only an epistemic asymmetry

[21] An epistemological worry one can raise about Schellenberg's position (and mine as well) is that, if information about perceptual state dispositions provides epistemic warrant for representations of object features, then the former will constitute a veil of perception standing between perceivers and objects, and thereby allowing a foothold for skeptical challenges. Schellenberg considers this worry but dismisses it because, on her view (unlike on traditional sense-datum views, for example) there is no *object* intervening between perceiver and distal object that could potentially veil off the latter from the former. I suspect that this response will be unconvincing to anyone worried about skepticism; for even if no *objects* intervene between subject and distal object, there remains on this picture an extra layer of *properties* (viz., perceptual state dispositions) intervening between subjects and object properties. Even if the lack of intervening objects prevents us from being entirely cut off epistemically from distal items, the interposition of intervening properties allows that we might be radically deceived about what those distal items are like. Thus, while it may be that we avoid the threat of widespread hallucination, the threat of widespread illusion remains. (For what it is worth, I am unbothered by this conclusion, for I do not believe that a theory of perception must foreclose all skeptical threats.)

here but also a causal asymmetry. For I take it that (whatever else they are) computations are warrant-preserving causal processes. If so, and if the perceptual system computes object features from perceptual state dispositions (but not *vice versa*), then representations of the former are asymmetrically *causally* dependent on representations of the latter. Second, and more importantly, I think we can show that the epistemic asymmetry Schellenberg notices is derivative on the causal/computational asymmetry by showing that, if the causal/computational asymmetry is reversed then the epistemic asymmetry will be reversed as well. Thus, let us imagine a case involving a subject whose visual system is seriously injured, and who is fitted with visual prosthetics that reverse the normal computational order. When this subject attends to an object, some kind of complicated laser-involving mechanism measures the object's size (the object feature) and the retina-to-object viewing distance (the perspectival feature) directly; the system then computes (for later needs) the visual angle subtended by the object (which we would ordinarily regard as the perceptual state) from the object and perspectival features. The point of constructing this bizarre case is to have a situation in which it is stipulated that the causal/computational order is backward: here the perceptual state depends on object features rather than *vice versa*. Interestingly, in this odd case, it seems that evidence/warrant about perceptual state dispositions also depends asymmetrically on evidence/warrant about object features. Since this case shows that reversing the causal/computational asymmetry also reverses the epistemic asymmetry, it gives us reason for believing that the epistemic asymmetry to which Schellenberg brings attention is derivative on the underlying computational organization of the perceptual system.[22]

4 Conclusion

The puzzle cases of this paper are interesting and important because they reveal (some of) the different things that perception does. I have argued that the only hope of accounting for the disparate behavior of perception lies in recognizing the perceptual representation of disparate sorts of features and the computational connections that hold between them. Besides allowing for a satisfactory treatment of the puzzle cases, the resulting computational treatment of perception is independently motivated by considerations about the ineluctably perspectival condition in which we find ourselves in the world. Moreover, it makes (testable) predictions about possibly unexpected representational states, and sheds light on the kinds of non-inferential epistemic warrant that underlie at least some of our perceptual states and the resulting perceptually-informed beliefs. For all these reasons, it seems to me that the

[22]That the asymmetry can be reversed in this way also tells against the claim in Hellie (2006) (again, translated into my terms) that the representation of perceptual state dispositions is partly constitutive of the representation of object features.

computational proposal offered here gives us a rich and sophisticated way of thinking about perception.[23]

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