Visual Experience

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In this chapter I will discuss a number of empirical approaches to conscious visual experience which fall under the general framework of embodied cognition. I will organize the chapter by treating the following topics in order: embedded and situated vision, extended vision, enactive vision, dynamical systems approaches to vision, and the embodied neuroscience of vision. In the first five sections of the chapter, I will present each approach along with some common objections. In the final section of the chapter, I will indicate questions for future investigation. As one might expect, there will be some overlap between the different approaches.

1. Embedded and situated vision

An embedded and situated approach to visual experience would place emphasis on the details of the embodiment of the visual system. This emphasis marks a clear departure from the orthodox computational approach to vision, an approach heavily influenced by David Marr (1983), in which the implementation of the visual system is thought to be of little importance. Embedded and situated approaches to vision, in contrast, suggest that the bodily details are crucial for understanding visual experience.

The details of embodiment reveal that human vision typically involves continuous eye and body movements. Action and visual perception seem to be interrelated in some important way. Eye tracking devices show that humans typically saccade, which is to make a ballistic eye movement, three to four times per second (Findlay and Gilchrist 2007). Even when we deliberately try to keep from saccading, we make involuntary eye movements described as drifts, tremors, or microsaccades (Martinez-Conde et al. 2009). When precise devices are used to stabilize the retinal image by counteracting saccades, subjects experience temporary blindness (Riggs and Ratliff 1952). Eye tracking studies have shown that we naturally saccade towards areas in a visual scene which are rich in information relevant for our current goals.[1]

In addition to these discoveries about eye movements, there are at least three other lines of evidence which suggest an important role for action in visual perception. The first involves selective rearing (Held and Hein 1963), the second involves distortion goggles (Kohler 1961, Taylor 1962), and the third involves sensory substitution (Bach-y-Rita 1972). Kevin O'Regan and Alva Noë (2001) have suggested that these lines of evidence indicate that human visual perception requires an understanding of "sensorimotor contingencies," which are the way appearances change due to self-generated movement.

In what remains of this section, I will discuss two main objections to the claim that action is tightly connected with visual experience. The first main objection is that the claim itself is not clear. Is it the strong claim that token actions are necessary for vision to occur, or is it something weaker? And if it is something weaker, who would deny it? Ken Aizawa, for instance, has attributed the stronger claim to Alva Noë (2004). Aizawa challenges Noë's view by presenting examples of individuals under complete paralysis during surgery who reported having visual experiences while paralyzed (2007: 23). These cases look to provide a counterexample to the stronger thesis about action and visual perception.

A second main objection to the connection between action and visual perception comes from what is known as the two-visual systems hypothesis (Block 2005, Jacob and Jeannerod 2003). Human visual processing involves two physiologically distinct

1 The early classic studies were carried out by Alfred Yarbus (1967). Due to the nature of early eye trackers, Yarbus' experiments were confined to the laboratory. In the 1990s, Michael Land and colleagues used mobile lightweight trackers to confirm the influence of task on eye movements in natural environments (see Land et al 1999, for example). Along the same lines, Dana Ballard and colleagues have shown that subjects use eye movements for "pointing" purposes as an efficient strategy for completing cognitive tasks (Ballard et al. 1997). Excellent overviews can be found in Findlay and Gilchrist (2003: chapter 7) and Hayhoe and Ballard (2005).

processing streams in cortex. The dorsal stream projects from primary visual cortex to posterior parietal cortex, and the ventral stream projects from primary visual cortex to inferotemporal cortex. According to the best known version of the hypothesis (Milner and Goodale 1995), dorsal processing is devoted to "vision for action" and is not available for consciousness. Ventral processing, in contrast, is devoted to "vision for perception" and can enter consciousness. In humans, the evidence for the hypothesis comes from lesion studies as well as the existence of illusions which affect conscious perception but not visually guided grasping. If vision for action is both unconscious and distinct from vision for perception, then the purported tight connection between action and visual perception may not be so tight after all.

