An Ecological Account of Visual "Illusions"

Luis H. Favela, *University of Central Florida*
and
Anthony Chemero, *University of Cincinnati*

Introduction

At its most basic, direct realism is the claim that perception results from direct or immediate awareness of events or objects that exist in the world independent of any mind.[1] With the hope of bolstering such claims, we offer a framework upon which to base an argument for direct realism in matters of perception. Better yet, we offer an empirically supported framework. The framework on offer is that of ecological psychology.

Our primary argument centers on the claim that whereas visual illusions are problematic for many direct theories of perception, an account of direct perception guided by the principles of ecological psychology can provide more satisfactory explanations. By making explicit the continuity of human visual perception and related action capacities with other creatures, the ecological psychologist rejects mental representations and inferences as necessary components for coping with the world. Moreover, by collapsing the dualism of perception and action, the ecological psychologist provides a way to conceptualize what is meaningful in a way that is grounded as much in the objective features of the world as it is in the capacities of the creature. Affordances, or opportunities for behavior, play such a role. Affordances are meaningful, at least partly, because they are specified by environmental information.[2] Such specification casts doubt on the explanatory import of conceiving of perceptions as veridical or not. A perception is properly understood as direct when it is placed within a framework that ties perception inextricably with action: perception is for action, and action is for perception. In this way, the perception-action engagement of a creature and environmental affordances dissolves the alleged "problem of illusion" as a way to undermine direct realism.[3]

We begin our defense of direct realism in matters of perception with a discussion of the main principles of ecological psychology. With the framework in place, we then discuss how ecological psychology can address visual illusions, one of the major challenges facing direct realism. Part of this discussion involves clarifying the meaning—or lack thereof—of "illusions" within an ecological framework.

Ecological Psychology and Direct Perception

Although many philosophers[4] interested in perception are aware of the work of James J. Gibson (1904-1979), very few have followed the decades of empirical work done by ecological psychologists who were influenced by Gibson's last two books.[5] Gibson's conceptual framework provided the initial impetus for what has become a thriving research program in cognitive science and psychology. Here, we outline three of the key principles of ecological psychology, each of which is a consequence of taking the evolution of perceptual systems seriously.[6]

The first principle is that perception is direct, unmediated contact with the environment. In being direct, perception is not mediated by mental images or other mental representations. This is, in part, motivated by the fact that perceptual systems evolved by natural selection. In cognitive science, visual perception, for example, is thought to begin with the retinal image, which is then converted into a representation available for computational manipulation within the cognitive system.[7] Yet, simpler creatures that do not have eyes or brains as complex as humans and other mammals are able to successfully carryout actions based on visual information. Were trilobites from half a billion years ago able to see with crystalline, holochroal "eyes?"[8] Do insects with compound eyes and tiny brains form mental images? What about animals with convex retinas and lensless eyes such as lobsters? They have no retinal images, so if they have mental images, they must be constructed neurally. But lobsters also have no centralized brain. Neither do earthworms, which also lack specific sense organs. Yet as Darwin learned in his decade long experimental study of earthworm behavior, earthworms alter their activity in subtle ways depending on environmental conditions.[9] These creatures perceive their environments, and it is extremely implausible to claim that they do so via mental images or other mental representations.

The second principle is that perception and action cannot be understood separately. Perceptual systems evolved specifically in order to enable adaptive action in the environment. Guiding action is why perception exists. Moreover, perceiving is always a kind of action. To read a street sign, we move our eyes across it, tilt our heads to try to get an angle that eliminates glare from the sun, and walk closer so the letters are big enough to read. We cannot understand how we see what the sign says only in terms of the light that strikes our retinal cells and brain activity that follows. We have to understand seeing the sign in terms of what Gibson called *perceptual systems*.[10] We see with our brain and eyes, facing forward on our moving heads, set atop our flexible and controllable necks, on our torsos, locomoting using our legs. Notice too that the activity of perceptual systems is temporally extended. Perceiving is a kind of action and all actions take time.

The third tenet follows, more or less, from the first two: If perception is for guiding action, and perception does not involve mental images or mental representations, then the content of

perception must be already relevant for action. Think again of the earthworm. It is implausible to think the earthworm's contact with a leaf causes it to form a mental representation of a leaf, then a retrieval of stored information about the size and pliability of leaves, then an inference that the leaf would be good for plugging a burrow, then a combination of the result of this inference with the result of a prior inference concerning the relative humidity and the need for burrow plugging, and so on. This is the origin of Gibson's theory of *affordances*.[11] Affordances are opportunities for action.[12] They are relationships between things that animals can do and features of the environment. Stairs are climbable for humans with the right leg length, muscle strength, balance, and flexibility.[13] They also afford climbing to dogs, squirrels, etc., and—using different means—spiders and ants. Earthworms do not perceive and identify leaves per se; they perceive what leaves afford to earthworms.

That affordances genuinely exist in the environment should be uncontroversial. There is a fact of the matter whether an animal can pass through an aperture or not.[14] What is less obvious is how and in what sense affordances are directly perceivable. In order for affordances to be perceivable by a creature in a way that is direct and non-representational, the information necessary for guiding behavior must be available in the environment.[15] This runs counter to traditional cognitive science and perceptual psychology, and indeed most analytic epistemology, which are based on the idea of the impoverished stimulus.[16] Sticking with vision, it is often claimed that there is not enough information available in retinal images to determine whether, say, an arrow is large and distant or small and nearby (see Figure 1). This is because the image cast on the retina by the two arrows would be identical. Indeed, many arrows at different distances and angles would cast the very same retinal image. Because of this, to perceive the distance of the arrow, we seem to have to make assumptions about the typical size of arrows. So, to put this in the terms used in cognitive science and psychology research guided by a computational-representational understanding of mind,[17] the stimulus is *impoverished* in that it does not contain enough information to make discriminations that we make. If the stimulus is impoverished, then perception must involve combining information from the stimulus with information stored in memory. Such a framework treats visual perception as an inferential process, whereby creatures are passive recipients of stimulation from the world; such stimulation is then converted into mental representations, which are then imbued with meaning via an inferential process in the mind. Ecological psychologists deny that the stimulus is impoverished and that such inferential steps are needed.[18]

It might be true that a retinal image is impoverished if understood as a snapshot. However, as noted above, vision has to be understood in terms of the whole visual system and activity over time: eyes move, head moves, animal moves, and seeing unfolds over time. This movement creates *optic flow*, a pattern of changes in the light corresponding to the relative movement of perceiver and

environment (see Figure 2). Optic flow generated by a moving animal is rich enough in information to tell whether an arrow is small and nearby or large and distant. One source of information produced via optic flow is the differences in motion parallax.[19] As you move your eyes and head, objects around you change the portions of the background they hide to an extent that is inversely proportional to their distance. When you lean forward, the parts of your office wall hidden by your nearby laptop change more than the parts hidden by the more distant speakers. To see whether someone is hiding behind the nearby tree, leaning is often sufficient; for the distant tree, you have to move more to uncover the same amount of background.[20] Moving your eyes, which you do constantly, generates enough information to tell how far away the arrow is. The same is true for more or less any perceptual discrimination you might want to make, including about what is afforded.

This last point has the consequence that to understand what an animal perceives, it is insufficient to look at its retinal image right now. Motion parallax, for example, is not available in an image, yet it is one of the kinds of information animals use to perceive distance and size. Motion parallax exists only for an animal moving around in an environment cluttered with objects reflecting light. So from the ecological perspective, how animals perceive and what animals perceive can only be understood in terms of an active animal, moving around its environment. Ecological psychologists often put this by saying that the subject matter of cognitive science and psychology has to be *animal-environment systems*.[21] It is with this framework that the direct realist can address challenges raised by visual illusions.

"Veridical" and "Illusory" Perceptions

In the thirty-plus years following Gibson's death, ecological psychologists have continued to provide empirical research to motivate a theory of perception that is direct and unmediated by mental representations. This theory runs counter to traditional theories of perception that are indirect, representational, and inferential. Contemporary philosophers who defend direct realism, such as disjunctivists,[22] often engage in debates that discuss perception in traditional terms. Words such as "veridical" and "illusion" are loaded with conceptual baggage. As Gibson pointed out, traditional theories of perception attempt to explain both perception and illusion with the same assumption, namely, that the same sensory data presented to the mind is sometimes organized to be like the world and sometimes not.[23] Following the principles presented in the previous section, ecological psychologists claim that an empirically justifiable theory of perception must first be a theory of correct perception. Nevertheless, as Gibson was clear to point out, although the goal is a theory of correct perception, an "account of the facts of perceiving must include the facts of error."[24] What

role do the concepts "veridical" and "illusion" play in the ecological psychologist's theory of perception? An answer to this question will help illuminate what direct realists can gain from the ecological psychology approach to direct perception.

