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Seeing Things As We Do: Ecological Psychology And The Normativity Of Visual Perception

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Abstract

In virtue of what is perception successful? In philosophy and psychology, we sometimes assume that visual accuracy amounts to a correspondence between percepts and subject-independent, physical properties. In this dissertation, I argue that we should reject this assumption in favor of norms grounded in the action-guiding nature of perception.

Recent theories of perception purport to cast off the intellectualist baggage of twentieth-century thinking, and to address perception in its own distinctive terms. I show that these approaches are unified in aiming to reduce spatial aspects of the percept to subject-independent geometrical facts about the object-perceiver relation. In doing so, these views remain guilty of an unwarranted assimilation of perception to cognition.

Perceptual constancy, the capacity to encounter a relatively stable world of object properties despite variation in sensory stimulation, is measured using a metric that has percept-physical property correspondence at one extreme, and retinal match at the other. Advocates of the correspondence norm freely redeploy this metric as gauging accuracy in perception, so that the closer a percept comes to invariantly matching the distal property, the closer it comes to veridically presenting the environment.

Yet, correspondence views are committed to widespread misperception that cannot be accounted for in terms of evolutionary complexity. I distinguish between descriptive and normative enterprises in cognitive science, and suggest that we reinterpret the constancy metric as an empirically useful, descriptive quantificational tool—one that does not straightforwardly entail normative facts.

With the correspondence norm undercut, I develop a more viable framework for understanding accuracy, one that draws on James Gibson's ecological theory. Accordingly, accuracy is best understood pragmatically, in ecological terms such as usefulness. Partial constancy is often sufficient for an organism to act effectively in its environment, a result that suggests surprising consequences for what is seen in perception.

In color ontology, there is some theoretical attention to descriptive facts about constancy. However, because of a worry about stipulating perceiver and context standards, theorists continue to reject ecological approaches to color. I resolve the worry by appealing to pluralism about scientific objects. The resulting framework is ecologically sensible, empirically useful, and deeply interdisciplinary.

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SEEING THINGS AS WE DO: ECOLOGICAL PSYCHOLOGY AND THE NORMATIVITY OF VISUAL PERCEPTION

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and for Samantha Stephanie Li

ABSTRACT

SEEING AS WE ARE: ECOLOGICAL PSYCHOLOGY AND THE NORMATIVITY OF VISUAL PERCEPTION

Louise Ellen Daoust

Gary Hatfield

In virtue of what is perception successful? In philosophy and psychology, we sometimes assume that visual accuracy amounts to a correspondence between percepts and subject-independent, physical properties. In this dissertation, I argue that we should reject this assumption in favor of norms grounded in the action-guiding nature of perception.

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INTRODUCTION

I was told once by a professor at Dalhousie University that vision is our dominant sense. We had been reading a Philip Larkin poem, “Aubade.” The professor compared the imagery in the poem to the imagery that Shakespeare uses in the scene following Juliet and Romeo’s night together. The breaking day and the lark as herald of dawn, are like the speaker’s anticipation of curtain-edges growing light in a dark and silent room, a telephone crouching, ready to start ringing. I was immediately fascinated by the idea that vision is so very important, and I went home to my Charles Street studio to test the theory with a blindfold. I imagined I’d run the trial for the weekend, and then arrive in class on Monday freshly acquainted with my special abilities to smell and hear and touch. But instead, I barely lasted the evening. It was harder than I’d thought!

I think the exercise was hard for two reasons. First, vision has an important epistemological status. More than any other sense, visual experience is treated as a bedrock on which the truth of cognitive states can be grounded. My blindfold had blocked my ability to see what was in my environment (when my friend knocked on the window on his way by, I couldn’t tell who it was, and stubbing my toe was a quick lesson to move more slowly). Second, though I intended the exercise to enliven the experience of my other sensory contents, I missed my ordinary visual experiences. Vision, it turned out, dominates the character of my phenomenal world.

In my first semester at Penn, I read Russell and Wilfred Sellars and Descartes, and began to question vision's epistemological status. In what sense, exactly, does vision give us access to the environments we inhabit? How exactly should we think of the interface between perception and our more paradigmatically cognitive states, like beliefs? The more recent work I encountered on the topic argued that cognitive states are conceptual, and that perceptual states are, well, not conceptual. I bought that the two were different, that a distinction can be drawn, but I wanted to know more about how perception puts us in touch with the world. Defining the contents of perception in terms of what they're not seemed to suggest to me that perception is somehow less important than cognition, whereas I thought of perception—perhaps as Larkin's speaker does—as the ultimate problem.[1]

If vision is supposed to ground our more sophisticated epistemic states, then perception must, in some sense, be capable of being *of* the world in the appropriate kind of way. This work is an investigation into this issue of appropriateness, an issue I now think about in terms of the normative standing of perception. What, precisely,

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[1] As Stephen J. Gould and Elisabeth S. Vrba note, "Students of geology are rightly offended that we refer to 5/6 of earth history as Precambrian" (1982, 12).

makes an instance of perceptual experience successful? In the philosophy and psychology of perception, it is often assumed that visual accuracy amounts to a matching or corresponding between percepts and subject-independent, physical, environmental properties. Perceptual size, shape, and color should fully match physically objective size, shape, and color. In the chapters that follow, I argue that we should reject this assumption in favor of a norm that appeals to perception's role in guiding action—an approach inspired by the ecological psychologies of James J. Gibson, Egon Brunswik, and others. I also undermine a long-standing objection in the color literature to ecological approaches to normativity.

At the heart of the project is an interest in how to think about *perceptual constancy*, understood as a capacity of sighted organisms. Imagine you are looking at a blue teapot. The light that's reflected by the teapot's surface projects onto your retinas. The linear size of each projection is miniscule, and shrinks as your distance from the teapot increases. Still, you see the pot as having a relatively constant size, even as your distance from the pot changes. This is a case of size constancy, but perceptual constancy is a more general phenomenon.

Consider, for example, a case of lightness constancy involving the appearance of coal in direct sunlight and the appearance of chalk in shadow. Coal normally absorbs most of the light that hits it irrespective of wavelength, which is why it appears black. Chalk, in contrast, appears white, because it reflects most of the light that hits it. Interestingly, direct sunlight is so intense that, absolutely speaking, coal in sunlight reflects more light than does chalk in shadow. Nevertheless, the coal in direct light looks black, and the chalk in shadow looks white (and this is true whether or not we know anything about coal or chalk). Given enormous variation in the type and amount of energy impinging on our sensory transducers as we move around in our environments, perceptual constancy allows us to encounter a relatively stable, abiding world of object properties.

These examples allow me to articulate what I have in mind when I accept a distinction between non-conceptual and conceptual aspects of perception, or between percepts and concepts. Roughly, percepts present things as being some way as regards size, shape, color and other visible properties, whereas concepts, as applied to perception, classify what is seen into kinds. It is the difference between an experience that presents a certain shape to me visually, and my classification of the shape as a circle or square. According to this distinction, we can see a circle (have the perceptual experience of a circle) independently of classifying it as a circle. As a description of phenomenal perception, constancy concerns how things look spatially and chromatically as opposed to how we classify those things.

Philosophers of mind regularly appeal to perceptual constancy to justify the correspondence norm they favor. In doing so, they rely on a conception of constancy according to which constancy yields invariant percepts of the environment. In *chapter 1*, I undermine this conception of constancy by appealing to the history of experimental psychology. In the nineteenth century, constancy was widely regarded—for instance by physiological opticians such as Ewald Hering—as yielding some, but not full phenomenal stability. Later theorists, such as Brunswik, Robert Thouless, and Alberta Gilinsky, set out to measure the degree to which human perception is constant. The resulting body of work is widely overlooked by recent philosophers of mind. Yet it establishes that humans rarely experience the world under conditions of full constancy.

Notions of invariance did find fertile terrain within the frameworks of some twentieth century thinkers. Kurt Koffka, a leading figure in the Gestalt psychology movement, took perception to involve certain invariants: relations of proportionality hold between aspects of perception within a perceptual scenario, for example, for shape and orientation, and for size and distance (Koffka 1935, 229). Gibson was deeply influenced by Koffka's theorizing on this topic, especially earlier in Gibson's career. Gibson came to develop a related notion of invariance as the central aspect of an expanded understanding of proximal (retinal) stimulation. He regarded invariant aspects of retinal stimulation as that which affords perceivers direct perception of the environment.

Neither of these latter appeals to invariance are quite like the commitment to correspondence as a norm for perception that dominates contemporary philosophy of mind, and each is motivated by idiosyncratic theoretical commitments that theorists working today are quick to rebuff. Nevertheless, these accounts represent important predecessors of the received view. In *chapter 2*, I explore versions of the recent assumption that correspondence is the ultimate norm for vision by concentrating on the issue of spatial perception. Dominant philosophical theories—whether acquaintance or representationalist views—claim to be developing accounts of perception that at long last cast off the intellectualist baggage of twentieth-century thinking about perception, to address perception in terms distinctive to this unique domain. I show that these approaches are unified in their aim to reduce spatial aspects of the percept to subject-independent geometrical facts about the viewing scenario, such as facts about the physical object viewed (e.g. slant) and viewing position (e.g. distance). In aiming for such a reduction, these views remain guilty of an unwarranted assimilation of perception to cognition.

Perceptual constancy is typically measured using a metric that has percept-physical property correspondence at one extreme, and retinal match at the other. Views that endorse the correspondence norm freely redeploy this metric as gauging accuracy in perception, so that, in the case of size constancy, the closer a percept comes to invariantly matching physical size, the closer it comes to presenting the environment veridically. Because perception rarely yields matches between percepts and subject-independent, physical properties, these views should be questioned because they attribute widespread misperception to perceivers in normal circumstances. In *chapter 3,* I explain why evolutionary complexity cannot account for the kind of widespread misrepresentation these views imply. I distinguish between descriptive and normative enterprises in cognitive science to support the analysis, and suggest that we reinterpret the constancy metric as an empirically useful, descriptive quantificational tool—but not one that straightforwardly entails normative facts.

With the correspondence norm undercut, I develop a more viable framework for understanding accuracy in perception, one that draws on central aspects of Gibson's account of visual perception (if not his association between full constancy and accuracy). According to my proposal, accuracy is best understood pragmatically, in ecological terms such as usefulness. For percepts to count as accurate, the relevant subject's environmental constraints, behavioral patterns, needs, and goals must be taken into account. On this view, partial constancy is often sufficient for an organism to act effectively in its environment, a consequence that invites openness to a non-standard range of conceptions of what is seen in perception.

Philosophers working on ontological questions about color have been more sensitive than their peers to the fact that constancy almost never yields a match between percepts and physical, subject-independent properties of objects. But because of a long-standing concern in the literature about standard perceivers and standard viewing conditions, those rejecting the correspondence norm have found themselves at a different extreme. According to the concern about standard perceivers and conditions, in specifying perceiver types or standard viewing conditions (as ecological accounts of normativity must), a theorist attempts to make precise what is inevitably indeterminate. For instance, to discuss how the color vision of normal human trichromats functions in daylight, we must say what counts as a normal human trichromat and what count as "standard" daylight conditions. Ordinarily, we refer to a broad range of illumination conditions as "daylight," and there is considerable variation between individual perceivers within a population, a normal distribution of responses. Any attempt to specify standards will therefore inevitably be *ad hoc* to some degree.

Color metaphysics is a difficult area, but I think we can make progress in understanding color as a scientific object by beginning from normative questions, such as questions about the conditions under which color vision is useful. Taking up the problem of standard conditions and standard perceivers, I draw on the pluralism literature in philosophy of science to argue, in *chapter 4*, against the dramatic response I described above, which abandons useful normative standards for vision altogether. Different areas of cognitive science, from computational neuroscience to ethology and comparative psychology, make use of different models of color. Instead of arguing for a view inspired by any one of these models, I defend a pluralist approach according to which different models of color emphasize different features of the phenomenon. The resulting picture of color is ecologically sensible and empirically useful, providing a secure foundation for interdisciplinary efforts between dynamic, biological, and comparative approaches to color vision, on one hand, and computational paradigms, on the other.

This work would not have been possible without the tremendous support and guidance I received from my advisor, Gary Hatfield. His influence on my life extends well beyond my understanding of and approach to philosophy, and I'm deeply grateful to him for all his help. Elisabeth Camp and Karen Detlefsen provided extensive feedback on multiple drafts, and also served as extraordinary mentors. Many others provided encouragement, discussion, and feedback. Thank you to Kameliya Atanasova, Ben Baker, Eilidh Beaton, Grace Boey, Marie Barnett, Matt Bateman, Justin Bernstein, David Brainard, Shereen Chang, Aditi Chaturvedi, Adam Clayton, Kevin Connolly, Devin Curry, Wiebke Deimling, Alkistis Elliot-Graves, Russell Epstein, Steve Esser, Natalie Feigenbaum, Lindsey Fiorelli, Allauren Forbes, Samuel Freeman,

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CHAPTER 1:

Intermediacy and Invariance: Conceptions of Perceptual Constancy

Abstract. Perceptual constancy—the relative stability with which we experience object and situational properties in our environments—is an elusive concept that is nevertheless at the heart of the scientific and philosophical study of vision. In this chapter, I review how a number of historically significant theorists accounted for constancy, beginning with the rise of experimental psychology in the nineteenth century. Doing so brings out the ambiguity of the concept, as there exist importantly distinct—and allegedly viable—conceptions of constancy. Moreover, tracing the history of the concept helps us to recognize the contingency of the conception that dominates recent discourse in psychology and philosophy of perception, according to which full constancy is taken to be the normative ideal in perception, putting us in a better position to re-assess that conception.

1. Optical and distal values

The empiricist idea that perception grounds or undergirds our more complex epistemic states is a central reason philosophers of mind are interested in perception, and, more specifically (since vision is the dominant sense in humans), in vision. The idea relies on the assumption that perception is, at least in most cases, accurate—that it presents or represents our environments correctly or successfully. There is of course something intuitive about this assumption: we can tell all kinds of things about the world just from looking, and perception seems to sustain and fit relatively seamlessly with our rich cognitive lives.

There is a long history in philosophy of distinguishing between perception and judgment. In a famous passage in the *Meditations*, Descartes describes a difference between what he sees and what he judges as he looks down on a street from a second-floor window. According to Descartes, he judges that there are men in the street, even though, strictly speaking, all he can see from his vantage point are coats and hats (Descartes 1984, 7:32). Others have suggested that there is no real distinction to be made between the contents of perception and the contents of belief or judgment.[2] One aim of the present work is to advance our understanding of the relation between the two types of intentional contents by developing a new narrative about the contents of perception, about the way in which perception gives us veridical access to our environments.

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[2] There is some recent debate about whether we ought to abandon the distinction between what is visual (or perceptual, more generally) and what is cognitive. I believe there are good reasons to endorse the distinction, even if there are also good reasons not to endorse a hard dichotomy. For my purposes, I require merely a distinction between what is visual (potentially including some visual cognition) and cognitive responses to the visual. For a recent defense of perception as distinct from cognition, see Nico Orlandi's (2015). For an example of a dissenting view, see Nicolas Shea's (2014).

Take an object we know nothing about—an unfamiliar object of an irregular shape, at an unknown (but not excessive) distance. Even in such a case, we can usually come at least close to guessing the object's physical size, shape and color just from looking at it. How does this ability to judge the properties of even unfamiliar objects relate to what is seen, to what is distinctively visual? For instance, do I simply see the object's real size? Or do I work from a visual—perhaps even two-dimensional—sensory experience, using reason and memory, to the judged conclusion that the object is of such-and-such a size?

We can begin to gain traction with these questions about the relation between vision and judgment by thinking through our physical relation with our object. In particular, we might consider the physical circumstances under which the energies affecting our sensory transducers change depending on the object's relation to us. Stimulation of our sensory transducers—in the visual case, light interacting with the cones in our retinas—changes dramatically depending on the circumstances in which the object is viewed. For instance, if the unfamiliar object, O, is several feet away, the light it reflects reaches a greater physical area of our retinas than if O moves farther away from us, assuming O does not vary in size. If O is viewed from a football field away, the light it reflects reaches only a tiny area of each retina.

As Euclid teaches us in his *Optics*, there is a lawful relation between (1) *visual angle*—the angle formed between a line running from the eye to the top of a perceived object and a line running from the eye to the bottom of the same object—and (2) the distance to the physical object viewed. Visual angle (and with it, retinal size) varies with the distance of the object viewed in a geometrically lawful way. When a perceiver is 360 feet from object O, the visual angle O subtends at the eye is small compared to the angle it subtends when the perceiver is 20 feet from O. As the space between the perceiver and O increases, the visual angle subtended diminishes at a regular, geometrically lawful rate. For every doubling of the distance, the visual angle subtended is halved.

We can represent this geometrically precise relation using the equation

$$a \propto A / D$$

where a is linear retinal size or visual angle, A is distal size (the physical size of the object viewed), and D is physical viewing distance. As the distance between an object viewed and the perceiver changes, so does the retinal stimulation to which the visual system has access.

Versions of the optical model above can be said to have purchase when it comes to other types of sensory stimulation, too. In the case of shape perception, $a \propto A / D$ captures the relationship between an object's shape (A), slant (D), and retinal projection (a). And in other cases of sensory stimulation, there is at least some sense in which sensory stimulation is a function of distal (A) and contextual (D) values. In the case of color perception, for instance,

$$a = A * D$$

applies to the relationship between the surface spectral reflectance (A); illumination (D); and the *retinal luminance spectrum* (a), that is, the light that falls on the retina. These models track the relation among (1) physical values of object properties, (2) physical conditions such as distance or illumination, and (3) physical values of stimulation at the eye. These relations can all be stated without taking perceptual experience (or any other type of perceptual response) into account. But we are in the end interested in how we respond perceptually to the physical situation. We must then ask: how are optical models of sensory stimulation such as these to be applied to our experiences of objects?

In the history of experimental psychology, there are a number of answers to this question. As we'll see in section 3, and again in section 6, influential views in the 19th and 20th centuries applied these models directly to our visual experiences of object properties—either by identifying the perceived value with a, the retinal value (as in section 3); or by identifying it with A, the distal value of the object seen (as in section 6). The latter discussion serves to illuminate the historical roots of our contemporary association between constancy and invariance.

Other theorists (explored in sections 4 and 5) argued that the relation between perceived values, on one hand, and both distal values and retinal values, on the other, must be more complex. In the final section (7), I'll connect my historical analysis to more recent applications of these models to visual experience. I'll conclude that we ought to be hesitant about the recent consensus in philosophy of mind: that percept values, in most cases, ought to be invariant, and can be identified with or correspond to mind-independent, physical distal values.

2. Perceptual constancy and the problem of underdetermination

To consider accounts of how the optical models of sensory stimulation are to be reconciled with our perceptual experiences of objects, it will be helpful to introduce what is sometimes called the *problem of underdetermination*. The problem of underdetermination arises when we attempt to bring the models of our optical relationship with distal object properties to bear on our perceptual experiences of those properties.

According to the models explored in the last section, two variables are needed to solve for any third, and two separate physical factors determine each retinal value. In the case of spatial perception, sensory stimulation at the retina is a function of distance and distal size. In the case of color vision, the retinal stimulation is a function of distal surface property and illumination. But because our visual systems function on the basis of stimulation that affects us physiologically at the sensory transducers, our visual systems seem to have access to only one variable (a).

Still, at least within certain boundaries, the properties of objects appear to remain relatively stable as our position relative to those objects changes, or as viewing conditions change. For example, the size of an object appears to remain relatively stable as that object recedes from us, even if it is an unfamiliar object, and so even if we don't know, prior to seeing it, what size it is, as in the case of O above. This stability is known generally as *perceptual constancy*: despite changing contextual factors, and so changing proximal stimulation, distal properties appear relatively stable or unchanging.

Therefore, our perceptual experiences of distal properties seem to be underdetermined by optical phenomena. Without knowing an object's size, shape, or color in advance, it's unclear how our visual systems ever have available to them more than proximal values. And yet without knowing a distal property value in advance, it seems that it can only be recovered given values for both proximal stimulation and for the relevant contextual factor, such as distance or illumination.

The problem of underdetermination is long-standing. In *An Essay Towards a New Theory of Vision*, Berkeley discusses a version of the problem in relation to distance perception, noting that different distal stimuli can cause the very same proximal stimulation, thus underdetermining experience of the distal stimulus. Distance information cannot be straightforwardly extracted from retinal projections. For any point on the retina, whether the light projected to that point comes from a short or long distance, the point "remains invariably the same" (Berkeley 1963, sec. 2-3). In fact, each retinal projection is compatible with an infinite number of distal size and shape stimuli (see figure 1.1).[3]

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[3] Of course, this last type of ambiguity runs in the opposite direction as well. For any physical object of a fixed physical form, there is an infinite number of retinal projections for which it can be considered a cause, depending on the relative position of the perceiver.

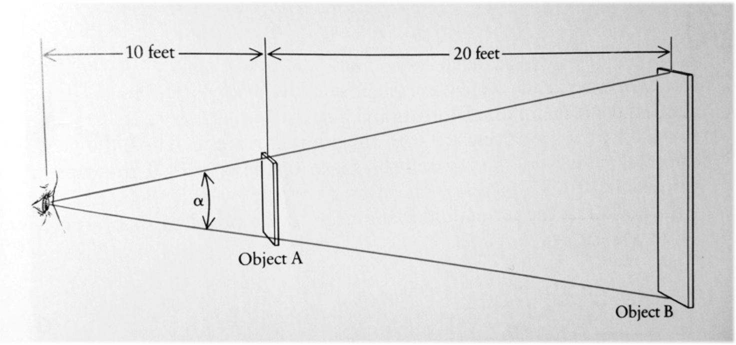

Figure 1.1. From Rock (1985). Visual perception is underdetermined by the proximal stimulus. Objects of different sizes can subtend the same visual angle (the same linear retinal size) if they are located at different distances. Here, the visual angle formed by object A is the same as that formed by object B.

Direction may be recoverable from retinal information, but distance cannot plausibly be recovered in the same way. The retinal information is inherently two-dimensional, and it is far from obvious how objects are thus perceived as relatively constant in size as they recede or approach. In response to Berkeley, one might note that information from accommodation must be available to the visual system—that is, information about the automatic adjustments of the lenses as the eyes focus on the distal stimulus. However, though it is correct that each lens must be accommodated differently for pencils of light arising at different distances, such information is far from metrically precise and is non-existent beyond near distances (beyond 10 ft or so). Information is also available for binocularly sighted animals in which both eyes converge on a single point. But this information is for the point of fixation alone and it also is non-existent beyond the near range. Consequently, the retinal information available to perceptual mechanisms remains highly ambiguous, as Berkeley claims.

Analogous forms of the problem of underdetermination apply to color, lightness, and shape perception. The experience of color, for instance, is dependent on the type and amount of light being reflected into our eyes. The light that falls on the retina (the luminance spectrum) is determined by the surface of the object being perceived (its surface spectral reflectance), but also by the light interacting with the object (the illumination spectrum). If one is looking at a bowl of cherries by the light of a candle, the luminance or light incident at one's eye (a), is jointly determined by two separate distal factors: illumination (D), and reflectance (A). Without independent information about either D or A, the single variable (a) isn't enough to recover a value for A.

Still, the apparent color of the cherries remains roughly stable under a range of relatively natural lighting conditions.[4] That is, you see the cherries as roughly the same purplish-red whether you are looking at them outdoors at a picnic, or indoors in dim artificial light. If the only values available to the visual system conflate illumination and distal surface value, the cherries should look extremely different from one illumination context to the next; but they don't. In this sense, physical stimulation reaching the sensory organs underdetermines the distal stimulus (A), and perception is unaccounted for by the optical models.

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[4] Many throughout the history of psychology have identified color with surface properties. Though I deliberately avoid becoming entangled in debates about the ontology of color here, it is worth noting that I reject the assumption that color can be identified straightforwardly with physical surface values. For positions advocating for this identification, and positions rejecting it, see chapter 4.

Given considerable variation in viewing conditions such as lighting and distance, and so in the type of sensory stimulation available, we are nevertheless able to experience object properties as more stable than their corresponding proximal stimulation. But if sensory stimulation underdetermines the experiential result, sensory stimulation cannot alone be responsible for the stability of our perceptual experiences, and something over and above the optical phenomena must, in some sense, amplify, or disambiguate, the retinal information to which we have access.

The fact that optical values are a function of object property and contextual factor historically has played a major role in attempts to theorize about our perceptual experiences of our environments. Though general models of the relation between optical values, on one hand, and object properties and contextual factors, on the other, may not be able to inform us about the psychological factors in virtue of which we are able to see or judge the properties of objects, they will come in handy as we parse proposed solutions to the problem of underdetermination.

The various proposed solutions implicitly rely on various distinct conceptions of perceptual constancy. Without trying to adjudicate between the different conceptions of constancy to which theorists appeal, I strive to clarify the differences between the distinct conceptions I explore. Doing so brings out the ambiguousness of the concept, as there exist importantly distinct—and allegedly viable—conceptions of constancy. Moreover, tracing the history of the concept helps us to recognize the contingency of the conception that dominates recent discourse in psychology and philosophy of perception, according to which full constancy is identified with accuracy in perception, putting us in a better position to re-assess that conception in the chapters that follow. To better understand how perception grounds our more cognitive mental lives, we must begin by better understanding perception.

3. Perception (cognition) as guiding action

The rise of the academic discipline of psychology in the second half of the nineteenth century brought with it systematic attempts to determine a satisfying solution to the problem of underdetermination. One well-explored answer to the problem has cognitive processes supplementing optical phenomena to yield the percept as we experience it. In fact, the suggestion that our visual experiences are the result of inferential or cognitive processes supplementing unstable sensations is older than the nineteenth century, and can be traced to the 1600s. Following Kepler's discovery early in that century that the lens focuses light on the retina, rendering the retinal image an inverted and reversed projection of the visual scene, it was natural to assume that, in the visual case, retinal images are directly seen in perception, and form the experiential basis upon which judgment can operate (Ross and Plug 1998, 499; see also Meyering

1989). According to prominent early modern empiricist approaches, perceptions are the result of a process of associative learning operating on two-dimensional sensations. According to Berkeley, for example, touch teaches vision: at first, we experience distance tactually and then learn to associate those tactual measurements with the phenomenal appearances of objects, so that the objects come to appear to be at particular distances.[5]

This pairing of (1) an emphasis on a correspondence between retinal stimulation and direct experience, with (2) a central role for learning in perception, was developed in detail by one of the fathers of modern psychology, the physiological optician Herman von Helmholtz. According to this influential nineteenth century formulation, the visual system learns the abstract mathematical relation between proximal stimulation (a), distal stimulus value (A) and the relevant contextual factor (D) in the course of childhood development. It also learns to make certain assumptions about the environment perceived, for instance, about D or A. The assumptions, in combination with the retinal information available (a), are sufficient to enable the visual system to perceive object properties (A) accurately.

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[5] Berkeley thought that other factors, such as texture gradient, occlusion, and convergence, likewise play a role in learned depth perception. (Berkeley 1963, sec. 4-8; see also Locke 1996, 11.ix.8, who's account relies on learning and judgment by habitual custom).

In the case of color perception, for example, an estimate of illumination values (D) is available to the visual system as a result of learning and experience. With at least approximate values for illumination and for the total stimulus information (luminance), the visual system can discount the illumination from the total stimulus information (a) and thus solve for surface spectral reflectance (A).

