PHILOSOPHICAL TOPICS
VOL. 33, NO. 1, SPRING 2005

Direct Perception: The View from Here

William H. Warren
Brown University

The view that perception is direct holds that a perceiver is aware of or in contact with ordinary mind-independent objects, rather than mind-dependent surrogates thereof. In this paper I try to articulate an account of direct perception from a Gibsonian point of view, located within the wider terrain of cognitive science and psychology. James Gibson's ecological theory proposes that perception is a relation in which an active agent is in contact with behaviorally relevant features and properties of its environment; this relation is causally supported by perceptual systems that are attuned to information which specifies those features and properties. I will argue that the theory offers the means to resist the main lines of attack on direct perception, including the Arguments from Illusion, Hallucination, Appearances, and Underspecification. In so doing, it also suggests a positive account of illusions and hallucinations, as well as the intentional (object-directed) and perspectival (from here) aspects of perception.

ASSUMING THE POSITIONS: THE DIRECT VIEW

The position that perception is direct begins with the commonsense intuition that everyday perceiving involves an awareness of ordinary environmental situations.[1] In the case of vision, when I see a copper beech tree with a cylindrical trunk, smooth bark, and copper-green leaves at a particular location on the ground ahead, the object of which I am aware is the mind-independent tree in the world.[2] The logic of perception consequently adheres to the logic of knowing rather than the logic of belief. In cases of genuine (veridical) perception, if one perceives a situation X, then X is perforce the case; in contrast, if one believes that X is the case, X may or may not be so. This comports with our everyday perceptual encounters with objects such as trees and tomatoes and daggers, as well as with our everyday praxis of acting successfully with respect to such objects.

One interpretation of the direct claim is that "awareness" of an object refers to the perceiver's conscious *phenomenal experience* of that object. Thus, when I perceive the tree I have a subjective phenomenal experience of the shape of its trunk, the smoothness of its bark, the copper-greenness of its leaves, its location in space, and so on. One concern with this formulation is that it limits direct perception to animals (such as primates) to whom we are willing to grant conscious experiences, and fails to extend to lower animals (such as frogs or honeybees) who may or may not enjoy conscious experiences. Yet in all of these species, behavior is observed to be oriented to environmental situations and thus demands some form of perceptual contact with the environment, whether or not it is consciously experienced.

A second interpretation is that "awareness" refers to the perceiver having *access to* its environment, such that the agent is in contact with or in touch with ordinary objects and their properties. On this reading, awareness is a relation between the perceiver and the environment, in which the perceiver is aware of or in contact with the environmental situation. It is the intentional, object-directed, world-involving content of perception that matters here, rather than the subjective phenomenology. Gibson (1979) put it this way:

> Perceiving is an achievement of the individual, not an appearance in the theatre of consciousness. It is a keeping-in-touch with the world, an experiencing of things rather than a having of experiences. It involves awareness-of instead of just awareness. (239–40)

Direct perception constitutes *epistemic contact* with the environment in the sense that the perceiver is informed of the environmental situation and has a basis for action within and knowledge about the world. Thus, when I perceive a tree, I am in contact with the tree such that I can act adaptively (avoid it, hug it, climb it), ostensively indicate it (point at it), make demonstrative judgments about it (Snowdon 1992), and so forth. This is the take I shall emphasize here. However, I hasten to add that for creatures with phenomenal experiences, subjective experience ordinarily goes hand in hand with perceptual contact. That is, except in anomalous instances, one subjectively experiences the things with which one is in contact.

It is worth noting that the direct claim does not by itself resolve the epistemological problem of skepticism. On the face of it, direct perception appears to provide the observer with strong justification for her beliefs, and hence knowledge, about the state of the environment: if one perceives X, then it follows that X is in fact the case. But direct perception does not ensure that the observer can *internally* distinguish instances of genuine perception from other kinds of sensory experience, such as illusions or hallucinations. The having of an experience of a tree thus does not provide one with an incorrigible justification for the belief that a tree is present, because one cannot tell "from inside" whether the experience is a case of perception or a hallucination.

However, the direct claim does have epistemological implications, for a successful direct account of perception would enable a satisfactory account of knowledge. On an internalist view, direct perceptual experience provides a noninferential basis for the internal justification of one's perceptual (and consequent) beliefs (Huemer 2001). On an externalist view, direct perception provides a reliable process that links environmental situations to perceptual beliefs, so that the beliefs are externally justified whether the observer knows the process is reliable or not (Dretske 1981; Goldman 1986). Either way, perception is the fundamental point of contact with the environment and provides the primary basis on which beliefs, concepts, and knowledge may be formed. To the extent that this contact is undermined, an epistemic barrier is raised between the cognitive agent and the world.

NO PERCEPTION WITHOUT REPRESENTATION: THE INDIRECT VIEW

The indirect position, in contrast, argues that the commonsense intuition of perception as the direct awareness of environmental objects is naïve. Upon closer examination, a perceiver is actually only in direct contact with the proximal stimulation that reaches the receptors, or with sense-data, or with the sensations or internal images they elicit—but not with the distal object itself. Thomas Reid (1785/1969) observes:

> All philosophers, from Plato to Mr. Hume, agree in this, that the immediate object of perception must be some image present in the mind. (Essay II, Ch. 7, 124)

Consequently, the perceiver must make an inference from the given sense-data to the environmental situation they betoken. Here is the early Bertrand Russell (1912):

> The real table, if there is one, is not the same as what we immediately experience by sight or touch or hearing. The real table, if there is one, is not *immediately* known to us at all, but must be an inference from what is immediately known. . . . Let us give the name of "sense-data" to the things that are immediately known in sensation. (11–12)

The result of such an inference is a percept, perceptual belief, propositional description, or other mental representation of the environment. The perceiver is directly aware only of some mind-dependent proxy—the sense-data, internal image, or representation[3]—and only indirectly aware of the mind-independent world.

There are several persuasive arguments in favor of the indirect position. The Arguments from Illusion and Hallucination contend that, because nonveridical sensory experiences are subjectively indistinguishable from veridical ones, the immediate object of awareness must be the same in both cases. Hence, one is directly aware of a mind-dependent proxy, not the environmental object. The Argument from Appearances asserts that one only has immediate access to the variable appearance of an object (e.g., its projected form in the field of view), which depends upon one's vantage point. Thus, one must perceive the object's constant properties indirectly, by way of the mediating appearance. The Argument from Underspecification, which is commonly taken for granted in cognitive science, contends that the proximal stimulation is inherently ambiguous and insufficient to specify the object and its properties. This assumption leads straight to the claim that the perceiver must make inferences from inadequate premises, somehow "going beyond the information given" in order to arrive at an internal representation of the environment. These arguments appear to effectively undercut the prospects for direct perception.

Yet the indirect view also has some undesirable implications. On the face of it, indirect perception does not comport with our phenomenology of seeing or feeling the world around us: we do not seem to be aware of mere stimulation or sense-data or appearances, but of full-bodied environmental objects; nor are we aware of making explicit inferences from sense-data to internal representations of such objects. To explain away this objection, the movement from proximal stimulation to representation can be ascribed to a process of *unconscious* inference (Helmholtz 1866/1925), such that the perceiver is aware of the resulting representation of the environment rather than the mediating sense-data and inference process. Yet still, phenomenologically, we seem to be aware of the environment around us, not a representation inside our heads, and indirect theorists owe us an account of the intentionality of perception.

More seriously, the indirect view creates an opening for a skeptical argument known as Hume's problem. On this view, the observer only has immediate access to proximal stimulation, sense-data, or internal representations. Without some sort of independent, extrasensory access to the environment, there is no way for the observer to work out which sense-data or patterns of stimulation correspond to which environmental features, or what environmental object is denoted by which representation (the "symbol grounding problem" is a recent manifestation). This inherent circularity leaves the perceiver trapped in a closed universe of phenomenal sense-data or uninterpretable representations (Bickhard and Terveen 1995; Searle 1980; Shaw 2003). The indirect position thus introduces a "veil of perception" between the perceiver and the world, behind which ordinary objects remain concealed. Worse yet, it has been argued that the indirect view cannot support realism in the face of the skeptical argument, and when pressed tends to slide into phenomenalism or idealism (Huemer 2001; Smith 2002).