Veridical perceptions are those perceptions that coincide with mind-independent reality.[25] In traditional theories of perception, a veridical perception is one that is a true representation of reality. Non-veridical perceptions, such as illusions, falsely represent reality. The ecological psychologist rejects the conceptual dichotomy of veridical/true perceptions and illusory/false perceptions. For the ecological psychologist perception is something that is inextricably tied to action and is carried out by perceptual systems that interact with the environment in an unmediated manner. Moreover, if the environment contains information sufficient to specify the content of perception and action (i.e., affordances), then it is unnecessary to talk about perceptual systems utilizing mental representations of the environment that are true or false. The animal's biological perceptual capacities will pick up information that is available in the environment it inhabits over time. A set of stairs will afford climbing for a particular animal or it will not. It does not make sense for a theory of perception that examines perceptual systems—in terms of whole-animal-environment-interactions-over-time—to discuss perceptual representations as being veridical or not. Information from the environment is picked up over time by the perceptual system, as it engages with the environment. The goal of the scientific researcher is to give accounts of the perceptual happenings of animal-environment systems. These perceptual happenings do not include representations of the environment, and so do not include veridical or false representations of the environment.[26]

At this point one could reasonably say, "Sure, the ecological psychologist does not discuss perception in the same way that traditional theorists do, but even Gibson said the facts of perceiving must include the facts of error. So, how does the ecological psychologist account for facts of error such as illusions?" In order to account for the perceptual happenings of animals, the entire perceptual system must be taken into account, i.e., the animal moving around its information-rich environment. This theoretical commitment in the study of perception has significant consequences. As one ecological psychologist put it, "Gibson has initiated a revised view by rejecting the uncritical use of Euclidean space conception and introducing new descriptive notions."[27] Since spatial dimensions are not absolute and unrelated to creatures, to explain how a creature moves about in the world, the notion of space must be conceived of in terms of relationships between the dimensions of the creature and dimensions of the environment. Information in ambient light, for example, is an objective feature of the environment. Nonetheless, the affordances the ambient light specifies arise in a context that includes creatures' perception-action capabilities as they unfold over time. Thus, the ecological psychologist centers her account of perception around the nature of the structure of information available to animals. She does not treat the animal as an entity that is

separate from a world that is merely background for its experiences and actions, or a world that simply provides stimuli for the animal to represent. Information in the environment at any given time is structured in particular ways (see Figure 3). Animals of particular kinds pick up information in particular ways. Thus, in order to account for perception, both the character of environmental information and perception-action capacities of the animal must be the target of study.

In the case of visual perception, the structure of information conveyed via light changes depending on environmental conditions. Fog and smoke can scatter light in the environment such that an animal with healthy eyes would not be able to clearly see a building in the distance. This is an example of the inadequacy of environmental information to be picked up and is not the "fault" of the perceiver. An animal with myopia, for example, inadequately picks up information that is conveyed by the environment, a case in which errors are the "fault" of the perceiver.[28] In neither case is there a representation that matches or fails to match up with the objective world.

Unsurprisingly, in addition to rejecting the concept of "veridical" as utilized by traditional theories of perception, the ecological psychologist also rejects the traditional usage of the term "illusion." Although Gibson himself classified various kinds of illusions, he did not treat them as traditional theories of perception have, that is, as inaccurate, false mental representations of the objective world that are produced by the same stimulus energy that results in accurate and true representations.[29] One of Gibson's categories of illusions is "The Bending of an Optic Array by Reflection or Refraction."[30] This kind of illusion is defined by the apparent displacement of the visible environment and its objects by the refractive bending of light. The straight stick that looks bent in water is an example of this kind of illusion caused by refraction.

An account of the bent stick illusion within a traditional theory of perception can go as follows: Jerry holds a stick in front of his eyes that looks straight to him. Jerry places the stick in a body of water. Jerry expects the stick to be straight, but it looks bent to him. The difference between the two perceptions is that in the first instance stimulus energy reflecting from the stick to retina sent signals to the brain that resulted in a veridical mental representation; the stick is *really* straight, so it *looks* straight. In the second instance, stimulus energy reflecting from the stick to retina sent signals to the brain that results in an illusory mental representation; the stick is not *really* bent, it just *looks* bent.

We recommend that direct realists reject the terminology of traditional theories of perception, especially the terms "veridical" and "illusion." In accordance with the principles of ecological psychology, perceptions are not veridical or illusory in isolation. If the target of investigation is the perceptual system, then perceptions do not represent a perceived world, but are the results of capacities and conditions. The stick is perceived as straight to Jerry if his eyes are healthy and the medium is clear, unobstructed, and typical for a human; where 'typical' refers

conditions compatible to those which humans were selected for over the course of evolutionary history. The stick is perceived as bent to Jerry if his eyes are healthy and the medium is atypical for a human and alters the behavior of light. The ecological psychologist can say, "Of course the stick is perceived as being bent when partially submerged in water; every time those conditions are so, it will be perceived as bent. With more exploration—such as pulling the stick out of the water—Jerry could see that the stick looks straight in the air."

The evolutionary background that constrains the perception-action capacities of creatures cannot be emphasized enough here.[31] Perceptual apparatuses were selected for environments particular to conditions that facilitate the acquisition of food, reproduction, and survival. Based upon the inability of the human eye to accurately perceive potential sources of food through the medium of water, it can be argued that the human eye was not selected primarily for engaging with a medium with reflectance properties such as hunting for fish in water (see Figure 4A). Based upon the ability of certain kinds of birds to accurately hunt for fish in water, it can be argued that the eyes of certain birds were selected for engaging with a medium with reflectance properties such as water (see Figure 4B).

The perception of a bent stick in water is a case of natural visual perception and is thus readily accounted for in ecological terms. However, not all instances of visual perception are natural. "Unnatural" instances of visual perception include the perception of two-dimensional drawings or pictures with ambiguous features. The "ambiguous tuning fork" picture is one such example.[32] Such illusions work best under artificially produced animal-environment interactions. In order for such pictures to be perceived as ambiguous, the perceiver must take a point of view that is unnatural, which, for example, could include not allowing the perceiver to move their head or eyes.[33] In natural circumstances, perceptions unfold over time in an exploratory manner, such as the case of reading a street sign as mentioned above. When allowed to perceive in a natural way—that is, when allowed to move—instances that are typically appealed to as evidence of indirect perception lose their status as false representations of the world. These instances are better accounted for as direct perceptions. They can be understood as direct perceptions because they are the results of what an animal with particular capacities, in an environment with particular features, moving about in particular ways, would be expected to perceive. The perception is systematic and not the unpredictable, occult result of an animal with particular capacities, in an environment with particular features, moving about in particular ways having under the same conditions a veridical perception at one time and at another time an illusory perception that just *seems* to be veridical but is actually not.

Another important distinction is worth making in order to demonstrate why illusions are not a problem for the ecological psychologist. The trouble that illusions cause direct realists could result from either a mislabeling of the phenomenon or misattributing properties to a phenomenon. A case

of mislabeling could occur when, for example, somebody says, "I'm having illusions driving me mad inside." [34] In this case, the speaker is actually experiencing hallucinations and not illusions. "Hallucinations" refer to the subjective, phenomenal experience of a single creature. For example, somebody with schizophrenia who claims to hear voices could experience an audio hallucination, or somebody under the influence of hallucinogens who claims to see lights moving would be experiencing a visual hallucination. In this way, hallucinations are irregular and often unpredictable failures or physiological malfunctions on the part of the perceiver.

Conversely, "illusions" are regular, predictable experiences linked more to the typicality or atypicality of environmental conditions. The straight stick that looks bent in water discussed above is one such example. Since such illusions involve environmental conditions, more than one mind can experience it at a time. Two humans staring at a stick in water will see it as bent because their perceptual apparatuses are the same and they both perceive the same environment. On the other hand, a human and a gannet would not perceive the same illusion because although the environment is the same, their perceptual capacities differ, that is, the gannet has eyes that can accommodate for light refraction at the air-water boundary.

The stick example is also a case of the second trouble plaguing direct realists, namely, the misattribution of properties. In the case of visual illusions, the properties that are often misattributed are those that are involved in hallucinations. For example, misattribution occurs when the neural dynamics involved in the experience of seeing lights moving when you are under the influence of hallucinogens (perhaps those involved with mental imagery and imagination) are appealed to as either causally related to or constitutive of the experience had in a visual illusion. A hallucination of a stick looking bent in water, when there is no stick and no water, is a failure by the experiencer. Seeing a real (i.e., in an environment) straight stick look bent in water is a visual illusion because the experience is linked more strongly environmental conditions. In the case of the stick looking bent in water, the human visual system evolved to see in an air-filled medium, and not to deal with the way light rays refract at the air-water boundary.