In spatial perception, the two-dimensional projection to which the visual system has access is interpreted on the basis of unconscious assumptions about distance, yielding a perceptual experience of a three-dimensional environment. Developmentally, we come to be able to interact so successfully with our environments because our visual systems learn which sensations—conceived of by Helmholtz as symbols corresponding to, and effects of, a mind-independent world—typically accompany particular objects at different distances and in different contexts. Our coming to experience a relatively stable world is, correspondingly, a matter of probability calculations: the visual system is thought of as computing which distal interpretation is most probable given retinal information (as using what is sometimes called the "likelihood principle"; see e.g. Hochberg 1968). These likelihoods may involve learned perspective cues, patterns of motion parallax, and optical cues such as accommodation and convergence, in which the ocular muscle information is combined with retinal information to yield an inference of size and distance.

These probability calculations are understood in terms of inference or judgment. Still, as our visual systems become adept at concluding the objective features of objects on the basis of learned assumptions and retinal information, these inferences come to be performed automatically, and go unnoticed in ordinary cases of perception. Indeed, it is difficult to say what of our perceptions is "due directly to sensation, and how much of them, on the other hand, is due to experience and training" (3:10). Phenomenal sensations are determined by and straightforwardly correspond to proximal stimulation, and these provide important constraints on what can be perceived. In experienced perceivers, sensations remain the objects of immediate experience, but for the most part are available to consciousness only by way of trained introspection. Perceptions as we know them involve higher, interpretive processes; in most cases, "reminiscences of previous experiences act in conjunction with present sensation to produce a perceptual image (*Anschauungsbild*) which imposes itself on our faculty of perception with overwhelming power" (3:12). We cannot, under such circumstances, tell what is due to memory, and what is due to immediate perception.

Objects in our environments appear to maintain their properties, on this account, despite radical changes in proximal stimulation, because our visual systems rely on assumptions that permit the inferring of objective properties in a way that effectively guides action. With experience, assumptions become increasingly refined, and the probability that experience will guide action effectively increases; perceivers become more attuned to using the cognitive representations to which they have access. Accordingly, constant perception is the result of cognitive processes operating on sensations; once developed, these processes produce perceptions that enable effective interaction between perceiver and mind-independent world.

Though we cannot compare the mind-independent world and the visual world we experience, since we know the mind-independent world only by way of the perceived world, the conceptions (ideas) which make up the latter can be evaluated in terms of how well they guide action. As Helmholtz writes, the perceptual idea of a particular table "which I carry in my mind is correct and exact, provided I can deduce from it correctly the precise sensations I shall have when my eye and my hand are brought into this or that definite relation with respect to the table" (3:23). Beyond this relation between the idea and the corresponding physical object (the table, in this case), we cannot conceive of percepts as similar to what they represent. The percept is a mere mental sign or symbol of the physical for Helmholtz on the basis of which we construct the corresponding physical environment. Though these symbolic sensations do not provide copies of their corresponding stimuli, they can come, with learning, to have quite exact predictive power for us.

Thus, the "laws of thought" can end up well-suited to the laws of nature, for Helmholtz; a close or exact matching between sensation and the physical property for which it is a sign can emerge. Still, Helmholtz is clear that the laws of thought need not be perfectly predictive—in fact, there are clear trade-offs between exactness and simplicity (or, in Helmholtz's terms, between perfection and convenience), just as there are in the case of languages. More exact systems of representation will also be costlier to learn, for example, and less exact systems will still be enormously useful. Constant perception—which brings the world under a strict law of causation, for Helmholtz—is learned. Exactness in correspondence between sensations and the physical properties for which they stand can be costly to achieve. The most relevant perceptual norm, therefore is set according to what it affords us given our needs and interests as particular types of organisms.

Views that conceive of constant perception as a probabilistic result of the visual system solving an inverse problem have clear roots in the Helmholtzian tradition. Julian Hochberg (1968), for example, who explicitly refers to his view as "neo-Helmholtzian," argues that we "perceive the most likely objects or events that would fit the sensory pattern that we are trying to interpret" (89). Irvin Rock (1983) downplays the role of learned knowledge and learned contextual factors in perception; still, perception uses the available information to rationally interpret the environmental surround using inference-like processes. For instance, it tends to explain coincidence by inferring a common cause.

More generally, the notion of unconscious inference in perception is making an impressive comeback in contemporary cognitive science, in the form of Bayesian approaches to perception, which appeal to sub-personal inferential processes to explain percepts in terms of probability calculations (Seth 2017). Correspondingly, core elements of the view continue to turn up in contemporary philosophy of perception (e.g. see Searle 2015, in which Searle defends the idea that, in a basic sense, we see two-dimensional sensations). Interestingly, it is the inferential and learning aspects, but not the normative aspects of Helmholtz's view, that survive.

4. A distinctively perceptual contribution

In the early 19th and 20th centuries, important critiques were advanced against the more cognitivist accounts of Helmholtz and his followers. Helmholtz's contemporary, Ewald Hering, worried that Helmholtz over-intellectualized perception by conceiving of all factors other than retinal stimulation in cognitive terms. Hering accused Helmholtz of moving in a "fruitless circle" with regard to perceptual stability. He argued that the experience from which Helmholtz derives the assumptions which are meant to lead to stable perception are themselves impossible without some degree of stability in perception.[6]

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[6] (Hering 1964, 21). For an overview of the extended controversy between Helmholtz and Hering, see (Turner 1994). For a modern formulation of Hering's critique, see (Leeuwenberg 1988). More recently,

Though Hering agreed with Helmholtz in certain respects, Hering's criticisms were tied to a competing conception of stable experience, one involving the contributions of distinctively perceptual mechanisms. Hering agreed that some cognitive elements aid in the attainment of full constancy in human perception. For example, Hering believed that we come to have cognitive memories of particular colors belonging to particular objects or types of objects. Retinal stimulation is the primary causal determinant of which colors are experienced, for Hering, but experience leads to the percept being affected by "the reproductions of earlier experiences aroused by all sorts of attending circumstances, and these secondary and to some extent accidental factors help to determine what is seen at a given moment" (Hering 1964, 6-7; see also Katz 1911). Snow looks white, even if we are viewing it in shadow, because we have come to associate whiteness with the idea of snow. For Hering, this "memory color" of an object can have a significant impact on how we see it.

Unlike Helmholtz, however, Hering pointed to a more substantive role for non-cognitive, non-retinal factors in the generation of percepts. What Hering refers to as "approximate" color constancy—the fact that "color changes in the visual field are kept

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Bayesianism has come under fire for a related set of issues. As Stephen Palmer (1999) notes, Bayesianism "implies a finite set of possible 3-D scenes and a finite set of possible patterns of sensory evidence. Neither assumption is easily justified in the case of an active observer exploring natural environments, for both sets seem to be quite open ended" (57). See also (Orlandi 2014).

within much narrower limits than those established by the intensity changes in illumination"—is conceived of as the result of physiological mechanisms, such as contraction and dilation of the pupil in relation to the amount of light available. Because the pupil contracts when illumination increases and dilates when it decreases, the luminance measured at the retina will remain more stable than does the changing illumination of the scene. More importantly, the visual system can adapt in sensitivity to illuminations of different intensities (Hering 1964, 18-20). Though cognitive factors such as memory color can affect how we perceive the surfaces of objects, this is only possible because of basic physiological factors which are independently responsible for considerable stability in perception.

In the spatial case, peripheral factors such as accommodation and disparity help to yield a percept that is more stable than the corresponding retinal projection. For instance, sensations arising from accommodation mediate the experience of depth in monocular vision. In binocular vision, the disparity between retinal images gives rise to a direct experience of depth (for discussion, see Baird 1903, 12). Moreover, stability in distal size is assisted by the disparity between retinal images. So, for Hering, the achievement of stability in perception is primarily the result of the supplementation of retinal information by perceptual-physiological factors, though cognitive factors also contribute in an important respect.[7]

If we think of perceptual values as falling somewhere on the scale between retinal values (which fluctuate with changes in perceptual context) and physical object property values (which are, in standard cases, stable or fixed), then given changing contextual factors, perceptual values will be less in flux than are their retinal counterparts, but more in flux than the objective values of real objects. In what follows, I use the term "intermediacy" to refer to this property of falling in value between proximal sensory values and distal physical values. The perceptual stability defended by Hering as occurring independently of cognition is conceived of as being of values intermediate between retinal and objective values.

The suggestion that perception, independently of cognitive factors, presents object properties in a way that can be characterized as involving stability that is not present in

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[7] In (Cohen 2015), Katz's discovery that color constancy effects can hold irrespective of cognitive contributions is listed as evidence against Hering's conception of memory color, partly because Hering and Helmholtz are both cited as holding that constancy is the result of cognition. It should be clear from the above discussion why I take Katz's finding to be, in at least certain key respects, in agreement with Hering's proposal. Hering, for example, did not take memory (or cognitive knowledge about objects) to be "necessary" (11) for color constancy, even if he emphasized that cognition could amplify the amount of stability experienced. Similarly, Hurvich's (1981) point that memory color could not plausibly be specific enough to account for phenomenal stability in color experience is not in tension with the core claims of Hering's proposal. In fact, Hurvich is responsible (together with Jameson) for developing and translating Hering's work.

the corresponding retinal stimulations, predates Hering. According to Edwin Boring, even Euclid, who had no stake in which types of physiological mechanisms make possible the perception of objects, acknowledged that two identical objects at different distances look closer in size than their projected retinal images are in size (an observation Boring refers to as an ancient instance of "phenomenological insight" (Boring 1942, 290); but see (Lindberg 1976, 13), where Lindberg explains why this is likely to be a later interpolation). In the very least, recognition of a psychological distinction between the visual perception of object size and the discrimination of visual angle appears in Ptolomy's work (see Hatfield and Epstein 1979, esp. 366).

Later, Leonardo Da Vinci was interested in studying binocular effects on the percept; and Descartes, to whom we often mistakenly attribute a homunculus view, is better understood as interested in experience as the result of a psychophysical process. Accordingly, proximal stimulation and psychophysical laws together yield a distinctively perceptual result in which perceived size is close to (or sometimes matches) object size, through the mediation of accommodation, convergence, and other sources of information for perceived distance (Hatfield 1992b; 2015). As Descartes writes in his *Optics*, "the images imprinted by objects very close to us are a hundred times bigger than those imprinted by objects ten times farther away, and yet they do not make us see the objects a hundred times larger; instead they make the objects look almost the same size, at least if their distance does not deceive us" (Descartes 1984, 6:140).

Hering's account of constancy was eventually critiqued on grounds of phenomenological plausibility. For instance, some of his contemporaries worried that Hering over-emphasized the results of pupillary function and retinal adaptation in color constancy. In most cases, as illumination changes, we remain able to detect those changes. However, it's unclear how we would be able to report fairly accurately on changes in illumination if our visual system were automatically adapting to the new conditions. Moreover, as David Katz (1935, 264) noted, being able to detect changes in contextual factors is useful.

Still, Hering's emphasis on the idea that non-cognitive factors can be responsible for some stability in perception, despite more dramatically changing retinal stimulation, was enormously influential on the perceptual psychology that followed. It proved vital in inspiring the theories of the Gestalt psychologists and James J. Gibson, among others. However, Hering's proposal that intermediacy is typically a feature of perceptual constancy (and the criticism that Hering himself over-estimates the degree to which humans experience visual stability), has received insufficient attention. As I aim to make clear in what follows, we do well to endorse intermediacy as a feature of perceptual constancy.

5. Describing the perceptual capacity

Hering advocated early on for the involvement of peripheral factors, such as accommodation and adaptation, in the achievement of perceptual stability, but the first psychophysical experiments investigating the stability of percepts were carried out in 1889 by followers of Helmholtz (Boring 1942, 294). Under the direction of Wilhelm Wundt, in an early example of what is now a standard experimental matching paradigm, Götz Martius suspended a wooden rod 50 cm from an observer. Martius asked participants to choose one of several rods at a distance of 300 cm, and again at 575 cm, as being of the same physical length as the suspended rod at 50 cm.

Observers were able in almost all cases to select rods of a length equal to the rod at 50 cm. Because the experiment made use of rods of lengths unknown to the subjects, and because the experimental design deliberately involved a paucity of distance cues, subjects were assumed unable to choose matches on the basis of knowledge. The results thus solidified the falsity of the Euclidian equation of perceived size with visual angle, and allowed a distinction between responses based simply on how the rods appeared and responses based on known size or other more cognitive inputs (Martius 1889; Woodworth and Schlosberg 1954, 471).

A number of studies relying on similar methods. Early in the 20th century, under the direction of Hering, Franz Hillebrand (1902) experimentally investigated the "alley" or "vista" problem, a phenomenon exemplified by the fact that train tracks appear to converge at a distance.[8] Instead of seeing the tracks (or parallel rows of trees, walls of an alley, etc.) as running parallel into the distance, we seem to see the lines converging as they approach the horizon. Considering what is projected onto the retina in this case, it can seem that the apparent convergence makes sense—there is convergence between the lines projected onto the retinae as well. This latter convergence can be explained using simple geometry. The further objects are from a perceiver, the smaller the area of the retina onto which they project.

However, appeals to retinal projections do not adequately account for how the tracks look. The apparent convergence will be much less severe than the convergence occurring in the corresponding retinal projection. This is because the apparent convergence occurs in depth, whereas the corresponding retinal projection occurs in a two dimensional plane. To study the way parallels running away from a perceiver look, Hillebrand seated an observer at the end of a table four meters long and one wide,

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[8] The vista problem was studied long before the twentieth century. Leonardo da Vinci, for instance, noted that the courses of horses running away from a perceiver on parallel tracks will appear to converge the further they get from the perceiver (Da Vinci 1956, Vol. 1, 113; see also Porterfield 1759, 381-4). As Boring (1942, 290) notes, "If the eighteenth century had had railroads, the fact that apparent size follows neither a law of constancy nor of visual angle would have been even more apparent to its scientists." See also (Ross and Plug 1998).

covered by white paper, and with an axis marked down the middle of the length of the table. Two black threads, attached to the far end of the table, were held at the opposite end by the observer, who then adjusted these to make the lines look parallel, with each other and with the axis running the length of the table. For the appearance of parallel lines, Hillebrand found that, to counteract the fact that parallel lines appear to converge at a distance, subjects adjusted the lines so that they diverged (see figure 1.2).

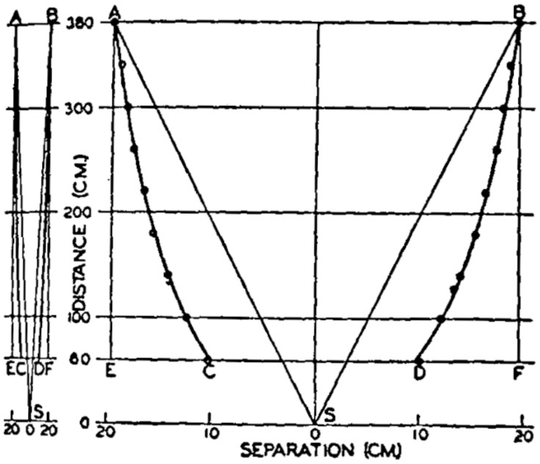

Figure 1.2. Originally from (Hillebrand 1902); taken from (Woodworth 1938).

In order to control for the fact that the threads built in to the experiment the assumption that the correct appearance will involve straight lines, the experiment was repeated with threads suspended from a ceiling at regular intervals in two rows, to form a kind of alley. The observer was required to adjust the threads until they appeared to form parallel rows stretching away from her (Boring, 1942, 294-5). The result was two rows which are slightly curved, and which lie between where they would if they tracked (1) visual angle, varying directly in relation to distance, and (2) a constant separation (parallel rows). The findings thus confirmed Hering's contention that visual appearances may be located somewhere on the spectrum of values between the retinal stimulus value, and the distal stimulus value (Hillebrand 1902; Poppelreuter 1911).

A clear description of the relation between percepts and their corresponding distal stimuli, however, was not yet available. In the early 1930s, a number of psychologists were interested in expanding on the work of Hering, Katz, Hillebrand, and others, by measuring the degree to which human perceivers experience constantly. Without doubting that a wide range of perceptual constancy experiments confirm that subjects can report objective features—for example, that subjects seeing a plate from an angle are able to judge that the plate is round despite retinal projections that are elliptical—these psychologists were interested in particular in what is seen independently of cognitive factors.

For instance, in his experiments investigating perceptual responses for shape at a slant, Robert Thouless strove to isolate a quantifiable measure of the seen aspect by manipulating the traditional instructions given to subjects, and by introducing novel features into the experimental design. In one set of trials, participants were shown a round figure at a slant and asked to identify the shape they saw by choosing from among a range of matching figures.[9] Participants viewed each circle with binocular vision under normal lighting conditions, so it was possible to assume they also knew the real size and shape of each test object. Subjects nevertheless chose “without hesitation” an ellipse which is intermediate (or, as Thouless put it, a “compromise”) between (1) the ellipse which would be selected were the report based solely on the laws of perspective—that is, the ellipse which best matches the retinal projection; and (2) the ellipse the subject would pick were the subject selecting on the basis of real shape (in this case, a circle). Moreover, it was found that, as the degree of slant increases, shape constancy is reduced (Thouless 1931; see also Massaro 1973). That is, as the degree of slant was increased, subjects selected objects further from the circle.

To control for the possibility that participants revert to square or circular shapes in reporting their phenomenal experiences, the experiments were repeated using ellipses, rather than circles. Thouless was concerned that subjects, despite accessing sensory or perceptual values, were then offering reports unintentionally biased towards the known values. Additional trials were therefore conducted using appearance values that tend away from the circular form, rather than in the direction of that form. For example, Thouless used an ellipse with its long axis pointing away from the subject,

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[9] Initially, subjects were asked to draw the shape they saw. This method was abandoned for the matching method because of the significant effect training in drawing can have on the performance of subjects. Drawers experienced with representing in perspective were shown to be more likely to draw something closer to the retinal stimulus shape. (Thouless 1931, 343).

and gave it a tilt such that the stimulus projection of the ellipse from the point of view of the subject was very near circular. On this basis, Thouless concluded that it is the physical shape of the object (in the latter case the ellipse) that determines the “distortion” away from the perspective projection, and that the effect must consequently have little to do with a subject’s tendency to revert to known shapes (Thouless, 1931a; for discussion, see also Hatfield 2014). Analogous studies varied illumination and measured the phenomenal aspects involved in brightness and color constancy.

Interest in the degree to which human visual perception is constant endured through the middle of the century. In an attempt to quantify the perception of size at a distance, Alberta Gilinsky had subjects stand at the end of an archery range and direct the experimenter to mark off successive distances from the subject such that each appeared to be one foot. The distances identified as feet decreased in size as the experimenter drew further from the subject. This finding suggested to Gilinksy that neither a theory equating apparent and retinal size, nor a theory equating apparent and real size, could be correct. She argued, instead, that visual space cannot be equated with physical space; nor can it be understood as a two-dimensional, “proportional replica of objective space in three dimensions. One is a distorted transformation of the other” (Gilinsky 1951, 461).

A major consequence of this upswing in empirical work investigating the possibility of a descriptive account of the constancy involved in human visual experience was the establishment of standard indexes for experimental measures of constancy. Both Thouless and Egon Brunswik developed formulas allowing for the systemized expression of experimental constancy results, on a scale of 1 to 0. On Brunswik's formulation, for example, the constancy ratio is a quantification of the degree to which the appearance departs from proximal stimulation, relative to the difference between the proximal stimulation and the physical value being matched. The Brunswik ratio can be expressed by the equation

$$Br = (R-a) / (A-a)$$

where R is the physical value of a selected match stimulus (the subject's response), a is the physical value for a stimulus match with no constancy, and A is the physical value for a stimulus match of full constancy. Unity (complete constancy) is the result if the subject's response matches A; it is zero (no constancy) if the subject's response matches a. In most experimental contexts, of course, the reported value is intermediate between the proximal and distal values. The Br thus provides, on a scale of 1 to 0, an index of the proportion of the distance from a to A that is represented by the value reported (R).

The Thouless ratio

$$Tr = (\log R - \log a) / (\log A - \log a)$$

was introduced in order to overcome certain problems facing Brunswik's earlier proposal, such as the fact that the results of Brunswik's ratio depend significantly on which object is taken as the comparison and which as the standard (see Myers 1980 for an overview and comparison of the two ratios; the reference is from Sedgwick 1986). However, the ratios share their output of a value of 1 for a match between the comparison and the physical object value, and 0 for a match between the comparison and the corresponding retinal projection. Under conditions of an exact match between appearance and object property, constancy will be full.

The formulas allow for comparison across experimental contexts, and were intended to help us identify systematic patterns in perceptual constancy across human and other types of subjects. Given a standard index against which constancy results can be interpreted, it is possible to compare results from experiments using distinct variables, for instance, results from size constancy and shape constancy experiments. It likewise allows us to compare different values within a single experimental context—e.g. to compare performances in a task by distinct human trichromats.

Inspired by successes in measuring and mathematically describing human perceptual constancies, Thouless proposed a general "law of compromise," which was meant as a descriptive refinement of the models of physical relations, $a \propto A/D$ and $a = A^*D$, as they apply to human experience. Appearances typically will be of a value that is a compromise between stimulus value and physical distal value. This tendency of appearances to fall between these extremes was characterized by Thouless as involving a "phenomenal regression" or "phenomenal regression to the 'real' object."[10] In the spatial case, as the distance between the perceiver and the perceived object decreases, phenomenal regression towards real (physical) size increases. At close range, apparent size approaches real size, but is still a compromise (intermediate) between retinal and objective values. In contrast, at astronomical distances, the apparent size of an object will be roughly equivalent to the size of its retinal projection.

Thouless' proposal, that compromise typically characterizes human perception in the above way, is but one attempt to characterize the fact that experimental evidence points to systematic discrepancies between the physical environment and the way it appears. Though experimental methods seem to make possible a rich description of perceptual constancy in humans, and so a precise articulation of our perceptual relation with the world, disagreements persist about how exactly to interpret the

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[10] See (Thouless 1931, especially 343; and Thouless 1932). Out of respect for the fact that Thouless was an early advocate of compromise as a feature of appearances (what I am calling "intermediacy"), Christopher Hill and David Bennett, go so far as to label phenomenal properties "Thouless properties" on the appearance theory they elaborate. Appearance properties, they write, are "Thouless properties of ordinary physical objects" (Hill and Bennett 2008, 309).

growing body of data, and, more generally, about how a descriptive account of perceptual constancy ought to be outlined. This is in part because of complications surrounding the specification and wording or alternative manifestation of instructions in constancy experiments, complications that are responsible for considerable debate (see, e.g. Hanneman 1935; Joynson 1949, 1958a, b; Gilinsky 1955; Carlson 1977; Radonjić and Brainard 2016).

A major assumption behind much of the work reviewed in this section is that manipulation of instructions can affect the attitude brought to bear by a subject in reporting on their experiences. The relevant if somewhat controversial belief is that experimenters can isolate a report of what is distinctively perceived, as opposed to what is known about the object viewed. Brunswik, for one, distinguished between "naïve realistic" and "analytic" perceptual attitudes, each of which can result from particular types of instructions. In the former case, participants are asked to judge, for example, shape without making a special effort to think about the real shape of the object or its projective size (Stavrianos 1945, 16). To achieve an analytic attitude, subjects are instructed to think of their experiences as collapsed into two dimensions.

There are mathematically expressible, discoverable facts about how values relate to proximal values, but it is much harder to operationally isolate reports for perceived values. There are difficulties involved in clearly defining appearance. Consequently, individuals may interpret unintentionally ambiguous instructions differently, and there is a risk that subjects will be operating under different assumptions. For instance, without care, a subject may interpret a task requiring a report of "apparent" value as requiring that they report proximal value or physical value. Or one subject may assume that apparent values can be equivalent to objective values, where another may assume that she must offer different responses for these two values (Carlson, 1977, 239).

Moreover, attitudinal influences can affect more than simply the results of an experiment; they can affect variables internal to the experiment itself (Epstein 1977, 441). Epstein and Brooda (1975), measured reaction times under different conditions, and found that there was considerable interaction between viewing distance and instructions given. When given objective instructions, reaction times of participants increased proportionally with distance. When asked to report apparent size, reaction times remained constant (with a zero slope) and independent of changes in distance. Reactions were also faster under the latter conditions. These results support the possibility that, under objective instructions, subjects make a deliberate judgment, a process which takes longer than does responding to apparent instructions. Correspondingly, in the apparent condition, subjects may be simply responding to appearances without undertaking a further act of deliberation. Evidently, instructions must be employed with care if they are to successfully pick out appearances across experimental conditions.

Despite impressive complications surrounding the possibility of an uncontroversial descriptive model of human visual perception, a number of particular proposals are defended in the literature. Specific models of the structure of visual space, for instance, are defended in (Luneberg 1947), (Koenderink et al. 2000), (Hatfield 2003b), (Todd 2004), and (Erkelens 2015). Others (e.g. Leibowitz and Harvey 1969) would deny that any single function could be sufficient to capture the relation between visual space and physical space; instead, a family of functions must be posited, one with variables sensitive to whether a test object is familiar to the subject, the relevant environment factors, the array of depth cues available, and instructions, among other factors.

There is considerable evidence suggesting that our visual experiences come apart in key respects from our physical environments, and that intermediacy is a characteristic of most of our visual experiences. Yet, consensus about how best to model our visual world remains forthcoming. Recognizing visual experience as complicated in this way can help us account for why it often seems important to talk about how things look, as opposed to how we know or believe things to be. It also reinforces a distinction between phenomenality and at least a range of cognitive factors, and highlights phenomenality as something deserving of further empirical and philosophical investigation in its own right.

The perceptual constancies now occupy a cardinal role in a number of leading philosophical theories of visual perception. For the most part, these theories rely on a particular conception of perceptual constancy distinct from those already discussed. It is to the emergence of this latter conception that I now turn. In the final section, I examine why a carefully formulated notion of constancy turns out to be more important to understanding perception in humans and across species than has been properly acknowledged.

6. Perceptual constancy and invariance

The stability with which we perceive object properties was first labeled "constancy" by the Gestalt psychologists. The concept was of use to the Gestaltists because they strove to develop an alternative to the structuralisms of Wilhelm Wundt and his student Edward Titchener. Structuralism was, in many ways, an attempt to formulate a psychological theory that captured the core commitments of modern empiricist thought about the mind. Experience, according to structuralism, can be analyzed into basic, two-dimensional sensations or "feelings," which, through a process of association or combination, come to yield our rich, often three-dimensional perceptual experiences. Over time, even if the impressions are incomplete or inconsistently combined, we come to be able to construct the perceptual whole from the sensations and feelings we do experience (see e.g. Wundt 1912, 80). In the case of visual perception, these primary, basic elements correspond to retinal stimulation.

The Gestaltists adamantly denied that such physical stimulation can, even permitting a role for learning, determine a corresponding percept. Instead, they argued that the whole percept, rather than its parts, is the phenomenon of fundamental interest, and largely the product of unlearned perceptual processes (Koffka 1935, 97). Their argument against structuralism was based on the supposition that we can never adequately account for the experienced structure of the whole by way of mere analysis of that whole's corresponding sensory parts. More specifically, it relied on the phenomenal fact of perceptual constancy:

> It happens again and again that different stimuli produce the same reaction… two surfaces may both look black, although one may reflect a thousand times as much light as the other…or expressed in terms of behavior: two stimuli as different as those which we have just mentioned may lead to the same behaviour, for instance, if the task is to pick up a black object. To account in terms of stimulus response for this uniformity of behaviour in the face of tremendous diversity of stimulation is impossible, particularly if one

> remembers that under other conditions a difference in stimulation of only 2% will lead to different behaviour. (Koffka 1935, 34)

Instead of trying to analyze perception, with the structuralists, in terms of the pure sensations of introspection, the Gestaltists took the constancies as their principal data. In the above example, one of the black-looking surfaces in question, say, a piece of coal, is viewed in a context of significantly greater illumination than another, say, piece of coal. Yet, Koffka remarks, each continues to look black. Because our visual experiences of object properties are relatively stable across contexts, and because proximal stimulation changes with changes in context, the two experiences of coal cannot be conceived of as straightforwardly corresponding to their respective proximal stimulation. Consequently, denial that experienced organization in visual perception is determined by retinal stimulation persisted as a core aspect of the Gestalt research program: retinal stimulation does not bear a one-to-one correspondence with the global visual experience.[11]

A related aspect of the Gestaltist program stressed that we need not appeal to cognitive factors to explain phenomenal experience, as Helmholtz supposed. As I noted in

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[11] Oddly, the idea of a one-to-one correspondence between percept and proximal stimulation was referred to by the Gestaltists (and others after them) as the "constancy hypothesis." To avoid the natural confusion that can result from this unfortunate choice of term, I refer to the latter idea simply in terms of one-to-one correspondence.

sections 4 and 5, a tradition going back to Hering advocated for a role for perceptual factors in understanding the vast difference between proximal values and the phenomenal appearances of a corresponding object's properties. By the time the Gestalt program took hold in the early twentieth century, a significant body of evidence affirmed the possibility that constancy is at least largely a distinctively perceptual phenomenon, and the Gestaltists became early champions of this thesis.