The indirect response to Hume's problem is "inference to the best explanation," according to which the observer constructs an internal representation of the external world that best accounts for the order in sensory experience. But such a process presumes that the observer has at his disposal a set of predicates that is adequate for describing the material world, and a basis for understanding how the world is causally related to sensory experience. The Argument from Underspecification only makes matters worse, for if the stimulation underdetermines the environmental situation, there is even less hope of inferring the latter from the former (Turvey and Shaw 1979). To resolve this dilemma, indirect theories rely on prior knowledge or assumptions about (1) the structure of the world (including descriptively adequate predicates), and (2) how the world structures stimulation (and sensory experience). However, the possession of such knowledge must again be accounted for in some extrasensory manner. The indirect position thus undermines the cognitive agent's access to the environment, casting epistemic doubt upon its primary point of contact with the world. And if the agent cannot perceive the environment, it cannot form concepts, entertain thoughts, acquire knowledge, or communicate about a shared social world.

Given the effort expended by philosophers in the last half century to discharge sense-data and defend some version of direct perception (Crane 2005), it may be surprising that most practitioners in cognitive science and psychology unflinchingly adhere to an indirect view. Although talk of "sense-data" is anachronistic and "sensation" is treated as a historical term, in practice it is still generally believed that our perceptions of the world are inferred from sensory data and correspond not to environmental objects but to images or representations in our own minds.

For many vision scientists, Helmholtz (1866/1925) still sets the tone:

> We can never escape from the world of our sensations to the idea of an outer world, except by inference from the changing sensation to outer objects as the causes of this change. (32)

A well-known cognitive science text presents a particularly bald statement of the representationalist view:

> The problem then is to take this set of excitations [of the two-dimensional array of receptors], infer what objects in what kind of layout these might betoken, create in the mind a representation of these objects in their layout. It is this representation, or model of the world and the results of the inferences which can be made within it, which we experience; not the world itself. (Oatley 1979, 166)

Currently the field is in the grip of a statistical Bayesian approach to vision, yet a familiar formulation persists:

> Perception is a process of unconscious inference, as suggested by Helmholtz (1925). Bayesian probability provides a normative model for how prior knowledge should be combined with sensory data to make inferences about the world. (Knill, Kersten, and Yuille 1996, 15)

Some of my closest colleagues are even avowed phenomenalists (Loomis 1992). The neurologist V. S. Ramachandran, echoing Taine's notorious remark that perception is merely "true hallucination," has actually said in public that we are hallucinating all the time (Ramachandran et al. 1998).

A GIBSONIAN VIEW OF DIRECT PERCEPTION

The holdouts in psychology and cognitive science for the last half century have been James J. Gibson and those influenced by his work (e.g., Mace 1977; Shaw 2003; Shaw, Turvey, and Mace 1981). Gibson began his first book (1950) by asking,

> If the mind constructs the world for itself, why does it agree so well with the environment in which we actually move and get about? If space perception is a subjective process then why are we so seldom misled by illusory perceptions? (14)

He spent the remainder of his life developing a scientific account of perception that was consistent with direct realism. Near the end of his career, he phrased his answer this way:

> When I assert that perception of the environment is *direct*, I mean that it is not mediated by *retinal* pictures, *neural* pictures, or *mental* pictures. (1979, 147)

> The function of perception is to keep us in touch with, in contact with, the world. (1974)

The cardinal problem with the indirect position is thus the introduction of mediating objects of awareness such as sensations, retinal or mental images, or internal representations; the problem of perceptual inference is a consequence of the twin assumptions of mediation and underspecification.

Gibson's ecological approach brings a number of contributions to the present discussion, and I will focus on four of them here.

1. The environment. What makes the approach "ecological" is that perception cannot be understood in isolation, but only in the context of an environment. The perceiver is embedded in a particular ecological niche, and its perceptual systems are adapted to the regularities of that niche and the energy arrays it structures. A perceptual system is tuned by evolution and learning to patterns of stimulation that specify environmental features and properties which are relevant to the perceiver's way of life, so that the agent "competently inhabits" its environment, in McDowell's (1994) words. The frog's visual system, for example, is tuned to particular patterns of motion that, in the restricted context of its niche, specify small edible prey and large looming threats. The fish's lateral line organ is tuned to pressure waves that specify obstacles, the movements of predators and prey, and the positions of neighbors in the school. Even the narwal's tusk turns out to be a sense organ tuned to salinity differentials that specify the freezing of the water's surface overhead. The narwal is thereby in perceptual contact with a property of its niche—the penetrability of the surface—that is critical to its survival. Such perceptual abilities cannot be understood without reference to the perceiver's environment and how it patterns the available stimulation. This is a second gloss on "the view from here," implicating a situated perceiver in a particular niche who possesses perceptual equipment enabling it to competently inhabit that niche.

2. Perception and action. Gibson's second contribution is his emphasis on perception as intimately related to action. Perception did not evolve to be the passive recipient of sense impressions from an "outer" world, but rather to guide effective action *in* the world. Reciprocally, action systems evolved not only to perform behavior, but also to explore the environment: "We perceive in order to move, but we also move in order to perceive" (Gibson 1979, 223). Successful behavior is the bottom line for evolution, given that natural selection is predicated upon survival and reproductive success. The demands of efficacious action in a particular ecological niche thus shape perceptual systems, including the variables of stimulation to which they are sensitive (specific patterns of light, pressure, salinity) and the environmental features with which they make contact.

Most basically, perceivers must make contact with behaviorally relevant features of their environments. Gibson dubbed these *affordances*, combinations of environmental properties that afford particular actions for a given animal: configurations of surfaces that support locomotion for a biped with a particular morphology, objects of a certain size and shape that can be grasped by a prehensile hand, things that are edible by a particular ingestive system, and so forth. Perception is thus pragmatic and task-specific. It need not "solve" general problems such as the recovery of absolute space and time, but must provide contact with behaviorally relevant features and properties such as reachable prey and looming threats.

The criteria for the veridicality of direct perception are similarly pragmatic: sufficiency in guiding action rather than accurate judgments of arbitrary physical properties. However, a broader perceptual competence emerges from this fundamental contact with the affordances of a niche. Given that affordances are constituted by material objects and their properties, perceptual systems evolve sensitivities to information specific to such properties (surface layout, shape, size, reflectance, material composition, motion), which generalizes to other environmental situations. As they differentiate informational variables and make finer discriminations, a richer perceptual awareness piggybacks upon the primary perception of affordances.

The argument that perception evolved to guide action has several implications. First, it offers an external rationale for the claim of direct perception. Beyond our intuition of direct awareness, or our sense of the real presence of perceived objects, the perceiver must be in epistemic contact with its environment because efficacious action is oriented to environmental objects. This also suggests a basis for the *intentionality* or object-directedness of perception. Object-directed perceptual systems emerged in the course of evolution because successful behavior is oriented to constant distal objects, not variable proximal stimulation. Perceptual systems thus became sensitive to information for persisting features of the environment such as objects and surfaces, rather than fleeting retinal images or an internal kaleidoscope of sensations, because it is those features to which effective actions are directed. The frog is in perceptual contact with the prey, not the motion pattern; the fish with the obstacle, not the pressure waves; and the narwal with the water's surface, not its salinity.

The intentionality of perception is closely related to the phenomena of perceptual *constancy,* such as position, size, shape, and color constancy. As the perceiver moves through the world, a flow of optical stimulation is generated at the receptors, such that the visual direction, visual angle, projected form, and luminance of objects in the visual field are continually changing, with an accompanying flux of visual appearances. Yet we are perceptually aware of more-or-less constant objects, which do not appear to dramatically change their size, shape, or surface properties as we move with respect to them. Gibson (1979), however, emphasized that perception is simultaneously intentional and perspectival: we co-perceive the persisting features of the environment and their varying relationship to us, which corresponds to the view from here. Self-motion allows the perceiver to disentangle properties attributable to the stable "objective" environment and the mobile "subjective" self. This is another gloss on "the view from here," alluding to the tension between the perception of constant objects and their variable appearances.