Notice that we did not present a case such as "seeing a pink elephant" as an example of visual hallucinations. Instead, we mention "seeing moving lights" as an example of visual hallucinations. The reason for this is that it is far from certain that hallucinations such as seeing pink elephants actually occur, and if they do occur, that they last long enough to be compelling sources of evidence for debates concerning the nature of visual perception. Sticking with the pink elephants example: Besides appearing in Disney cartoons (always a reliable source of empirical data), the first recorded mention of hallucinating pink elephants is in Jack London's *John Barleycorn*. There, London discusses seeing pink elephants as a hallucination resulting from alcohol abuse.[35] When alcoholics hallucinate, it is typically due to alcohol withdrawal delirium or hallucinosis, and involves altered

mental status including distress and confusion.[36] In a word, the perceptual reports of such individuals are unreliable. It is unclear that such an individual *really* experienced a visual hallucination of a pink elephant, or merely thought they did. By calling into question whether or not people really have visual hallucinations such as those caricatured in Disney cartoons, we are not also questioning that any visual hallucinations occur. Visual hallucinations have undergone serious empirical investigation since at least the 1920s.[37] One feature of visual hallucinations that has received a compelling explanation is their geometrical structure.[38] Ermentrout and Cowan drew attention to the neural activity underlying common visual hallucinations that fall within the category of "form constants."[39] These form constants include hallucinations of shapes such as cobwebs, honeycombs, spirals, and tunnels. More recently, Bressloff and colleagues provided an account suggesting that particular cortical mechanisms are not only causally related to the geometric visual hallucinations, but that the structure of the hallucinations match the architecture of the retino-cortical map, especially V1. It should not be surprising that the kinds of visual hallucinations that are the most vivid—i.e., in terms of consistent reports across experimental subjects and in various conditions (e.g., diverse hallucinogens)—are those that are modulated by physiological structures and processes.

An additional reason against placing much credence on alleged pink-elephant-like-hallucinations stems from temporal considerations. As discussed above, perceiving is a kind of action and all actions take time. This is true of any event that claims to be sensory-perceptual. Similar to reasons why the retinal image alone is not enough to account for sensorimotor capabilities, conceiving of the temporal dimension of perception-action in terms of slices of individual units of time will not work either. In the case of motion parallax, distance is not revealed via information contained in a slice of time. The animal must move in order to pick up information that specifies if an object is nearer (i.e., faster movements) or further (i.e., slower movement). Along these lines, opportunities for action in the environment are revealed as being meaningful or not, for example, if a gap in the ground is far enough to afford my having enough distance to run and jump over it. In other words, the content of perception does not happen instantaneously. If it is true that the content of perception happens in an event that spreads across time, then that is another reason to discredit the importance of hallucinations as serious considerations when developing an understanding of perception(-action). The reason for this is that even if hallucinations of the pink elephant variety do happen and are not merely the result of a confused memory, they are not temporally extended. To see how this works in detail consider what is sometimes called the "paralyzed eye [hallucination],"[40] which has received some attention from philosophers.[41]

The hallucination was discovered because of reports of surgical patients who were given doses of curare, which causes a temporary paralysis of all voluntary movements. Upon waking from anesthesia, but while still incapable of voluntary movement, patients reported a striking

hallucination: When trying to look around the room, they experienced the room as moving in the direction of their intended eye movement. For example, an attempt to look to the left, which is unsuccessful because the muscles surrounding the eyes are paralyzed, generates an experience of the whole visual field jumping to the left. The patient experiences what she sees when trying to look to the left as actually being on the left, even when her eyes fail to actually move to the left. We agree with Hurley that this "hallucination" shows that perception and action are constitutively linked. Indeed, a more complete disruption of normal action capabilities, including paralyzing involuntary eye movements such as focusing and nystagmus, produces a different visual perception.[42] Notice, though, that the curare-induced experience of the room jumping to the left is necessarily short lived. The patient would also experience the visible parts of her body, along with the respirator required to keep her breathing, as jumping to the left. But there would be no proprioceptive information about the body moving to the left, both because the patient is paralyzed and because her body did not move to the left. That is, over time, the patient's initial experience of the moving room is replaced by a realization that her ability to explore the environment is compromised.

The ecological psychologist does not have to refer to "seemings" or disjunctive contents to explain this hallucination.[43] Perception is an activity that takes time. To understand what we perceive, we need to look at the activity of the whole perceptual system as the experiencer explores the world. Such hallucinations and other perceptual errors appear when the animal cannot or does not explore the environment sufficiently to make the discriminations relevant to guiding its behavior. When she is paralyzed, the patient cannot explore the environment. In the case of illusions such as the bent stick, Jerry can lift the stick out of the water and watch the apparent bend stay always at the point where the stick breaches the water's surface. Information sufficient to perceive what the world is like, including what it affords, is available to animals with the time and abilities to gather it. By gathering that information, animals are in direct contact with the environment.

Metaphysics of Direct Realism

We have defended direct realism in matters of visual perception via the principles of ecological psychology. This non-representational and non-inferential framework dissolves the problem of illusions. Illusions, as discussed above, are attempts to perceive in evolutionarily atypical conditions, and hallucinations are failures or inabilities to perceive. The primarily environmental nature of illusions leaves them readily amenable to ecological psychology, which emphasizes the primacy of perception-action behavior occurring within animal-environmental systems. Further issues concern the nature of the phenomenal experiences themselves during visual perception. Some have argued

along Gibsonian lines that phenomenal experience itself is constituted by animal-environment system interactions.[44] Sensorimotor accounts of perception make similar claims.

Alva Noë's sensorimotor account of vision is highly influenced by Gibson and is intended to be a kind of direct realism.[45] Coates argues that Noë and other sensorimotor theorists have not provided an explanation of the core claim of direct realism: how physical objects are immediately present in phenomenal experience—e.g., the phenomenal aspect of the red color of an apple.[46] Coates sums up this criticism as follows: "[P]ractical knowledge or mastery of sensorimotor contingencies alone does not constitute experience; we need also to account for the occurent, phenomenal component of experience."[47] Coates concludes that "the sensorimotor view of perception provides no help in clarifying Direct Realism," for it "presupposes that subjects have a first-person perspective on the world, in so far as it accepts that there is a phenomenology to perception."[48] Can we address Coates' criticisms and provide a more compelling account of the metaphysics of direct realism? In short, the answer is no. We do not think we can provide Coates with a satisfactory account of the metaphysics of direct realism because of a fundamental difference between our claims about what can be accomplished via a theory of direct perception.

Coates defends a type of direct realism he calls "critical realism." According to critical realism, the perceptual experience of a physical object had by a subject is comprised of two components. The first is a conceptual component, which is a thought that refers directly to the object perceived. The second is phenomenal, which is an inner experience.[49] "Inner experiences" are "conscious states with phenomenal qualities, and in a logical sense could occur independently of the existence of any particular object outside the subject's skin."[50] This understanding of perception is explicitly Kantian. For Kant, perception is a heavily inferential process that arises within a mind that passively receives stimulation from the world (i.e., manifold) and then transforms that stimulation into meaningful inner experiences. A very simplified understanding of Kant's treatment of perception is that it requires intuitions (i.e., ways of structuring perception such as in terms of three-dimensional space) and concepts (i.e., ways of organizing experience in a meaningful manner). Similarly, Coates' critical realism requires that a conscious state include more than just the features of the world the subject is aware of; such a state "always involves something more than the mere phenomenal states."[51]

Coates' provides a strong defense of critical realism. To criticize the entirety of it goes well beyond the scope of the current work. Although he disagrees with them, attempts have already been made to account for one part of Coates' necessary components of direct realism by building phenomenal experience into frameworks that treat the animal-environment as a single system—e.g., enactivism[52] and sensorimotor theories.[53] As such, insofar as both components are part of his

metaphysics of direct realism, we limit our critique to the role of concepts in a theory of direct perception as being necessary for meaningful action.