The Helmholtzian tradition characterized learning as a wholly cognitive phenomenon, so Koffka's claim that constancy is distinctively perceptual appealed to evidence of innateness. If the ability to report that the object recedes, remaining constant in size, is a learned ability, then the assumption "must be that originally any diminution of the retinal image would produce a shrinkage of the seen object and that experience can only teach the organism that an object that seems to grow smaller need not really be shrinking." This assumption, however, is in tension with experimental evidence that very young animals, such as human infants, experience size constantly.[12] Developmental evidence explained the fact that, instead of producing an apparent shrinking of the object perceived, a diminution of an object's retinal projection will

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[12] Koffka (1935, 88) cites (Frank 1926); see also (Rapoport 1967). For more recent evidence of size and shape constancy in infants, see (Granrud 1987); (Slater et al. 1990). On color constancy in non-human animals, see (Neumeyer 1998); (Chittka 2014).

typically, "arouse the perception of its recession with conservation of its apparent size" (Koffka 1935, 88).

The claim was further bolstered by appeal to evidence that animals "who have no great intelligence," such as chimpanzees (Köhler 1915) and three month old chicks (Götz 1926), respond to size constantly:

> Chicks must be geniuses if they can discover in the first three months of their lives that something that looks smaller is really bigger. Since we do not believe that they are endowed with such miraculous gifts we must conclude that they select the bigger because it looks bigger, even when…, within wide but definite limits, its retinal image is smaller. (Koffka 1935, 89)

If perceptual constancy can be identified in beings with little or no cognitive abilities, and in infants with almost no chance yet to learn, then we have reason to think it is an innate, and distinctively perceptual, process.

To defend their claim that perceptual constancy is a distinctively perceptual process, however, the Gestaltists needed offer some account of how perceivers overcome the problem of underdetermination. Retinal values alone cannot be responsible for the disambiguation of perceptual experience, but cognition nevertheless remains unnecessary. To avoid appealing to cognitive processes to explain determination of the percept, the Gestaltists posited a set of innate, psychological forces that operate on proximal stimulation. Perceptual constancy is the result of these ordering forces or laws, and we need make no appeal to learning or cognition in accounting for it. Distinctively non-cognitive, perceptual forces, on this view, resolve retinal stimulation into whole percepts.

Gibson agreed with the Gestaltists that the perceptual constancies provide decisive ground for rejecting structuralism. It may seem like we need to appeal to cognition in explaining our ability to see an object's properties constantly, but Gibson found it questionable whether it is "necessary to call upon so intellectual a process to explain this particular kind of perception" (Gibson 1950, 169). Drawing on laboratory studies that aimed to bracket cognitive influences, such as those reviewed in section 5, above, Gibson affirmed that "we do not have to be familiar with an object in order to see the same shape at different angles of view. Knowledge and past experience of the object in question are not essential for constancy. The constancy of its dimensions must depend, instead, on our ability to see it in three dimensions" (171). Because we see objects in three dimensions, we see slant or tilt of the object's surface, for instance, and this allows us to see the object's shape constantly.

In contrast with both structuralist and Gestaltist approaches, however, Gibson advocated that we consider the structure of the perceiving organism's environment or ecology in trying to understand perception. In doing so, Gibson embraced the correspondence between percept and proximal stimulation that the Gestaltists were keen to deny. He did so by appealing to an expanded understanding of stimulation. For Gibson, the fact of incessant sensory variation pointed not to a need for supplementation, as theorists before him had assumed, but to the existence of sensory factors that remain stable across changes in perceptual context. Gibson called these invariant factors higher-order invariants, because they operate at the global level, the level of the percept taken as a whole and over time. The invariant, higher order properties of sensory stimulation control the perceptual result sufficiently to render that result constant despite variant factors, so that invariance of apparent properties occurs in virtue of higher-order invariant sensory information.

It is in virtue of these sensory invariances that we can consider the proximal stimulus as a correlate of not only the percept, but also the physical environment of the organism, according to Gibson. Apparent invariances directly correspond to fixed or stable environmental invariances. For example, if we are standing on a gravel road, the retinal projection corresponding to the gravel on the road becomes increasingly dense as proximity decreases (see figure 1.3). This regular increase in density, captured by the retinal image, corresponds to real distance, and also to the visual experience of distance. Thus, the naturally textured ground facilitates a direct visual experience of the road extending away from the perceiver in space. Because the gradient of density is itself available in the sensory pattern caused by the naturally textured ground, the straightforward correspondence between the physical gradient in the road, and the visual experience of the road at a distance is unproblematic (Gibson 1950, 61; 1979, 160).

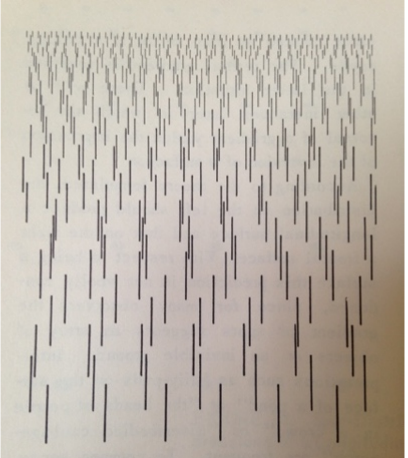

FIGURE 34. A Gradient of Textural Elements which Project Upward from the Surface

Figure 1.3. From (Gibson 1950).

At the heart of this insight is the observation that the proximal-distal relationship is unique in almost all cases. An isolated piece of the environment and its isolated proximal counterpart may be ambiguously related (as in figure 1.1, above), and seem to lead us to the problem of underdetermination. But, as Gibson explains shows us, aspects of the dynamic interplay between the whole scene perceived and the total proximal stimulation it causes will remain constant. This is because, for Gibson, the information required for constant perception is simply available in sensory form.

This account of the particularity of the relation between proximal and distal stimuli was patently novel. As one commentator puts it, it "represents a daring break with a centuries-old assumption [that sensory stimulation underdetermines perceptual experience] and makes it possible for Gibson to offer a stimulation-based theory of veridicality" (Epstein 1977, 4). Interestingly, Gibson arrives at this insight by way of the fact of perceptual constancy: perception is constant so some stimulus properties must be invariant. That is, the very fact that we experience the world as stable around us indicates that somehow the sensory information must be itself responsible for that invariance. For Gibson, constancy is understood as involving the invariance of apparent properties, but here this is because of rather than despite changes in sensory stimulation.

Despite foundational differences between Gestalt psychology and Gibson's ecological approach, the frameworks have much in common. Both emphasize percepts as phenomenally accessible and interpretable; and both are rooted in questions about the whole percept, rather than its parts, or their proximal counterparts. The sum of the parts can never, for either psychological framework, account for the significance of the whole, a commitment which was tied, especially for Gibson, to a new theoretical emphasis on the temporality of perception. In most cases, temporality is essential to the significance of a percept; and consideration of temporally isolated percepts will lead to a failure to appreciate the higher order invariant factors which are responsible for eliminating the ambiguities supposed to sustain the problem of underdetermination.

For my purposes, their understandings of perceptual constancy represent some of their most important common ground. On either approach, the phenomenal stability enjoyed by perceivers results from distinctively perceptual factors. But more substantively, at least for my purposes, both are critical of the conception of constancy implied by the ratios of Thouless or Brunswik. Koffka dislikes, in particular, that the ratios cannot account for the range of ways in which psychological forces impact constancy. As he explains, an ellipse looks like a circle under certain conditions. This is because the psychological ordering forces make our perceptions tend towards organization. A circle is a more stable form than an ellipse, so under many conditions, we see an ellipse as circular. Because the ratios make no reference to psychological ordering forces, they do not capture such patterns in the variability of appearances.

Crucially, for Koffka, appearances tend towards order even if this involves a percept going beyond what, according to the ratios, counts as full or perfect constancy—a match between percept and object property viewed. The metrics provided by Thouless and Brunswik thus assume a false "range of possible constancies" (Koffka 1935, 226), and so fail to capture the full range of constancy effects.

Moreover, the Thouless and Brunswik ratios are purported to be of value in experimental work because they provide a clearly delimited range of possibilities against which results can be compared within and across modalities, with each "having its own range defined in the same way" (227). The fact of even occasional "over constancy," however, undermines the advantage conferred by such a well-defined range. The ratios are biased in the sense that they privilege values intermediate between distal stimulus values and proximal stimulus values. The aptness of the range itself becomes a function of the findings. Though the comparison of values for brightness constancy with those for size constancy, for instance, might appear fruitful in light of the well-defined ranges of the ratios, it requires some further theoretical motivation.

Gibson follows Koffka in thinking that the percept cannot adequately be measured using the ratios proposed by Thouless and Brunswik, according to which percepts are typically modeled as of a value intermediate between proximal value and distal property value. But, in Gibson's case, this is because the suggestion that constancy is a perceptual achievement, measured in degrees by the indexes, implies that perception involves the *correction* of sensory stimulation. Because constant experience is the direct result of sensory stimulation, for Gibson, yielding a direct experience of physical, environmental properties, the perceptual relation between organism and environment leaves no room for the idea of a correcting of proximal stimulus. Thus, in defending constant perception as possible independent of cognitive factors, Gibson is happy to draw on the burgeoning body of work attempting to measure the degree to which humans perceive the world constantly. But he firmly rejects its suggestion that intermediacy is a feature of ordinary perception:

> Perceptual space as we get it under optimal conditions—with constancy of size and shape—is so plainly and simply the space from which Euclid abstracted his geometry, and this conception is so illuminating for all the constancy experiments which yield 100 per cent constancy, that to deny it for the sake of the alley experiments seems unjustified. (Gibson 1950, 190)

He prefers to conceive of fully constancy perception as resulting, along the lines sketched by Koffka, from aspects of the percept invariantly coupled together. For Gibson, these coupled aspects result in invariant appearances. For instance, in the case of shape perception,

> Any perception of the stimulus object involves two components, the shape and orientation. These two aspects of the percept are, as [Koffka] says, coupled

> together.[13] The shape is not experienced in isolation; it is always a shape-in-a-given-orientation. We can suppose that the perceived orientation combined with the apparent shape yields a constant shape. If the orientation is seen correctly, the constancy will be complete; if the slant is not visible, there will be no constancy. (171-2)

Because we directly perceive distance and slant information, we experience size and shape directly as well. So long as you adopt a natural attitude towards ordinary objects, like mailboxes and doors, perceptually encountering them at a variety of angles will not affect the fact that they will look to possess their "proper shape in three dimensions" (169). Perception is accurate in the straightforward sense that it directly presents us with the properties in our environments, and the stability with which we experience the environment is what provides the grounds for this straightforward accuracy. Accordingly, if we simply swap distal (P) value for perceived value, perception can be modeled using our original optical models. In the case of size

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[13] Koffka points to simple invariant relations between aspects of the percept and proximal stimulus, such as a size-distance invariance relation. As an object gets further away, its corresponding retinal projection gets smaller such that the two variables are invariantly related. Furthermore, as Gibson notes in this passage, Koffka identified invariant relations between coupled aspects of the percept, such as orientation and shape, or distance and size. Shape and orientation, for instance, are "coupled together, so that if one changes, the other changes also." In the case of size and distance, for example, "a relation of proportionality exists between [them], so that if two equal retinal lines give rise to the perception of two behavioral lines of different length, these two lines appear at correspondingly different distances" (229). It is plausible to think that both of these notions of invariance (simple and more complex invariance relations) profoundly influenced Gibson's early thinking about perception.

perception, perceived value is, in accurate cases, a straightforward function of retinal size and distance:

$$P \propto a * D$$

Similarly, in the case of color perception, perceived value is taken to be straightforwardly related to retinal values and illumination information:

$$P = a / D$$

The notion of a matching or correspondence between percept and physical environment is less central to the Gestalt account, partly because of the emphasis the Gestaltists place on phenomenology, and their commitment to the idea that a phenomenal "behavioral environment" mediates between the mind-independent physical environment (the "geographical environment") and the perceiver (Koffka 1935, 36). Still, the conception of constancy operating within the Gestalt framework can be read as implying that percept-distal property matches are a normative ideal for perception. Constancy, for the Gestaltists, is a tendency towards order or stability; in perception we encounter a stable world in virtue of stabilizing, psychological forces. Perception, consequently, seems to operate according to the following generalization: "the response to a change of stimulation will be such that things retain their [physical] properties as much as possible" (304). This tendency, for objects to retain their properties when possible in experience, does not need to be framed in terms of the indexes that assume that apparent values fall between retinal values and object property values. It does, however, affirm a normative standard according to which constant perception involves perceptual invariance despite changes in corresponding retinal stimulation.

7. Constancy as perceptual invariance in contemporary philosophy of mind

The conception of constancy at play in the Gestalt and Gibsonian frameworks was, like the frameworks themselves, enormously influential. In key respects, it continues to prevail in vision science. Specifically, full constancy continues to be treated by scientists as the normative ideal in perception.

This is evident from how our capacity for constancy is described in the literature. For example, lightness constancy, according to Stephen Palmer (1999), is “the perception of a given achromatic surface (one that is perceived as some shade of gray from white to black) as having the same surface lightness regardless of differences in the illumination or viewing conditions” (125). According to another authoritative source, “perceptual constancy is the tendency for a perceived object to appear the same when the pattern of sensory stimulation (i.e. ‘proximal’ stimulus) alters via a change in distance, orientation, or illumination, or some other extraneous variable” (Roeckelein 2006, 126).

Even in comparative psychology, invariance is often treated as a normative ideal. To support the contention that imperfect color constancy in bees is, normatively speaking, problematic, Fred Dyer emphasizes that a lack of full "correction" in cases of color constancy often leads to selective pressures in the perceiving species or in its co-evolving species. He cites a case from (Endler and Thery 1996) according to which birds displaying in forests compete for patches of particular illumination, which "may be to maximize the communication of colour signals in the absence of perfect colour constancy" (Dyer 1999).

Though Dyer offers no resultant disadvantages for bees, he explains that the limits in their "accuracy of colour constancy for all colours in colour space" (452; see also Dyer 1998) may result in selective pressure for those rare plants whose flowers are UV-colored, as bees experience less stability when it comes to colors that are rarely found in nature. On a scale according to which full or perfect constancy is equivalent to a match between percept and object property, visual systems often fall short of the prescribed normative aim.

Appeal to the invariance conception of constancy among scientists is easy to accept. Scientists are often more interested in the mechanisms that make constancy possible, and less in how we should, strictly speaking, understand the concept or its normative implications (Epstein 1977, 6-7). But, perhaps unsurprisingly given its presence in vision science, the conception of constancy as invariance also remains at the forefront of appeals to constancy in contemporary philosophy of mind. As one would expect, these latter normative claims tend to be more deliberate, and so must be taken more seriously.

In the nineteenth century, perceptual constancy was widely regarded—for instance, by physiological optician Hering—as yielding some, but not full stability. Later theorists, such as Thouless, Brunswik and Gilinsky, set out to measure the degree to which human perception is constant. Though the body of work that resulted establishes that humans rarely experience the world under conditions of full constancy, it was largely overshadowed by the theoretical work of Gibson, work which seemed to these later theorists to require the identification of full constancy with accuracy.

Though Gibson had good theoretical reasons to understand constancy as invariance, we do not. Gibson required the invariance conception because of his commitment to rich sensory stimulation as directly affording perception of the environment. And the Gestalts were motivated, first and foremost, by a commitment to their idea of psychological ordering laws that result in a tendency towards stability and order.

Though conceiving of perceptual constancy as invariance does yield a tidy philosophical account of how perception can be *of* the environment in a way that can be straightforwardly understood as grounding cognitive mental states (as I will explain in the next chapter), we ought to check our reasons for adopting the conception, especially in light of the experimental literatures emphasizing intermediacy as a feature of perceptual constancy. In the next chapter, I highlight the recent influx of appeals to the invariance conception of constancy in philosophy of perception, and discuss motivations for adopting it. I argue that the conception ought to be rejected in chapter 3.

CHAPTER 2:

Perspectival Geometry and Spatial Perception

Abstract. How should we understand the visual perception of spatial properties such as size and shape? Two general strategies dominate the philosophical literatures on spatial perception. The first, representationalism, takes the perception of spatial properties to occur in virtue of mediating appearances, or mental representations. Object views, in contrast, take perception to involve a direct acquaintance relation with objects and their spatial properties. In this chapter, I establish that dominant versions of these two strategies are united by a central commitment to an invariance conception of constancy. Specifically, I show that, on either strategy, spatial aspects of the percept, when it is accurate, are reducible to facts about perspectival geometry. Consequently, the dominant approaches have coordinated in a small region of the space of possibilities for how organisms perceptually relate to their environments. In doing so, they are guilty of an unwarranted assimilation of perception to cognition.

1. The centrality of spatial perception

In chapter 1, I explored how some major (and some more minor) figures in the history of experimental psychology attempted to overcome the problem of underdetermination: the problem of how it is that we experience objects and their properties stably despite highly unstable sensory stimulation that underdetermines the percept. In offering solutions to the problem (or, in Gibson's case, in rejecting it), these theorists appealed to different conceptions of perceptual constancy.

Helmholtz thought that we directly see only sensory appearances—appearances that correspond to retinal values. Invariance in our experiences of object properties as we move around in our environments, consequently, is the result of cognition (unconscious inference) on his view. For Hering and 20th century psychologists inspired by Hering's work, perceptual constancy resulting from distinctively perceptual capacities yields some stability, relative to the more radically changing proximal stimulation, but not nearly enough for perceptual appearances to match object property values. Where object properties do appear invariant or almost invariant, this is usually the result of cognition (e.g. memory) supplementing any stability that is distinctively perceptual. Percepts are, in almost all cases, intermediate in value between retinal and distal values.

Gibson needed to understand perceptual constancy as a capacity to experience the world invariantly because, if perception is unmediated, there is no theoretical room for percepts of a value intermediate between retinal and distal values. Consequently, Gibson rejected the work (empirical and theoretical alike) espousing intermediacy and instead advocated for the invariance conception of perceptual constancy. According to that conception, perception is accurate when it presents object properties invariantly, despite changing proximal stimulation. These differing conceptions and theoretical motivations provide us with a richer sense of the conceptual possibilities for understanding perceptual constancy than we encounter in contemporary philosophy of mind.

In this chapter, I turn to recent work in the philosophy of perception. My aim is to show that mainstream positions in this literature are constrained by a common commitment about perception and perceptual constancy, a commitment that is also implicit in much of our everyday discourse about perception: perception, when accurate, presents or represents the physical world to us as it is independently of us. Therefore, dominant approaches in philosophy of perception have coordinated in a small region of the available conceptual space for understanding our perceptual relation with the subject-independent environment. In doing so, and despite wanting to understand perception in its own terms, they remain guilty of modeling perception on cognition.

Two major families of philosophical positions have taken the invariance conception of constancy as a mainstay of their philosophical views of perception. The first, a family of positions I'll call representationalisms, embraces the fact that perception is mediated, but thinks that the mediating representations, when accurate, allow us to experience the subject-independent physical properties that are in fact in our environments (see, e.g., Harman 1990; Dretske 1995; Tye 1995; Crane 2000; Byrne 2009; Churchland 2010; Burge 2010; Schellenberg 2011).

The other family encompasses views referred to as object view (or acquaintance or naïve direct realist views), because they share with Gibson the contention that perception involves a direct, unmediated relation between the perceiver and the subject-independent, environmental properties perceived. Despite radically changing proximal stimulation, the perceiver experiences the subject-independent, physical properties of objects directly; in veridical cases, perceived values can be identified with objective values (see, e.g., Armstrong 1961; Noë 2004; Brewer 2011).

Of course, not every account of spatial perception fits neatly into one of the above categories. Some views, for instance, embrace the language of direct realism (language associated with object views) but posit phenomenal representations, at least in some cases. For my purposes, here, it will be sufficient to consider such views as hybrid accounts (e.g. Smith 2002; Searle 2015).

Theorists from each of the two major camps as I've defined them begin from a core assumption about the aim of vision: that vision functions to present us with the world as it is, independently of us. Percepts, when accurate, match or correspond to subject-independent object properties. Theorists sometimes frame this commitment it in terms of the role of perceptual constancy in visual perception, taking perceptual constancy to be the invariant presentation of object properties despite changing viewing conditions (changing proximal stimulation), such as changes in illumination or the distance from which an object is viewed. On such formulations, perceptual constancy accounts for how perception puts perceivers in the "right" sort of relation with their environments.

However, the commitment need not be made in terms of the language of perceptual constancy. This understanding of perceptual constancy is best understood as a resource drawn from perceptual psychology by philosophers of mind, a resource that is marshalled to protect the core commitment to accuracy as invariance. Whichever way a theorist might choose to specify the commitment, accuracy norms for vision and a conception of the visual world are in tow. The standard for accuracy in perception is a kind of matching or correspondence between percepts and the properties in the subject-independent world that these percepts are thought to present (as on object views) or represent (as on representationalist views). And the visual world just is, in the good cases, the physical world.

The core commitment to accuracy as invariance is appealing to philosophers for numerous reasons. For instance, it can seem to offer compelling resources for explaining our ability to effectively navigate our environments. If accurate spatial perception amounts to detecting physical facts, then, assuming we have accurate spatial perception much of the time, we can use this fact to explain how it is that perception allows us to get around in the world so successfully. We see things as they are, so we're able to navigate our environments with precision.

Relatedly, philosophical accounts that endorse the match-conception of constancy have available to them a prima facie appealing story about how non-human perceivers are able to interact so successfully with their environments. Though there are good reasons to think that distinctively conceptual forms of thought are not exclusive to humans, many types of perceivers are probably best construed as perceivers but not as cognizers (see, e.g. Camp 2007). Given the current fascination with understanding what we have in common with other perceiving organisms, the constancies are naturally seen as a valuable tool for identifying perception as action-guiding and also as distinct from, and much more widespread than, cognitive and linguistic capacities. If perception aims to put perceivers of all types in touch with a subject-independent world, then an attractive proto-epistemic continuity holds from the most basic perceiving creature to the thinking human.

Furthermore, the commitment offers the physicalist an apparently straightforward way of avoiding the unpleasant task of trying to account for phenomenal experience. If perception aims for the presentation or representation of properties that are physical, then percepts may have a good chance of being neatly incorporated into what many consider to be a “naturalized” (that is, physicalist) ontology.

Perhaps most significantly, though, the commitment seems to afford a plausible grounding for perceptual belief, and cognitive states more generally. If, independent of cognitive factors, perception grants us access to the subject-independent properties in our environments, then accurate cognitive states can be understood without much complication as conceptualizations of already accurate perceptual contents. The constancies, understood as capacities to experience the mind-independent world invariantly, consequently seem to make viable the central, foundational role perception is sometimes given in the empiricist and rationalist traditions.

Finally, the suggestion that constancy affords perceivers mind-independent facts about the physical environment confirms our intuitions about how perception should work. We often talk of seeing things as they are, for instance. During development, a range of questions about perception demand answers (e.g. What color is it? Who is taller?), and typically we come to have impressive confidence about what perception delivers. As Mausfeld notes, “hardly any other domain of rational inquiry is so deeply and almost ineradicably imbued with commonsense intuitions as is perceptual theory” (Mausfeld 2010, 125).

In what follows, and though I believe the arguments outlined in this chapter and the next apply to other aspects of perception as well, my focus will be on spatial perception.[14] Traditionally, spatial perception, such as size or shape perception, is treated as the best candidate for accurate perception. For instance, Galileo and Locke famously distinguished spatial perception from other forms of perception, such as color and odor perception. According to Galileo, size and shape are real qualities that corporeal (material) objects possess. In contrast, colors, temperatures, and smells are less essential and more accidental. Naming colors and smells has misled us into thinking that these latter properties genuinely belong to objects, when they do not. Beyond bodily sensations, colors and smells are "mere names" (Galileo 1623, 10).

For Locke, our common-sense assumption that our ideas resemble their objects and

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[14] The term 'spatial perception' is somewhat misleading. As Harvey Carr puts it in his introduction to spatial perception,

> The term 'space perception' is unfortunate because it suggests that space is something that we perceive. Only objects are perceived, and these objects possess a number of attributes—qualitative, intensive, and spatial. The term refers to the perception of the spatial attributes of objects, viz., their size, shape, stability, motility, and their distance and directional locations in reference to each other and to the perceiving subject. Space as distinct from these spatial attributes is a conceptual construct. The objection may be urged that we see the space or distance between two objects, and hence that we perceive space per se, rather than an object having spatial attributes. The visual world, however, is a sensory continuum—a continuum of sense objects. An object is always seen as distinct from an environing background of objects. Any two separated objects are seen against an intervening background consisting of a part of some other object or group of objects such as a wall, a forest, a lake, the ground, or the sky. When we speak of seeing the distance between two objects, we are merely referring to the magnitude of this intervening visible background. Space is a conceptual object, and it cannot be perceived. Only objects with spatial attributes are perceived. (Carr 1935, 1)

their properties is correct only for a certain class of "primary" qualities, which includes spatial properties such as size and shape. Other ideas—such as color sensations and smells—resemble their bodies in a way analogous to the way that words resemble what words represent. Locke's ideas of "secondary" qualities are merely ideas caused by primary qualities, for instance, when physical corpuscles of certain sizes and with particular motions act on our brains. We can call them ideas of "secondary qualities" to conform with out ordinary way of talking, but really secondary qualities are identical to primary qualities of objects (Locke 1689, 112-3).

Since the time of this well-known discussion in the modern period, theories about perception have focused on cases of spatial perception. Because size and shape perception are assumed to be the most unassailable instances of perception, providing us with access to a subject-independent, physical world, spatial perception is often assumed to sustain the case for the core commitment that I wish to undermine, that perception, when accurate, must present or represent the physical world as it is independently of perceivers.

Many throughout the history of philosophy have appealed to perspectival geometry in understanding spatial vision. According to the spatial version of the core commitment, spatial aspects of the percept in veridical cases can be understood exhaustively by appeal to subject-independent, physical facts about the object perceived, such as position or size, plus facts about the physical, geometrical relation between the perceiver and the object perceived, such as distance or viewing angle. In what follows, I call this distinctively spatial version of the commitment the "Mind-Independent Perspectival Geometry Commitment" ("MIPGC" for short).

In what follows, I explore standard versions of each type of dominant philosophical framework for understanding size perception, as well as two non-standard accounts that are best characterized as hybrid views. In section 2, I examine ways in which size perception is explained by mainstream if competing versions of representationalism, where representationalists understand perception in terms of representational content such that appearances in veridical cases represent the physical world as it is independent of perceivers. These standard views are limited by the MIPGC.

In section 3, I turn to object views, and how standard versions of these views understand the spatial aspects of perception. On these accounts, perception is to be understood most fundamentally in terms of a direct, that is, unmediated, relation between perceivers and physical, environmental objects. Object accounts of the spatial aspects of perception, however, are likewise limited by the MIPGC.