3. Information. Gibson's third contribution is his concept of *information as specificity.* An energy array is informative about the environmental situation when it is lawfully structured by, and specific to, that situation. Specificity means that the mapping from higher-order patterns of stimulation to a perceived environmental feature or property is generally univocal: it may be one-to-one or many-to-one, but it is rarely one-to-many. A given property (say, surface shape) might be specified by multiple variables (e.g., texture, shading, disparity, motion) in multiple modalities (e.g., vision, haptics; Gibson 1966, 54–55). However, as the mapping from stimulation patterns to environmental situations becomes one-to-many (equivocal), the variables become ambiguous and increasingly underspecify the situation, and at some point must be considered probabilistic cues. The line here is admittedly fuzzy. Some noise in informational variables under ecological conditions must be tolerated, of course, such as occasional blowing bits of bark that mimic the motion of bugs; such cases can yield perceptual illusions or unsuccessful actions. The visual system also appears to make some use of statistical regularities (e.g., Geisler et al. 2001), which might be bootstrapped by specific variables. The claim here is that perceptual systems rely primarily on specific variables that correspond to the environmental situation with a very high probability, or converge on them during learning (Jacobs and Michaels 2006).

Ecological information is *lawful* not in the Newtonian sense of being universal in space and time, but in an ecological sense of being regular within an ecological context of constraint. Informational variables may specify environmental features by virtue of general laws of optics and physics (Euclid's law of visual angles, physical laws of wave propagation) or by virtue of local constraints in an ecological niche (the moving black specks in the frog's niche are overwhelmingly edible bugs; terrestrial objects normally rest on the ground). An evolving perceptual system cannot know, and does not care, whether such informational regularities are the consequence of general physical laws or local ecological constraints—it simply exploits regularities, whatever their origin. Such information may specify environmental features and properties (what Gibson called *exterospecific* information), the configurations and movements of the agent's own body (*propriospecific* information), the environment in relation to the agent (information for affordances, egocentric position, self-motion), and reciprocally guide the agent's actions in relation to the environment (control information; Warren 2006).

Gibson's concept of information offers a basis for both the intentional and perspectival aspects of perception. His hypothesis (Gibson 1979) is that constant environmental objects and properties are specified by the *invariant structure* in the flow of stimulation, that is, by higher-order spatiotemporal patterns that remain invariant under transformation (as the observer moves, objects move, lighting conditions change, etc.). Thus, the persisting material composition of a granite vase is specified by a particular pattern of optical texture, its polished surface by the sharpness of specular reflections, its saddle shape by second-order spatial derivatives of texture, shading, disparity, and motion (Koenderink and van Doorn 1992; Lappin and Craft 2000), and so on. Reciprocally, the varying spatial relationship between objects and the perceiver is specified by the *perspective structure* of stimulation. This corresponds to the view of the environment *from here*, which locates environmental surfaces and objects relative to the perceiver, and the perceiver relative to its environment. The co-perception of intentional and perspectival properties thus has a basis in the invariant and perspective structure of stimulation.

Gibson's concept of specific information bears certain similarities to the notion of *natural signs* that carry *natural information*, as developed by Dretske and Millikan. According to Dretske (1986), natural signs are reliable indicators of states of affairs by virtue of lawful relations, objective constraints, or pervasive regularities between the sign and the state of affairs; such relations are nonaccidental and support counterfactuals. The motion pattern of black specks is a natural sign of the presence of edible bugs by virtue of both general laws of optics and ecological constraints of the frog's niche. That the relation is univocal is indicated by the claim that it supports counterfactuals: if there were not bugs in the immediate vicinity of the frog, the motion pattern of black specks would normally not be present. Millikan (2004) usefully introduces the idea of *locally recurrent natural signs* that carry *local information* about affairs within a bounded natural domain, analogous to an ecological context of constraint. Unfortunately, in an effort to develop a general theory of signification, she weakens the relation to one of mere correlation, encompassing low probabilities. This undermines Gibson's account of perception as a reliable process that yields contact with the environment, and plays into the hands of the Argument from Underspecification. Low-probability, partially diagnostic relations may be exploited by inferential cognitive processes in doing detective work, medical diagnosis, weather forecasting, and so on, but our primary perceptual contact depends on high-probability, specific information—including our perceptual contact with the material clues, symptoms, and cloud formations that provide premises for cognitive inference processes.

4. *Perceptual systems.* Gibson's fourth contribution is his concept of a *perceptual system.* A perceptual system is an active organ whose function is "seeking and extracting information about the environment from the flowing array of ambient energy" (Gibson 1966, 5). The visual system, for example, consists not only of the retina, optic tract, and visual cortex, but also moving eyes in a moving head on a locomoting body, the associated musculature, and attentional capacities, with descending as well as ascending neural pathways. Through evolution and learning a perceptual system becomes attuned to information, and when it is attended to and detected these neural loops become active so that the system "resonates" to the information. The claim is that *the detection of information by an attuned perceptual system yields awareness of the specified environmental situation.* In Millikan's (1984) terms, detecting information to yield awareness (in both senses) of the environment is the biological *proper function* of a perceptual system.

Of what does this attunement consist? In some sense, the perceptual system comes to embody an implicit mapping from patterns of stimulation to specified features and properties, such that the detection of information causally supports perceptual contact with and subjective experience of the environmental situation. The proximal stimulation is thus "transparent," so the perceiver sees the environment, not the stimulation or information. Here Hume's problem seems to rear its head once again. But we can now see how a perceptual system might become adapted to informational regularities in the course of evolution and learning, such that its attunement is understood as *emergent* rather than *a priori.* First, by developing sensitivity to invariant patterns of stimulation, the activity of the perceptual system comes to covary with persisting environmental entities. Reciprocally, by developing sensitivity to patterns of simulation that vary systematically with self-movement (as optic flow varies with locomotor proprioception), the perceptual system's activity comes to covary with the agent-environment relation, and these patterns become control information for self-movement. Third, by developing sensitivity to those patterns of stimulation that enable successful action (as moving black specks specify edible things), its activity comes to covary with the affordances of the environment, and these patterns become control information for actions that realize affordances.[4] Finally, given that affordances are constituted by combinations of properties, the perceptual discrimination of properties co-evolves with differentiated actions; and a perceptual system that is sensitive to properties becomes generative, enabling a richer awareness of the environment at large. An attuned perceptual system thus, in some sense, comes to embody mappings from information to environmental situations and their behavioral meanings, thanks to the fact that these relations are semantically closed over the perceiving-acting agent-environment system (Shaw 2003).

Note, however, that biological proper functions do not always guarantee successful outcomes. In the present case, the activation of an attuned perceptual system does not ensure veridical perceptual experience. Information-based perceptual systems are reliable, but not infallible. A frog may experience the occasional blowing bit of bark as an edible bug, and end up with a mouthful of wood. For a terrestrial observer in a gravitational field, objects generally rest on the ground (with a few recognizable exceptions such as birds), and hence the declination angle of an object's base from the horizon specifies its distance along the ground plane (Ooi, Wu, and He 2001). A perceptual system that relies on declination angle can yield anomalous results in instances when the gravitational constraint is violated. For instance, a floating or invisibly suspended object looks to be resting on the ground plane at the point where its base occludes the ground texture, yielding concomitant shifts in judged distance and size (Gibson 1950).

Yet such anomalies are also a spectacular vindication that the perceptual system is doing the job it evolved to do: extract informational variables that, within its ecological context of constraint, normally specify environmental features and properties.[5] To regard these cases as "perceptual errors" or "misperceptions" is a mark of logical rather than ecological analysis (Ben-Ze'ev 1984). Such anomalies are sufficiently rare under ecological conditions that they do not undermine the day-to-day reliability of perception, but they do raise the question of what is being experienced in such instances.

To set up an answer to that question, let me distinguish two levels of the analysis of perception. Gibson's focus was on the functional relations among behaviorally relevant environmental features, specific information, and a perceiving agent. I will refer to this as the *functional* level of epistemic contact, on which the agent is informed about its environment (McDowell [1994] calls it the "semantic" level). The scientific questions at this level are what environmental features are perceived, what information is available under ecological conditions, and which informational variables are actually used by perceivers.

Exactly *how* the neural machinery of a perceptual system detects variables of stimulation is an important but distinct scientific question. It sits at the level of *causal support* for perception (McDowell [1994] calls it the "syntactic" level). At this level, active perceptual systems extract higher-order spatiotemporal variables from the flowing energy arrays at their receptors. They become attuned to such regularities over phylogenetic and ontogenetic time, yielding integrated neural networks with ascending and descending pathways that are selective for higher-order variables of stimulation. A case in point is the extended family of networks of motion-sensitive cells in visual cortex that are selective for complex optic flow patterns, and whose activity appears to covary with self-motion, object motion, and surface shape.