We agree with Coates that direct perception—i.e., conceived of as a type of direct realism—includes the claim that in cases of typical perception, creatures perceive their environment without being conscious of mediating entities such as mental images.[54] Indeed, we think that there are no such mediating entities. We disagree with Coates that direct perception requires an inferential step in the form of concepts in order to account for a creature's ability to act meaningfully in the world, for example, able to make meaningful perceptual discriminations.[55] Our view is explicitly not Kantian. Gibson himself was an avowed anti-Kantian.[56] The ecological approach we defend both disagrees and has no need for a distinction between concepts and intuitions in order to account for a creature's perceptual capabilities as meaningful. Consequently, Coates' Kantian challenges do not raise problems for a view like ours. Affordances are directly perceived opportunities for behavior and are meaningful, at least partly, because they are specified by environmental information. In light of the fact that affordances arise at the scale of relations within animal-environment systems,[57] it is unnecessary to posit inner "concepts" as necessary for meaningful behavior. As discussed above, scaling down the phylogenetic tree of life demonstrates that much simpler systems than humans and other mammals are able to successfully carryout meaningful behaviors, such as an earthworm navigating terrain and obtaining food. If we are to be good Darwinians and maintain that humans are also part of this tree, then we should be ready to accept that many of our action, cognition, and perceptual capacities are rooted in simpler physiology. Such considerations served as the foundation for early successes in robotics that based the development of artificial intelligence primarily on non-representational capacities to perceive and act in a world.[58]

An immediate response to this line of thought is that although early life on Earth and simpler creatures than humans and mammals may not require concepts, inferences, or representations in order to carryout successful and meaningful action in the world, that does not mean that humans do not require those either. We limit ourselves to two responses. Our first response is to ask, "Why not?" If humans are a part of the tree of life, then a reasonable starting assumption is that the principles guiding human perceptual capacities function very similarly, if not exactly, like other creatures. If affordances are the proper objects of perception for all perceiving creatures on Earth, and if affordances occur as relations at the animal-environment scale, then the same principles would apply across all species: perception is for action and action for perception; perception need not be mediated by mental representations; and affordances are already meaningful for creatures. Affordances are meaningful as a result of the capacities of the creature and properties of the environment. Many creature capacities are grounded in physiological attributes such as leg length and what portion of the electromagnetic spectrum can be detected. What an environment

affords is specified by ambient energy in forms such as acoustic, haptic, and optical. This leads to our second response: We are not confident that the kind of explanation of perception that Coates provides—i.e., as comprised of phenomenal and conceptual components—actually helps explain direct perception.

Consider the following example: If a human subject is placed in a well-lit room facing a wall that has a rectangular shape on it, where that shape has a pattern that is a different color than the wall, would the human's perceptual abilities be able to judge if the different color of the rectangular contour is an image on the wall or the color of another wall some distance behind the rectangular opening (see Figure 5)?[59] If Coates is correct, and perception is an act that alone requires a phenomenal experience combined with concepts, then there does not seem to be a way for the subject to discriminate a wall with a rectangular panting from a wall with an opening that leads to another wall at a distance away. If this is a novel experience for the subject, it is not compelling to think that *conceptualizing* the experience would facilitate an accurate judgment. However, if perception is something that is inextricably tied to action, happens at the scale of animal-environment systems, and is of affordances—in this case the affordance pass-through-able—then an ecological approach seems more suited to explain how an accurate judgment could be made. The ecological psychologist can point out that, like the example of motion parallax discussed above, movement over time is required to make judgments involving distance. If the retinal image alone is the source of perceptual data, then it seems obvious that the stimulus is impoverished and would require an inferential step such as the combination of phenomenal image with conceptual content. However, as we have argued, visual perception is not based on the retinal image alone. Visual perception happens within animal-environment interactions that are temporally extended. In this way, the human subject need only move around (e.g., sway side to side) in order to generate optic flow in order to make the perceptual judgment. Optic flow is necessary here because if the rectangular contour were merely an image on the wall, then it would move in sync with the wall. If, however, the rectangular contour were part of another wall that is behind the larger wall that is seen, then the optic flow would reveal two nested flow fields. Yet again we see that the information in the environment is far from impoverished. Moreover, this example further adds to our case that perception—real perception, carried out by real creatures, including humans—is fundamentally an act of movement and temporal extension and not one of mental inferences. Additionally, this example could also be considered another case that would be treated as an "illusion" and could be problematic for theories of direct perception such as those that cling to Kantian considerations. Like the stick that appears bent in water and the location of fish in water, when the perceptual capacities of the creature is taken into account (e.g., gannet eyes) and the properties of the environment (e.g., reflectance properties of

water), the "problem of illusions" dissolves for theories of direct perception guided by the principles of ecological psychology.

Conclusion

A challenge for direct theories of perception is to account for perceptual errors. A way to understand perception as direct is by utilizing the conceptual and methodological tools of ecological psychology. Ecological psychologists defend direct perception by treating perception as an activity that encompasses animal-environment interactions, and not as the deliverance of the world to a mind. In this way, certain key concepts take on meanings that differ from how they are utilized in traditional, indirect theories of perception such as computational-representational theories of mind. The concept of a "veridical perception" is no longer about explaining how the same sensory stimulus in one case is true and in another not. The concept of an "illusory perception" is no longer about explaining how the same sensory stimulus in one case is false and in another not. Cases of visual illusions are just another perception, or way information is engaged with in animal-environment interactions and utilized for action. A stick looking bent in water is a problem for indirect realists because their problem space involves comparing the distinct kind "illusory perception" to "veridical perception." Ecological psychologists who treat such perceptual occurrences as expected given particular animal capacities and environmental conditions readily account for a stick that looks bent in water. Perhaps making the move from traditional, indirect theories of perception to non-traditional, direct theories of perception requires a more radical break than contemporary direct realists such as disjunctivists typically make. We think it is a necessary move if one wishes to convincingly defend direct perception.

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First, we would like to thank Senior Editor Michael Strawser and former editor Peter Olen for helping to bring this project to publication. Second, we also thank two anonymous reviewers for their very helpful comments and feedback. Third, we thank audiences at the 61st Annual Meeting of the Florida Philosophical Association and the 2013 meeting of the Southern California Philosophy Conference for helpful comments on earlier versions of this paper. Finally, we thank Mary Jean Amon for comments and edits on earlier drafts of this paper.

Figures

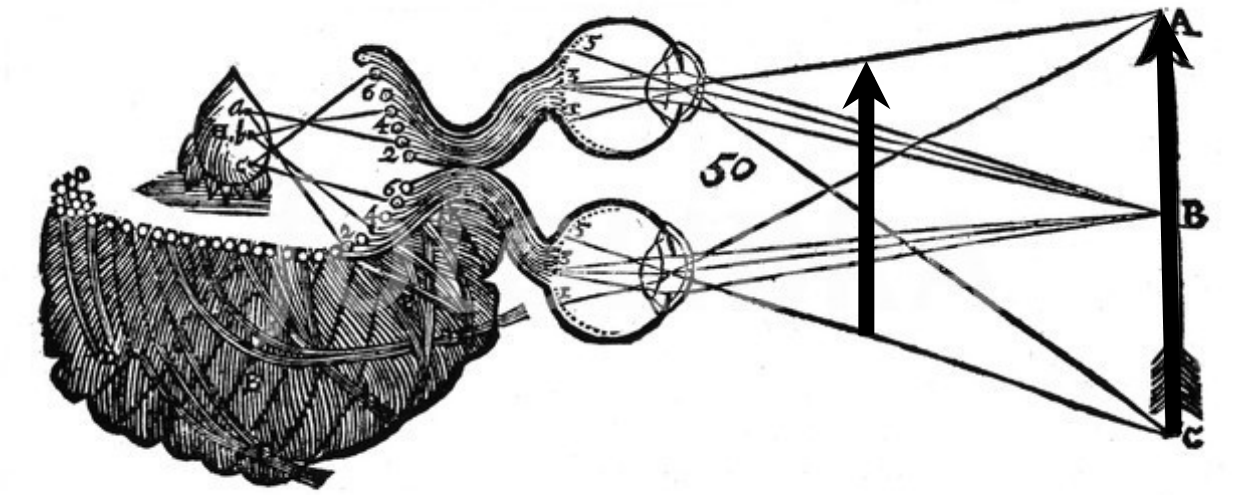

Figure 1. The nearer and smaller arrow casts the same retinal image as the further and larger arrow. From *Treatise on Man* by Descartes, Figure 60 slightly altered.[60]