In section 4, I consider two hybrid positions—those developed by John Searle and A. D. Smith. Though these views succeed in some respects in unifying the two dominant types of accounts, they too fail to leave behind the MIPGC. Even bracketing the possibility of hybrid views in this debate, there are important distinctions to draw between competing versions of the views within either of the core frameworks. I am less interested in what follows in the differences between the various views than I am in the ways in which they are similar. Specifically, my focus below will be on claiming that these sometimes very different views adopt the MIPGC.

A common motivation of recent positions of either framework is the avoidance of an assimilation of perception to thought that characterizes the most prominent theories of perception in the latter half of the 20th century (e.g. see McDowell 1994). In section 4, I argue that, by committing themselves in the problematic way they do, these recent positions (hybrid views included) are themselves guilty of an unwarranted assimilation of perception to cognition. That is, I suggest that the prevalence of the MIPGC is explained by an implicit assimilation of perception to belief, an assimilation that theorists making the commitment would themselves wish to avoid. To understand our perceptual relation with the world around us, and despite the MIPGC's prevalence in mainstream philosophy of perception, we ought to begin by abandoning it.

2. Representationalism and size contents

The term ‘representation’ is associated with a number of different positions, including indirect realist positions according to which appearances are real, are directly perceived, and are the grounds for our belief in physical, environmental objects and properties (e.g. see Russell 1912, Moore 1953, Price 1973, Jackson 1977). Indirect realist positions are out of favor, in part because they have us seeing appearances rather than environmental objects or properties, a claim routinely taken to be phenomenally implausible. For instance, Harry Heft takes anything but a direct relation between objects or object properties, on one hand, and perceivers, on the other, to lack appropriate sensitivity to the facts of evolutionary theory, and, in particular, the fact that “psychological processes are adaptive with respect to environmental conditions possessing functional significance” (Heft 2001, 377). It is implausible, according to Heft, to think of adaptive processes as yielding merely indirect knowledge of ecological resources and dangers. If organisms and their environments are in large part the result of a process of co-evolution, then we should only accept the tenet that perception is indirect as a last resort.

The term “representationalism” is now mostly treated as synonymous with what is sometimes called the content view, or content physicalism, a position traditionally associated with Marr (1982). According to this type of view, perceptual experience is to be understood, most fundamentally, in terms of representational content. This is the most standard position in the philosophy and cognitive science of perception today.

When we see the world around us, we see it in virtue of appearances that have representational content. In contrast with indirect realism, we see mind-independent, physical objects (such as tables and trees) and their properties; we do not *see* mediating objects. In veridical cases, our contentful experiences provide us with information about the physical environment, and can be (in most cases) understood exhaustively in terms of the physical environment represented. It is in this sense of content physicalism that I use the term "representationalism" in what follows.

Representationalism has some clear theoretical advantages over object views, and these help to account for why the position is defended prominently in the literature. Because the representationalist understands perception in terms of content, they have at hand a straightforward account of how perception grounds belief: concepts are brought to bear on one kind of content, perceptual content, resulting in conceptual content. The representationalist analyses perception in terms that apply to both perception and cognition, so there is no special problem to overcome about how one grounds the other.

Furthermore, many take the representationalist to have valuable resources with which to manage the well-known problems of illusion and hallucination. The representationalist purports to be able to explain the indistinguishability of, on one hand, illusory or even hallucinatory experience, and, on the other, veridical perceptual experience, by appeal to similarities in the contents of each type of experience. In this way, these views are taken to inherit the benefits of indirect realism while overcoming its central weakness (that our perceptual relation is with a representation rather than an environmental object). In part because of this purported strength, competing views, such as object views, are often framed in terms of offering a solution to the problems of illusion and hallucination from a non-representationalist perspective (e.g. also Brewer 2010, especially chapters 4 and 5).

Representationalists standardly hold that appearances represent physical reality by corresponding to mind-independent physical properties. Perception is accurate or veridical when we see physical object properties invariantly, despite changing proximal stimulation. Of course, humans are not sensitive to all types of environmental energies—we are not sensitive to ultraviolet light, for instance, even though ultraviolet light is a feature of our physical environments. Representationalists usually do not think that perceivers of a given type (say, humans) represent all aspects of their physical environments, including aspects to which they have no perceptual sensitivity. But they do think that, for the physical aspects to which the perceiver type is sensitive, visual experience ought to be evaluated on the basis of whether it represents those aspects as they are physically, independently of perceivers.

In the size case, perception is accurate when we see the subject-independent size of the object we are viewing. For example, when I look down the block and see a food truck, I veridically see the truck just in case my visual experience represents the truck as having the features that it in fact has (at least those to which I am sensitive as a human, such as size and shape).

Take Christopher Peacocke's classic view about perceptual content as exemplary. When viewing two trees at different distances, it is perceptual content that represents the trees as the same size. Interesting, however, according to Peacocke, it cannot be that phenomenal experience is exhaustively representational; that is, it cannot be that representational content can be taken to exhaustively account for our perceptual experiences. Peacocke explains:

> Suppose you are standing on a road which stretches from you in a straight line to the horizon. There are two trees at the roadside, one a hundred yards from you, the other two hundred. Your experience represents these objects as being of the same physical height and other dimensions… 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 is its representing the trees as being the same height. (Peacocke 1983, 12)

With this example, Peacocke aims to bring out that there are both sensational and representational properties of perceptual experience. Perceptual experience cannot plausibly both (1) represent the trees as being the same size, and (2) represent the trees as being different sizes (the closer tree as bigger than the further tree). Perception, Peacocke concludes, represents the former but not the latter. What is important for our purposes is that Peacocke takes the representational content of the visual experience he describes to be as of two trees of equal size. The visual experience in such a case, according to Peacocke, presents us with two identically sized objects at different distances by representing those two objects as equal in size.

Many representationalists prefer a more pervasive role for content in visual experience. Such theorists think we can account for even Peacocke's sensational properties in terms of representational content. For instance, Michael Tye (1995) offers a different solution to Peacocke's conundrum (see also Dretske 1995). For Tye, the elements that Peacocke counts as sensational can themselves be understood as representational. In discussing Peacocke's tree case, Tye writes that the closer tree is "represented in the experience as being larger from here, that is, as subtending a larger visual angle" (1995, 226). To count the first tree as represented in the experience as "larger from here" seems to avoid the problem outlined by Peacocke, since "being represented as larger from here is different from being represented as larger without qualification" (226). The experience can consistently represent the experience as of two trees of the same height, and as of two trees of different heights from here. Thus, for Tye, abandoning sensational aspects of perception for a thoroughly representationalist account does not entail contradictory contents. Nor does it involve relinquishing the MIPGC. For Tye agrees with Peacocke that the trees are, in veridical cases, represented as being the same size (even if, for Tye, the tree at half the distance of the other is also represented as twice as big from here).

Susanna Schellenberg develops a version of this representationalist response to Peacocke by offering a more precise characterization of the additional type of content. On her account, as on Tye's, perceivers see the mind-independent properties of objects, such as their sizes. On this view, mind-independent properties of objects, possession of which does not depend on an object's relation with perceivers or other objects, are called intrinsic properties.

Perceivers, such as humans, see intrinsic properties of objects in virtue of objects being presented in ways that depend on situational features of the perceptual circumstances (Schellenberg 2008, 55). Situational features, for Schellenberg, are the environmental features that "determine the way an object is presented" (56) in perception, such as lighting conditions and viewing position relative to the object viewed. Perception represents the intrinsic properties of objects, but it also represents situation-dependent properties of objects, the properties an object has in virtue of its intrinsic properties and situational features. Situation-dependent properties of objects are mind-independent, just as the intrinsic properties of objects are mind-independent. But it is in virtue of the representation of situation-dependent properties that we are able to perceive intrinsic properties.

Once we recognize that objects are presented in terms of situation-dependent properties, we can understand physical change in the scene presented, or in our relation with the object, as change in the situation-dependent properties. Simultaneously, we can maintain that our perceptions of the intrinsic properties of objects are unchanging, that is, that "perceptual content remains the same with regard to the intrinsic properties of objects" (62) (at least in veridical cases). In the case of spatial perception, the position of the perceiver relative to the object perceived will be the most important situational feature in determining how the object is presented.

As Schellenberg writes,

> Take the cup on my table. It is presented in a certain way given my location. One side is closer than the other; one part faces away from me. Its shape is presented in an egocentric frame of reference, which in turn means that the object and its parts are presented as standing in specific spatial relations to me. The way the cup is presented to a location is on the suggested view an external and mind-independent, albeit situation-dependent property of the world. Any

> perceiver occupying the same location would, ceteris paribus, be presented with the cup in the very same way. (61)

The way the cup is presented to a location can be specified by a set of mind-independent, physical facts about the perceptual context. As one shifts in one's chair, the change that occurs in how one sees the cup can be accounted for in terms of changing situation-dependent properties, since the situational features change as one's viewing position changes. What doesn't change, according to Schellenberg, is the shape or size we see the cup as having—its intrinsic properties. These are represented constantly (invariantly) in the veridical case.

Similarly, in the case of Peacocke's trees, no appeal to a visual field is necessary: the case can be explained by appeal to "the world as it presents itself to the perceiver's location, that is, with regard to external, mind-independent, but situation-dependent properties of objects." In veridical perception of the trees at a distance, experience "represents the trees as having the same intrinsic size properties, but as having different situation-dependent size properties" (66).

Schellenberg argues that this view offers an improvement over Tye's since subjects need not be aware of situational features, on her view, whereas Tye's view is more cognitively demanding. For Tye, perceivers are required to represent not only the relevant situation-dependent properties along with relevant intrinsic properties, but also whether a property is situation-dependent or intrinsic (68). Nevertheless, both theorists help themselves to the commitment that in the veridical case, the intrinsic, subject-independent properties of objects are represented in perception: the trees are represented, for example, as of the same size, even though they are at different distances.[15]

On each of these views, there is a commitment to accuracy as invariance. In the case of the trees, the representational aspects of the percept are reducible to mind-independent physical and perspectival facts. For Peacocke, these are mind-independent facts about the physical sizes of the trees. On later views, the representational contents of perception come to include perspectival facts about the physical relation between the perceiver and the object viewed.

This commitment to invariance of spatial aspects is sometimes upheld by explicit

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[15] It is worth noting that Schellenberg is clear that her view does not require that all phenomenological differences are understood in terms of representational differences. For instance, she describes Mach's case of being able to switch between seeing a figure from the same viewing position (1) as a square and (2) as a diamond, as a case in which there is plausibly some non-representational aspect that must account for the change. In such cases, "there is no external difference to be represented and so the difference in phenomenology cannot be explained in terms of a difference in representations of mind-independent properties or objects" (63). I think Schellenberg is right about this case, but I think her choice to highlight it is also significant: where external change is present, the phenomenal change is to be accounted for in terms of representational content alone. When the way a shape is presented changes because we shift our physical position relative to the object (say, the teacup), the change in how the cup is presented can now be accounted for exhaustively in terms of changes in the representation of situation-dependent properties. This case is therefore different from Mach's: "the change in the experience due to the change in situational features can be explained with regard to the situation-dependency, rather than the subjectivity of perception" (63-4).

reliance on an understanding of perceptual constancy as invariance. Tyler Burge, for one, develops a representational story about perception by appealing to an invariance conception of perceptual constancy, according to which perceptual constancy is a perceptual capacity to see the properties of objects invariantly despite changing environmental conditions, such as distance or viewing position. As Burge puts it, perceptual constancies are capacities in a variety of animals

> systematically to represent a given particular or attribute as the same despite significant variations in proximal stimulation—despite a wide variety of perspectives on the particular or attribute. Such constancies are explanatorily associated with systematic filtering mechanisms that yield sensitivity to a single environmental particular or attribute. For example, a perceptual system might enable an animal to represent a body's size as the same even as the retinal image, the body's immediate effect of proximal stimulation, grows or diminishes. (Burge 2010, 274, see also 114)

The constancies, on this view, allow us to see environmental particulars (e.g. an object's size) as it is, independent of subjective factors. And this type of invariant perception is the hallmark of perceptual objectivity and accuracy, for Burge.

According to Burge, perceptual constancies allow one to see two trees that are the same size but different distances as the same size, just as one might "see a round orange body (say, an orange) as being of a given size whether it is close—causing stimulation of a substantial number of the retinal receptors—or farther away—stimulating a much smaller number of receptors. Size constancy is the capacity to see something as of the same size under very different proximal stimulations" (Burge, 2010, 387-8). For Burge, as for other defenders of representationalism, accuracy in size or shape perception is achieved under conditions of full stability (invariance). Perception is understood as veridical when it presents physical contents invariantly, as they are independently of subjects.

3. Object views and seeing size directly

A different class of philosophical approaches, object views, take the representationalists' appeal to representations to be unnecessary. Object-view theorists seek to simplify the relation between perceiver and the physical world by developing the idea that experience is unmediated by mental representations. Perceptual experiences are not representational states. Rather, these theorists hold that perception involves a direct, unmediated relation between the perceiver and the mind-independent, environmental properties perceived.

Features of the environment, on this approach, are independent of organisms, but have the potential to be perceived directly. The objects we commonly take to be in the world, this desk and this computer, for example, are really in the world. And these are the sorts of objects we perceive, unmediated by anything; that is, these are the sorts of things that are the objects of direct awareness in perceptual consciousness.

In 20th century psychology, J. J. Gibson is virtually the only theorist to defend a direct, unmediated account of perception (Heft 2001, 154; see also 386-7). Today, however, especially as Gibson's ideas continue to gain prominence in philosophy, the view is defended by a number of distinguished philosophers, and is considered one of the main contenders in the philosophical literature about how to understand perception.

Intuitively, object views have some straightforward advantages over representationalism. For instance, if the relation between perceivers and mind-independent objects is unmediated, then we need not be concerned that appearances may be systematically deceptive, or that visual experience misrepresents the world in a radical sense. Instead of conjecturing that subject-independent physical objects exist on the basis of appearances, as a representationalist must, the direct realist takes as their theoretical starting point the tenet that perception is, constitutively, a relation of awareness or acquaintance between the perceiver and those subject-independent objects.[16]

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[16] Gibson considered this to be a central advantage of his approach over the approaches of the Gestalt psychologists, who, while privileging the perceived world, took that world to represent a more basic physical environment. For discussion, see (Henle 1974, 42).

Because the perceptual relation is unmediated on object accounts, it is sometimes proposed that object views have the best chances of accounting for the phenomenal character of experience—specifically, what is sometimes called the "transparency" of experience (Martin 1998, 2002; Crane 2000), the idea that when we introspect to try to analyze phenomenal experience, that experience is transparent: we see right through it to the objects themselves. As John Searle puts it, "if you try to describe the subjective visual experience in your head, what you will find is that you are giving the same description that you would give of the state of affairs in the world" (Searle 2015, 59).

On standard versions of the view, experience veridically presents us with subject-independent objects when those objects look to have the properties they in fact have. In the spatial case, perception presents us with an object of a given physical size, and if we perceive the object accurately, then the object looks to have the size it in fact has. The percept is taken to directly present us with the subject-independent, physical sizes of the objects we see.

For example, in Bill Brewer's *Perception and Its Objects*, Brewer sets out to defend the following conjunction: (1) physical objects are mind-independent, and (2) physical objects are the direct objects of perception. According to Brewer, "the fundamental nature of perceptual experience is to be given precisely by citing and/or describing those very mind-independent physical objects of acquaintance" (Brewer 2011, 94). For Brewer, our basic perceptual relation with the physical world "is *just that*. Perception is a matter of our standing in relations of conscious acquaintance from a given spatiotemporal point of view, in a particular sense modality, and in certain specific circumstances of perception, with particular mind-independent physical objects themselves" (xii).

By "circumstances of perception," Brewer has in mind the physically specifiable viewing conditions in a perceptual scenario that might not be specified by the spatiotemporal point of view, such as lighting conditions. These three factors (spatiotemporal point of view, sense modality, and the specific circumstances of perception) "conjoin to constitute a third relatum of the relation of conscious acquaintance that holds between perceivers and the mind-independent physical direct objects of their perceptual experience." Accordingly, any variation in the perceptual experience of an unchanging object

> may all perfectly adequately be accounted for by variations within this third relatum. For example, head-on v. wide-angle experiences [of a coin], and those of the head side v. the tail side involve different spatial points of view. Experiences of the newly minted v. tarnished and battered coin involve different temporal points of view. Seeing v. feeling it clearly involve different sense modalities; and bright light v. dim light viewings involve different

> circumstances of perception. Still, these are all cases of conscious acquaintance with the very same mind-independent physical coin—with variations in the third term of the perceptual relation. The basic idea of OV [Brewer's object view] is that these complex specifications of my overall perceptual relation with the particular coin in question constitute the most fundamental characterization of my experiential condition in each case. (96)

Accurate perception, for Brewer, depends on the way an object looks being appropriately related to the way the object is. The requisite appropriate relation involves the look of the object being analyzable into facts about the physical nature of the object perceived, plus facts about the three factors that together make up Brewer's third relatum of the relation of conscious acquaintance: spatiotemporal point of view, sense modality, and the specific circumstances of perception.

Accurate perception of an object's shape will depend on that object's appearance being analyzable into geometrically specifiable facts, for instance, about the viewing position and slant of the object relative to the perceiver. Accurate perception of an object's size will depend on that object's appearance being analyzable into geometrical facts about the distance of the object from the perceiver, height of the perceiver, and so on.

Alva Noë similarly is committed to understanding the spatial aspects of the percept in terms of geometrical facts about the object, and the relation between the perceiver's spatiotemporal viewpoint and the object viewed. For Noë, it is important to distinguish between physical size of the mind-independent object perceived, and "apparent size," or how the object looks *"with respect to size from here*," what Noë calls, using Gibson's terminology, "size in the visual field" (Noë 2004, 82; Gibson 1950).

Apparent size is to be understood as corresponding to "the size of the patch that one must fill in on a given plane perpendicular to the line of sight in order to perfectly occlude an object from view" (82). If we specify the position of the perspectival plane at a distance from the perceiver in the direction of the line of sight, then "how things look with respect to size can be recognized to be a perfectly definite property of the scene" (83). On this approach, size in the visual field is a property of the scene because there is a geometrical fact about the size-in-the-plane and the relations between the object viewed and the viewer. This size-in-plane is available to the perceiver in virtue of the principles of linear perspective.[17] Within the system of linear perspective, size-in-plane is precisely geometrically determined by objective size, objective distance, and

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[17] See (Edgerton 1975) for a brief history and overview of the method of linear perspective in art. Noë cites Gilbert Harman (1990) and David Armstrong (1961) in understanding human perception of size at a distance in terms drawn from the depictive principles of linear perspective.

location of the plane. Noë takes these principles to apply to the case of human vision also.

Thus, according to Noë, we need not worry, for instance, with Peacocke (1983, 12), that our experiences can involve contradictory contents. Recall Peacocke's example of the experience of two trees of the same size, where one is at a greater distance from the perceiver, so that one tree (the further one) takes up much less of the perceiver's visual field. If the content of that experience is of the trees as being the same size (they are in fact the same size, and, according to Peacocke, look that way); but also of the trees as being different sizes, then the experience must have inconsistent contents. Peacocke was motivated by this concern to say that the differing "sizes" of the trees in the visual field are merely sensational, nonrepresentational features of the experience. The experience in this case has only one relevant type of size content, and it is of two trees as of the same size.

Noë's solution to the two contents problem in the tree case is different: apparent size, or size in the visual field, is a content of the scene, just as object size is a content. However, apparent size and object size contents are consistent because apparent size is a content about how each tree appears from a specific viewing position. Apparent size, for Noë, is an object of sight (something we see) just as the physical size of the trees is an object of sight. The relation between apparent size and real size can be "given by precise mathematical laws (e.g. the laws of linear perspective).” The apparent size of the trees is

> a fact about how the trees look, with respect to size, from the location of the perceiver: It is identical to the size of a patch we can imagine drawn on the occlusion plane. If there is a mind/world divide (in a Cartesian sense, a divide between the mental interior and the nonmental outside), then [apparent properties] are firmly on the world side of the divide. They depend on relations to perceivers, yes. But perceivers (at least their bodies) are also on the world side of the divide.[18]

The way the trees look can be wholly accounted for, in other words, in terms of facts about the physical world: physical properties of the object, and perspectival facts about the relation between the physical position of the perceiver and the object.

4. Searle and Smith as offering hybrid accounts

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[18] (Noë 2004, 83). Because of my present interest in problematizing the claim that “apparent size” can be understood in terms of physical geometrical facts, I choose not to discuss in detail the problems facing Noë’s appropriation of the idea of a “perspectival plane” at a specified distance from the perceiver. This notion makes perfect sense in the context of art practice, where the aim is to reproduce the scene viewed in a two-dimensional plane held, say, at arm’s length from the viewer and/or artist. But in the context of apparent properties in perception, the notion makes no sense at all. How could we pick a distance at which to fix our perceptual perspectival plane? Presumably, any position would be utterly arbitrary, and so any “apparent size” would likewise be arbitrary. For an excellent discussion of this crippling problem (and related issues with Noë’s view), see Hatfield’s (2016).

A similar reliance on the conjecture that apparent size can be understood in terms of the principles of linear perspective is to be found in John Searle's new work, *Seeing Things as They Are*. On Searle's view, there is a basic sense in which we see a two-dimensional projection of the visual world, and this projection works in tandem with higher forms of perception and cognition to yield direct experience of physical objects as they are in our environments. In other words, the percept, at its most basic level, tracks linear retinal size; invariant, physical size perception is a result of higher-level perceptual or cognitive content.

The suggestion that a two-dimensional retinal projection is phenomenally primary has been defended by a number of thinkers, such as Peacocke and Irvin Rock, but Searle's particular formulation of the idea is new. Crucial to Searle's account is his distinction between the objective visual field, and the subjective visual field. The objective visual field is ontologically public and objective. It is identified relative to a particular perceiver and their point of view. Everything is seen, or can be seen, in the objective visual field. So my objective visual field right now, according to Searle, consists of the objects and states of affairs I can see under these particular lighting conditions from where I'm sitting in my present physiological and psychological state.

Visual experiences are part of the total conscious subjective visual field, which is an intentional presentation of the objective visual field. The subjective visual field is ontologically private; a first-person set of experiences that go on inside the head. Nothing is seen or can be seen in the subjective visual field, because, whatever you are seeing, you can't see that you're seeing it.

Searle wants the specificity of the intentional relation between the percept and the mind-independent objective properties viewed to be a causal one, but that relation can't be explained causally because, as he puts it, anything can cause anything. So specificity in the perceptual experience comes instead from the fact that seeing involves, at the most basic level, the experience of a certain class of objective, mind-independent features for which being that feature is partly constituted by being able to cause that perceptual experience. These are Searle's Basic Perceptual Features (sometimes called Basic Perceptual Properties): "the set of (ontologically objective) properties which can be perceived without perceiving anything else by way of which you perceive them" (2015, 112). Basic Perceptual Properties include colors, lines, angles, and shapes.

When we see an object, that object produces basic visual experiences in the subjective visual field—that is, it produces "the subjective visual correlates of colors, lines, angles, textures, shapes, etc." (139). It is then in terms of these basic features that we are capable of all sorts of seeing, given the help of background capacities and presuppositions. For instance, the color and shape of my bicycle are basic perceptual features, but being a bicycle or being my bicycle are not basic, and require supplementation by cognition and biologically-given background presuppositions.

Depth, interestingly, is not one of the basic perceptual features of our visual experiences, on Searle's account. The intentionality of the visual experience "fixes the three-dimensional spatial relations" (138); however, according to Searle, "whatever you get in the subjective visual field by way of depth you can get from a two-dimensional stimulus" (139). So how does this work in the case of depth perception? How does one get from basic perceptual features to the perception of depth?

For simplicity, we can focus on the case of monocular vision here, as Searle does. It is the background mastery of the principles of linear perspective that allows us to perceive depth as a non-basic feature of the objective visual field. He writes, for instance, that "the principles of perspective that so revolutionized Western painting are themselves part of the Background capacity of any competent perceiver in such a way that the perceiver is able to see the world as having three dimensions because of his Background mastery of perspective" (139).

For Searle, one might report that one has seen a cube or a sphere. However, the basic visual experience in the case reported was not of a cube or sphere. Rather, in the case of the cube, the basic perceptual features "consisted of a set of connecting and crossing lines. Given the subject's mastery of perspective, these lines are perceived as a cube" (140). Accordingly, depth perception is understood as a kind of higher-level, seeing-as.

When we look down a straight set of train tracks, for Searle, we see—at the most basic level—two lines converging dramatically, in a two-dimensional plane. We don't simply use the two-dimensional content to see other contents in depth; we see it too. Notice, for instance, what Searle says one sees when one encounters a row of trees, extending away from one:

> I see a row of trees in front of me. They all look the same size, even though at the basic level the trees farther away look smaller because of the difference of the impact of the distant trees and the nearby trees on my subjective visual field. As I walk along the rows of trees, the subjective visual field changes to accommodate this change in the perspective. My intentional content at the higher level is that the trees are always the same size, but at the lower level there is no question that there is a change in the basic perceptual properties… at the basic level [size constancy does not] exist. (151-2)

Trees are seen as the same size in depth, and they are also seen as they would be if they were projected into a two-dimensional plane before the perceiver. The first is at times described as a cognitive, interpretative result. Searle writes that, in seeing the rows of trees, "you have 'size constancy.' If asked, did the objects look as if they changed size?

The answer is no, they looked the same size. But you are able to see the world as you see it because of the cognitive capacity to interpret the experiential content in a certain way" (139).[19] So, Noë and Searle share Brewer's commitment to the MIPGC: when we see the trees accurately, we see them as being the same size, even if, in some sense, they also look very different in size.

Like Searle, A. D. Smith begins his analysis of vision from the assumption that two-dimensional sensations are basic to vision. And at places, it seems clear that Smith likewise adheres to the MIPGC by conceiving of constancy as invariance. For instance, Smith discusses size constancy mechanisms as generating a close or exact match between percept and mind-independent physical size. The constancies make possible, according to Smith's picture, "a change in visual experience, a change in visual sensation, despite the fact that the object of awareness does not itself appear to change

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[19] Elsewhere, it seems that Searle is understanding interpretation and inference in terms of a mere discrepancy between (1) the informational content of the whole subjective visual experience and (2) the informational content of the perception of basic properties (150). Presumably, he intends his suggestion that constancy is a cognitive result to be compatible with babies and all sorts of other animals having size constancy. So perhaps we need not worry about his referring to contents such as the content that my bicycle stays the same size as I move towards it, for example, as "visual," even when he thinks of this result as interpretive. Still, this raises a substantive issue. Searle sketches a conception of "the visual" in terms of what could be decided by looking. I can see that my bicycle is where I left it, but I can't see that a man is drunk, for instance. I worry, however, that this conflates the structure of the phenomenal space as we experience it in vision, with the cognitive responses we have regarding known sizes of objects. For my purposes here, it is important to distinguish cognitive responses from phenomenal space as we experience it, which consists of our experience of surfaces arrayed at locations, and possessing phenomenal spatiality. When we investigate how perception works, after all, and how it could guide action and belief formation, we are concerned primarily with how things look, and so I prefer a narrower notion of "looks" than does Searle.

at all" (2002, 172). The sensuous changes that accompany movement in the world, Smith writes, "always manifest to us a changing relation in which an intrinsically unchanging object comes to stand to us" (172). Veridical perception, for Smith, involves the perceived feature of the object appearing unchanged despite changes in the viewing circumstances, such as changes in viewing distance.