Thus, at the causal level the frog's eye and brain are detecting the motion patterns of black specks, while at the functional level the frog (under normal ecological conditions) is in contact with edible bugs and can behave accordingly. Following McDowell (1994), the relation between these two levels is a causal enabling, not constitutive, one: the neural machinery enables the frog to perceive its environment, but it is not constitutive of the epistemic contact relation. The frog's motion-sensitive cells crank through their physio-chemical rounds but themselves "know" nothing about the external world, or even about the proximal cause of their activity. Thus, to say that the neural machinery is framing hypotheses or drawing inferences about the world, or making assumptions about the laws of optics, is something of a category mistake. Imputing such intentional properties to the causal level is purely metaphorical and can be misleading in regard to actual neural processes. Informational regularities, from moving black specks to salinity, are simply facts of nature to which perceptual systems have adapted. At the causal level, attuned neural systems are simply resonating to patterns of stimulation. At the functional level, the agent is in contact with and experiences its environment.

Marr (1982) famously accused Gibson of "seriously underestimat[ing] the complexity of the information-processing problems involved in vision" (29). He was surely right about this at the causal level of neural mechanisms that detect patterns of stimulation, which was of subsidiary interest to Gibson and about which little was actually known at the time of his writing on the subject (Gibson 1966). But Marr confused the level of causal support with Gibson's functional-level claim that information does not have to be decoded, processed, or interpreted. The specificity of information allows the perceiver to be in direct contact with its environment, without inferential or interpretive processes.

REPRESENTATION REDUX

How does Gibson's approach to perception compare with the representationalist one? On the standard representationalist view, perception is conceived as a process of getting an image, description, or symbol—some representation—of the environmental object into the head or mind of the perceiver. The representation stands for something in the world and constitutes the object of awareness; the observer does not immediately perceive or experience the environment, but only her mental representation thereof.

However, getting a representation of the world into the head does not really solve the problem. First, it sets up a logical regress analogous to the classic homunculus problem of picture-in-the-head theories: if the object of awareness is an internal image or representation, who perceives the image or interprets the representation? Second, this returns us to Hume's problem, for interpreting a representation presumes prior knowledge of the environmental entities for which the representations stand, and how they correspond. Third, it commits the *representationalist fallacy* of confusing the *object* of awareness with the *vehicle* of awareness (Huemer 2001). One may perceive the environment (the object of awareness) by *means* of an internal state (the vehicle of awareness), but to say that one perceives the vehicle of awareness itself is a category mistake that leads to the regress. The representationalist ends up claiming that we only perceive our internal states, which involves creating an internal representation of an internal representation (etc.), thereby ringing down the veil of perception.

Alternatively, perception may be conceptualized as a *relation* between the perceiver and the environment, in which the perceiver is aware of or in contact with ordinary environmental objects. Gibson's view of direct perception is of this stripe. But the question persists: what goes on in the perceiver when she becomes aware of an environmental object, if not getting a description of it into her head? For Gibson, the observer's perceptual system, which is attuned to specific information, resonates to that information. There are thus coordinated changes of state in the environment and the perceiver. The perceptual system's activity covaries with distal environmental features and properties, enabling actions to be oriented to them. The object of awareness is the environmental object, and the vehicle of awareness is the resonating perceptual system.

Recently, a revisionist notion of representation—call it representation_1—has been developed, partly inspired by Gibsonian theory (Dretske 1981, 1986; Millikan 1984, 2004). A representation_1 is an internal state that covaries with some distal feature of the environment and thus *tracks* it.[6] Moreover, it has the *function* of indicating the presence of that feature to another part of the system (a "representation_1 consumer"). That is, a representation_1 is selected for because it enables the consumer to successfully orient its behavior to the indicated feature; the system thus incorporates a "semantic mapping function" that maps the representation_1 onto the feature. A representation_1 can consequently carry information about a distal environmental feature without representing the intervening chain of natural signs (reflected light, proximal stimulation, neural activity, etc.). It can also "misrepresent" the presence of a feature in cases when, for example, proximal stimulation occurs in the absence of the feature. Millikan (2004) calls them *intentional representations.*

This notion of representation_1 should sound familiar, for it is closely related to Gibson's notion of an attuned perceptual system. Both covary with an environmental feature and enable behavior oriented to that feature. Representations_1 are not presumed to constitute objects of awareness, unlike mental images (call them representation_2), and are not vehicles of inference or computation (Millikan 2004, 84), unlike symbolic representations in a language of thought (representation_3). Indeed, Millikan (2004, 159–60) herself claims that the changes in inner states that result from the Gibsonian detection of information and guide behavior satisfy her definition of intentional representations.

However, the definition of representations_1 is sufficiently weak that they turn out to be rather promiscuous. They can be plausibly attributed to almost any system with moving parts, including simple physical mechanisms. As Chemero (2000) argues, an adequate description of such a system in $\text{representational}_1$ terms requires a prior understanding of how the system works (e.g., in dynamical terms) in order to appropriately ascribe representations to its parts. Once one has such an understanding, the representational redescription seems superfluous: a $\text{representational}_1$ story can be told, and may be descriptively convenient, but it does not add value to the prior explanation. In the present case, it may be possible to redescribe the detection of information by an attuned perceptual system in $\text{representational}_1$ terms, but this does no further work for us in explaining perception than the more specific Gibsonian concepts that have already been introduced. It also risks confusion with more intractable versions of representationalism. Thus, I propose to stick with the present concepts.

TO SEE OR NOT TO SEE: THE ARGUMENTS FROM ILLUSION AND HALLUCINATION

How, then, might direct perception be sustained in the face of the indirect critique? Having developed a Gibsonian account of direct perception, in the remainder of the paper I use it to resist the standard lines of attack, beginning with the Arguments from Illusion and Hallucination. In illusions and hallucinations the world is not as it appears to be, and hence they seem to provide counterexamples to direct perception. Although they are distinct phenomena, the forms of the arguments are similar, so following Smith (2002), let us review.

1. *Indistinguishability:* The first stage in the argument is the claim that it is possible in principle to have instances of illusion/hallucination that are subjectively indistinguishable from instances of veridical perception.[7] In an illusion, an object appears to have a property or feature that the physical object itself does not actually possess. In a hallucination, an entire object appears to be present that is not actually present.

2. *The sense-datum inference:* The second stage is the inference that, when experiencing an illusion or hallucination, there is *something* of which one is aware, even though it is not physical. In the case of illusion, when a physical object appears to have a property that it does not actually possess one must be aware of *some* object that possesses that property. By virtue of Leibniz's Law of the indiscernibility of identicals, the object of awareness cannot be the normal physical object, so we must be aware of some *nonnormal* object. The case of hallucination is more straightforward: since no normal physical object that corresponds to one's experience is actually present, the object of awareness must be some nonnormal object. This nonnormal object of awareness is variously interpreted as a sense-datum, sensation, appearance, mental image, or internal representation.

3. *The generalization step*: The third stage in the argument generalizes the nonnormal object of awareness from nonveridical cases to veridical ones. If one is

immediately aware of sense-data in cases of illusion/hallucination, and if one's subjective experience in such cases is indiscernible from that in cases of genuine perception, then the objects of immediate awareness in genuine perception must be sense-data as well. This follows from the converse principle of the identity of indiscernibles, to the effect that if one cannot distinguish an illusory/hallucinatory experience and a genuine perceptual experience "from inside," the objects of awareness must be identical. McDowell (1982) calls this the *highest common factor* conception, in which the common element in perception and illusion/hallucination—the experience or appearance—is taken to be the object of awareness in both cases. The conclusion is that in perception one is directly aware only of sense-data, and hence indirectly aware of ordinary physical objects.

There is a bestiary of perceptual illusions that seem to fit this general picture. For example, in geometrical illusions such as the Muller-Lyer (double arrow) or the Ponzo (converging lines) illusions, two line segments appear to have different lengths when they are actually of equal physical length on the page. In Kaniza's subjective triangle, interpolated contours are seen where there is no local stimulation at all. A floating object that looks to be resting on the ground appears farther away and larger in size than it actually is. In cases of outright hallucination, the pink elephant that appears before me is not present at all, and yet I have a very compelling experience of one. What am I seeing in such cases if not an illusory, nonnormal object of awareness with such properties?