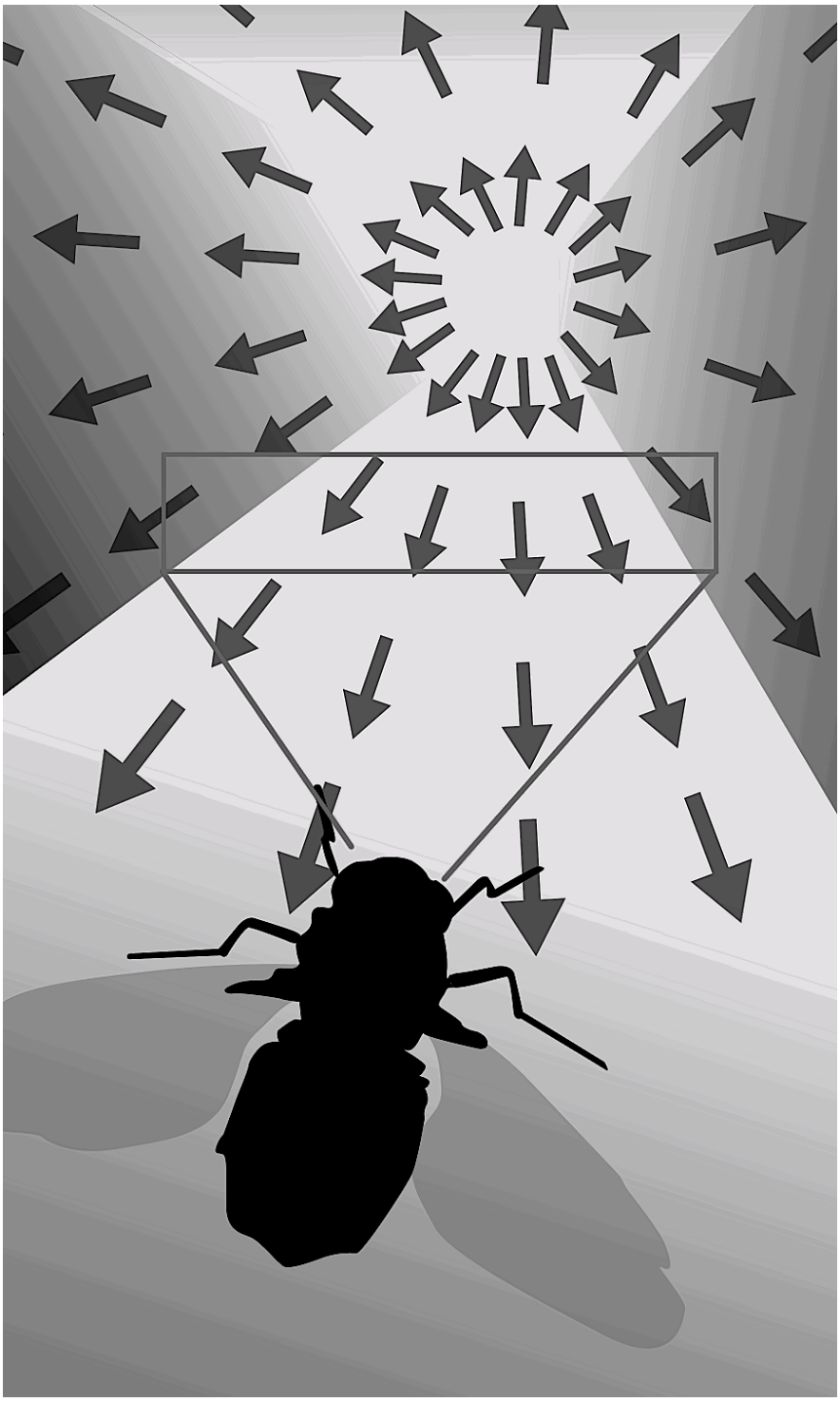

Figure 2. Optic flow generated by a fly in motion.[61]

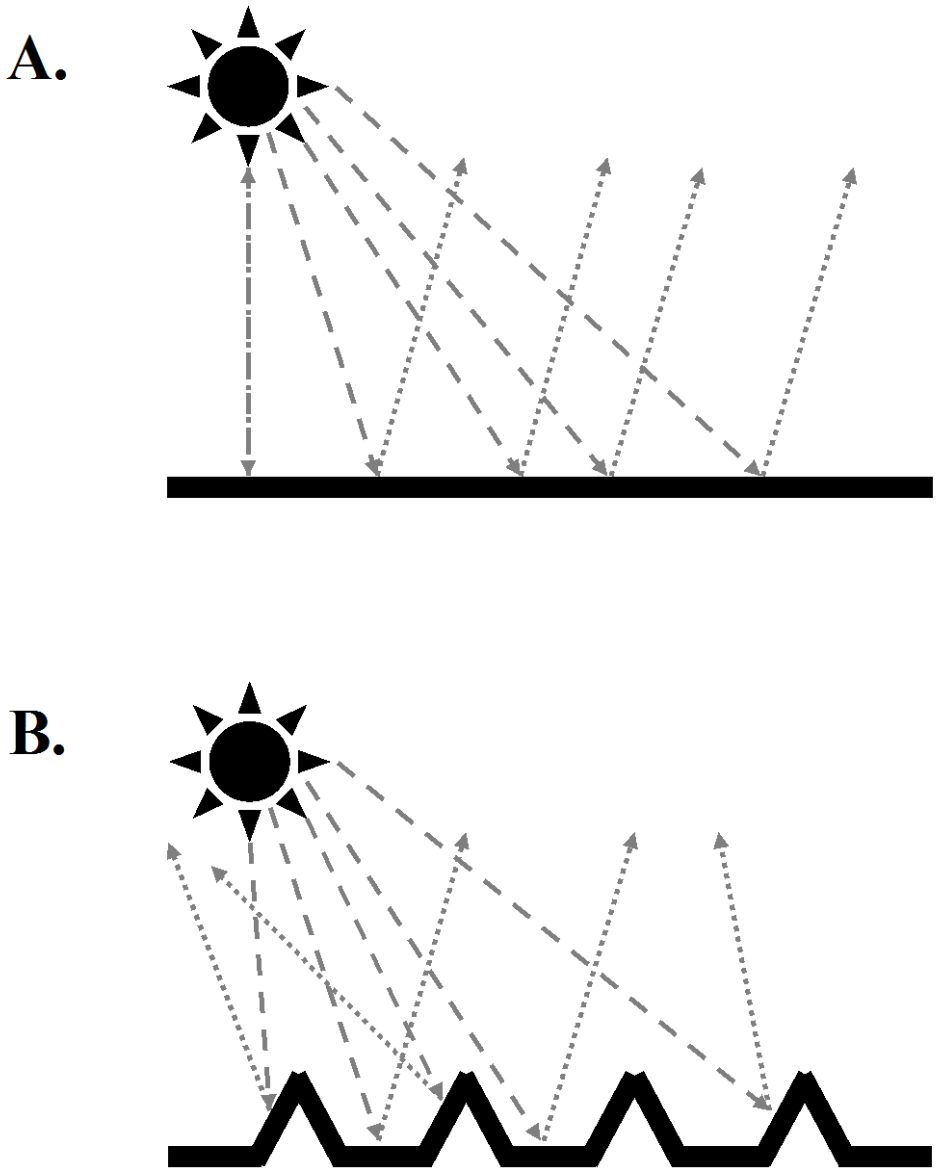

Figure 3. Depiction of changes in ambient optical array. Visual perception is not grounded in retinal image alone, but on the structure of "information"—or energy structure—in the environment and reflectance from objects. (A) Light reflectance off a smooth surface. (B) Light reflectance off a jagged surface. Dashed lines indicate light from source, and dotted lines indicate light as reflected from surface. As perceptual systems (e.g., bird, human, insect, etc.) move, the structure of the ambient array is "sampled" from various points of observation.