Though I think it is clear that Smith adheres to the MIPGC, strictly speaking, his account could fairly easily be amended to avoid making the MIPGC. That is, given the framework that Smith defends, he need not insist on the objects of perception appearing in "unchanging" ways. Smith introduces the constancies into his account in the first place because he is interested in pushing the Kantian insight that a distinction can be drawn in the case of perception between a mere change in experience and an experience of change in the object of experience, whereas in the case of sensation such a distinction is nonsensical. Any situation in which there is a discrepancy between a change in experience and a change in the object of experience, that is, should work for Smith's purposes. If this is right, he could do with a significantly more modest claim about the way objects and their properties ought to appear in veridical perception, that is, Smith could make room for widespread intermediacy as a feature of perceptual constancy.

Take, for instance, a dog running to fetch a stick thrown to the other end of the park. We can make perfectly good sense of a distinction between the changes in experience undergone—the changes in the quality or intensities of the sensations experienced—and the changes we experience with regards to the object of experience, namely, the dog. Even if someone were to be subjected to a visual space which phenomenally contracted to a great degree, Smith would still be able to distinguish the object which appears to get smaller from the sensations which necessarily change the moment there is a change in the physical circumstances of perception (e.g. a change in the distance between the dog and the perceiver). All Smith needs is some degree of *unum e pluribus* (233). Smith doesn't need sensory changes to result in an unchanging experience of object properties. He could instead accept that there is stability, or "otherness" as soon as there is more phenomenal stability than there is change at the proximate level.

Of course, Smith's account is likely complicated by such an amendment. But if I am right, a revised version of Smith's view could provide an interesting exception in this literature, a way of avoiding the perspectival geometry commitment. I conclude by positing a more philosophical reason to resist adopting the MIPGC.

5. The MIPGC as over-intellectualization of perception

It's possible that no transition better defines the philosophy of mind in the past 30 years than the shift away from an intellectualist approach to perception, according to which perception is modeled on belief; to an interest in treating perception in its own terms, as a non-conceptual, embodied capacity we share with a remarkably broad range of non-human creatures (Crane 1992; Gunther 2003).

For instance, central to Smith's account is the proposal that perception is possible in the absence of even a single concept. If we understand perception to involve something akin to thought, this necessarily "over-intellectualizes what is but a function of the senses, a fairly basic animal endowment" (Smith 2004, 99). Concepts, according to Smith, are irrelevant to what makes a sensory state perceptual, whether one takes concepts in a narrower (or "high") sense, or in a looser (or "low") sense. In taking the involvement of concepts to be unnecessary to a state's being perceptual, Smith strives to distinguish himself from the likes of Thomas Reid and Wilfred Sellars. Sellars, for instance, has a "high" account of thought and conceptualization, according to which concepts come in batteries: any conceptual scheme has a holistic character, so that one has no concepts until one has many (Sellars 1997, 66). Nevertheless, according to Smith, Sellars holds that perceptual awareness requires conceptual activity.[20] For

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[20] I believe this accusation fails to appreciate that Sellars uses the notion of awareness in a technical way. Sellars is perhaps more correctly interpreted not as failing to provide theoretical room for unconceptualized noticings, but as simply reserving the terminology of awareness for conceptual awareness. A mere pain in a being with no conceptual abilities, that is, does not have awareness of the pain in Sellars's technical sense, though of course the being notes the pain, and, plausibly, suffers too.

Smith, a view such as this one is unacceptable because it is implausible to suppose that "in order to notice a light coming on, or to feel a kick in the pants, one must be able to engage in all of these sophisticated self-referential and linguistic conceptual episodes" (Smith 2002, 100).

In an effort to preserve the idea that perception is fundamentally conceptual in some way, one might instead accept what Smith calls a "low" account of concepts. But Smith takes this strategy to be even worse. The claim that conceptualization requires mere discrimination is empty, since the involvement of discriminatory abilities is evidently not what anyone would take to be meant by "conceptual," given the existence of the debate. A recognitional capacity as sufficient for conceptualization, on the other hand, is a more interesting suggestion, for then we might conceive of the possession of a concept as the possession of an ability to classify objects, as a sensitivity to kinds.

Smith finds the suggestion that a recognitional capacity could be essential to perception, however, to be a bad one: "I can see something and be wholly unsure whether it is even animate or inanimate… the suggestion that you have to recognize

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Sellars, that is, cannot be straightforwardly taken to "deny awareness of the environment to all non-linguistic creatures" (Smith 2002, 100). (This point comes out of discussions in a seminar on Epistemic Realisms with Gary Hatfield, fall 2012.) On John McDowell's "high" concept approach, a conceptual ability entails the possibility of its exercise in non-perceptual settings. For a recent account of concepts that requires stimulus-independence, but without the commitment to perception as conceptual, see (Camp 2009).

(or seem to recognize) everything you perceive is absurd. Indeed, it is incoherent: what about the first *time* you perceived a certain sort of thing?" (112). Classificatory capacities are, instead, directed at objects already perceived. Perception grants what is needed to then develop classificatory or recognitional capacities (113-4). Recognizing things as things, or as objects, moreover, cannot be explanatorily helpful, for it tells us nothing about what it is about perception that makes it "exhibit its admitted objectivity" (120). Smith is far from alone in wanting to do away with "conceptualized" accounts of perception. And even within the realm of views that align with Smith on this issue, there are accusations about modeling perception on belief.

Brewer, for instance, emphasizes the superiority of the object view framework over representationalist approaches for its ability to avoid assimilating perception to belief. Representationalists, according to Brewer, model perception on belief when they take perception to involve contents that in turn make direct reference to mind-independent physical objects, instead of having perception itself make such direct reference. Representationalists, that is, make compatible (1) the idea that the physical objects we perceive are the objects presented to us in perception, and (2) the idea that these physical objects are mind-independent, by

> a kind of assimilation of perception to thought: perception involves representational contents that make direct reference to mind-independent physical objects. I believe that this…is unsatisfactory. Just as certain early

> modern empiricists notoriously face problems as a result of the way in which their theory of ideas seeks to assimilate thought and belief to perception, I contend that the reverse assimilation of orthodox modern philosophy of perception [representationalism] faces serious difficulties in truly accommodating the datum that we are consciously presented in perceptual experience with the physical objects themselves that we perceive. (xi)

Object-view theorists like Brewer take their determination not to model perception on belief as granting their views an edge over representationalist positions. And yet, in at least many cases, representationalists are likewise motivated by a desire to explain how perception need not be modeled on conceptual thought. For instance, Burge's (2010) is fundamentally a defense of the idea that objective perceptual representation "precedes and does not depend on having thought, let alone language" (23).

To add to Brewer's charges, I want to suggest that mainstream representationalists and object-view theorists fail to do away with belief as a model for perception, but not for the reasons that so often color debates about the relation between perception and thought, such as those mentioned above. Instead, I want to argue that, in virtue of making the perspectival geometry commitment, these theorists—whether representationalists or object-view theorists—ask us to use veridicality norms developed in the context of belief to evaluate perception.

When theorists commit themselves to the idea that the spatial aspects of the percept can be exhaustively accounted for in terms of perspectival geometry, they assume that perception aims at truth in the way that belief does. We take belief to have truth conditions—my belief that there are carrots in the fridge is standardly evaluated on the basis of whether there are in fact carrots in the fridge. That is, we evaluate the representational contents of a belief on the basis of whether that belief specifies a state of affairs that is true. This normative framework for thinking about belief is at the center of Western philosophy: when belief is true (and justified), that representational state amounts to one of knowing. Plausibly, it is extremely useful to be able to understand and remember facts about states of affairs that are out of sight, or that are not the types of states of affairs that can be perceived at all.

But how did a truth-like normative standard come to govern how we understand the normativity of perception? Perception, as recent accounts emphasize, is importantly different from belief. In perception, what we are interested in explaining is the way percepts help us. Perhaps in many cases, perception helps us by telling us about states of affairs as they are independently of us. But is this always the case? And even if it is often the case, should these come to stand for the only successful instances of perception? Application of this normative standard to perception doesn't come from thinking of perception as action-guiding, that is, as helping perceiving organisms interact with their environments.

If perception functions to help organisms interact with their environments, then there is no clear motivation for expecting or wanting perception to present or represent things as they physically are, independent of perceivers. The point is developed in disciplines such as spatial geography and design, where importance is placed on the idea that which information dominates an experience depends on what the system is doing (e.g. see Smallman et al. 2002; 2005).[21] It is also long-recognized in ecologically-invested areas of perceptual psychology. Referencing Jameson and Hurvich (1989), Vincent Walsh and Janusz Kulikowski puts this point nicely: "the visual system does not trouble itself to give a perfect description of the world. Indeed, mechanisms that provided absolute constancy would risk losing valuable information" (Walsh and Kulikowski 1998, 3). Where information is useless or distracting to organisms, less can be more.[22]

Representationalists and object-view theorists require of veridical perception that we see objects and their properties as they are. However, objects often look different than

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[21] Thanks to Christian Schunn for emphasizing this point, and for directing me to the appropriate literature (email correspondence from September 2014).

[22] The comparative color literature (which is significantly more developed than the comparative spatial literature), teems with examples. For an introductory review article on this topic, see Gerl and Morris (2008).

they are: a more distant tree can look smaller in size than a nearer tree of the same size, and a dinner plate can look elliptical, even if it is round. In their (2015) for instance, Walsh et al. offer a meta-analysis as well as new experimental evidence to support the tenet that the degree of compression of the in-depth dimension of visual space relative to the frontal dimension changes as a function of distance, and that the function varies depending on the distance of the object viewed (as well as on other experimental conditions such as the reduction of cue conditions). Still, there is debate about the structure of phenomenal space. Given the tension between the MIPGC and plausible accounts of the function of perception, the burden for action may well rest on those who espouse the perspectival geometry commitment. I turn to arguments against the commitment next.

CHAPTER 3:

The Ecological Approach to Normativity

Abstract. In this chapter, I develop and recommend an ecological approach to normativity in visual perception. Drawing on evidence from evolutionary and comparative psychology, I juxtapose the approach with (1) the standard correspondence approach examined in chapters 1 and 2, and (2) etiological approaches. My proposal leaves open the possibility that percepts of a value distinct from retinal and distal values may be better candidates for successful perception than percepts that track physical distal values. Practically speaking, measures of stability in visual perception will inevitably involve reference to distal values, and there is nothing wrong with using percept-distal value matching in quantification. Meaningful normative assessment, however, is a more perplexing enterprise. In contrast with etiological approaches, the ecological approach countenances systematic environmental changes and the emergence of new uses for pre-existing traits. In conclusion, and in keeping with the ecological approach, I conjecture that perceptual constancy may be best conceived as a capacity merely to enjoy percepts that are more stable than their corresponding proximal stimulations.

1. Functional analyses and normative standards

There are different ways to think about norms governing perception. As I showed in chapter 2, it is standard to take the cardinal norm for perception to be a kind of matching or correspondence between percepts and mind-independent physical objects or object properties. However, there are other ways to think about vision as successful or unsuccessful that do not depend on such a matching or corresponding between percepts and mind-independent physical properties.

Normative assessments are often tied to ideas of functions or aims. The word function can have a range of meanings, many of which we evoke regularly in our everyday lives. We can say that the pressure of a gas is a function of its temperature, that I was in Montreal attending a function, that the jug is functioning as a vase, that the heart functions to pump blood, or that the heart functions to produce measurable electrical pulses. I'm interested in what follows specifically in how we think about functions in especially biological and psychological contexts. In characterizing a trait, T, as having a biological or psychological function, one also specifies some sort of standard for T's successful functioning.

Two general ways of ascribing functions continue to dominate the biological and psychological literatures. On what I'll call "systems" accounts, the function attributed to a part of a specified system T just is the role that T plays in the system, where the system in question is delimited by research interest. On this approach, theorists delimit the system of interest S, and then attribute to the part or trait T a function on the basis of the role T plays in achieving the overall aim of S.

For instance, if I construe my cheese-grater as a system that allows me to grate cheese, then the individual holes in the grater will function to cut small pieces of cheese from the block. If I hang the cheese-grater on my wall in the bathroom, and use it as an earring-display, the small holes will function to catch individual earrings, and display them in an organized manner. These different ways of construing the system of which the small holes are parts will have serious consequences for how successfully we take the holes to be functioning. If the grater is rusty and dull, this will not necessarily have a negative impact on the earring-display system.

A systems account of color vision might result in the correspondence standard for color vision by understanding color vision as contributing to a larger system, S, where S's overall structure is such that it aims to detect a mind-independent, physical environment. If the overall aim of the visual system is specified as the detection of a mind-independent, physical environment, an aim we are free to posit, then color vision will, when the capacity is functioning properly, contribute to this system by tracking mind-independent, physical properties, such as surface spectral reflectances. The function of the part T depends on the how the system S is understood, and how S is understood depends on the parameters specified by the theorist making the attribution.

On this type of approach, we don't necessarily ascribe functions because we want to say something about why T exists. We do it because we want to explain how the part contributes to the activity of the system that happens to be of theoretical interest. As Robert Cummins puts it, "a what-is-it-for question is construed as a question about the contribution 'it' makes to the capacities of some containing system" (Cummins 2002; see also 1975). As in the color vision example, when the correspondence norm follows from a functional attribution, it is typically tied to a systems account of function.

A competing tradition makes functional attributions primarily on evolutionary grounds. The approach takes as a starting point the intuition that there is something especially explanatorily legitimate about functional explanations that invest in the evolutionary history of a trait. Functional attributions, on this type of approach, pick out what a trait is for by asking why the trait exists. Trait T has some function F only if it was favored by natural selection for doing F (Wright 1973 is the classic etiological account). Nature itself is understood as being responsible for a kind of teleology, such that traits have functions irrespective of our interests as theorists.

Functional attributions based upon what we take to be the etiological history of a trait or part can lead to conditions on the success of the capacity which can seem at odds with certain systems ascriptions. For instance, evidence from phylogenetic analysis suggests that trichromatic vision evolved as a means of increasing foraging efficiency, as it helped primates find red fruits among green foliage (evidence reviewed in Surridge et al. 2003). If we ascribe a function, and with it a normative standard, on the basis of what we take the trait to have been originally an adaptation for, then we might think the (etiological) function of color vision is something like the discrimination of objects of different biologically-relevant classes of surfaces.

Taking the function of color vision to be the discrimination of biologically-relevant classes of surfaces means that trichromatic vision that affords courser visual discrimination between classes of surface spectral reflectances could be more successful than trichromatic vision that affords discrimination among all surface spectral reflectances (Hatfield 1992a, 2003a). The success of trichromatic vision would be measured not in terms of whether it allows an organism to detect all mind-independent, physical differences, but in terms of whether it allows the organism to, e.g. forage and navigate in a maximally efficient way given the needs, goals, and environment of the organism in question. Thus, our etiological and systems functional attributions come apart in significant respects in how they entail success conditions for a given trait.

In this chapter, I am not interested in adjudicating between these general approaches to functional attribution. In fact, and though I argue against systems functions that entail a correspondence norm for perception in what follows, I think that, ultimately, we can conceive of etiological accounts as a special class of systems functions, and that the two approaches are more alike than is commonly recognized.[23] It is nevertheless against the backdrop of these more traditional functional analyses that I wish to tackle the question of normativity in perception.

In what follows, I strive to draw attention to a different way of thinking about normativity in perceptual psychology and philosophy of mind, one inspired by the work of ecological psychologists such as James J. Gibson and Egon Brunswik. I argue for the conclusion that description of perceptual capacities and organism-environment interaction is a better starting point for thinking about normativity than are either physically defined facts about the environment, or evolutionary narratives, and that an ecologically-grounded notion of normativity deserves our attention.

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[23] Traditionally, systems views are associated with a rejection of historical considerations. In fact, though, any theoretical framing of the aim of the system will result in a functional attribution in a systems framework for the part in question, even when that framing theory is etiological.

In section 2, I explore the suggestion that we may accept a plurality of normative standards as applying to perceptual capacities, and that we need not abandon the correspondence approach to make room for an ecologically-generated approach. Though I agree with the pluralist sentiment of this suggestion (a sentiment I develop in more detail in chapter 4), I argue in section 3 that we nevertheless have reason to reject correspondence as a relevant normative standard. Correspondence between percepts and mind-independent physical properties is best construed, not as a normative standard, but as a non-normative benchmark against which we can make precise measurements that allow us to better understand perception.

I turn to considerations from evolutionary and comparative psychology in sections 4 and 5, respectively, where I argue for the value of beginning from description of the visual capacity and the niche in which it functions. In section 4, I discuss the importance of evolutionary theory for making pragmatic normative standards precise, contrasting the ecological approach with the more traditional etiological one. In section 5, I discuss evidence from comparative psychology that supports the contention that percepts of a value distinct from either retinal and physical distal values can be a feature of perception for a range of sighted organisms. In the final section, section 6, I conjecture that perceptual constancy, understood as a capacity of sighted organisms, is best construed minimally, as a mere capacity to represent properties in a way that is more stable than their corresponding proximal stimulations.

If we are interested in building a legitimate philosophical theory of perception and perceptual objectivity, one that begins from perceptual intentionality, normative commitments must be made with caution. In all cases, taking descriptive facts to have normative import involves making substantive philosophical commitments about the nature or purpose of perception. Moreover, without attending to the distinction between description and normativity, it is easy to inadvertently attribute normative force to descriptive facts. Normative implications therefore must be vigilantly distinguished from descriptive facts.

2. Pluralism about normative standards

James Gibson's commitment to a stimulus-based account of perception, according to which we need not appeal to representations of any sort in understanding perception, is out of fashion, though versions of the correspondence approach to normativity he endorsed in his earlier works remains standard in perceptual psychology and philosophy of mind. As I contended in chapter 1, Gibson had idiosyncratic motivations for endorsing a tight connection between perceptual invariance and accuracy, such that successful perception is taken to involve a matching between percept and physical object property. Gibson took perception to be the direct uptake of environmental information via proximal stimulation. On this proposal, there is no room, theoretically speaking, for the resolution of an underdetermination problem, that is, for any correction or amplification of the proximal stimulation. The invariant relations available in sensory form directly specify the environmental objects perceived.

In a clear sense, then, Gibson was committed to perceptual invariance as a normative ideal. Still, he developed resources that suggest an alternative domain of normativity for visual perception. Gibson's ecological psychology emphasizes the idea that perception guides action, where action is understood in terms of the reciprocal relation between an organism and its environment. Perception is, fundamentally, a capacity that allows organisms to interact effectively with their environments. This way of approaching perception suggests a normative standard for vision according to which successful vision is action-guiding.

Gibson was deeply influenced by other theorists already thinking about the environment in terms of how it is experienced by the organism. For instance, at the center of the Gestalt account is a distinction between (1) the environment in which an organism behaves, that is, the organism's behavioral environment; and (2) the physical environment, independent of the perceiving organism, or, the geographical environment. The behavioral environment is never independent of the geographical environment (Koffka 1935, 32). Instead, it mediates between the latter and the perceiver's behavior.

Koffka illustrates the relationship between these environments using the example of a hare and a hound:

> the hare starts from a bush and runs across an open field in a straight line; the hound will follow him; when he comes to a ditch, the dog will change its running movement into a jumping movement and clear the creek. Now the hare changes his direction; at once the dog will do the same. I need not continue; what I have said will suffice to draw the inference that the behavior is regulated by the environment. Which of the two environments does the regulating, the geographical or the behavioral? From our last example one might be inclined to answer: The geographical. But suppose now that the ditch were covered by a thin layer of snow, sufficient to bear the weight of the hare, but not that of the hound. What would happen? The dog would fall into the ditch, i.e., he would not jump when he came to the ditch but would continue to run. He would, before his fall, behave in a ditchless environment. Since, however, the geographical environment contained the ditch, his behavior must have taken place in another one, namely, the behavioural. But what is true of the few short moments in which the dog stepped on the treacherous layer of

> snow, must be true of his entire behavior; he has been in that behavioural environment all along. (28-9)

According to Koffka, it is within the behavioral environment that the perceiver behaves and experiences her own behavior. Though the behavioral environment depends on the geographical environment, it can, in principle, come apart from that environment in sizable ways (see also Lewin 1951; Köhler 1938; Von Uexküll 1934).

Percepts, on this way of thinking, are not located within the organism, but are relations between the behavioral environment and the self or Ego of the perceiver. On Koffka's view, these percepts are what constitute the behavioral field, which is comprised of the Ego of the perceiver and the relations between that Ego and the objects in the behavioral environment. Insofar as each is understood as a phenomenal world that can and does come apart from the physical environment with which the organism engages, this notion of a behavioral field is similar to Gibson's conception of a visual world. For Gibson, the visual world

> can be described in many ways, but its most fundamental properties seem to be these: it is extended in distance and modelled in depth; it is upright, stable, and without boundaries; it is colored, shadowed, illuminated, and textured; it is composed of surfaces, edges, shapes, and interspaces; finally, and most important of all, it is filled with things which have meaning. (1950, 5)

This notion of a visual world, or behavioral field, is useful in thinking about the environment as it is experienced from the perspective of the seeing organism. In Gibson's later work, there is still a sense of psychophysical correspondence between percept and environment, but the environment is increasingly defined in an ecological way—that is, it comes increasingly to be defined in terms that are relevant to how the environment is experienced by the organism of interest.

For instance, in physics, scientists talk of the physical concept of matter. But in visual perception, it is difficult to deny that we interact with substances—not substance in the sense of matter, but substance as it is "connected with the complicated 'states' of matter the gaseous state being wholly insubstantial and the liquid to solid states being increasingly substantial (for terrestrial animals)" (Gibson 1982, 111; see also 1959, 469-470). Within the domains of perceptual psychology and philosophy, we ought to take a realist attitude to the environment as it manifests itself to the creature in question, rather than in terms of a physical description of that environment.[24]

Where the environment perceived is defined in terms that stem from the organism's experience, an ecological domain of normativity makes sense. Accordingly, we can

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[24] Koffka makes a similar distinction between "molecular" and "molar" levels of analysis; Koffka's distinction is sometimes taken to have influenced Gibson's shift towards an organism-oriented description of the environment, though Gibson's later emphasis on evolution surely also played a role (see Lombardo 1987 for discussion, especially chapter 14, 252).

then interpret perceptual success in terms of whether perception serves the organism, given that organism's aims and goals, etc.[25] We should care, first and foremost in evaluating perception, about what appears important for behavior, such as foraging and, more generally, continuing existence. Instead of thinking of perception in terms of systems functions or etiological functions, I want to suggest in what follows that we think of it, most fundamentally, as allowing sighted organisms to act and interact with ecologically-defined environmental properties. On this proposal, accuracy in perception will be measured, roughly, in terms of whether perception guides action effectively.

To advocate for the value of an ecological normative standard, must I reject the value of all other standards we might impose? That is, must we limit ourselves to one normative standard in attempting to understand vision? It is sometimes supposed that normative attributions are mutually exclusive. In discussing the contrast between etiological and ahistorical systems approaches to functional attribution, D. M. Walsh

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[25] Gibson liked the Gestaltists' distinction between behavioral and geographical environments because of the grounds it provides for thinking about environmental objects as having meanings that depend on the interests of perceiving organisms. Because those valences can change depending on, for example, the appetites of a perceiver, they are well-suited to the suggestion that a behavioral field is particular to an organism. In his later work, however, Gibson critiqued Koffka for insisting upon two conceptually distinct environments. It was important to Gibson that the visual world is also the single, shared world, whereas Koffka was less invested in this identity relation (see Gibson 1971; Henle, 1974). Gibson went on to develop an account of the environment on which objects have ecologically relevant meanings ("affordances,") but where such meanings do not change relative to perceivers (1979, e.g. 139). For discussion, see (Heft 2001, esp. 168-9, and chapter 6).

writes, for instance, that there is “a reciprocal animus between exponents of these two types of theories, a general consensus that if the aetiological theory is right then theories incorporating ahistorical function are wrong, and vice versa” (Walsh 1996).

We can resolve certain discrepancies between the results of competing normative standards by acknowledging a plurality of such standards. This is the strategy of many that advocate for the correspondence norm for perception. For instance, while holding that a standard of matching between physical object properties and percepts is the principle sort of normativity to be considered in theorizing about perception, Tyler Burge notes that there are alternative ways to think about normativity in vision. In particular, a second domain of normativity—normativity that stems from biology—deserves acknowledgment, even if the notion of accuracy, properly understood, must be reserved for the correspondence domain of normativity.

In discussing representation and its norms, Burge distinguishes norms that stem from biology (including evolution) and the norms of representation. Representational norms are not biological norms, because representation is a kind distinctive of psychology, a discipline that is not reducible to biology. Burge defends the importance of the psychological norm (correspondence) by “focusing on actual explanation in science” (Burge 2010, 291). Specifically, Burge argues that, in the case of psychology, explanation “of the formation of states that can be representationally successful or unsuccessful—perceptually accurate or illusory—is the central organizing theme of the science" (298).

Accuracy, within the explanatory paradigm particular to psychology, must be understood as a semantic, as opposed to practical value, for explanations that make use of the ideas of accuracy and inaccuracy in perceptual psychology have nothing to do with practical value, or how useful a visual system is to the organism under study. For Burge, "one cannot assimilate issues of accuracy and inaccuracy to issues of practical use. Functioning to be accurate is not in itself a biological function, at any level. Biological functioning is not a semantical matter" (301-302; see also Burge 2003, especially sections 1 and 2; Cohen 2007). Correspondingly, the semantical norm does not come from evolution, for Burge:

> Evolution does not care about veridicality. It does not select for veridicality *per se*. Being fitted to successful evolution is a matter of functioning well enough to contribute to survival and reproduction. Well enough often coincides with veridicality. But even coincidence is not identity. Biological explanations of function explain a different feature of reality than do explanations of veridicality and error. Biological explanations of sensory registration and function, on one hand, and psychological explanations that center on accuracy, on the other, are different types of explanation….Explaining the way veridical and non-veridical representational states arise, given proximal stimulation, is a

> different explanatory enterprise from that of explaining any states in terms of their *biological* functions—their contributions to fitness. So biological explanations cannot reduce explanations whose point is to explain accuracy and inaccuracy of representational states. Since what they explain is different, the former cannot take over the job of the latter. (303)

It is the semantic norm that helps to "make psychology independently interesting" (303) on this view. Moreover, the norm is supported, according to this line, by "the system and specificity found in the objectifying capacities present in the perceptual constancies" (Burge 2010, 411). Perceptual constancy, understood as a capacity for invariant representation of physical, environmental features, serves, then, as a kind of evidence for the correspondence norm. It is therefore problematic for Burge that we do not have a capacity to track object properties invariantly (more on this below).

I do not think that psychology needs to appeal to a correspondence norm for psychology to be interesting. In fact, I think it's more interesting when we embrace that this is not a norm to which it is worth subscribing. Though I am all for acknowledging a plurality of normativities in perceptual psychology and philosophy of mind (see my chapter 4), I think we lack good motivation to endorse the correspondence norm as relevant in this context.

3. The problem of widespread misrepresentation, and two types of standards distinguished

It is widely recognized in perceptual psychology today that perception is rarely if ever fully constant. As we move around in our environments, object properties appear stably, but not invariantly.[26] Part of my office wall might be illuminated directly by sunlight (I am imagining that my shared graduate student office has windows!), while part of it is only indirectly illuminated. Though normally I will have no trouble judging that the two areas are painted with the same paint, I will nevertheless be able to distinguish between them because of a difference in how the two areas look. In the case of shape perception, a saucer seen at a severe angle will look different, in some sense, from a saucer seen from above such that a circle is projected onto the retina.