But the argument is potentially vulnerable to attack at each stage. First, with regard to indistinguishability, it is often the case that illusions can be dispelled by a little perceptual exploration. Under ordinary mobile viewing conditions, the floating object is revealed to be suspended in the air, as specified by differential motion between its base and the ground texture. Perception is not constituted by an instantaneous percept but an encounter with the world that is extended in time and space, involving perceptual exploration and the consequences of action. However, granting this does little to infirm the argument, for it turns on the mere *possibility* of an indistinguishable illusion: as long as illusion/hallucination is possible in principle, then whatever highest common factor it may share with veridical perception can be construed as the object of awareness. It is certainly possible to concoct in-principle examples, such as a perfect virtual environment that can be actively explored by a moving observer, or an interactive hallucinated world induced by means of direct neural stimulation, à la *The Matrix*.

The second and third stages are more vulnerable. The sense-datum inference holds that there must be some nonnormal object of awareness in cases of illusion/hallucination. But when one is experiencing a hallucination, there is no compelling reason to make the inference that one is *seeing* or *aware of* any object at all, normal or nonnormal. One is merely having an experience, which does not imply the reification of *any* object of awareness. We may be seduced into making the inference by our ordinary way of speaking, in which "seeing" and "being aware of" imply successful contact with objects. But despite my habit of saying "I see a pink elephant" when hallucinating, I am not successfully seeing a pink elephant, I only seem to be seeing one. The subjective experience does not permit the conclusion that I stand in an awareness relation to a real or nonnormal pink elephant. I am merely having an experience of a pink elephant, with no object of awareness at all. To anticipate, if we can develop a clearer understanding of what "having an experience" means, we may find that we can account for illusory/hallucinatory experiences without introducing a new ontological class of nonnormal objects of awareness. We can thus resist the sense-datum inference.

The generalizing step holds that the indistinguishability of veridical and nonveridical experiences is reason enough to conclude that they both have nonnormal objects of awareness. But this does not follow necessarily, for it remains logically possible that in instances of genuine perception the object of awareness is an ordinary mind-independent object, whereas in instances of illusion/hallucination it is something else (or nothing at all).[8] This line of argument has a disjunctivist flavor (Hinton 1967; Martin 2002; McDowell 1982; Snowdon 1980–81)—an experience is either a veridical perception *or* an illusion/hallucination—except that it does not deny subjective experience as a common element. Perceptual and illusory/hallucinatory experiences may be the same internally, and yet be externally distinguished by whether or not one is aware of an ordinary environmental object.

The trouble here is that the generalization step seems the more reasonable and parsimonious one to take: even if it is not logically necessary that there be only one object of awareness, why should we believe there are two? To anticipate, if we can make it reasonable that veridical and hallucinatory cases produce the same subjective experience, one with a normal object of awareness and the other without one at all, then we can also resist the generalizing step.

Let me begin by assembling a positive account of illusion/hallucination. The argument's driving assumption that perceptual awareness should be assimilated to illusion/hallucination has it precisely backward: rather, the phenomena of illusion/hallucination are predatory upon direct perception. They are byproducts of an attuned perceptual system that is adapted to regularities of its ecological niche and provides the causal support for direct perception. Why is it that we have illusions of surface edges and object size and hallucinate bounded three-dimensional objects like daggers and pink elephants with surface properties—at all? Because these are manifestations of the proper function of a perceptual system that is tuned to information for environmental surfaces, edges, and objects.

The key to undoing the argument is the following claim: *phenomenal experience (an internal matter) supervenes upon the activity of an attuned perceptual system, whereas perceptual awareness or contact (an external matter) supervenes jointly upon the perceptual system and the environment.* Recall that Gibson's account of direct perception drives a wedge between awareness as conscious phenomenal experience and awareness as epistemic contact (see the first quote above). In everyday perceptual encounters with the environment, subjective experience is normally congruent with the situation the perceiver is in contact with. This is because perceptual systems are tuned by evolution and learning to variables of stimulation that specify the environment, such that when the information is detected the specified situation is experienced and behavior is adaptive. This is the proper function of perceptual systems. Consequently, the activity of an attuned perceptual system is sufficient to give rise to phenomenal experiences. This was, roughly, Shakespeare's own theory of hallucinations:

> Or art thou but
> A dagger of the mind, a false creation
> Proceeding from the heat-oppressed brain?
>
> (*Macbeth*, Act 2, Scene 1, 49)

But neural activity in the heat-oppressed brain at the causal level is not by itself sufficient for epistemic contact at the functional level, because the latter is constituted by a relation between the perceiver and its environment.

Although there are various classes of illusions, each with its own etiology, most trade on the information to which perceptual systems are (or are not) attuned within their ecological context of constraint. Some illusions derive from insufficient information, such that the available stimulation is either outside the range of the sensors or is insufficiently structured for the perceptual system to determine the property in question. For example, in dim light strawberries and bananas look gray because the retinal cones are insufficiently stimulated, whereas under narrow-band sodium vapor light they look gray because the stimulation does not contain a sufficient range of wavelengths to determine their spectral reflectance. These illusory experiences thus stem from insufficient activation of the relevant perceptual system.

Other illusions derive from stimulation that mimics the information that is normally present under ecological conditions closely enough to activate an attuned perceptual system. Some optical displays closely replicate the information that ordinarily specifies an environmental situation, for example, a *trompe l'oeil* painting, the optical shimmer of a mirage, or the patch of sunlight on my kitchen counter that looks like spilled sugar. A persuasive case can be made that many geometric illusions, such as the Muller-Lyer and Ponzo figures, present 2D optical patterns containing fragments of perspective information that are sufficient to engage visual constancy mechanisms which evolved to determine 3D size and shape (Gillam 1980). Subjective triangles may derive from contour integration mechanisms that evolved to detect continuous object edges in complex noisy scenes (Geisler et al. 2001). In these cases, the presented pattern of stimulation activates an attuned perceptual system, yielding an illusory experience of the environmental situation such stimulation ordinarily specifies.

Often illusory effects are a consequence of taking the perceiver outside its normal ecological context of constraint. When the frog snaps hungrily at moving inkspots in the laboratory or the moth flies toward a streetlamp, they are guided by nonecological stimulation that mimics the information specific to the affordances of bug edibility or moon-oriented navigation within their respective niches. The frog and the moth experience the affordances (to the extent that they have conscious experiences) because subjective experience supervenes on the activity of their perceptual systems, and their behavior is adapted to the affordances in accordance with the proper functions of their perceptual systems. But they are not in perceptual contact with the affordances, nor bugs or moon, for these things are not actually present. Rather, the frog and the moth are in contact with the ordinary entities that are present—the inkspots and the lamp—even though they are experienced as having illusory properties they do not actually possess.

To summarize, in cases of illusion, the detection of stimulation patterns by an attuned perceptual system at the causal level yields phenomenal experience of the environmental properties they ordinarily specify, but without perceptual contact with those properties at the functional level. Similarly, in cases of outright hallucination, activity in an attuned perceptual system (however it is produced) yields phenomenal experience of environmental objects and properties for which the system is tuned, but without perceptual contact with anything at all.

We now have the tools we need to deflate the argument from illusion/hallucination. The sense-datum inference appeals to the intuition that when one is experiencing an illusion or hallucination, there must be some nonnormal object of awareness. But we now have an understanding of "having an experience" that allows us to account for illusions/hallucinations without reifying objects of awareness. At the causal level, the detection of stimulation patterns yields activation of an attuned perceptual system, upon which supervenes a phenomenal experience of the specified situation. In principle, any condition that serves to generate the same (type-identical) activity in the perceptual system will result in an indistinguishable subjective experience, whether the condition is a virtual reality display, electrical stimulation of the cortex, or an old-fashioned hallucination. "Having an experience" is attributed to activity in the attuned perceptual system upon which it supervenes. There is no need to introduce nonnormal objects of awareness, because there is no corresponding thing the observer is aware *of* or in contact *with*, just a phenomenal experience that supervenes on perceptual system activity. We can thus resist the sense-datum inference.