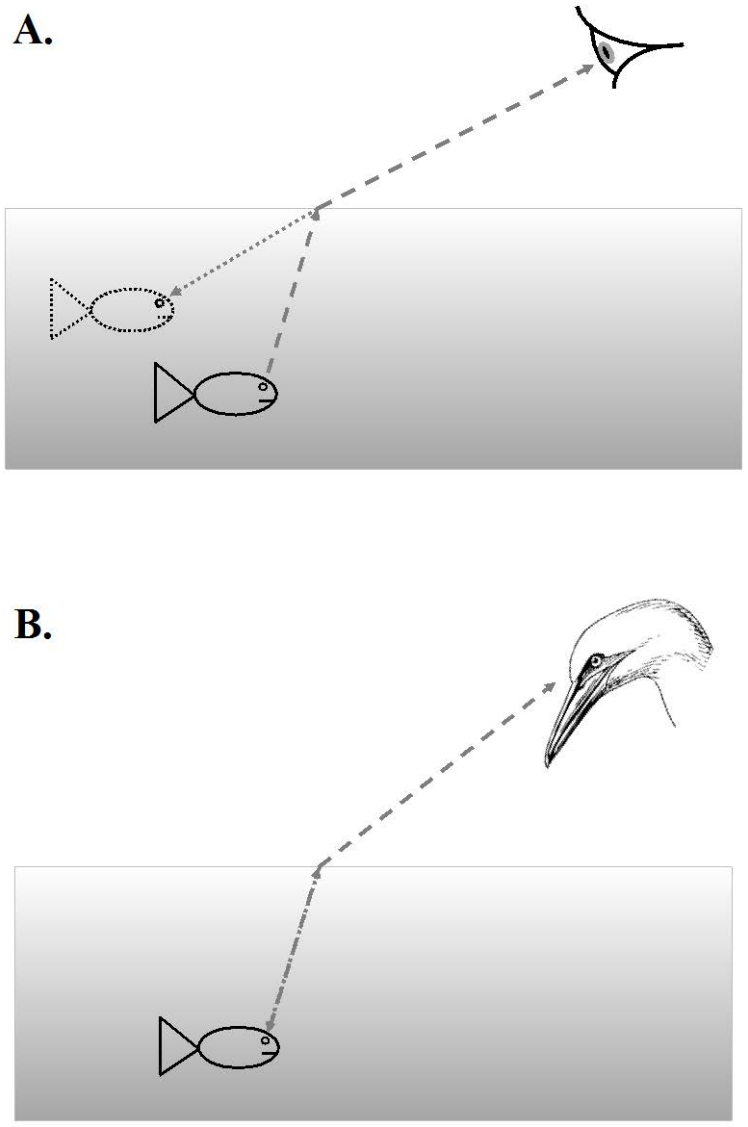

Figure 4. Two visual systems: one can accommodate for the reflectance properties of water and the other cannot. (A) The human eye does not have a lens that can accommodate for light refraction at the air-water boundary. Thus, humans perceive objects underwater as further away and higher than objects really are, e.g., fish, partially submerged stick, etc. (B) The eyes of birds such as albatrosses and gannets, which hunt for underwater fish from the sky, have lenses that can accommodate for the reflectance properties of water. Thus, albatrosses and gannets can successfully hunt for fish.[62]

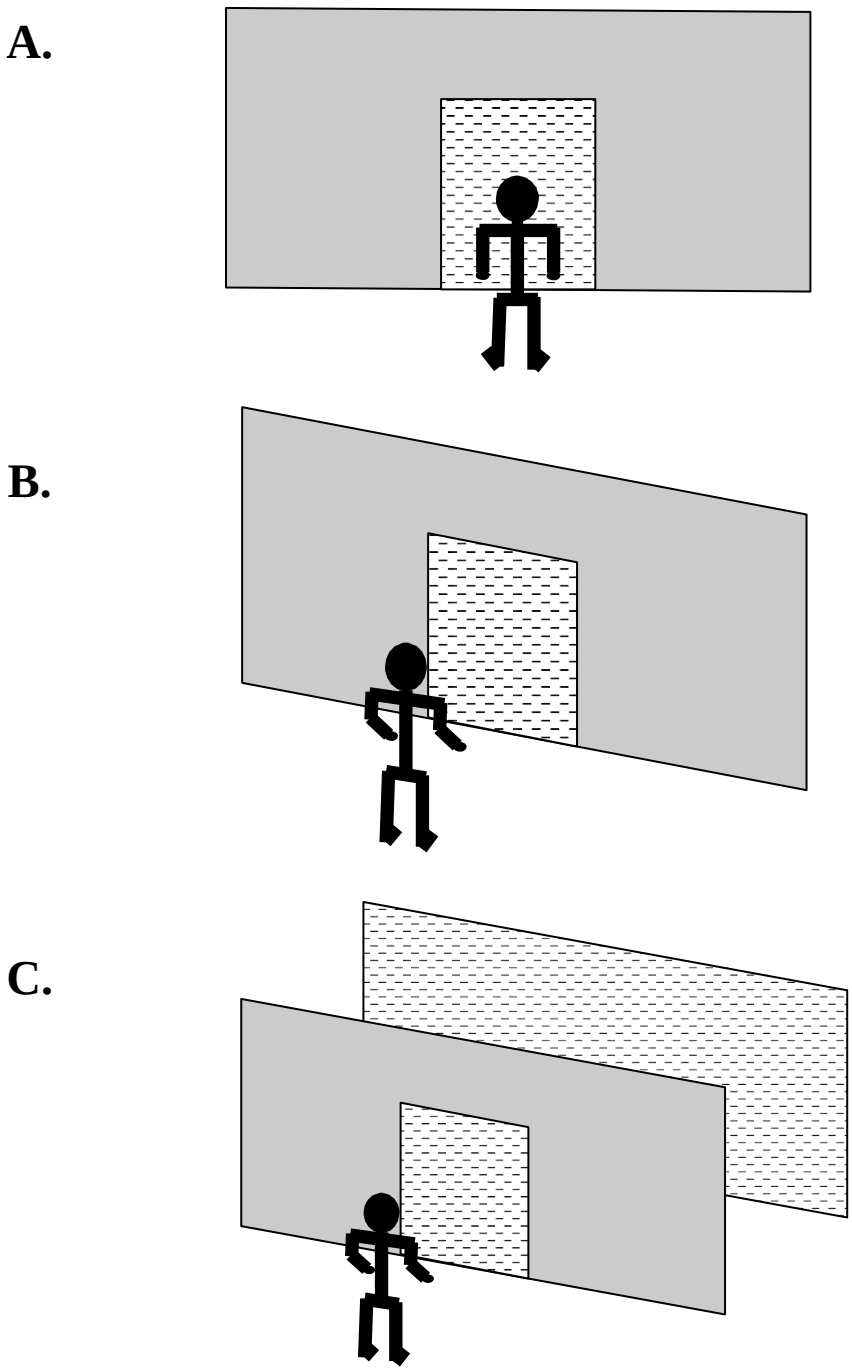

Figure 5. (A) Human subject facing a wall with rectangular contour. (B) Based on the retinal image alone, from a stationary position the subject would not be able to differentiate a black and white dashed pattern painted on a gray wall or (C) the pattern of a wall some distance behind the gray wall and visible through a rectangular opening.

Notes

[1] Pierre, Le Morvan, "Arguments Against Direct Realism and How to Counter Them," *American Philosophical Quarterly* 41.3 (2004): 221.

[2] In previous work, one of the current authors defended a view of affordances/information relations in terms of *specificity relations*, which are more probabilistic than the dominant neo-Gibsonian program of Shaw and Turvey (Rob Withagen and Anthony Chemero, "Naturalizing Perception: Developing the Gibsonian Approach to Perception along Evolutionary Lines," *Theory & Psychology* 19.3 [2009]). For present purposes, such nuances concerning explaining how affordances and information relate are not important. What is important is that there is enough information in the environment to specify affordances for creatures without recourse to mental representations or inferences.

[3] We thank one of the anonymous reviewers for pushing us to get clear on this and for providing other helpful suggestions.

[4] E.g., Paul Coates, *The Metaphysics of Perception: Wilfred Sellars, Perceptual Consciousness and Critical Realism* (New York: Routledge, 2007); Alva Noë, *Action in Perception* (Cambridge: The MIT Press, 2004); and Mark Rowlands, *The New Sciences of the Mind: From Extended Mind to Embodied Phenomenology* (Cambridge: The MIT Press, 2010).

[5] James J. Gibson, *The Senses Considered as Perceptual Systems* (Westport: Greenwood Press, 1966/1983); James J. Gibson, *The Ecological Approach to Visual Perception* (Boston: Houghton Mifflin, 1979/1986).

[6] Anthony Chemero, "Radical embodied cognitive science," *Review of General Psychology* 17 (2013): 145-150.

[7] Shimon Edelman, *Representation and Recognition in Vision* (Cambridge: MIT Press, 1999); Jerry A. Fodor and Pylyshyn Zenon, "How Direct is Visual Perception? Some Reflections on Gibson's 'Ecological Approach,'" *Cognition* 9 (1981): 139-196; David Marr, *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information* (Cambridge: MIT Press, 1982/2010).

[8] Ivan R.Schwab, "The Eyes Have It," *British Journal of Ophthalmology* 86 (2006): 372.

[9] Darwin, Charles, *The Formation of Vegetable Mould, Through the Action of Worms, with Observations on their Habits* (Chicago: University of Chicago Press, 1881/1985).

[10] Gibson, *The Senses Considered as Perceptual Systems.*

[11] Gibson, *The Ecological Approach to Visual Perception.*

[12] Anthony Chemero, *Radical Embodied Cognitive Science* (Cambridge: MIT Press, 2009), and Michael T. Turvey, "Affordances and Prospective Control: An Outline of the Ontology," *Ecological Psychology* 4.3 (1992): 173-187.

[13] William H. Warren, Jr., "Perceiving Affordances: Visual Guidance of Stair Climbing," *Journal of Experimental Psychology* 10.5 (1984): 683-703.