As I discussed in chapter 2, many theorists attempt to account for these purported "differences" in appearance—between the area of wall in direct light, and the area in indirect light, for instance—in terms of the representation or detection of other environmental features, such as the differences in the illuminations of the two areas of the room. According to this line, the two areas look different because the visual system is also representing the illumination present in the two different areas. Even though

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[26] See, for example, (Joynson 1958a, b) (Arend Reeves 1986), (Lucassen and Walraven 1996), (Foster 2011), and section 4 of chapter 1 of this work.

the visual system represents the mind-independent property constantly (invariantly), the two areas are discriminable because the visual system also represents the difference in illumination. Perception is nonetheless successful when it represents the mind-independent, physical environment as it is.

Perceptual psychologists understand that visual perception in humans is rarely fully constant, and one may even argue that little hangs on the philosophical issue for the practice of perceptual psychology (though see the penultimate section of chapter 4, below). However, accepting widespread misrepresentation in human visual perception, let alone across other types of non-human animal perception, is a costly result for a philosophical theory of veridicality. If perception frequently involves intermediacy, the unattractive proto-epistemic implication must be that humans rarely perceive the world veridically. If we almost never enjoy the relevant matches in perception, then in general we typically fail where we ought to succeed to have perceptual access to a mind-independent world.

Moreover, if we count almost all percepts as misrepresenting the environment, then it becomes more difficult to make an in-principle distinction between perception that is "normal" for a human trichromat, and perception that is illusory or hallucinatory in our more ordinary uses of the terms. We are confident calling certain paradigm cases of misperception illusion (seeing a pink elephant where there is a grey elephant, for instance). The notion of illusion becomes considerably more fraught when we must also count almost all our visual experiences as illusory.

We must seriously consider what is meant by the notion of accuracy in this context, if that standard is never achieved in ordinary cases. In the very least, if perception is rarely or never accurate, according to the correspondence norm, some of the intuitive appeal of the norm must be undermined, at least for philosophers. If this is right, the correspondence norm fails to model a measure of value that is relevant in perceptual psychology when it comes to understanding the performance of visual systems. Still, it seems that we can take the norm to be successfully modeling something. How should we interpret the correspondence norm if this is right; that is, in what sense can we take the correspondence standard to be a benchmark?

We can begin by distinguishing between two relevant senses of a "standard" as the notion might be applied in perceptual psychology. Standards, understood broadly, are used regularly in science and in ordinary life. I sometimes use a ruler to draw up a calendar (this is one of my monthly rituals, though it probably will be lost on my more technologically advanced colleagues). When I use the ruler, I use the "standards" numbered and marked into the edge of the aluminum to make each column or row the same size (and, of course, I spend way too long fastidiously making the measurements as exact as possible, so I get precise results).

My ruler provides me with a set of markers, a set of benchmarks or points of reference, against which I can make exact my spatial engagement with the construction paper that I'm using to make my calendar. The ruler provides me with a set of standards, where these standards can be understood as markers or benchmarks, rather than as ideals or aims. It is useful to rely on the points of reference as a guide; they play a role in the speed and exactness with which I am able to make my calendar. Still, it seems inappropriate to think of these points of reference as normative standards in this scenario, or as prescriptive in any sense, even if they serve as benchmarks. Use of the ruler in the scenario I describe, I want to suggest, involves appeal to *merely descriptive standards*.[27] In another more clearly normative sense, we take standards to stand for aims or ideals, to be *prescriptive*. We have standards for what can pass for a dissertation in the philosophy department, for instance; these are benchmarks, like the marks on my ruler, but they are also value-laden in a richer sense.

The correspondence norm for perception is more like the former type of standard: in the case of perception, it seems inappropriate to think of a percept-distal property matching as a normative standard in ordinary scenarios, whereas it is helpful to think

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[27] As we should expect from the system-function framework, some scenarios will render the same markings normatively important. For instance, if I am driven by the goal of making each column exactly an inch and a half wide, then the line marking an inch and a half comes to stand, in some sense, as a normative standard or ideal in this scenario.

of the correspondence norm as providing us with a relevant point of reference for measuring and understanding perceptual capacities. We can take the percept-distal property matching as a standard that facilitates and makes precise claims about how close the percept comes to matching mind-independent, physical values without taking it to stand also for a normative, that is, prescriptive ideal defining successful perception.

This practical advantage of using the scale helps to account for the fact that it flourishes as a tool in vision science. As a tool, though, the standard is merely descriptive, and non-normative. To assume that there is an important sort of normativity built into the benchmark is to make a substantive (and in at least many cases unwarranted) additional claim. Using psychophysical methods, for instance, we can measure the degree to which appearances are constant—that is, the degree to which percepts approximate a mind-independent, object property match. But these results will not tell us automatically about whether that percept successfully presents or represents the environment.

Because the notion of "accuracy" is deeply, if not analytically, normative, I reject Burge's restriction of the term to percepts that meet the correspondence norm.[28] The

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[28] One might reply, here, that "accuracy" can be used in a distinctively non-normative sense. If so, it avoids the worry I am raising. However, I am skeptical that the term can be appropriated in this way,

issue is terminological, here, so I will not belabor the point. It is worth noting, however, that even if we take the standard to be normative in the sense favored by Burge, denying my contention that the correspondence standard for perception is a merely descriptive standard, it is unclear why this norm will be interesting except as providing us with descriptive facts that help us to measure and compare visual capacities. In the very least, it is highly dubious whether this should be the primary sort of normativity to which we attend in thinking about the nature of perception.

As the history of psychology teaches us, a full descriptive account of any visual capacity will be enormously difficult to achieve. I imagine that this is in part why the empirical value of the correspondence standard is indisputable. According to Koffka, the fact that this scale (as articulated in the Thouless and Brunswik ratios, for instance) doesn't capture within its primary range the phenomena of perceptual over-constancy, renders it useless as a tool for comparing the degree of perceptual constancy across modalities. Koffka worried that the standard it implies is artificial, and therefore stipulative.

In contrast with Koffka, I want to suggest that there is nothing inherently wrong with the scale as a measurement tool. It seems evident, for example, that the scale provides a

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and truly divested of its normative baggage (and of whether it can really come apart from that baggage at all).

metric against which we can compare measurements within a single modality, for a single perceiver, or across perceivers of different types. The scale can be thought of as standardizing appearance measurements for the purpose of intersubjective comparison and prediction. It offers a straightforward way of describing the degree to which organisms of a range of types perceive in similar or different ways, as in phylogenetic comparisons, or diagnostic purposes in veterinary pathology. In using it, we simply must keep in mind that it is a construct, and without normative purchase. We can recognize the correspondence standard as a useful benchmark while simultaneously denying that perceptual normativity is primarily about detection of a mind-independent, physical environment.

As philosophers, it is worth treading carefully in this context. Many of us purport to be trying to understand the normative dimension of perception. In this section, I have argued against the received view for understanding normativity in perception. Though we shouldn't count on having full accuracy all the time, we should be suspicious of a theory that makes it virtually impossible for us to see accurately. I also distinguished between prescriptive and merely descriptive standards in perception. The philosophical risk comes not in measuring constancy, but in attributing to those measurements normative force.

4. The value of description, and considerations from evolutionary psychology

A commitment to the idea that objectivity involves a matching between percept and physical object property entangles us in the problem of widespread misperception, or misrepresentation. Though Burge does not take the correspondence norm to stem directly from the course of evolution, many do. For instance, some claim that, while widespread misperception may seem to be an unattractive philosophical consequence of an appeal to the correspondence norm, we should expect imperfect capacities in creatures that are the products of a messy evolutionary process.

For instance, in (Kraft and Brainard 1999) the authors explain that if the achievement of constant perception is a difficult computational problem, then it is "not surprising that the visual system accomplishes it only approximately" (311). Similarly, as Foley et al. (2004) put it, our space perception system is "not very elegantly designed, nor is it very accurate, but it is good enough to keep most of us alive most of the time" (154). Evolutionary processes virtually never produce ideally adaptive traits, so widespread inaccuracy is not only to be accepted; it is to be anticipated. Color vision might almost never be accurate, but enough of the time it is accurate enough to serve (at least some of) our behavioral goals. The assumption here is that perceptual correspondence is best for organisms—a maximum amount of information about our surroundings will be most effective in guiding our actions.

But this assumption is mistaken. It is not helpful to humans to perceive radio waves. If we did perceive this forms of electromagnetic energy, it's suspect that it would translate into any behavioral advantage. Moreover, the presumed connection between the correspondence norm and evolution emphasizes the complexity of our evolutionary history in order to hold on to a normative standard for vision that makes no sense as an evolutionary possibility in the first place. Specifically, we should reject the assumption that full correspondence between percept and physical surface property would be optimal, even if it were possible. It is reasonable to posit that perceivers adapted to enjoy appearances which are more stable than their corresponding proximal stimulation, thereby ensuring that the same object under typical variations in lighting conditions offers appearances that are similar to one another. Such stability would have afforded organisms enormous behavioral advantages.

Coming up with a story for why full constancy would be optimal for vision is a much more difficult project. In at least many cases, the fine-grained surface properties of objects are irrelevant to our interests in interacting with those objects. For instance, if full constancy of the sort envisioned by physical information theorists were to obtain, there would be a different hue for each of an infinity of surface spectral reflectances. The normative standard that the view provides for full or perfect color vision is therefore *ad hoc* in an important sense. The above response assumes the legitimacy of the inappropriate normative aim it is summoned to protect.[29]

Theorists drawing a tight connection between evolutionary history and the correspondence norm likely would be quick to respond to this criticism by noting that appeals to evolution are always tenuous to some degree. So even if we can be confident that selection would never yield a visual system that fully meets the correspondence norm, we have to worry also about appeals to evolution that ground etiological functional attributions. This concern stems from facts about the complexity of the evolutionary process. The classic articulation of this worry about etiological normative accounts is in a paper by Gould and Lewontin (1979), in which the authors expound their objection to what they call the "adaptationist programme."

Gould and Lewontin seek to establish that evolution is a much more complicated process than we tend to acknowledge. A number of evolutionary mechanisms may be responsible for which features organisms acquire on an evolutionary scale, and natural selection is merely one of these factors. Other factors include genetic drift (roughly, the effect of chance on which genes survive in a small population), sexual selection,

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[29] The point is corroborated by a series of simulations run by Donald Hoffman, which show that formalizations of percepts meeting the correspondence norm can be driven to extinction by alternative strategies tuned to utility rather than correspondence. See, for instance, (Hoffman 2009) and (Mark et al. 2010).

and genetic linkage (the tendency of certain genetic sequences to be inherited with others).

These factors can each impact the traits exemplified by a population. If all sorts of evolutionary mechanisms can be involved in the evolutionary history of organisms, we need to rethink our confidence that the trait in which we're interested is even primarily the result of natural selection. In a recent paper (Lloyd 2015), Elisabeth Lloyd extends the point to argue that, when we're in the game of doing historical functional analysis, we ought to be asking "does this trait have a function?" before we ask about what the function of the trait might be. We must resist treating evolution as a simple process, and instead acknowledge that we cannot be sure whether a trait even is a straightforward result of natural selection. The point is critical given that, in the case of any trait, we are typically subject to overwhelming epistemic limitations regarding what we know about why the trait emerged (see also Mach 1959, 80-2; Garson 2015, especially chapter 3).[30]

At its root, the concern from evolutionary complexity is a normative one: if we assume that natural selection was straightforwardly responsible for the traits we observe, then

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[30] In cognitive science, appeals to natural selection as explanations of function can be especially challenging. In this domain we are often dealing with broad and ill-defined capacities, such as rationality or memory, which in all likelihood evolved in tandem with a range of other cognitive capacities (for discussion, see Donald 1991, chap. 1).

we risk assuming traits do operate in optimal or relatively optimal ways, given the environment in which the organism is embedded. In Gould and Lewontin's terminology, the adaptationist programme is Panglossian—if we focus on immediate selection for local conditions, we treat the evolutionary process as one that generates (or at least comes close to generating) the best possible trait for the environment in question, and we tend to ignore a range genetic and environmental constraints on natural selection.[31]

Where we think a trait is primarily the result of selection, there are often competing hypotheses about why a trait emerged. In comparative color vision, for example, there are different theories about why we or other seeing organisms have trichromacy, the presence of both long and medium wavelength-sensitive cones in addition to short wavelength-sensitive cone. According to one major evolutionary hypothesis, trichromatic color vision in primates is the evolutionary result of sexual selection, as it fostered communication between conspecifics via skin color signaling (Changizi et al. 2006). According to a competing evolutionary hypothesis, trichromacy occurred in primates because it afforded an enhanced capacity to see ripe fruit against surrounding foliage.

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[31] Use of the name "Pangloss," here is a reference to Voltaire's character in *Candide* (1759), a Professor who takes our world to be the best of all possible worlds. Voltaire uses Pangloss to satirize Leibnizian optimism.

According to Ellen Gerl and Molly Morris, phylogentic analysis reveals that the fruit-in-foliage hypothesis is superior to the pigment-change hypothesis as a view of why primates have trichromatic color vision. In this case, we can use phylogenetic evidence to help us adjudicate between evolutionary explanations of a trait. Phylogenetic analyses reveal that trichromatic color vision is an older evolutionary adaptation in primates than is pigment change (see figure 3.1). So we have reason to prefer the fruit-in-foliage hypothesis.

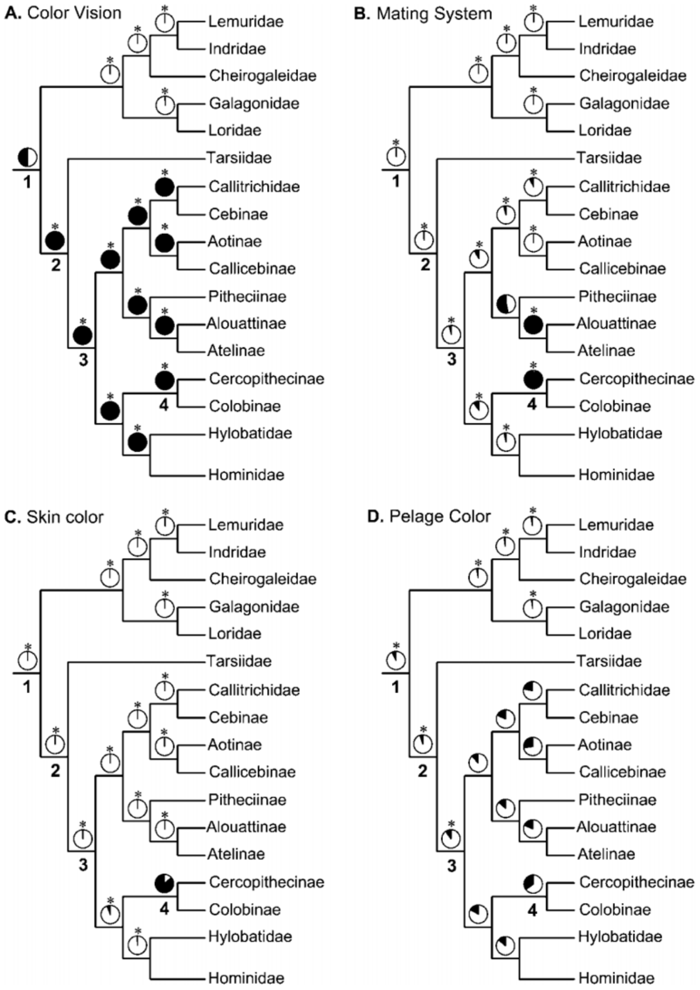

Figure 1: Ancestral-state reconstruction using maximum likelihood and the stored Mk1 model (i.e., equal likelihood) implemented in Mesquite (Maddison and Maddison 2005). Areas of pies indicate relative support for ancestral states. *A*, Color vision: presence of trichromatic color vision indicated in black; dichromatic/monochromatic indicated in white. *B*, Mating system: gregarious (multimale/multifemale, polygynous) indicated in black; nongregarious (solitary, monogamous) indicated in white. *C*, Skin color: presence of red skin indicated in black; absence of red skin indicated in white. *D*, Pelage color: presence of red pelage indicated in black; absence of red pelage indicated in white. Pie charts with asterisks indicate significant support for ancestral-state reconstruction at that node.

Figure 3.1. From (Fernandez and Morris 2007).

However, as Gerl and Morris note, the fact that phylogenetic analyses reveal that trichromatic color vision in primates pre-dates pigment change does not mean that trichromatic color vision is irrelevant for intraspecific signaling. Rather, it is likely that

> the red traits took advantage of a preexisting sensory bias to detect red. Mutations that made already red traits like skin more visible and attractive to potential mates would have been passed on more frequently…. In other words, red/green color vision was a preexisting sensory bias that male or female primates could have taken advantage of, thereby enticing potential mating partners to pay attention to them. (Gerl and Morris 2008, 480)

Though we can discover reasons to take certain evolutionary hypotheses to be likely, we do well to remember that these hypotheses remain, in most cases, at least somewhat tentative. Even in the color vision case, for which there is considerable evidence, it could be that a range of evolutionary mechanisms contributed to the current presence of trichromacy in primates. Given a renewed commitment to epistemic modesty when it comes to evolutionary explanations, talk of anything like optimality will be challenging, if not impossible (for further discussion, see Chirimuuta 2015, 99, 180; Mausfeld 2015). We can use comparative phylogenetic evidence to narrow in on our best evolutionary narrative about what a trait is for. We can also use molecular genetic analyses, postmortem analyses, and behavioral studies. Ultimately, however, in doing so we are almost always in the business of pitting tentative evolutionary hypotheses against others.

Exaptations raise a related set of concerns about etiological functional attributions. Exaptations are useful traits or structures that were selected for some specific use x or were not the result of natural selection at all, and which have since been co-opted for a fitness-enhancing use that is different from x. For instance, late Jurassic fossils suggest that the earliest known birds were feathered but not capable flyers. It is therefore proposed that feathers were originally selected for insulation (thermoregulation), rather than flight (Ostrom 1979; Bakker 1975; references are from Gould and Vrba 1982). Cases such as this one present a challenge to traditional etiological accounts of function, because feathers aid birds in flight, even if we suspect they were not the result of this fitness advantage. Even if we can be sure that T currently serves a purpose for some organism, there is no guarantee that that same trait evolved in the same context, or for the same use (for accounts that attempt to amend the etiological approach to avoid issues relating to exaptations, see, e.g., Schwartz 2002, Godfrey-Smith 1994, Baum and Larson 1991).

Identifying etiological, biological functions is a difficult project. As Peter Godfrey-Smith writes,

> in some cases, traits are, as a matter of biological fact, retained largely through various kinds of inertia. Perhaps there is not constant phenotypic variation in many characters, or new variants are eliminated primarily for non-selective reasons. That is, perhaps many traits around now are not around because of things they have been doing…. If functions [in the historical sense] are to be understood as explanatory, there is no avoiding risks of this sort. (1994, 356-7)

To complicate matters further, plasticity and niche construction are turning out to be remarkably significant factors in determining which traits organisms manifest, and can in turn play important roles in phylogenesis (Barker 2015). Moreover, overestimating the force of evolutionary hypotheses at the cost of overlooking the role of these powerful mechanisms can be harmful (Lloyd 2015, Barker 2015, Fine 2016).

There are therefore numerous reasons to avoid entangling ourselves in commitments to functional accounts that bet upon evolutionary hypotheses. Given the difficulties of pinpointing evolutionary histories, etiological functional analyses are also threatened, just as are correspondence analyses, by what we know about evolution. Though there are going to be scenarios in which it's helpful to talk about etiological functions, I think in many cases, maybe especially those having to do with perceptual and cognitive capacities, attempts to read normativity off evolutionary history are going to confuse the issues at stake more than they clarify them.

It can seem tempting to abandon all appeals to evolution under these circumstances. But granting that we do best not to think of normativity as falling straightforwardly out of what we take to be evolutionary history, evolutionary hypotheses can help to improve our normative thinking in a range of ways. Different organisms have different needs and interests, and, often consequently, have different perceptual systems. Evolutionary narratives have the potential to remind us that organisms are fitted to their environments in many respects, even if that fit is limited by the evolutionary process and changing environmental conditions. Evolutionary hypotheses, then, can help us to think creatively about what a trait systematically affords an organism, by encouraging us to focus of systematic utility, as James put it, “in shaping our reactions on the outer world” (James 1984, 11). When we ask, for example, “was this trait adaptive, and if so how might it have been adaptive?” we reflect on what we know about the history and nature of the relation between organism and environment, something that can help us, not to concoct a theory about why the trait is present, but to think about how best to make precise the sense in which the capacity guides action.

Evolutionary hypotheses can play an important role in restricting the normative domains to which it makes sense to appeal. Asking whether a normative standard to which we may want to appeal in the analysis of a trait is evolutionarily plausible, for instance, can help us decide whether it is worth considering, given our theoretical interests. In such scenarios, evolutionary narratives serve more as a means of checking functional attributions than as a pure basis for those attributions. That is, they can help us to rule out poorly conceived hypotheses, and to come up with more innovative ways of thinking about functional attribution.

In this sense, evolutionary hypotheses are one form of description, and it would be surprising if description couldn’t help us get a clearer sense of how to begin approximating meaningful norms for perception. We can pair evolutionary narratives with an investigation into the niche of an organism, and think critically about what fosters efficient interaction with that niche for the organism of interest. Normativity isn't a simple problem, but description will give us a better start than physics. In the case of evaluating a capacity for perceptual constancy, for instance, description won't be sufficient for the establishment of norms for perception. Full perceptual constancy may be helpful to one type of perceiving creature, while another creature is conceivably better served by less.

Deciding whether a creature is well-served by its capacities in an ecological scenario isn't simply a matter of analyzing the creature's capacity for stability. Rather, one needs to ask questions about whether (and not only how) the organism's needs would be better met by its environment were an increase in stability present. However difficult it might be to assess, the normative concept of performance is more appropriately associated with this type of pragmatic interest in creatures and how they see. That is, the normativity associated with a visual capacity is best understood in relation to how well that capacity serves the organism given its environment—how effective the capacity is. Understanding why a type of creature has a capacity can provide important clues as to the degree to which the capacity serves the organism.

The suggestion that perceptual normativity is best understood in terms of what guides action is not new. As Helmholtz once wrote about normativity in perception,

> To expect to obtain an idea which would reproduce the nature of the thing conceived, that is, which would be true in an absolute sense, would mean to expect an effect which would be perfectly independent of the nature of the thing on which the effect was produced; which would be an obvious absurdity. Our human ideas, therefore, and all ideas of any conceivable intelligent creature, must be images of objects whose mode is essentially codependent on the nature of the consciousness which has the idea, and is conditioned also by its idiosyncrasies. In my opinion, therefore, there can be no possible sense in speaking of any other truth of our ideas except of a practical truth. (Helmholtz 1962, v.3, 19)

The notion of a semantic (correspondence) norm for perception is misplaced. What serves the organism—practical normativity, or "practical truth"—will be a much better gauge for understanding the success of perceptual capacities.

Recently, Mazviita Chirimuuta has developed the idea that practical value is a significant normative aspect of color perception. On Chirimuuta's proposal, normativity is closely aligned with use. Given our ordinary goals of getting around in the world and recognizing objects, dim lighting in which there is little to no color constancy, as in the cloakroom of a dimply lit nightclub, is typically a recipe for misperception, where misperception is understood as “not seeing things as well as we are accustomed to—not seeing well enough to perform our usual visually guided tasks without difficulty” (Chirimuuta 2015, 180). Interestingly, though, such a case *need* not count as misperception, for Chirimuuta:

> if your practical aims shift radically, this can change the criteria for misperception. Imagine that you are tired of your burgundy coat and wish you had bought a more neutral looking one, for example, a conservative dark grey. But because you are too law-abiding to deliberately go home with another person’s coat, it serves your unconscious desires if you find yourself in a situation in which your coat is indistinguishable from a conservative, gray-looking one and make an “honest mistake” in swapping coats. Relative to your idiosyncractic interests, your failure to visually discriminate the coats would not count as a case of misperception. (181)

A momentary shift in a perceiver’s goals can change whether perception counts as veridical or inaccurate, for Chirimuuta.

I like that this account employs a broad sense of “use,” so as to include, for example, human preferences and goals, as opposed to simply that which increases fitness. However, I think we do better to think of normative standards as applying in a more systematic way across perceptual scenarios, such that we can think of them as characterizing the current and reasonably consistent relation between an organism and its environment. I elaborate this point (and Chirimuuta's motivations) in further detail in chapter 4.

Here, it is worth noting that a more substantive systematicity requirement for normative standards will allow us to better integrate into our normative thinking the idea that evolution can help us determine which biological functions we do best to attribute in a particular case. There is much that is reliable about our environments, and in the interactions between organism and environment, and I take these reliable features and relations to be a major part of why it is interesting to understand perception at all.[32] If we abandon them in order to prioritize the idiosyncrasies of the particular goals of an organism at any particular time, it becomes difficult to make any lasting or useful generalizations about the perceptual capacity. This concern is encouraged by recent efforts to understand perception as an embodied or situated capacity (e.g. see Thompson 2010; Chemero 2011; Shapiro 2011).

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[32] For instance, in Donald Hoffman's (2009), Hoffman discusses the males of a species of Australian beetle. These males can't discriminate between discarded brown beer bottles, which have come to be a regular fixture of their niche, and the brown cases of females of the same species. Because the males prefer to (attempt to) procreate with the larger, shinier bottles, the species as a whole is threatened. The visual systems of the males are not guiding action effectively, even though they may have in the environment in which the beetle evolved (a niche lacking beer bottles). There is an important sense which the visual system of the beetle is systematically underperforming—it is confusing the beetle to the point of extinction.

A systematicity requirement leaves room for the possibility of long-term changes in perception, such as physiological deterioration or perceptual learning (see Gibson and Gibson 1955; Connolly 2014). Still, in part because of the systematicity recommendation, ecological, action-guiding norms for perception will in some cases look a lot like etiologically-grounded norms. However, the action-guiding framework affords greater flexibility than does the etiological approach. Normative assessments of a trait will not be limited to the application of a single "correct" or "proper" normative standard, on my suggestion. Rather, functional attributions can change as niches change in systematic ways, or as new functions emerge for pre-existing traits.

In many cases, of course, perception will ground perceptual judgments that are useful but also true or false (and so to which a correspondence norm applies). For instance, a carpenter frequently relies on the knowledge that a tape measure retains its physical length across perceptual contexts. In using the tape, the carpenter must perceive the markings on the tape, and these perceptions make possible true beliefs about the environment. Regardless of any phenomenal changes in how particular sections of the tape look up close or at a distance, the carpenter uses the tape measure to form perceptual beliefs about physical sizes that may be true or false.

At least in many cases, a correspondence norm is fruitfully applied to perceptual judgments or beliefs. However, percepts should not be evaluated primarily in terms of their correspondence to physical, environmental facts. On the pragmatist, ecological approach to normativity I've juxtaposed with the etiological and systems approaches, the functional attributions we make should be evolutionarily reasonable, grounded in the notion of useful action, and systematic in a way that takes seriously the reliability of environmental circumstances.

5. Evidence from comparative psychology

In what sense could intermediacy be a feature of perception? In this section, I turn to some examples from comparative psychology that help to illustrate the contention that we ought to look to description as we develop norms for vision, even if descriptive results strain the plausibility of the correspondence norm for perception by entailing widespread misrepresentation on that framework.

It is well known that different visual capacities reflect different ecological situations, and different behavioral patterns among organisms. Bees, for instance, tend to choose flowers of the same color across spectrally diverse conditions.[33] This holds in particular for flowers whose colors fall within a certain area of bee color space, a fact explained by

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[33] Curiously, a number of insect pollinators, including bees, will limit their foraging to a single flower type, even given a range of available flower types. Some researchers have proposed that, in doing so, such insects are exploiting improved foraging efficiency (Darwin 1876; Chittka et al. 1997). It is easier to see how the tendency benefits the flowers. (The loyalty that bees show to a specific flower type is referred to in the literature as "flower constancy").

the fact that bee colors which involve significant ultraviolet reflectance are less stably perceived than bee colors which lack significant ultraviolet reflectance. As Dyer (1998) puts it, "the correction is relatively poorer for bee colours… [which] are relatively rich in ultraviolet (UV) reflectance" (446). This is likely tied to the fact that ultraviolet-colored flowers make up a very small percentage of the world's flower populations (Chittka et al. 1994).