The generalization step relies on the apparent reasonableness of the conclusion that if veridical and nonveridical experiences are internally indistinguishable, then they must share the same (nonnormal) object of awareness. But we now have a compelling account of how it is that the same subjective experience can occur in perceptual cases when the object of awareness is an ordinary environmental object, and in corresponding hallucinatory cases when there is no object of awareness at all. In cases of direct perception, the information in an ordinary environmental situation activates an attuned perceptual system, yielding a phenomenal experience and perceptual contact with the specified situation. In corresponding cases of illusion/hallucination, some other condition creates the same activity in the perceptual system, which *must* yield the same phenomenal experience, but without the corresponding perceptual contact.[9]

Thus, despite indistinguishable phenomenal experiences, in the perceptual case the object of awareness is an ordinary environmental object, whereas in the illusory/hallucinatory case there is no property/object of awareness. This is no longer a mere logical possibility, but a scientifically grounded one that follows from a theory of perceptual systems. Moreover, the generalization step commits the representationalist fallacy by proposing that mind-dependent entities are the objects of awareness. In the face of this, it is the introduction of *nonnormal* objects that seems unreasonable, and ontological parsimony is actually upheld if we refuse to introduce them. We can thus resist the generalization step. In sum, direct perception as epistemic contact is not threatened by the argument from illusion/hallucination.

THE VIEW FROM HERE: THE ARGUMENT FROM APPEARANCES

A related argument against direct perception claims that the perceiver only has immediate access to the appearance of an environmental object, not the object itself. Hume put it this way:

> . . .nothing can ever be present to the mind but an image or perception, and the senses are only the inlets, through which these images are conveyed, without being able to produce any immediate intercourse between the mind and the object. The table, which we see, seems to diminish, as we remove farther from it: But the real table, which exists independent of us, suffers no alteration: It was, therefore, nothing but its image which was present to the mind. (Hume, 1748/1993, XII.I, p. 104)

It is the variable appearance or image that is immediately perceived, not the constant real object, and hence there can be no immediate intercourse between the mind and the world. Perception of the environment is necessarily indirect, mediated by appearances.

The argument from appearances is essentially a restatement of the problem of perceptual constancy. Hume was referring to size constancy: as one's viewing distance from the table changes, its apparent (projected) size varies, yet we perceive a constant (full-size) table. William James (1890) pointed out shape constancy: as one's view of the table-top changes, its apparent (projected) shape has an infinity of trapezoidal forms with varying obtuse and acute angles, yet we perceive the table as having a constant (square) shape. This raises a further paradox: How can it be that we see one and the same table to be both small and large, both trapezoidal and square?

The indirect solution is plain: one is immediately aware of only the varying appearance of the table, from which the real constant table must be inferred. A standard indirect account is that, with experience, we learn to associate the real shape of the table with the various projected forms of which we are immediately aware. Perception is thus a two-step process, in which we first see the apparent shape (the projected form) and then infer the real shape based on prior knowledge.[10] But how do we acquire these associations, without having perceptual access to the real shape? Noë (this issue) offers what I take to be a variant of this solution when he also argues that perception is a "two-step process" in which we perceive an object "by way of" seeing its appearance, "mediated by" prior sensorimotor knowledge of the way the object's appearance would change with bodily movement. To the extent that only appearances are immediately accessible and percepts of the environment are arrived at on the basis of mediating knowledge, this is redolent of the indirect view.

The paradox stems from a failure to recognize that one is seeing different properties of the same table, its intrinsic and perspectival properties. The diameter of the tabletop is an intrinsic property, measured on the physical table, that is independent of viewing distance; whereas its projected size is a perspectival property, measured as a visual angle from an observation point, that depends on viewing distance. Its geometric shape is an intrinsic property measured on the tabletop, whereas its projected form, aspect, or silhouette is a perspectival, view-dependent property measured as a visual solid angle (the sheaf of visual directions to its bounding contour). There is no contradiction between seeing the tabletop's surface shape to be square and its silhouette to be trapezoidal, for they are simply intrinsic and perspectival properties, respectively, of one table.

This distinction is closely related to what Gibson (1950, ch. 3) initially called the *visual world*, the three-dimensional layout of environmental surfaces, and the *visual field*, a two-dimensional array of projected forms (nested visual solid angles) that corresponds to the view from here. He argued that one can attend to either the visual world or the visual field, but that they involve different "kinds of seeing"—the former more natural, the latter more analytic. Claude Monet tried to teach his acolytes how to adopt an analytic attitude by saying,

> Try to forget what objects you have before you. . . . Merely think, here is a little square of blue, here an oblong of pink, here a streak of yellow, and paint it just as it looks to you.

We normally attend to environmental objects and surfaces, and their perceived size, shape, and surface color remain roughly constant over changes in viewpoint and illumination. We can alternately attend to the visual field—much as the practiced painter does when sighting a scene—yielding an experience ("a little oblong of brown") that varies with viewpoint and illumination. We seem to experience the visual direction of an object as "the direction from here," its projected size or visual angle as "the portion of the visual field it takes up," and its projected shape or visual solid angle as "the form of the silhouette in the visual field." This phenomenology suggests that both constant objects and their variable appearances are accessible to attentive awareness, and yet our primary mode of attention is to the environmental objects toward which our behavior is directed.

This dual access does not imply that environmental objects are perceived *by way of* their appearances, in a two-step inferential process. Rather, the constant sizes and shapes of objects are directly specified by the *invariant structure* in stimulation. Gibson (1979) argued that invariant patterns in the (typically) flowing optic array specify the persisting properties of the environment, thereby accounting for the perceptual constancies. For example, one of his most important insights was the role of the textured ground surface and other background surfaces in providing a stable scale relative to which objects are perceived. The constant location of a table is specified by its optical contact with the ground surface (Bian, Braunstein, and Andersen 2005). Its constant size is specified by the invariant *ratio* of the table's visual angle to that of the ground texture. In a compelling demonstration of this effect, observers do not notice that a virtual room doubles in size as they step from one side of it to the other: despite accurate disparity and motion information, size judgments are dominated by the relative size of a test object with respect to the textured background (Glennerster et al. 2006). Similarly, the constant shape of the table is specified by the invariant ratio of the visual solid angles of the tabletop and the ground texture: as the viewpoint changes, both solid angles deform together, leaving their higher-order relations invariant. For more complex 3D surfaces, the invariants that specify shape are second-order spatial derivatives of the texture, shading, disparity, and motion fields, as noted above.

Thus, constant size and shape are directly specified by what Gibson called "formless invariants," higher-order relations that remain invariant over changes in viewpoint, not by momentary forms or appearances. Of course, the optic array is described in terms of visual directions and visual angles, but it is the abstract relations defined over them that constitute the invariant information. The visual system has evolved extended networks to extract these higher-order relations at the causal level, which may incorporate neural circuits that register visual directions, visual angles, and their changes. And to the extent that projected sizes and forms are present in the visual field, they may be accessible to attentive awareness. But perception of environmental objects at the functional level is based on the detection of the formless invariants, not on awareness of momentary forms and inference to object properties.

Conversely, *perspective structure* provides a basis for the perspectival aspect of perception, in the sense that it corresponds to the view from here. The perspective structure of the optic array at a stationary viewpoint consists of visual directions, visual angles, visual solid angles, and their inclusion relations. It provides information about the positions and orientations of environmental surfaces relative to the observer, and locates the perceiver relative to the environment. For example, the distance of the table along the ground plane is specifed by the visual angle between its base and the horizon (the declination angle), and the slant of the tabletop to the line of sight is specified by the texture gradient within its contour. Perception of such egocentric relations at the functional level is based on the registration of the informational variables by an attuned visual system at the causal level, not inference from an awareness of projected forms. Yet given that projected sizes and forms are present in the visual field, and are accessible to attentive awareness, then one is able to attend to an object's appearance.

The essential point is that although one can attend to environmental objects or to their appearance from here, it does not follow that the former are perceived *by way* of the latter. Constant size and shape can be perceived directly by detecting formless higher-order invariants, independently of awareness of their projected sizes and forms.

SEEING OR NOTHINGNESS: THE ARGUMENT FROM UNDERSPECIFICATION

The Argument from Underspecification asserts that environmental features are inherently *underspecified* or underdetermined by proximal stimulation. This is often presented as a self-evident truth, based on the observation that the environment is three-dimensional and the retinal image merely two-dimensional. As the well-known Ames demonstrations (Ittelson 1968) forcefully showed, for any static image of, say, a table, an equivalence class of exploded-view 3D configurations, stretched along the line of sight, can be constructed that all project the same image. Even if the observer is allowed to move, an equivalence class of deforming configurations could be concocted that all project the same dynamic image of a table; this was actually done by the special effects team for *The Fellowship of the Ring.* If we take this assertion at face value, directly perceiving the environmental situation from the proximal stimulation is indeed hopeless, an "ill-posed problem," for a given image could in principle correspond to an infinite number of 3D worlds.