[14] William H. Warren, Jr., and Suzanne Whang. "Visual Guidance of Walking Through Apertures: Body-Scaled Information for Affordances," *Journal of Experimental Psychology: Human Perception and Performance* 13.3 (1987): 371-383.

[15] Anthony Chemero, "An Outline of a Theory of Affordances," *Ecological Psychology* 15.2 (2003): 181-195, and Anthony Chemero, "Information for Perception and Information Processing," *Minds and Machines* 13 (2003): 577-588.

[16] Fodor and Zenon Pylyshyn, "How Direct is Visual Perception?" 139-196; Michael T. Turvey, Robert E. Shaw, Edward S. Reed, and William Mace, "Ecological Laws of Perceiving and Acting: In Reply to Fodor and Pylyshyn (1981)," *Cognition* 9 (1981): 237-304, for a detailed debate concerning this topic.

[17] E.g., Paul Thagard, *Mind: Introduction to Cognitive Science* (Cambridge: The MIT Press, 2005).

[18] Luis H. Favela, "Commentary: Purves, Morgenstern, & Wojtach. (2015). Perception and reality: Why a wholly empirical paradigm is needed to understand vision," *Frontiers in Systems Neuroscience* 10 (2016): 1-2.

[19] A simplified video of motion parallax is available at http://en.wikipedia.org/wiki/File:Parallax.gif

[20] Cf. Daniel Jokisch and Nikolaus F. Troje. "Biological Motion as a Cue for the Perception of Size," *Journal of Vision* 4 (2003): 252-264.

[21] Luis H Favela and Anthony Chemero, "The Animal-Environment System," in *Foundations of Embodied Cognition: Volume 1: Perceptual and Emotional Embodiment* ed. Yann Coello and Martin H. Fischer (New York: Routledge, 2016) 59-74.

[22] E.g., William Fish *Perception, Hallucination, and Illusion* (Oxford: Oxford University Press, 2009); Adrian Haddock, "What is Disjunctivism?" *Philosophy Now* 81 (2010): 21-22; John M. Hinton, "Visual Experiences," *Mind* 76.302 (1967): 217-227; John McDowell, "Criteria, Defeasibility, and Knowledge," in *Meaning, Knowledge, and Reality* (Cambridge: Harvard University Press, 1982/1998), 369-394; Mike Thau "What is Disjunctivism?" *Philosophical Studies* 120.1/3 (2004): 193-253.

[23] Gibson, *The Senses Considered as Perceptual Systems,* 287.

[24] Gibson, *The Senses Considered as Perceptual Systems*, 287.

[25] Fish, *Perception Hallucination, and Illusion*; John M. Hinton "Visual Experiences," *Mind* 76.302 (1967): 217-227; Michael G. F. Martin "The Transparency of Experience." *Mind and Language* 17.4 (2002): 376-425.

[26] Gibson, *The Senses Considered as Perceptual Systems*, 304.

[27] Sverker Runeson, "The Distorted Room Illusion, Equivalent Configurations, and the Specificity of Static Optic Arrays," *Journal of Experimental Psychology: Human Perception and Performance* 14.2 (1988): 301.

[28] Gibson, *The Senses Considered as Perceptual Systems*, 287-288.

[29] Gibson, *The Senses Considered as Perceptual Systems*, 310-317.

[30] Gibson, *The Senses Considered as Perceptual Systems*, 311.

[31] Rob Withagen and Anthony Chemero, "Naturalizing Perception: Developing the Gibsonian Approach to Perception along Evolutionary Lines," *Theory & Psychology* 19.3 (2009): 363-389.

[32] Gibson, *The Senses Considered as Perceptual Systems*, 248.

[33] James J. Gibson, "The Psychology of Representation," in *The Purple Perils: A Selection of James J. Gibson's Unpublished Essays on the Psychology of Perception*, ed. John Pittenger, Edward S. Reed, Myeong Kim, and Lisa Best 1969/1997. Unpublished manuscript, retrieved August 16, 2015, from http://www.trincoll.edu/depts/ecopsyc/perils/folder4/representation.html.

[34] Louis Freese, "Illusions" (Cypress Hill). *III: Temples of Boom* (New York: Columbia Records, 1995), CD-ROM.

[35] Jack London, *John Barleycorn*, (1913), Project Gutenberg. Retrieved April 1, 2016 from http://www.gutenberg.org/files/318/318-h/318-h.htm; Harper, Douglas. "Pink." *Online Etymology Dictionary*, retrieved April 1, 2016, http://www.etymonline.com/index.php?term=pink

[36] Max Bayard et al., "Alcohol Withdrawal Syndrome," *American Family Physician* 69.6 (2004): 1443-1450.

[37] See Paul C. Bressloff et al., "Geometric Visual Hallucinations, Euclidean Symmetry and the Functional Architecture of Striate Cortex," *Philosophical Transactions of the Royal Society of London B* 356 (2001): 299-330, for discussion of empirical research on hallucinations going back to the 1920s.

[38] Bressloff et al., "Geometric Visual Hallucinations, Euclidean Symmetry and the Functional Architecture of Striate Cortex," 299-330; Paul C. Bressloff et al., "What Geometric Visual Hallucinations Tell Us about the Visual Cortex," *Neural Computation* 14 (2002): 473-491.

[39] G.B. Ermentrout and J. D. Cowan, "A Mathematical Theory of Visual Hallucination Patterns," *Biological Cybernetics* 34 (1979): 137-150.

[40] Note that the phenomenon was referred to as the "paralyzed eye illusion" in the original paper (Leonard Matin et al., "Oculoparalytic Illusion: Visual-Field Dependent Spatial Mislocalizations by Humans Partially Paralyzed with Curare," *Science* 216 [1982]: 198-201). However, to be consistent with the definitions we have made in the current work, we refer to it as the "paralyzed eye hallucination."

[41] E.g., Susan L. Hurley, *Consciousness in Action* (Cambridge: Harvard University Press, 1998).

[42] D. Alfred Owens and Edward S. Reed, "Seeing Where We Look: Fixation as Extraretinal Information," *Behavioral and Brain Sciences* 17 (1994): 271-272.

[43] E.g., Geoffrey P. Bingham, Richard C. Schmidt, and Lawrence D. Rosenblum, "Hefting for a Maximum Distance Throw: A Smart Perceptual Mechanism," *Journal of Experimental Psychology: Human Perception and Performance* 15.3 (1989): 507-528.; John M. Kennedy and Andrew Portal, "Illusions: Can Change of Vantage Point and Invariant Impressions Remove Deception?" *Ecological Psychology* 2.1 (1990): 37-53; Matthieu M. de Wit, John van der Kamp, and Rob Withagen, "Visual Illusions and Direct Perception: Elaborating on Gibson's Insights," *New Ideas in Psychology* 36 (2015): 1-9.

[44] Michael Silberstein and Anthony Chemero, "Complexity and Extended Phenomenological-Cognitive Systems," *Topics in Cognitive Science* 4 (2012): 35-50.

[45] Alva Noë, *Action in Perception* (Cambridge: The MIT Press, 2004).

[46] Paul Coates, *The Metaphysics of Perception: Wilfred Sellars, Perceptual Consciousness and Critical Realism* (New York: Routledge, 2007), 86.

[47] Coates, *The Metaphysics of Perception*, 91.

[48] Coates, *The Metaphysics of Perception*, 94.

[49] Coates, *The Metaphysics of Perception*, 4.

[50] Coates, *The Metaphysics of Perception*, 2.

[51] Coates, *The Metaphysics of Perception*, 41.

[52] Evan Thompson, *Mind in Life: Biology, Phenomenology, and the Sciences of the Mind.* (Cambridge: Belknap Press, 2007).

[53] Noë, *Action in Perception.*

[54] Coates, *The Metaphysics of Perception,* 52.

[55] Coates, *The Metaphysics of Perception*, 11.

[56] E.g., Gibson, *The Ecological Approach to Visual Perception*, 3.

[57] Chemero 2003.

[58] E.g., Rodney A. Brooks, "Intelligence without Representation," *Artificial Intelligence* 47 (1991) 139-159.

[59] This is a slightly modified version of an example we borrow from Kevin Shockley.

[60] Rene Descartes, *The World and Other Writings*, edited and translated by Stephen Gaukroger (Cambridge: Cambridge University Press, 1998), 148.

[61] Creative Commons Attribution-ShareAlike 3.0 License. Retrieved January 10, 2015, http://en.wikipedia.org/wiki/File:H1-neuron_optic-flow.gif.

[62] Image of gannet modified from Pearson Scott Foresman 2010. Wikipedia Commons, retrieved March 26, 2016, https://commons.wikimedia.org/wiki/File:Gannet_(PSF).png.