It should be obvious from what I've said so far why I disagree with Dyer's labelling of the bee percept in these cases as the result of a failure to make the relevant "correction." It is unclear why we should think of the bees' color constancy capacity as limited, or deficient, when it comes to seeing ultraviolet colors, given that bees almost never encounter ultraviolet-reflecting flowers in their environments. The capacity that would be hypothesized as lacking here, according to the correspondence norm, is one the bees never, or almost never, need to use. In contrast, measuring success on the basis of how well the visual capacity guides action does not require that the bee represent all spectral surface reflectances with the same degree of stability. Measurement of the success of the capacity shifts from a model according to which detection of the mind-independent world is the aim, to a model according to which success is responsive to a range of factors, including the bees' goals and environment.

More than any other class of vertebrates, birds are dependent on vision (Jones et al. 2007; Hodos 2012). Among even closely related species of birds, differences in ecological goals correlate with significant differences in visual abilities. For instance, among diurnal raptor species of similar size, differences in foraging strategies tend to be reflected in differences in visual capabilities. Harris's hawks, which pursue mobile prey, and black kites, which take immobile prey, differ in visual acuity such that pursuit of immobile targets is correlated with greater acuity, suggesting that greater acuity resulted from greater reliance on immobile (and so, harder to detect) prey (Potier et al. 2016; see also Martin and Portugal, 2011).

Many raptors have much greater visual acuity than humans. Amazingly, for instance, an eagle can detect an insect 0.23cm long under superb viewing conditions from 35 meters up (approximately the height of a 10-story building). And, at least among many types of raptors, movement of the target can allow for detection of an even smaller object. Such acuity is partially explained by the typically large tubular eyes of raptors, creating large retinal projections, and the densely-packed photoreceptors in their retinas (Gaffney and Hodos 2003). Impressive acuity alone does not challenge the model of veridicality according to which the percept, when accurate, is reducible to facts about the geometrical relation between the bird and its physical, mind-independent environment.

What is more problematic for the standard correspondence approach to representation or presentation in visual perception is the raptor's fovea (called a *convexiclivate fovea*), a deep convex depression in the retina of the eye where there is the highest density of photoreceptors. In raptors, the fovea is not shallow as it is in primates, but is a deep depression with steep walls that bulge (see figure 3.2) (Hodos 2012; Fite and Rosenfeld-Wessels 1975). Some suggest that the raptor's fovea works as an internal telephoto lens, an optical element that projects a magnified image on the receptors at the center of the fovea, an area responsible for the center of the field of vision. In a human-sized falconiform eye, for instance, the magnification factor at the center of the field of vision is estimated to be approximately 1.45 (Snyder and Miller 1978; Hirsch 1982).[34]

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[34] Vertebrates are not the only class of organisms in which deep fovea create magnification effects. Similar magnification effects are well-documented in the eyes of jumping spiders (*Salticidae*), for instance (Williams and McIntyre 1980).

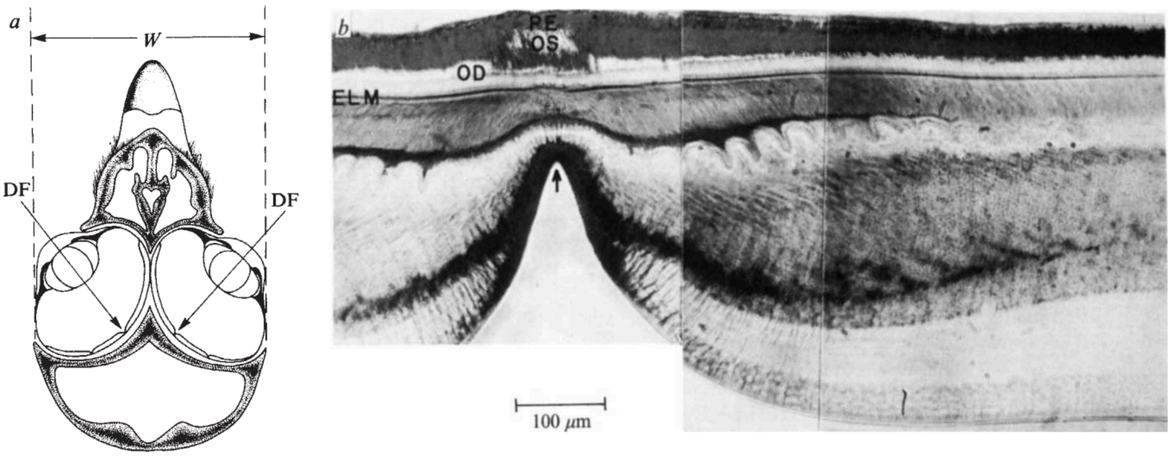

Fig. 1 *a*, Schematic of an avian eye viewed ventrally, illustrating the relative position of the deep or nasal fovea (DF). The figure is adapted from the hawk *Buteo latissimus*[14]. *W*, the head width, approximately equals twice the axial eye length *L*. *b*, Unstained 10-μm thick section of glutaraldehyde-fixed retina of red-backed hawk in region of deep fovea. Section photographed using interference contrast. Increasing darkness indicates higher refractive index. Arrow indicates concave region of foveal pit which we hypothesise may function as a diverging optical element to project magnified image on receptors at centre of fovea. Note that *n* is uniform between internal and external limiting membranes outside of fovea on extreme right of figure. Dark densities sclerad to ELM are the result of pigment and do not necessarily relate to *n*. ELM, external limiting membrane, OD, oil droplets; OS, outer segments; PE, pigment epithelium. Scale bar, 100 μm.

Figure 3.2. From (Snyder and Miller 1978).

As in the bee case, the lack of stability that results from changes in eye position must be counted by the correspondence norm as imperfection. Yet, the deep fovea of the raptors offers the birds an ecological advantage. Profound acuity from great distances allows the birds to forage in superior, more efficient ways given their ecological environments. The norm we take to govern the performance of the visual capacities of these creatures should be tied to the actions they take. Variations in degrees of constancy resulting from the magnifying effect of the deep fovea are best counted as an advantage for the birds.

Some theorists have proposed systematic variations in constancy in normal human vision, and it may be that these too are more fruitfully understood as useful variations. For instance, psychophysical evidence suggests that distance is compressed in phenomenal space, such that phenomenal size varies systematically as distance increases (Hatfield 2012; see also chapter 1, above). Systematic discrepancies between spatial aspects of the percepts and spatial aspects of the mind-independent physical environment could be important to the successful navigation of our environments. According to such a proposal, intermediacy would be indicative of a kind of phenomenal partiality for ecologically-relevant parts of the physical environment, those parts that are physically proximate to the perceiver.

To capture the possibility that discrepancies between physical space and visual space could be beneficial to the organism—that we need to distinguish between behavioral and geographical environments, we might say—it seems clear that our most viable norm will depend in an important respect on the type of organism being considered, what kinds of processing costs the system can manage, the environment, and more. A richer understanding of the usefulness of percepts in a particular type of organism will depend, however, on having a clear descriptive understanding of the capacity in question. Unfortunately, the difficulties involved in finding a descriptive account of any single perceptual constancy in a particular type of creature are numerous. Consider, for instance, the fact that constancy does not necessarily fluctuate in a linear, or even necessarily systematic way. Holaday (1933, 463), for example, suggests there is an orthoscopic distance for viewing objects (according to this study, between 2 and 4 meters), a distance from which objects come closest to appearing to be the sizes they are known to be. In (Stefanucci and Geuss 2009), the authors find that even temporary changes in body dimensions can affect the perception of aperture width.

Many have likewise emphasized certain daytime illumination conditions as orthoscopic in color perception (see e.g. Katz 1911; Kelly and Judd 1976; Hatfield 2003a). (For problems associated with appealing to standard conditions in developing an account of color perception, see Hardin 1988, 67-76; but see also chapter 4). The project of positing any quite exact descriptive account of constancy, even within a particular modality, will inevitably be a difficult one. Additionally, a number of more fleeting factors are known to have substantive impacts on the kind of constancy achievable in a given context. Moreover, motivational and attitudinal facts can impact the degree of constancy obtained.

6. Perceptual constancy, understood as a capacity

Some questions about perceptual constancy, such as about the pervasiveness of intermediacy, or about the conditions under which size, color and shape appearances are more or less stable and why, should eventually be resolvable by empirical investigation. The question of how to think about perceptual constancy, understood as a capacity, however, presents us with distinctively philosophical issues. If perception is a matter of an intentional relation with a distal object, and if it is in virtue of constancy that our perceptual experiences are intentional, then constancy will be a capacity at the core of our best understanding of our perceptual relation with the world.

Many theorists assume that constancy is best understood as invariance, whether or not any sighted organisms experience the world invariantly. However, an account of perceptual constancy, especially one on which we base our theory of perceptual objectivity, needs to be more nuanced. Specifically, it will need to address the facts of intermediacy kicked up by the experimental literature (reviewed in chapter 1) in a way that does not necessarily render them flaws of the mechanisms responsible for the stability we experience in perception. Perception is not helpfully understood as more veridical the more closely it maps to mind-independent physical properties. Any linking between the normativity of vision and a description of a visual capacity must depend on specific facts about the organism and environment in question. In this section, I sketch a proposal for an alternative, more normatively cautious, conception of constancy, understood as a capacity. I suggest that constancy, understood as a capacity, is best conceived as a mere capacity for stability.

An ecological account of successful perception underpins an alternative understanding of how stable, if somewhat variant, perception can guide action effectively. Recall that, on the models endorsed by Thouless and Brunswik, full or perfect constancy involves a match between percept and object property. In other words, it involves a matching between, on one hand, the visual world or behavioral field, and, on the other, the physical world or geographical environment. Consequently, some degree of "distortion" (Koffka 1935, 305) or "regression" (Thouless 1931a, b) towards the distal value is taken to occur in cases where the visual world or behavioral field does not correspond invariantly to its physical counterpart.

Still, if the world as it is experienced comes apart significantly from the physical environment of which it is an aspect, how are we to explain the fact that perception guides action so successfully? It is this, in many instances at least, that theorists are trying to account for when they develop stories about constancy as the mechanism by which we achieve objectivity in perception. Like Thouless and Koffka, Brunswik discusses invariance in appearance despite proximal changes as "ideal," and as constituting "perfect" perceptual constancy (1956, 67). Still, Brunswik acknowledges that ecological considerations matter in how we evaluate an organism's perceptual abilities. For instance, for Brunswik, constancy is "nothing but the mechanism that makes the behavioral environment conform to the geographic environment to a considerable extent, especially in its biologically more relevant distal aspects, thus making higher life possible" (Brunswik 1956, 62). It is this notion of biologically relevant distal aspects, and with it the idea of considerable conformity, that can help us reconcile descriptive facts about perceptual stability with the action-guiding nature of perception.

In the human case, phenomenal size changes as an object gets further away, but it does so in such a way as to remain more stable in size than were the size appearance to correspond to retinal size. In the case of color perception, and though appearances do change with changes in lighting, they change less dramatically than they would were the percept tracking retinal changes. Keeping the normativity question separate, we can embrace a wholly non-normative, general conception of perceptual constancy, according to which perceptual constancy is any degree of stability in appearance that occurs despite variance in retinal stimulation. This suggestion brings to the fore what is implicit on any of the conceptions surveyed in chapter 1: that perceptual constancy is involved in any temporal grouping of sensations, such that the percept is more stable than it would be were it tracking changes in retinal stimulation.

All would probably agree that some constancy occurs when appearances differ from retinal values in the direction of distal values. However, we need not assume that veridicality increases the closer apparent values come to distal values. Instead, the proposed conception works at the descriptive level, capturing facts about what it's like for a human to perceive, and feeding without fixing the investigation of how best to think about the normativity of visual perception. The most effective type of constancy for a given creature in a given context might involve intermediacy, as it well may in at least many human cases. Perceptual constancy is simply a capacity to experience a world of object properties as to some degree stable, despite more radical changes in proximal stimulation.

In a recent statement about perceptual constancy, Jonathan Cohen emphasizes that there are both constant and inconstant aspects of normal human perceptual experience. The inconstant aspects, like the constant ones, are representational. The discriminable difference between the area of a uniform porcelain cup in shadow and the part in direct light is the result of the visual system representing variance—in this case, variance in illumination. Our visual systems likewise represent invariantly in this case. He writes, for example, that "there is some interesting respect in which perception is unchanging in its treatment of an object despite differences in the conditions under which it is perceived, and despite the attendant differences in the total signals impinging on our sensory transducers" (Cohen 2015, 7). This unchanging treatment of an object is, for Cohen, the phenomenon to be accounted for by a conceptual analysis of perceptual constancy. The perceptual system "arrives at a verdict about whether the perceived objects change," for instance, about whether the porcelain cup, illuminated in diverse ways, is or remains uniform in color.

Cohen finds the “traditional characterizations,” according to which constancy involves invariance or sameness of the percept across changes in the sensory stimulation impinging on our sensory transducers, to be inadequate, just as I do. But he does not question invariance as a feature of perfect perceptual constancy. Rather, he strives to bring out that the “traditional characterizations” have not adequately appreciated the fact that there are variant aspects in perception, in addition to invariant ones. Indeed, the variant contents are distinct from the constant ones, for Cohen. When two sections of the porcelain cup are illuminated differently because one is in shadow, the visual system is representing the cup as uniform in some “color-related respect,” just as it is representing the difference between the two areas (that they are illuminated differently).

Accordingly, the invariant aspects of experience do involve a kind of correspondence between percept and objective feature. Though, according to Cohen, we lack a general account of constancy, it “remains true, indisputable, and important, that some aspects of our perceptual responses are stable even through changes in perceptual circumstances that result in changes in transduced perceptual signals” (Cohen 2015, 12). What these aspects are supposed to be is unclear, however, especially given that elsewhere Cohen follows other relationalists about color in rejecting the idea that color vision aims to recover surface spectral reflectances (Cohen 2009; see also chapter 4).

He does not consider the possibility that intermediacy may in some cases be more ecologically effective than a percept-object property match.

On the ecologically-sensitive conception of normativity for which I am advocating, the fact that perceptual mechanisms do not themselves yield a match between percept and object feature does not automatically indicate inadequacy. Instead, the alternative embraces the tenet that, phenomenally, our experiences of the properties we perceive often do vary with changes in proximal stimulation. Crucially, of course, they are stable enough to guide our actions effectively. What degree of stability is needed of a particular constancy for this effectiveness in guiding actions is an important, if difficult, problem. Cohen claims that “there is no completely general account of which dimensions of perceptual response must remain fixed, and which may vary, across which kinds of variation in perceptual conditions, for a perceptual episode to count as an instance of perceptual constancy” (Cohen 2015, 12). I believe this attitude is symptomatic of thinking of perceptual constancy in terms of a matching between percept and object feature. For now, I conclude with some general considerations about why the more modest conception of constancy I have outlined better serves our normative-theoretical goals.

First, the more modest conception leaves room for the assessment of a type of visual capacity relative to what it affords the organisms who possess it. Because any degree of stability in perception, despite changes in retinal stimulation, counts on this conception as constancy phenomena, the account does not pre-theoretically rule out the possibility that some stability of appearances despite changes in retinal stimulation (as opposed to full stability), could be a desirable perceptual situation for an organism.

Furthermore, the conception permits cross-modal generalizations about constancy. We can embrace the fact that the mechanisms that make possible stable percepts are impressively diverse—even within a single modality—without worrying that such diversity renders the corresponding stability exceptional to our definition of perceptual constancy, a worry that leads Foster (2003), to question whether we can even talk coherently about, for instance, color constancy.

The conception likewise suggests a rethinking of what is meant by “perceptual.” Perception might rarely provide us with the presentation or representation of mind-independent facts, even though it might also remain enormously effective in guiding action. Rather than conceiving of perception as delivering mind-independent information to the perceiver, we might understand “perception” as potentially applicable to any type of stability in distal focusing, where stability is understood in relation to the amount of change occurring at the level of proximal stimulation. This would bring with it important implications for how we understand our perceptual, behavioral, and epistemic relations with the world around us.

CHAPTER 4:

Using Standard Perceivers and Contexts to Understand Color

Abstract. The dominant positions in color ontology have much to offer one another when it comes to understanding color as an object of theoretical inquiry. Valuing scientific tractability, cognitive scientists treat colors as physical, and so stable, perceiver-independent properties of objects. A supposedly competing philosophical tradition values flexibility in the face of variation in color appearances across species, individuals, and lighting conditions, and so understands colors as relational, unstable properties that depend on specific viewing circumstances and minds. I articulate a principled pluralist approach to color normativity according to which these different views of color succeed at modeling different features of the phenomenon. I argue against the assumption that taking colors to be stable properties of objects is incompatible with a commitment to the dependence of colors on perceivers. Moreover, views with both of these features will tend to be the most philosophically interesting and empirically useful accounts. The proposal undergirds connections already developing between ecological approaches to color, on one hand, and more traditional computational paradigms, on the other.

1. Introduction

Color has been an object of scientific investigation since at least the modern period. Today, color science is among the most developed areas of cognitive science, in part because of color's relevance across a range of disciplines. Philosophers remain committed to drawing on empirical results in their theories of the ontological status of color. Still, the diversity of priorities at play across the color sciences makes consensus in philosophy challenging. Theorists who emphasize neuro-computational approaches, such as David Hilbert, Alex Byrne and Michael Tye, advocate for a "naturalizing" of color, understanding colors as physical, stable and subject-independent properties of objects (I call such accounts *physical information views of color*). In contrast, philosophers such as Evan Thompson, Jonathan Cohen and Mazviita Chirimuuta who are engaged by findings in the biological cognitive sciences—ethology and ecological and comparative (non-human animal) psychology, in particular—have emphasized the varying phenomenal aspect of color vision, defending the view that colors are dependent on perceivers, as well as on a host of contextual factors, such as viewing position and illumination conditions (I call these views *hyper-relationalist views of color*).

These accounts entail apparently antithetical conceptions of the normativity of color vision, where "normativity" is understood as a specification of the standard or standards against which we should measure the success of color vision, the conditions under which color vision is accurate.[35] The dialectical relationship between the two positions, moreover, is generally framed in terms of direct opposition, and their divergent normative implications are often cited by opponents of each as grounds for rejecting their ontological commitments. This chapter clears new ontological space by prioritizing normative concerns. By isolating desirable features of the normative standards proposed by each account, we can better see how valuable middle ground between these more extreme positions is attainable.

In what follows, I begin by exploring the experimental utility that comes of treating color as a stable property of objects (as on physical information views). Physical information views are untenable, in part because they struggle to account for variations in how surfaces appear—for example, the variations in appearance resulting from differences in the color vision capacities of distinct species. Still, in characterizing color as a property of objects that persists stably across changes in perceptual circumstances, such as illumination conditions, these views enable significant cross-disciplinary investigation of color vision. In section 2, I turn to hyper-relationalist views of color, views that develop ontologies of color aimed at countenancing variations in color appearances that result from changes in illumination, viewing

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[35] Some theorists prefer the notion of veridicality to the notion of accuracy. The issue is terminological; in the discussion that follows, I treat all conceptions of the normativity of color vision as conceptions of what makes color vision accurate.

position or perceiver. Here, I critically examine their tendency to countenance all forms of variation in color vision, finding that the proposal that color fluctuates with minute changes in context renders color irrelevant to empirical inquiry. Furthermore, the view is phenomenologically and epistemically unsatisfying. In section 3, I argue for a pluralist, ecumenical approach to theoretical representations of color, according to which the variable priorities at stake in modeling color result in theories that emphasize different features of the phenomenon. I show that taking colors to be stable properties of objects is compatible with a commitment to the dependence of colors on perceivers. Moreover, the most philosophically satisfying and empirically useful theoretical representations of color will have both these features. In the final section, I point to an example of how traditional computational paradigms are, in practice, already incorporating some of the ecological considerations my theoretical account brings explicitly to the fore.

2. Stability of Chromatic Properties

Experimental utility. Traditional computational approaches take the aim of color vision to be detection of subject-independent, physical properties. Physical information theorists develop the ontological consequences of this supposition, taking colors to be just such properties (Hilbert 1992; Byrne and Hilbert 1997; Tye 2000). Accordingly, the standard for accurate color perception is representation or presentation of these properties.[36] These theorists propose that the supposition that the visual system aims (and, presumably, evolved in response to pressures) to present or represent these mind-independent properties explains our tendency to see chromatic properties as relatively stable across changes in viewing conditions, such as changes in illumination—a tendency known as “color constancy” (Foster 2011). Light is reflected from the surfaces of objects, is focused on our retinas, and consequently sets off a chain of neurological events that results in color experience. As the scene illumination changes (the sun slides behind a cloud for a moment, or we turn on another desk lamp), so does the type or amount of light reaching our retinas. Still, our experiences of object hues remain relatively stable across most illumination changes, even when the change in illumination is considerable.[37]

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[36] The most prominent of these views take colors to be spectral reflectances of object surfaces (which assign a percentage of light reflected at each wavelength in the visible range of light). The visual system is conceived of as solving an inverse inference problem to recover physical descriptions of surface reflectance profiles. Given some particular received luminance or light incident at the eye (a), and an estimate of the illumination (D), the visual system aims to solve for the surface reflectance profile of the object viewed (A), thus presenting or representing A accurately (Matthen 1988; Hilbert 1992; Dretske 1995; Byrne and Hilbert 1997; Tye 1995, 2000). There are physicalist information views that do not identify color with reflectance properties (e.g. McLaughlin 2003). For simplicity, and because it is the most widely recognized physicalist alternative, I discuss spectral reflectance versions of the view. However, the criticisms I develop below should apply to alternative accounts of color as a physical, subject-independent property as well.

[37] Exceptions include highly artificial illumination conditions, such as when a lemon appears green under a monochromatic light that stimulates our medium wavelength-sensitive cones.

Conversely, these theorists take color constancy to substantiate physical information views about the nature of color. In the case of human color constancy, for instance, theorists agree that "the fact that humans possess approximate color constancy indicates that our visual system does attempt to recover a description of the invariant spectral reflectance properties of the object" (Kang 2006, 233). Constancy allows us, given full or perfect functioning, to recover colors (the physical surface spectral reflectance profiles of objects) on these views. Full or perfect recovery amounts to a matching between the percept (color appearance) and the subject-independent physical property. So if percepts are going to track the relevant color properties successfully (accurately), they will remain invariant despite changes in illumination.

Physical information views have some clear advantages. Most importantly, they underpin practices at the core of color vision research, such as in computational neuroscience and perceptual psychology. For example, neuroscientific work on color vision typically is framed in terms of measuring the ability of visual systems to discount illumination, and to represent chromatic appearances invariantly, whether under conditions of seeing the same scene simultaneously or successively under multiple illuminants (Rescorla 2015). In such investigations, the normative standard for the visual system is invariant color appearances (full constancy). As Larry Maloney writes, the experimental study of color is "typically framed in terms of invariances or constancies: the experimenter doesn't know what colour a homogeneous object ‘should’ be, but has the intuition that whatever it might be, it should remain the same under changes of illumination in the scene” (Maloney 2003, 329).[38]

Moreover, because the central goal of vision research is to explain and predict visual performance (Geisler 2011, 771), studies of color vision frequently need to treat colors as properties that can recur in non-identical contexts, be perceived across changes in illumination, and be perceived by distinct perceivers. Operationalizing colors as the surface spectral reflectances of objects allows experimenters to evaluate any color vision capacity against a single metric, one which applies across contexts, and seems to translate straightforwardly into normative claims about performance. In this sense, the normative standard endorsed by physical information views has the benefit of being highly general, holding irrespective of which type of creature is being considered, and in which environment. Further, it permits a folding of color into a more general physicalist ontology (no uneasy reference to non-physical properties is necessary), affording hope of an eventual integration of functional and implementational levels. Such advantages help to account for why a physical information conception of color

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[38] This tendency is at least partly the result of the prevalence of the language of computation, to which treatment of color as physical and subject-independent is well-suited. Computation has played a cardinal role in facilitating cross-study comparisons because it has allowed for a unifying of approaches to questions about color, and for a sharing and comparing of results across disciplines which would otherwise make use of disparate standards, measures, and experimental contexts (for discussion, see Gardner 1985; Palmer 1999, especially xviii).

remains a popular commitment in vision science, let alone among philosophers dedicated to the theoretical significance of computational approaches.

Problems from subject-independence. Unfortunately, physical information views are untenable as general theories of color. First, the view effectively is committed to ubiquitous misperception or misrepresentation of color. Undeniably, color appearances change with changes in lighting, even if they change significantly less than they would were our appearances tracking proximal (retinal) changes. When the lighting in a room changes, for example, the appearances of the objects in the room in some sense change. Though the appearances of objects continue to be relatively stable (the red sofa continues to look roughly the same shade of red and the brown table continues to look roughly the same shade of brown), the change in lighting does cause some differences in the looks of the surfaces. All such departures from invariance in appearance will need to be counted as misperception on this view. Surface properties are almost never invariantly perceived as physical information views say they must be for color vision to be fully accurate.[39]

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[39] The history of experimental work on color vision teems with evidence for the systematic presence of imperfect constancy in human and non-human visual perception; see, for example, (Boring 1942). More recent treatments of the topic can be found in (Hardin 1988; Thompson 1995, 110; Hatfield 2003a; Chirimuuta 2008; Cohen 2012). For discussion of a standard reply to this worry, and my rebuttal, see chapter 3.

Perhaps more devastatingly, the in many cases valuable generality of the normative standard for color vision espoused by physical information views is bought at the expense of being unable to say that two species with physiologically different color vision systems each perceives the same colored surface accurately, just because each perceives it differently. That is, because a single normative standard holds for all forms of color vision, the physical information theorist is committed to saying that either just one species perceives the surface accurately, or that neither perceives the surface accurately (Hardin 1988, chapter 2, especially 67-82; Cohen 2009, chapter 2, especially 26-36). In rejecting physical information accounts of color, however, we can nevertheless take note of the benefits of treating color as a stable property of objects, one that can play a significant role in the empirical investigation of color vision.

3. Subject-dependence

Acknowledging variation. Spurred by the problems with physical information views, and increasingly influenced by findings in the more biologically-based cognitive sciences, such as comparative psychology, a number of philosophers now contend that we can sidestep the problems faced by physical information views by conceiving of colors as relational properties, depending on the physical nature of what is seen, but also on the perceiving subject (Chirimuuta 2015; Cohen 2007, 2009; Thompson 1995; Hatfield 1992a; 2003a). Color, on these accounts, is a subject-dependent property of objects (or of the process of perception of objects, as on Chirimuuta's account), one that cannot be specified independently of reference to perceivers.

Different types of organisms have different interests and discriminatory powers, and thrive in different environments. Taking colors to be subject-dependent, relational properties supports a more authentic acknowledgment of this backdrop of varying niches and physiologies than is available to the physical information theorist. For example, it allows for a more plausible story about the dimensionality of (the number of types of cones involved in) particular types of color vision.[40] Tree and ground squirrels are dichromats, possessing two types of cones in their retinas. In contrast, goldfish and chimpanzees (like normal human perceivers), are trichromats, with three types of retinal cones. There are some visual discriminations, therefore, that chimps can make but squirrels cannot. By treating colors as dependent on perceiving subjects, each type of visual capacity may be evaluated autonomously, according to its own distinct standard. This seems desirable: for instance, the squirrel's dichromatic color vision capacity might render it perfectly well-tuned to achieving its normal behavioral

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[40] In dichromats, light from two widely separated spectral locations can be mixed to match the chromatic appearance of any test stimulus. In trichromats, two such chromatic stimuli are inadequate, but three are sufficient. Whether a color capacity is dichromatic or trichromatic (or monochromatic or tetrachromatic, etc.), is referred to as the dimensionality of that color vision capacity, because it amounts to a question of the number of dimensions required to map the color space of an organism (three for trichromats, two for dichromats, etc.). Color vision can also be classed in terms of amount (acuity), peak sensitivity, and the extent of spectral sensitivity (for discussion, see Jacobs 1981, especially pages 21-23, 153; see also Land and Nilsson 2012).

ends, even if the squirrel discriminates fewer surfaces than a chimp does. Creatures with very different visual systems may be counted as perceiving a single surface accurately, even if their chromatic experiences of the surface differ.