The next step in the argument is the claim that the perceiver must consequently go "beyond the information given" and infer the state of the world from an ambiguous image. The only way to do this is to introduce auxiliary assumptions that sufficiently constrain the "inverse optics problem" so that a unique 3D interpretation of the 2D image is possible. David Marr (1982) summarized this approach as follows:

> In each case the surface structure is strictly underdetermined from the information in images alone, and the secret of formulating the processes accurately lies in discovering precisely what additional information can safely be assumed about the world that provides powerful enough constraints for the process to run. (265–66)

For instance, Marr's student Ullman (1978) proved that if one assumes that objects are rigid, then the image sequence produced by a rotating nonplanar object has a unique Euclidean shape interpretation.

As Helmholtz originally observed, the assumptions necessary to solve the inverse problem represent prior knowledge on the part of the perceiver about two things: (1) the structure of the world, and (2) how the world structures patterns of stimulation. The first includes knowledge about the situations, objects, and properties that exist in the environment, including worldly predicates in which to frame hypotheses and conclusions; the rigidity assumption and the use of Euclidean predicates to describe shape are examples. The second includes knowledge about regularities such as the laws of geometrical optics, which are necessary to determine the inverse relations that take the perceiver from the image back to the world, as in Ullman's structure-from-motion algorithm. These two forms of prior knowledge are likewise explicit in the Bayesian approach to vision, which frames perception as a problem of statistical inference that incorporates assumptions about the structure of environmental scenes and principles of image formation (Knill et al. 1996, 15).

The argument from underspecification suffers two key deficiencies. First, the claim of inherent underspecification depends upon treating perception as a logical rather than an ecological matter. Although it is indeed logically the case that the 2D image is ambiguous regarding the distance, size, and shape of an object in empty 3D space, under ecological conditions with textured surfaces, a ground plane, and free observer movement, many behaviorally relevant properties are specified (as sketched above). Although the same image can logically be produced by an infinite number of exploded-view Ames configurations, the environment does not conspire to generate such configurations (the *generic viewpoint* principle), and the odd accidental view is dispelled by ordinary head movements. Gibson's (1950; 1979) fundamental insight was that when the problem of perception is ecologized in this manner, many environmental properties turn out to be specified by higher-order information, and many longstanding puzzles can be reframed or resolved. This is a factual matter that must be worked out through the study of ecological optics.

The deeper trouble with the inferential solution to underspecification is its circularity—it runs smack into Hume's problem, which was after all a case for skepticism, not indirect realism. In order to perceive the world, prior knowledge about the world and how it structures stimulation is assumed. But where does this knowledge come from, if not by way of the senses? As Gibson (1979) observed,

> The error lies, it seems to me, in assuming that either innate ideas or acquired ideas must be applied to bare sensory inputs for perceiving to occur. The fallacy is to assume that because inputs convey no knowledge they can somehow be made to yield knowledge by "processing" them.... Knowledge of the world cannot be explained by supposing that knowledge of the world already exists. (253)

Both nativism and empiricism ultimately require some form of direct perception as an enabling condition, or else nothing could be perceived (Turvey and Shaw 1979). The indirect view owes us a serious account of how an initially blind system could work out, through evolution or learning, knowledge of inaccessible features of the world and their relations to patterns of stimulation, without assuming some degree of specificity.

The direct view offers a reasonably straightforward account of perceptual evolution, based on specificity. Perceptual systems become attuned to informational regularities in the same manner that other systems adapt to other sorts of environmental regularities (such as a food source): possessing the relevant bit of physiological plumbing (whether an enzyme or a neural circuit) to exploit a regularity confers a selective advantage upon the organism. Since the water beetle larva's prey floats on the surface of the pond and illumination regularly comes from above, possession of an eye spot and a phototropic circuit can enhance its survival and reproductive success. But if the illumination were ambiguous and prior knowledge were required to infer the direction of the prey, it is not clear how such a visual mechanism would get off the ground. Natural selection converges on specific information that supports efficacious action.

What the indirect view treats as assumptions imputed to the perceiver can thus be understood as *ecological constraints* under which the perceptual system evolved. The perceptual system need not internally represent an assumption that natural surfaces are regularly textured, that terrestrial objects obey the law of gravitation, or that light comes from above. Rather, these are facts of nature that are responsible for the informational regularities to which perceptual systems adapt, such as texture gradients, declination angles, and illumination gradients. They need not be internally represented as assumptions because the perceptual system need not perform the inverse inferences that require them as premises. The perceptual system simply becomes attuned to information that, within its niche, reliably specifies the environmental situation and enables the organism to act effectively.

This is not to say that *any* environmental feature of interest is so specified. It is undoubtedly the case that many environmental properties are not directly perceived but must be ascertained by other cognitive means. Gibson's (1959) claim is merely that, *for every **perceivable** property of the environment, however subtle, there exists an informational variable, however complex, that specifies it.* This points up the fact that our analysis of specificity depends on what properties we assume are perceived and exactly how we describe them. If surface shape is described qualitatively (e.g., as a locally planar, spherical, cylindrical, or saddle-shaped patch of surface), then the second-order spatial differential structure of stimulation provides specific information for shape, and perceptual judgments are highly accurate and precise. However, if surface shape is described in Euclidean terms (e.g., in terms of metric local depth, slant, or curvature), surface shape is only specified up to a scale factor, and judgments are an order of magnitude worse (Koenderink 2001; Tittle et al. 1995; Todd 2004). Perceptual performance can only be as accurate and precise as the available information will allow. The study of perception is thus something of a closed circle: it must include ascertaining what environmental properties are in fact reliably perceivable, what informational variables are specific to them under ecological conditions, and which variables are actually used by the perceptual system.

In sum, when considered ecologically rather than logically, the argument from underspecification does not hold up. There are in fact patterns of stimulation that specify some environmental features and properties under ecological conditions. At a minimum, such information supports direct perception of certain behaviorally relevant features so that perceptual systems can get off the ground; more ambitiously, it renders prior knowledge and inference unnecessary for perception of the environment.

REPRISE

I have argued that Gibson's ecological theory provides the elements of a plausible account of direct perception and offers means to fend off the standard arguments against it. Specifically, direct perception is a relation of epistemic contact between an active agent and environmental situations, with a causal basis in the detection of information specific to those situations by an attuned perceptual system. The specificity of information under ecological conditions allows for direct perception without prior knowledge or inference. Illusions and hallucinations are understood as phenomenal experiences that supervene upon the activity of perceptual systems, in the absence of perceptual contact, and do not imply nonnormal objects of awareness. Perceptual constancy reflects the invariant structure of the optic array, which specifies persisting objects and properties, whereas variable appearances reflect attention to their projected sizes and forms in the optic array, which correspond to the view from here. The former are not perceived by way of the latter, for formless invariants can be detected without seeing momentary forms and inferring object properties. The ecological view thus suggests a basis for the intentionality of perception: evolution produced perceptual systems that are attuned to invariant structure and are object-directed because successful behavior is oriented to environmental objects.

NOTES

Thanks to Chris Hill, Tony Chemero, Jeff Hutchison, and Josh Siegle for their helpful comments on a previous draft. All errors of omission and commission are of course my own.

1. I use the term "situation" generically to cover the environmental layout of surfaces, objects, events, and their properties, as well as their relationship to the perceiver.
2. Perception should be distinguished from recognition. "Seeing the copper beech tree" does not mean recognizing the object before me as a copper beech tree (which presumes that I have the concept, *copper beech tree*), but rather perceiving the object and its properties, such as its shape, size, surface color, material composition, location, affordance properties, and so on.
3. This use of the term *representation* is consistent with standard "representationalist" theories of perception as well as with common parlance in cognitive science, in which a mental representation is an internal image or description that stands for something in the world and constitutes the object of awareness. Revisionist views of representation will be considered below.
4. Anticipating Millikan's (2004) "pushmi-pullyu representations."
5. In fact, such manipulations are exactly how vision scientists test their hypotheses about a perceptual system's reliance on informational variables.
6. The internal state might be a mental state or a neural state. The latter is close to what neuroscientists call the *neural representation* of a feature, some neural real estate whose activity is correlated with the presence of a distal feature (e.g., a physical edge) and is used by other neural processes (e.g., to determine surface layout).