Without entering into the details, here are two quick points about this objection. First, it seems obvious that conscious visual experience *can* guide action. But it is not clear that the hypothesis can accommodate this fact so long as we keep a strict distinction between vision for action and vision for perception (Briscoe 2009, Noë 2010). Second, another way to describe the differences between the two streams is to say that the dorsal stream is faster and devoted to peripheral vision, while the ventral stream is slower and devoted to central vision (Madary 2011). This way of distinguishing the two streams accommodates the empirical evidence and avoids placing a wedge between action and visual perception.

2. Extended vision

Much of the research on *extended* cognition has focused on the possibility that unconscious mental states are partially constituted by entities outside of the brain (Clark and Chalmers 1998, Menary 2010). Some philosophers, however, have defended a thesis about the constitutive base of visual experience extending outside of the brain. They have defended something like the following thesis:

Externalism about the Vehicles of Perceptual States (EVPS): The vehicles of human conscious visual states can sometimes include the body and environment in addition to the brain.

Both Susan Hurley and Alva Noë are known for defending EVPS. In this section, due to space limitations, I focus on Hurley's argument for EVPS.[2]

This is one way of formulating Hurley's argument in support of EVPS. I will discuss each premise in turn.

(1) The subpersonal mechanisms of conscious vision are temporally extended.

(2) Temporal extension can lead to spatial extension.

(3) In the case of the human visual system, temporal extension does lead to spatial extension.

Conclusion: EVPS

The main inspiration behind (1) is Daniel Dennett's attack on the Cartesian Theater. The Cartesian Theater is his name for the particular place in the brain in which experience happens, where "it all comes together" (1991: 107). By appealing to results from visual masking experiments, Dennett makes the case that there is no Cartesian Theater. Hurley picks up on this idea and attacks what she calls "temporal atomism," which is the view that each instant of visual consciousness is "carried by subpersonal processes moment by moment, snapshot by snapshot" (Hurley, 1998: 31). The alternative to temporal atomism is (1), or, in other words, the idea that the subpersonal processes which enable visual experience are always dynamic by nature; a frozen snapshot of neural activity does not determine any visual state (also see Noë 2004: 218).

I take premise (2) from a passage of Hurley's published posthumously:

> Temporal extension leads to spatial extension; Dennett (1991) famously

2 Some of this material is covered in my (2012) in more detail.

made the intracranial version of this point in his arguments against a Cartesian theater, but the point extends promiscuously across the boundaries of skull and body. (2010: 111)

What I take Hurley to mean here is that some systems have the following structure: if causal influences are traced over time, then we find an expanding spatial area which is a part of that system. As a matter of empirical fact, according to Hurley, human vision is such a system. Hurley's support for (3) is that, if "we track the causal arrow through time" in the human visual system, we find feedback loops at multiple spatial and temporal scales (1998: 307). Some feedback loops are neural, and some include the active body (Hurley 1998: chapter 10). Further support for (3) can be found in dynamical systems approaches to vision, which I will cover in section four below.

The main objection to EVPS is that its proponents fail to distinguish causation from constitution (Block 2005, Prinz 2006, Adams and Aizawa 2008).[3] All parties agree that the body and the environment play an important causal role in conscious visual perception. But the opponents of EVPS see no need to make the further claim that the body and environment partially constitute the substrate of visual experience. It is tempting for proponents of EVPS to reject the distinction between causation and constitution, but note that this move may not be available: EVPS itself seems to depend on there being such a distinction. Hurley indicated that she would rather frame EVPS in terms of explanation rather than constitution versus "mere" causation (2010: 113-14). Don Ross and James Ladyman (2010) have made a strong contribution to the debate by arguing that the causal/constitutive distinction has no place in the mature sciences.

3. Enactive vision

"Sense-making" is a central theme within the *enactive* approach to cognition.[4] Roughly,

3 There are at least two other objections to be found in the literature. The first is that brain stimulation alone is sufficient for visual experiences (Penfield and Jasper 1954, Prinz 2006). The second objection is that dreaming involves visual experiences without the active body. For Noë's defense of EVPS against these objections, see his (2004: 209-215).