Bibliography

Bayard, Max, Jonah Mcintyre, Keith R. Hill, and Jack Woodside, Jr. "Alcohol Withdrawal Syndrome." *American Family Physician* 69.6 (2004): 1443-1450.

Bingham, Geoffrey P., Richard C. Schmidt, and Lawrence D. Rosenblum. "Hefting for a Maximum Distance Throw: A Smart Perceptual Mechanism." *Journal of Experimental Psychology: Human Perception and Performance* 15.3 (1989): 507-528.

Bressloff, Paul C., Jack D. Cowan, Martin Golubitsky, Peter J. Thomas, and Matthew C. Wiener. "Geometric Visual Hallucinations, Euclidean Symmetry and the Functional Architecture of Striate Cortex." *Philosophical Transactions of the Royal Society of London B* 356 (2001): 299-330.

Bressloff, Paul C., Jack D. Cowan, Martin Golubitsky, Peter J. Thomas, and Matthew C. Wiener. "What Geometric Visual Hallucinations Tell Us about the Visual Cortex." *Neural Computation* 14 (2002): 473-491.

Brooks, Rodney A. "Intelligence without Representation." *Artificial Intelligence* 47 (1991) 139-159.

Chemero, Anthony. "An Outline of a Theory of Affordances." *Ecological Psychology* 15.2 (2003): 181-195.

Chemero, Anthony. "Information for Perception and Information Processing." *Minds and Machines* 13 (2003): 577-588.

Chemero, Anthony. *Radical Embodied Cognitive Science*. Cambridge: MIT Press, 2009.

Chemero, Anthony. "Radical embodied cognitive science." *Review of General Psychology* 17 (2013): 145-150.

Coates, Paul. *The Metaphysics of Perception: Wilfred Sellars, Perceptual Consciousness and Critical Realism*. New York: Routledge, 2007.

Darwin, Charles. *The Formation of Vegetable Mould, Through the Action of Worms, with Observations on their Habits*. Chicago: University of Chicago Press, 1881/1985.

Descartes, René. *The World and Other Writings*. Ed. and trans. Stephen Gaukroger. Cambridge: Cambridge University Press, 1998.

Edelman, Shimon. *Representation and Recognition in Vision*. Cambridge: MIT Press, 1999.

Ermentrout. G. B. and J. D. Cowan. "A Mathematical Theory of Visual Hallucination Patterns." *Biological Cybernetics* 34 (1979): 137-150.

Favela, Luis H. "Commentary: Purves, Morgenstern, & Wojtach. (2015). Perception and reality: Why a wholly empirical paradigm is needed to understand vision." *Frontiers in Systems Neuroscience* 10 (2016): 1-2.

Favela, Luis H. and Anthony Chemero. "The Animal-Environment System." In Yann Coello and Martin H. Fischer (Eds.), *Foundations of Embodied Cognition: Volume 1: Perceptual and Emotional Embodiment* (59-74). New York: Routledge, 2016.

Fish, William. *Perception, Hallucination, and Illusion*. Oxford: Oxford University Press, 2009.

Fodor, Jerry A. and Zenon Pylyshyn. "How Direct is Visual Perception? Some Reflections on Gibson's 'Ecological Approach.'" *Cognition* 9 (1981): 139-196.

Freese, Louis. "Illusions" (Cypress Hill). *III: Temples of Boom* [CD]. New York: Columbia Records, 1995.

Gibson, James J. *The Senses Considered as Perceptual Systems*. Westport: Greenwood Press, 1966/1983.

Gibson, James J. "The Psychology of Representation." In John Pittenger, Edward S. Reed, Myeong Kim, and Lisa Best (Eds.), *The Purple Perils: A Selection of James J. Gibson's Unpublished Essays on the Psychology of Perception*, 1969/1997. Unpublished manuscript. Retrieved August 16, 2015 from http://www.trincoll.edu/depts/ecopsyc/perils/folder4/representation.html

Gibson, James J. *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin, 1979/1986.

Haddock, Adrian. "What is Disjunctivism?" *Philosophy Now* 81 (2010): 21-22.

Harper, Douglas. "Pink." *Online Etymology Dictionary*, 2001/2016. Retrieved April 1, 2016, from http://www.etymonline.com/index.php?term=pink.

Hinton, John M. "Visual Experiences." *Mind* 76.302 (1967): 217-227.

Hurley, Susan L. *Consciousness in Action*. Cambridge: Harvard University Press, 1998.

Jokisch, Daniel and Nikolaus F. Troje. "Biological Motion as a Cue for the Perception of Size." *Journal of Vision* 4 (2003): 252-264.

Kennedy, John M. and Andrew Portal. "Illusions: Can Change of Vantage Point and Invariant Impressions Remove Deception?" *Ecological Psychology* 2.1 (1990): 37-53.

Le Morvan, Pierre. "Arguments Against Direct Realism and How to Counter Them." *American Philosophical Quarterly* 41.3 (2004): 221-234.

London, Jack. *John Barleycorn*, 1913/2012. Project Gutenberg. Retrieved April 1, 2016 from http://www.gutenberg.org/files/318/318-h/318-h.htm

Machovsky-Capuska, Gabriel E., Howard C. Howland, David Raubenheimer, Robin Vaughn-Hirshorn, Bernd Würsig, Mark E. Hauber, and Gadi Katzir. "Visual accommodation and active pursuit of prey underwater in a plunge-diving bird: the Australasian gannet." *Proceedings of the Royal Society B* 279 (2012): 4118-4125.

Marr, David. *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*. Cambridge: MIT Press, 1982/2010.

Martin, Graham R. "Eye structure and amphibious foraging in albatrosses. *Proceedings of the Royal Society of London B* (1998) 265: 665-671.

Martin, Michael G. F. "The Transparency of Experience." *Mind and Language* 17.4 (2002): 376-425.

Matin, L., E. Picoult, J. K. Stevens, M. W. Edwards, Jr., D. Young, and R. MacArthur. "Oculoparalytic Illusion: Visual-Field Dependent Spatial Mislocalizations by Humans Partially Paralyzed with Curare." *Science* 216 (1982): 198-201.

McDowell, John. "Criteria, Defeasibility, and Knowledge." In *Meaning, Knowledge, and Reality*, 369-394. Cambridge: Harvard University Press, 1982/1998.

Noë, Alva. *Action in Perception*. Cambridge: The MIT Press, 2004.

Owens, D. Alfred and Edward S. Reed. "Seeing Where We Look: Fixation as Extraretinal Information." *Behavioral and Brain Sciences* 17 (1994): 271-272.

Rowlands, Mark. *The New Sciences of the Mind: From Extended Mind to Embodied Phenomenology*. Cambridge: The MIT Press, 2010.

Runeson, Sverker. "The Distorted Room Illusion, Equivalent Configurations, and the Specificity of Static Optic Arrays." *Journal of Experimental Psychology: Human Perception and Performance* 14.2 (1988): 295-304.

Schwab, Ivan R. "The Eyes Have It." *British Journal of Ophthalmology* 86 (2006): 372.

Silberstein, Michael and Anthony Chemero. "Complexity and Extended Phenomenological-Cognitive Systems." *Topics in Cognitive Science* 4 (2012): 35-50.

Thagard, Paul. *Mind: Introduction to Cognitive Science*. Cambridge: The MIT Press, 2005.

Thau, Mike. "What is Disjunctivism?" *Philosophical Studies* 120.1/3 (2004): 193-253.

Thompson, Evan. *Mind in Life: Biology, Phenomenology, and the Sciences of the Mind*. Cambridge: Belknap Press, 2007.

Turvey, Michael T. "Affordances and Prospective Control: An Outline of the Ontology. *Ecological Psychology* 4.3 (1992): 173-187.

Turvey, Michael T., Robert E. Shaw, Edward S. Reed, and William Mace. "Ecological Laws of Perceiving and Acting: In Reply to Fodor and Pylyshyn (1981)." *Cognition* 9 (1981): 237-304.

Warren, Jr., William H. "Perceiving Affordances: Visual Guidance of Stair Climbing." *Journal of Experimental Psychology* 10.5 (1984): 683-703.

Warren, Jr., William H. and Suzanne Whang. "Visual Guidance of Walking Through Apertures: Body-Scaled Information for Affordances." *Journal of Experimental Psychology: Human Perception and Performance* 13.3 (1987): 371-383.

de Wit, Matthieu M., John van der Kamp, and Rob Withagen. "Visual Illusions and Direct Perception: Elaborating on Gibson's Insights." *New Ideas in Psychology* 36 (2015): 1-9.

Withagen, Rob and Anthony Chemero. "Naturalizing Perception: Developing the Gibsonian Approach to Perception along Evolutionary Lines." *Theory & Psychology* 19.3 (2009): 363-389.