Notably, however, the relationalist theories most prominent in the literature take the position further: color is subject-dependent, but also radically context-dependent. On these hyper-relationalist theories, such as those defended by Evan Thompson, Jonathan Cohen, and Mazviita Chirimuuta, color depends on the individual perceiver as well as on the idiosyncratic environmental circumstances manifest in each perceptual context, such as particular illumination conditions. Because contextual changes are virtually ubiquitous in perception, the dependence of color on this broader range of factors means that color is an extremely unstable property. As Cohen writes, we must accept that in perception "there is a Heraclitean perceptual flux of fine-grained colors" (2009, 128). Holding the perceiver constant, a surface that looks red under red light and white under daylight will also *be* red under red light and white under white light. On hyper-relationalist views, each individual visual system in each complex viewing scenario introduces its own set of accuracy conditions against which the accuracy of color vision is to be assessed.[41]

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[41] Chirimuuta's (2015) identifies colors as properties of the ever-changing process of perception. Process change, for Chirimuuta, is enough to entail a change in color. So, as on Cohen's view, colors are highly unstable. (An interesting difference is that under cases of no spectral contrast, we are subject to misperception, and see merely what Chirimuuta calls "pseudo-colors" (179-81)). Thompson likewise

Problems from instability. As we did physical information views, we should reject hyper-relationalist views as general theories of color. First, there is a normative worry about these views complementary to the one raised earlier about physical information views. If colors are contingent in the way hyper-relationalists say they are, then color vision is trivially accurate. Since every shift in perceptual circumstance introduces new success conditions for color vision, misperception or misrepresentation are only possible in the philosophically contrived cases of illusion resulting from deviancy in the causal process producing an appearance, and of hallucination (Cohen 2007). Because color vision is perfectly accurate in all but these contrived cases, any connection between normativity and action can be only accidental. For example, a species struggling to interact effectively with its environment because of a poorly adapted visual capacity is treated by hyper-relationalist views as having on all occasions fully accurate color vision (with the exception of instances of illusion through deviant causation and hallucination, should those occur). So on hyper-relationalist views, color vision counts as accurate independently of how effectively it guides action.

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endorses hyper-relationalism about color. As he writes in his (1995), "apart from a specification of the perceiver and the viewing conditions there is no fact of the matter about what colours… things have… [B]ecause colours are perceiver-dependent and viewing-condition dependent properties, the same thing can have different colours" (246).

To render hyper-relationalist views compatible with at least our ordinary ways of talking about and cognizing colors, Cohen appeals to a second, categorical level of color representation (Cohen 2004; 2007; 2009, 125-128; see also Thompson 1995). Our ability to think and speak in terms of color concepts, according to this approach, explains our ability to see colors as temporally and spatially stable: cognition groups our ontologically basic color perceptions, so that we treat colors as properties of objects that persist stably across changes in illumination. It is in virtue of these "coarse-grained" color representations that we can make intersubjective claims about color vision (which can be right or wrong depending on our conventions, and the presuppositions we take to hold in the situation to which we are referring).[42] As Cohen writes,

> [E]ven though Sam's and Pam's visual systems represent the ripe lemon's distinct colors *yellow to Sam in* C_{Sam} and *yellow to Pam in* C_{Pam} (respectively), Sam's and Pam's cognitive systems can agree in representing the lemon as bearing the single coarse-grained color *yellow simpliciter*. Similarly, should Sam and Pam choose to make verbal reports of the lemon's color, their utterances will both represent the lemon as bearing the one coarse-grained color *yellow simpliciter*. (2009, 127)

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[42] Coarse-grained colors are relational properties, just as ontologically basic colors are relational. But coarse-grained color properties are taken to be color properties for the *prima facie* reason that they are "properties that are expressed by utterances of color predicates" (Cohen 2009, 109).

Color concepts can help to explain how we talk about and refer to colors, so they certainly do help to explain a certain class of our color-directed behaviors. But they fail to explain phenomenal color experiences whereby colors look relatively stable, or constant, across changes in illumination. For example, when I look at an orange in partial shadow, the retinal stimulation corresponding to the two regions of the fruit is much more dramatically different than is the difference between how the two areas appear (a case of simultaneous color (partial) constancy). Given that there is a discriminable difference in appearance between the two areas, hyper-relationalist views must count them as distinct in color. However, color vision doesn't conflate illumination and the chromatic appearances of objects to this extent. Rather, colors appear to be temporally and spatially extended across surfaces, and to remain at least relatively stable through a range of changes in illumination. Further, it is largely in virtue of this stability that we are able to discriminate, track, and identify objects (see Byrne and Hilbert 2003, 58, for a similar concern about the role of color vision in recognition).[43] On hyper-relationalist views, however, colors cannot persist stably

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[43] There is an extensive literature on the presence of color constancy in all sorts of non-human animals that standard accounts of concepts count as incapable of conceptual thought (Götz 1926; Neumeyer 1998; Chittka 2014). This is true on even a fairly liberal view of conceptualization (e.g. as in Camp 2009). Still, Cohen is "prepared to bite the bullet" on this point, citing (Spelke 1990) as evidence that many infraverbals (e.g. human infants) are capable, at least in an important range of cases, of tacit commitments to presuppositions about their visual environments (e.g., about object movement in continuous space-time trajectories) (Cohen 2007, 346-7; but see Neumeyer 1998; Hatfield 2009).

across differences in illumination, whether such differences occur spatially, as in the case of the orange, or temporally (in cases of successive color (partial) constancy).

Finally, the assumption that chromatic experiences can be shared by perceivers of a given type is crucial to much of perceptual psychology and neuroscience, so that a further consequence of hyper-relationalist views is that color, as an object of scientific inquiry, is more or less irrelevant to the core vision sciences. This irrelevance, along with a poverty of alternative relational accounts in the literature, of hyper-relationalist views of color to computational color science helps to explain why the subject-dependence of color is under-explored as a theoretical premise in computational work.

To conclude: hyper-relationalist theories of color are epistemically unsatisfying, in that they are bound to count virtually all color vision as accurate. Furthermore, their conflation of surface appearances and contextual factors such as illumination conditions is phenomenally implausible. Finally, hyper-relationalist views characterize color in a way that undermines color's importance to vision science. In rejecting hyper-relationalism about color, however, we need not overlook the value of taking color to be a subject-dependent property, a commitment that allows us to acknowledge variation in color vision capacities across different types of sighted creatures.

4. Principled Pluralism about Normativity

Taking stock. Theorists who take color to be a stable, mind-independent property of objects profit from the scientific tractability of color. However, taking colors to exist independently of perceivers makes it difficult to understand differences in color vision capacities as they are found across types of organisms. Moreover, because these theorists model color, and the conditions necessary for successful color vision, without reference to perceivers, they commit themselves to widespread misperception in human and non-human animals.

Taking colors to depend on subjects is the leading way to accommodate the possibility that different color vision capacities allow for accurate color vision, even when such capacities differ from one another in the discriminations they afford. Philosophical accounts that take this line, however, often extend it further by taking colors to depend on token perceivers and token environmental conditions, such as specific background illumination conditions and viewing position. In part 2 I argued that taking color to be contingent and so unstable in this strong way renders color trivially accurate and undercuts its importance for science. How, then, should we think of the normativity of color vision?

Attaining middle ground. Prior attempts to legitimize the middle ground between (1) arguing that color appearances ought to be invariant, with physical information views, and (2) saying they are radically variant, with hyper-relationalist views, as I want to, have been critiqued for needing to stipulate a perceiver type and environmental parameters (Hardin 1988, 67-91, 1990; Thompson 1995, 108, 118-120; Cohen 2009). For example, concerned to render color both subject-dependent and stable, some theorists have appealed to species classes as perceiver types in terms of which we can legitimately specify normative standards for color vision (Hatfield 2003a; Matthen 2005). However, species classes are ill-suited to serve as the perceiver types in terms of which all normative standards for accurate color vision ought to be specified, because systematic sorts of variation can occur within a single species. Some types of intra-species variation are sex-linked, for instance. Male New World monkeys are typically dichromats, whereas females are typically trichromats (see Jacobs 2007). Other intra-species variation is episodic, as in fish that experience seasonal, and even daily changes to their visual systems (Whitmore and Bowmaker 1989). Moreover, there will typically be some slight variation—a normal distribution of responses—in how surfaces appear to individuals within any particular species.[44] Appeal to species as the perceiver types

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[44] There are usually subtle differences between color vision capacities in perceivers of even the narrowest phylogenetic type. For example, if we ask a large number of normal human trichromats to perform one of any number of color vision tasks, a standard distribution of responses will be elicited. In a task asking perceivers to identify the spectral location of a monochromatic light that looks yellow, with no admixture of red or green, for example, there will be variation. The difference between normal human trichromats in such a task is not typically large (it might be 10nm), but is substantial enough given that

in terms of which normative standards ought to be specified can therefore seem stipulative, or *ad hoc*.

Normative standards that render compatible the subject-dependence of color and chromatic stability likewise seem to require appeal to precise environmental parameters, such as a particular range of ordinary daylight illumination conditions. Theorists embracing such standards therefore also face the difficulty of accounting for appearances under a variety of non-standard conditions. For example, if the normative standard for human color vision is specified in terms of a particular range of daylight illuminations, then the appearances of surfaces under slightly different lighting conditions will need to be counted as at least to some degree inaccurate, since they will differ at least slightly from the appearances of those surfaces under the specified conditions. To many, these normative consequences have seemed unacceptable. To avoid stipulating perceiver types and environmental parameters, it has seemed there are only two good realist options: either a standard is set independently of all perceivers and environmental parameters (as on physical information views); or, the standard varies with all types of variation, and colors are highly unstable (as on hyper-relationalist views).

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all visible light corresponds to a nanometer range of 400-700nm. What is important for our purposes is that the distribution in such cases should not (necessarily) be understood as error: it is aptly characterized as actual diversity within a population of perceivers (for further discussion of this case, see Kaiser and Boynton 1996, 416-20).

But if our normative standards for color vision are going to be non-trivially accurate or inaccurate, perceiver types and environmental parameters are needed. Moreover, worries about stipulation in delimiting a normative standard for color vision incorrectly assume that a single approach to specifying perceiver types and environmental paramaters must function for all our normative-theoretical purposes. If we accept a plurality of evaluative frameworks as legitimate, we can be forthright about the interest-relative nature of modeling color and evaluating color vision. The proposal is not as radical as it seems. In making normative assessments, we employ evaluative frameworks particular to our aims as theorists. Accordingly, the conditions necessary for accurate color vision embraced by any theoretical framework will involve some idealization, just as any model does (Levins 1966; Giere 1990; Weisberg 2006, 2013). And particular models of color will be more useful in some contexts than in others. Pluralism about which theoretical representations of color are legitimate thus allows us to overcome problems associated with maintaining both that there is chromatic stability across some changes in context, and a normative sensitivity to at least some variations in how a surface looks to different perceivers.

Perceiver types and environmental parameters. All evaluative frameworks for color vision already involve at least implicit specification of a perceiver type and environmental parameters. And the amount of intersubjective (or even intrasubjective) variation in which we invest depends on our interests as theorists, or what we are assessing. The perceiver type specified might pick out a group or individual actor, for instance. Though phylogenetically-individuated groups are often principled starting points for the specification of perceiver types (especially where our interests are more general, as in some areas of comparative color vision where little is known about large classes of perceivers) a perceiver type need not be specified on phylogenetic grounds. For example, a perceiver type need not pick out all members of a given species. We might be interested, instead, in sex-linked or seasonal differences within a species.[45] Nor, on the other hand, must perceiver types acknowledge differences between token perceivers. In many cases, considerable intersubjective variation is most usefully counted as irrelevant, as normal variation within a type (variation with which we as theorists may not presently be concerned). An ontogenetic case can help to bring this out. In evaluating a purported instance of perceptual learning, such as a house-painter's ability to discriminate finely between shades of red or blue, we are interested primarily in what makes the perceiver distinct from other normal human trichromats, or in what makes her like other expert color perceivers. The relevant perceiver types in such a case (and so the relevant normative standard)

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[45] Use of the term "species" itself tends to involve a weighing of pragmatic considerations. Darwin considered the term "as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other… it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms" (1964, 48-52). Indeed, how to make precise the notion of species is still openly debated (see de Queiroz 2005).

will need to be quite fine-grained.[46] Physiology, processing costs, and behavioral patterns and needs are all potential factors in how a perceiver type is specified.

For a non-trivial normative standard, environmental parameters must also be specified. For instance, consider appeals to standard illumination conditions in industrial treatments of color, such as in the Munsell chip system, a system of chips used to standardize color samples for the purposes of color matching. How a surface looks to normal human trichromats under a specific range of ordinary daylight conditions will be the point of interest in this context – specifically, North Daylight or scientific daylight, with a color temperature of between 6500 and 7500 Kelvin (Munsell 1946; Munsell Color Company 1976; see also Hardin 1988, 68).

C. L. Hardin, Cohen, Thompson and others worry that specified environmental parameters such as these cannot hope to tell us about the content of color vision in

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[46] More generally, my approach connects with recent theorizing about perceptual learning. In cases of perceptual learning, experience viewing certain properties renders one's visual experience systematically different from the experiences of non-experts (Gibson 1963; Connolly 2014). In studying cases of perceptual learning, we might be interested in fine-grained differences between organisms of the same species who have been raised in even slightly different niches, and who have different capacities in some salient respect as a result. According to my account, we can aspire to capture what such organisms have in common. Additionally, given that perceptual learning occurs, and therefore that empirical generalizations across subjects can be problematic, my account suggests a subtler way forward. In this respect, the concept of a perceiver type not only does not undermine, but actually underpins, the value of disagreement about color. Systematic, long-term changes in phenomenal experience are just the sorts of variation a types-based approach can accommodate.

general, and so cannot contribute to the definition of a legitimate normative standard. They emphasize that such instructions “provide no guidance at all about how to choose between variants in other sorts of conditions under which we are inclined to say that veridical color perception occurs” (Cohen 2004, 34). Thompson, for example, acknowledges that visual science is “replete with very precise ways of specifying viewing conditions,” but worries that “the specifications are interest-relative, suited to the pragmatic demands of specific colour-matching tasks, not to the philosophical demand for a principled determination of the ‘real’ colours of things” (1995, 246). I suggest, in contrast, that we can at once acknowledge these “very precise,” interest-relative evaluative frameworks for what they are, while also finding continuity between these frameworks and ones that are more satisfying as general philosophical frameworks for evaluating color vision.[47]

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[47] One might think that our philosophical understanding of color needn’t necessarily have much to do with how color vision capacities are treated empirically (or, rather, that the appropriate kind of influence runs from science to philosophy but not in the other direction). This is an apt concern especially in light of the wide range of assumptions at play across the various disciplines working on color, from graphic design and dye manufacturing to psychophysics and colorimetry. I take it, however, that my pluralist approach is satisfying in part because it can accommodate the multiplicity of approaches found in actual color science, approaches which often purport to yield normative conclusions. For a long time, for example, standards in the psychology of vision came primarily from computer vision, and in comparative psychology, from human psychology. For instance, Gerald Jacobs notes explicitly in his important 1981 work on comparative color vision that normative qualifiers such as “poor” and “excellent,” are to be “understood in reference to the capacities of the average normal human trichromat” (1981, 32). Thanks to Karen Kovaka for pressing me on this point.

The fact that a system explicitly or implicitly specifies a perceiver type and environmental parameters is what makes that system useful and intelligible. The Munsell system, for example, was designed to operate over a fairly narrow range of contexts and perceivers, and for well-defined artistic, educational and industrial ends. Thus, we should expect it to have limited applications. In fact, it would be odd to expect more applicability from a system that explicitly offers such a specific normativity of color vision. On my proposal, we need not be embarrassed about the limitations—or better, scopes—of normative standards. The fact that there is no way to specify a non-trivial normative standard without appeal to a perceiver type and environmental parameters shouldn't lead us to abandon either (1) the possibility of accurate color vision in sighted creatures that differ in the chromatic discriminations they can make, or (2) the possibility that colors may persist stably despite changes in viewing conditions, such as background illumination. Rather, it should lead us to question the assumption that normative standards compatible with both these possibilities are stipulative in any objectionable sense.

Keen to reject the physical information theorists' tenet that there is only a single normative standard for color vision, hyper-relationalists like Thompson and Cohen effectively embrace a limitless number of standards, so that any change in viewing conditions or perceiver introduces a new and legitimate normative standard. My worry about this sort of unbridled ecumenicism about normativities is that it emphasizes relatively useless standards (and infinitely many of them) at the expense of those which have the potential to be informative and productive. My pluralist approach is ecumenical, in the sense that it remains open to two creatures with different visual systems perceiving the same surface accurately, but it is ecumenical in a constrained and motivated way.

On the pluralist view of normativities I've sketched, all evaluative frameworks sacrifice some virtues in order to prioritize others. Often, general perceiver types and environmental parameters will serve our aims, whereas in other contexts, we may be primarily interested in a highly precise standard (as in an applied robotics case, where we might care specifically about what counts as maximally effective or efficient). Accepting a pluralist view about normativities does not entail finding all evaluative frameworks to be of equivalent worth (Rheinberger 1997; Mitchell 2003).

In philosophy, the most interesting and productive frameworks will tend to model color as a stable property that is subject-dependent. Color vision allows organisms to interact with their environments effectively; evaluative frameworks that are able to take into account questions of fit between environment and perceiver type are especially liable to generate further philosophical questions and points of interest. And these will tend to be frameworks explicitly sensitive to variation, between species, or between broader or narrower classes of perceivers. Such normativities will also tend to construe color as a somewhat stable property. For such stability is fundamental to our interest in color as an action-guiding property.

No normativity of color is metaphysically basic, on this proposal, but normativities can be more or less helpful and more or less interesting. At a minimum, an interesting sense of normativity isn't going to make normal perception trivially accurate or inaccurate. Foregrounding normativity, as opposed to ontology, can help us to see that this is so.

I said above that computational research is especially prone to making use of physical information models of color vision. In the next section, I suggest that much of the empirical work at the center of vision science—so often couched in normative language—is better understood as generating non-normative (merely descriptive) information about color vision capacities. Computational studies are nevertheless capable of appealing to interesting normative standards.

5. Ecological Considerations and Computational Approaches

Normative and non-normative metrics. Work in computational color science standardly assumes a physical information model of color, thus relying on a standard for color vision that (as I argued in section 1) entails a commitment to widespread misperception, a result that cannot be explained plausibly as symptomatic of a complex evolutionary process. Recall that a metric allowing us to measure the degree to which appearances match mind-independent properties is nevertheless useful: it is straightforwardly applied, and allows for comparison of color vision capacities across perceiver types. There are many more measures than there are normative measures, however. Getting clear on where our measurements in cognitive science are best construed as non-normative (that is, as merely descriptive), and where normative evaluation is fruitful, will lead to more refined research programs for understanding color vision, and color vision performance.

Computational approaches sometimes do draw substantive normative conclusions about color vision performance, for example, by incorporating into their models physiological or biological information about the type of visual system under investigation. Inaccuracy in one perceiver can then be understood against a backdrop of assumptions about what creatures of its type ought to share. Theorists can also make use of ecologically realistic environmental parameters in designing experiments (Brunswik 1956; Geisler 2004), which can result in a foregrounding of normative questions about fit between sighted organisms and their natural habitats.

An example from ideal observer theory. Efforts to incorporate organism and environment-specific information are conspicuous in certain areas of visual neuroscience, for instance, in cases of ideal observer theory, where the study of color vision involves specifying as closely as possible a descriptive model of a perceiver type's color vision capacity, and then using that model as an "ideal observer" benchmark against which theorists can quantify color deficiency, information loss or information preservation in subjects. Once an ideal observer calculation is made, that calculation provides "a principled method for evaluating how efficiently a real observer performs a particular task" (Brainard 2003, 322).

For example, a benchmark model might provide a standard against which human performance can be assessed: human perceivers are compared to an ideal human observer calculation which might take into account a number of factors, such as which specific photoreceptors are found in humans, and a model of what, statistically speaking, can be said about our environments. Discrepancy between the benchmark and a real subject can then help to direct researchers to the sites of information loss in visual processing, or to those of information preservation.

Of course, developing and testing such models involves treating them as metrics against which human performance can be legitimately assessed. For instance, any prediction made on the basis of the performance of the ideal observer typically is assumed to use the information in the stimulus "optimally" (given the constraints imposed by the type of visual system examined) to perform a psychophysical task such as discrimination (Geisler 1989; 2004; 2011). In virtually all cases, the descriptive measurements used to calculate the ideal observer standard will be approximate and partial.[48]

Still, computational approaches like these come closer to generating the kinds of standards that could be legitimately treated as normative—standards against which we can make sense of misperception, or of color vision being better or worse. Though the benchmarks employed in ideal observer theory remain standards that are specified in physical terms, they are deeply subject-relative. Such empirical investment in the possibility of incorporating into assessments of performance information about the type of organism studied and its habitat, makes this area of research exemplary of how computational work can bring ecological considerations into play in the study of color vision.[49] These forays into engaging the subject-dependent, or at least subject-relative, nature of color vision are indicative, more generally, of computational efforts to work in tandem with the conclusions theorists invested in the biological sciences are reaching about vision, and to foster connections between the computational sciences

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[48] For example, in many cases, the relevant natural scene statistics are yet to be measured (Geisler 2011, 778). There is a clear sense in which physical information views of color continue to operate in the background of ideal observer theory research.

[49] For discussion of the CIE system of colorimetry, on which the notion of a standard human observer in ideal observer theory is ultimately reliant, see (Kaiser and Boynton 1996, especially 525-578).

and the increasingly non-physicalist, non-reductive, embodied approaches that now populate the landscape in philosophy of mind.

Conclusion. In Chirimuuta's recent book, she argues that,

> If we step back a moment, we can appreciate how very weird it is to even expect there to be a connection between the manifest visual world, brought to us by our senses, and the rarefied scientific image of a world made up of physical particles, etc. The latter is the product of ever-finer empirical dissection and mathematical deduction, but even then it might only be a tool that enables physicists to predict experimental outcomes. (2015, 31; Chirimuuta is referencing Sellars 1991)

Commitment to the idea that we should not expect a connection between these two domains, however, seems premature. In contrast, I take it there is clear reason to expect important connections between the domains, especially given the increasingly integrated and inter-disciplinary approaches of cognitive science.

Though color vision research (philosophical and empirical) is often informally understood as being about performance, normative issues in philosophy have served primarily as mere grounds on which ontological positions are rejected. Subject-dependent accounts of color privilege the phenomenal aspect of color vision; subject-independent accounts, in contrast, privilege the physical properties of objects. Because of their differences in emphasis, these dominant approaches to color ontology bring distinct theoretical advantages to the study of color. By beginning from normative issues, I have shown that the core insights of these opposed traditions are compatible, and probable ingredients of our best philosophical theories of color. My approach embraces a plurality of evaluative frameworks for assessing color vision. This sharpens the range of metaphysical commitments available to us, while leaving significant room for ontological debate.

CONCLUSION

Perception is at the heart of our understanding of the world. As Edwin Boring puts it, constant experience is, in a sense, the most primitive form of scientific understanding:

> Take what psychologists call object constancy. The retinal image of a seen object gets smaller as the object recedes although both the physical object itself and the perception of it remain constant in size. The uniformity of nature here is the rule that objects do not change size when they move or when their observers move. That is a scientific physical generalization. The human organism is, however, so constructed that its perception, in general, follows the same general rule: the organism sees the same object as the same size regardless of the distance between it and the object. So the scientific generality is 'understood' by the organism in the sense that its perception includes this generalization. The generalizing organism can be man, an ape, a chick or even a lower animal form, since some degree of objective generalization is present in all perception. (Boring 1957, 5)

Because of the relation between perceptual stability and the stability of physical environmental properties, we strive to attribute to perception the job of grounding perceptual belief, thereby grounding scientific observation, propositional belief, and, ultimately, theoretical knowledge in general. Plausibly, propositional beliefs are the sorts of states or relations it is useful to talk about as true or false. The capacity for stimulus-independent thought, for instance, enables us to retain and draw upon useful information about our broader, rather than merely immediate, environments.

If our beliefs are going to be the sorts of things that are truth-apt, however, then an epistemology on which we can say straightforwardly that perception is itself in some sense truth-apt is going to be preferable on grounds of theoretical elegance. Such considerations of elegance are no doubt behind the great empiricist and rationalist traditions of understanding perception in terms of a norm according to which percepts ought to match mind-independent physical properties of objects.

In this work, I argued that it is nevertheless unwise to build these types of accuracy norms into our theoretical understanding of the nature of our perceptual relation with the mind-independent environment. We ought to focus our analyses at the level of organism-environment relations, rather than at the physical, physiological, or species levels. Analysis at the organism-environment level suggests a pragmatic, ecologically-grounded interpretation of perceptual success in terms of the way perception guides (or fails to guide) effective action. If this is right, and if, concurrently, we are going to maintain that more traditional truth norms apply to belief, much more needs be said about the interface between perception and belief. How can perception, to which we apply a set of ecologically-grounded accuracy norms, work as an epistemic foundation for propositional, truth-apt beliefs? Perhaps, as I suspect, it will turn out that an ecological framework for perception reveals, rather than obscures, interesting facts about the nature of belief and this interface.

In emphasizing organism-environment relations as central to an understanding of perception, the ecological approach is naturally aligned with pluralist approaches to science more generally (Heft 2001, 375). For an ecological approach is, to some degree, already wedded to a rejection of a reductive picture of the sciences, according to which the life sciences, such as biology and psychology, are, ultimately, understandable in terms of the language of physics. On a pluralist understanding of science, normative standards bring a certain degree of indeterminacy, but that indeterminacy is principled. Useful norms will generate empirical work that helps us to model and explain the relevant phenomena.

In perceptual psychology, a theoretical emphasis on the interaction between perceiving organism and environment clarifies issues related to experimental design. Vision science aims to understand how vision works in natural circumstances, and yet, in contrast with simpler, artificial stimuli typically used in laboratories, natural stimuli are difficult to characterize in precise, generally applicable mathematical terms. Because of disanalogies between the lab and the natural habitats of subjects, we cannot always justify the application of results about the behavior of organisms under laboratory conditions to the behavior of those organisms in their natural environments. As Brunswik (1956) emphasized, experimental designs must be *representative*. That is, we must be careful in assuming that we are justified in generalizing from experimental results achieved in particular experimental contexts to broader sets of conditions.

The ecological approach helps us to see why artificial tasks might be especially uninformative, and it suggests strategies for designing experiments that better approximate natural habitats, for instance, by highlighting the properties of natural stimuli that are especially valuable for a given natural task. More than ever before, attention is being paid to the benefits of thinking ecologically in the cognitive sciences. In comparative psychology, for instance, experimenters are increasingly invested in experimental designs that are representative of natural ecologies (Cheney and Seyfarth 1992). In the context of human perception, there is growing recognition of the importance of ecological plausibility (Burge 2014; Radonjić 2016). These recent shifts in priority reflect—and underpin—the value of an ecological framework for the normativity of perception.

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