7. Note that in neither case must one be deceived into *believing* that the world really is as it appears—the perceptual appearance itself is sufficient for the argument, even if one knows it's illusory.
8. Another way of putting this is that since it is the subjective experiences that are indiscernible, the principle of the identity of indiscernibles strictly applies only to the subjective experiences, not to their putative objects of awareness.
9. A revisionist representationalist like Huemer (2001, 128) would say that the experiences are the same because experience *represents there to be* the same objects and properties; whereas I say the experiences are the same because the activity of an attuned perceptual system is the same.
10. Huemer (2001) tries to put a direct realist spin on this solution, in which projected angular size and shape are mind-independent properties (true!), and hence we directly perceive objective properties, namely visual angles. But this is unsatisfactory because the constant size and shape of environmental objects must still be inferred from their appearances.

REFERENCES

Ben-Ze'ev, A. 1984. "What Is a Perceptual Mistake?" *Journal of Mind and Behavior* 5:261–78.

Bian, Z., M. L. Braunstein, and G. J. Andersen. 2005. "The Ground Dominance Effect in the Perception of 3-D Layout." *Perception and Psychophysics* 67:802–15.

Bickhard, M. H., and Terveen, L. 1995. *Foundational Issues in Artificial Intelligence and Cognitive Science: Impasse and Solution*. Amsterdam: Elsevier.

Chemero, A. 2000. "Anti-Representationalism and the Dynamical Stance." *Philosophy of Science* 67:625–47.

Crane, T. 2005. "The Problem of Perception." In E. N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy*: URL = *<http://plato.stanford.edu/archives/spr2005/entries/perception-problem/>*.

Dretske, F. 1981. *Knowledge and the Flow of Information*. Oxford: Blackwell.

Dretske, F. 1986. "Misrepresentation." In R. J. Bogdan (ed.), *Belief: Form, Content, and Function*. Oxford, UK: Oxford University Press.

Geisler, W. S., J. S. Perry, B. J. Super, and D. P. Gallogly. 2001. "Edge Co-occurrence in Natural Images Predicts Contour Grouping Performance." *Vision Research* 41:711–24.

Gibson, J. J. 1950. *Perception of the Visual World*. Boston: Houghton Mifflin.

Gibson, J. J. 1959. "Perception as a Function of Stimulation." In S. Koch (ed.), *Psychology: A Study of a Science* (Vol. I, 456–73). New York: McGraw-Hill.

Gibson, J. J. 1966. *The Senses Considered as Perceptual Systems*. Boston, MA: Houghton-Mifflin.

Gibson, J. J. 1974. *Lecture (recording)*. Paper presented at the Ohio State University, *URL = <http://www.trincoll.edu/depts/ecopsyc/isep/index.html>*.

Gibson, J. J. 1979. *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.

Gillam, B. 1980. "Geometrical Illusions." *Scientific American*, 242 (1): 102–11.

Glennerster, A., L. Tcheang, S. J. Gilson, A. W. Fitzgibbon, and A. J. Parker. 2006. "Humans Ignore Motion and Stereo Cues in Favor of a Fictional Stable World." *Current Biology* 16:428–32.

Goldman, A. 1986. *Epistemology and Cognition*. Cambridge, MA: Harvard University Press.

Helmholtz, H. v. 1866/1925. *Treatise on Physiological Optics* (trans. J. P. C. Southall, 3d ed. Vol. III: The Perceptions of Vision). Optical Society of America.

Hinton, J. M. 1967. "Visual Experiences." *Mind* 76:217–27.

Huemer, M. 2001. *Skepticism and the Veil of Perception*. Lanham, MD: Rowman and Littlefield.

Hume, D. 1748/1993. *An Enquiry Concerning Human Understanding* (2 ed.). Indianapolis, IN: Hackett.

Ittelson, W. H. 1968. *The Ames Demonstrations in Perception*. New York: Hafner.

Jacobs, D. M., and C. F. Michaels. 2006. "An Ecological Theory of Information-Based Perceptual Learning." Manuscript submitted for publication.

James, W. 1890. *The Principles of Psychology*. New York: Holt.

Knill, D. C., D. Kersten, and A. Yuille. 1996. "Introduction: A Bayesian Formulation of Visual Perception." In D. C. Knill and W. Richards (eds.), *Perception as Bayesian Inference* (1–21). New York: Cambridge University Press.

Koenderink, J. J. 2001. "Ambiguity and the 'Mental Eye' in Pictorial Relief." *Perception* 30:431–48.
Koenderink, J. J., and A. J. van Doorn. 1992. "Second-Order Optic Flow." *Journal of the Optical Society of America* 9:530–38.
Lappin, J. S., and W. D. Craft. 2000. "Foundations of Spatial Vision: From Retinal Images to Perceived Shapes." *Psychological Review* 107:6–38.
Loomis, J. M. 1992. "Distal Attribution and Presence." *Presence* 1 (1): 113–19.
Mace, W. M. 1977. "James J. Gibson's Strategy for Perceiving: Ask Not What's Inside Your Head, But What Your Head's Inside Of." In R. E. Shaw and J. Bransford (eds.), *Perceiving, Acting, and Knowing: Toward an Ecological Psychology* (43–66). Hillsdale, NJ: Erlbaum.
Marr, D. 1982. *Vision*. San Francisco: W. H. Freeman.
Martin, M. G. F. 2002. "The Transparency of Experience." *Mind and Language* 17:376–425.
McDowell, J. 1982. "Criteria, Defeasibility, and Knowledge." *Proceedings of the British Academy* 68:455–79.
McDowell, J. 1994. "The Content of Perceptual Experience." *Philosophical Quarterly* 44(175): 190–205.
Millikan, R. G. 1984. *Language, Thought, and Other Biological Categories*. Cambridge, MA: MIT Press.
Millikan, R. G. 2004. *Varieties of Meaning*. Cambridge, MA: MIT Press.
Noë, A. (this issue). "Real Presence." *Philosophical Topics*.
Oatley, K. 1979. *Perceptions and Representations*. New York: Free Press.
Ooi, T. L., B. Wu, and Z. J. He. 2001. "Distance Determined by the Angular Declination below the Horizon." *Nature* 414:197–200.
Ramachandran, V. S., K. C. Armel, C. Foster, and R. Stoddard. 1998. "Complex Object Recognition, Semantics, and Perceptual Learning Can Drive Apparent Motion." Paper presented at the Annual Meeting of the Psychonomic Society, Dallas, TX.
Reid, T. 1785/1969. *Essays on the Intellectual Powers of Man*. Cambridge, MA: MIT Press.
Russell, B. 1912. *The Problems of Philosophy*. New York: Henry Holt.
Searle, J. R. 1980. "Minds, Brains, and Programs." *Behavioral and Brain Sciences* 3:417–57.
Shaw, R. E. 2003. "The Agent-Environment Interface: Simon's Indirect or Gibson's Direct Coupling?" *Ecological Psychology* 15:37–106.
Shaw, R. E., M. T. Turvey, and W. M. Mace. 1981. "Ecological Psychology: The Consequence of a Committment to Realism." In W. Weimer and D. Palermo (eds.), *Cognition and the Symbolic Processes, II* (159–226). Hillsdale, NJ: Erlbaum.
Smith, A. D. 2002. *The Problem of Perception*. Cambridge, MA: Harvard University Press.
Snowdon, P. 1980–81. "Perception, Vision, and Causation." *Proceedings of the Aristotelian Society*, 81, 175–92.
Snowdon, P. 1992. "How to Interpret 'Direct Perception'." In T. Crane (ed.), *The Contents of Experience* (48–78). Cambridge: Cambridge University Press.
Tittle, J. S., J. T. Todd, V. J. Perotti, and J. F. Norman. 1995. "Systematic Distortion of Perceived Three-Dimensional Structure from Motion and Binocular Stereopsis." *Journal of Experimental Psychology: Human Perception and Performance* 2:663–78.
Todd, J. T. 2004. "The Visual Perception of 3D Shape." *Trends in Cognitive Sciences*, 8, 115–21.
Turvey, M. T., and R. E. Shaw. 1979. "The Primacy of Perceiving: An Ecological Reformulation of Perception as a Point of Departure for Understanding Memory." In L.-G. Nilsson (ed.), *Perspectives on Memory Research: Essays in Honor of Uppsala University's 500th Anniversary*. Hillsdale, NJ: Erlbaum.
Ullman, S. 1978. *The Interpretation of Structure from Motion*. Cambridge, MA: MIT Press.
Warren, W. H. 2006. "The Dynamics of Perception and Action." *Psychological Review* 113:358–80.