4 The term "enactivism" is used in slightly different ways in the literature. Here I understand the term to reflect an

the idea is that meaning and significance emerge out of the interaction between an organism and its environment. This theme raises interesting issues for our understanding of visual experience. On one hand, the received view is that the content of visual experience is a representation of the objective world. On the other hand, according to the enactivist's commitment to sense-making, one's environment is always partially determined by the interests and goals of the perceiver. To put the disagreement bluntly: do we see the world, or do we see the emergent result of our particular interaction with the world? In this section I will outline some of the enactivist's reasons for rejecting the received view.

The received view in the philosophy and science of perception is that vision has the task of representing the world around us more or less as it really is (Lewis 1980: 239, Marr 1983). Evan Thompson has described the received view as the "objectivist" view of representation (2007: 52). One of the main motivations for the objectivist view is it is reasonable to think that our visual representations must be accurate if they are to guide behavior in a successful way.

The enactivist, in contrast, rejects the supposition that an organism represents features of an objective world. Following Merleau-Ponty (1963), Thompson asserts that living organisms create meaning based on their own autonomous metabolic structure. A simple example of this process can be found in the behavior of bacterial cells. Some bacteria respond to sugar gradients in a solution by swimming against the gradient towards areas of greater sucrose concentration. Thompson elaborates:

> "While sucrose is a real and present condition of the physicochemical environment, the status of sucrose as a nutrient is not. Being a nutrient . . . is enacted or brought forth by the way the organism, given its autonomy and the norms its autonomy brings about, couples with the environment."

approach to the mind associated with the works of Humberto Maturana, Francisco Varela, and Evan Thompson. I regard Thompson's (2007) to be the most comprehensive expression of this approach.

(2007: 74)

If the interaction between organism and environment is one of "sense-making," as enactivism suggests, then there should be implications for human vision.

One way in which we might apply the enactivist concept of "sense-making" to vision would be to claim that the content of visual perception is always informed in some way by our own goals and interests. According to this claim, we do not simply see the objective world; we do not merely seek "to know what is where by looking" (Marr 1983/2002: 229). Instead, what we see depends in some way on the details of our own situation, similar to the way in which the nutritional status of sucrose depends on the metabolism of the bacterium. There are a number of lines of empirical evidence which can be cited in support of this claim. First, and perhaps most obviously, the evidence for task dependence on saccade patterns, sketched above, could be used. Another line of support would be evidence that sociocultural factors can influence visual experience (Bruner and Goodman 1947, Boduroglu et al. 2009). Another line of evidence available to the enactivist comes from neuroscience, which I will cover in section 5.

One objection to this aspect of enactivism has been raised by Dennett, who claims that there is nothing new or revolutionary about enactivist sense-making:

> As I and others have argued, all meaning in organisms is constructed by self-regarding processes that gerrymander the 'given' categories of physics to suit their purposes. (2011: 30)

He goes on to suggest that this idea can be found in Sellars, Quine, and "most AI systems" (ibid.). Thompson has replied that sense-making, as he intends it, can only be carried out by a system that has a particular kind of autonomy, a kind which is not found in most AI systems (2011: 189). Is enactivist sense-making a new and radical idea, or is it already widely accepted? I leave this question open.

4. The dynamical systems approach to vision

Modeling cognitive processes as *dynamical* systems has met with success in a number of areas of cognitive science (Port and Van Gelder 1995, Thelen and Smith 1994, Spivey 2008). One main way in which dynamical systems are relevant for vision will be familiar from section two above on extended cognition; dynamical models of the physical substrate of visual experience might provide a motivation for EVPS, for the claim that the physical substrate of vision expands beyond the brain, and perhaps even the body.

Recall that EVPS is the thesis that the vehicles of perceptual states can sometimes extend beyond the brain, into the body and environment. One of Hurley's main motivations behind EVPS was that tracing the causal arrow over time leads to extended spatial boundaries of the system (premise (3) from the argument above). This idea can also be found in dynamical systems models. One common feature of dynamical systems is that the parts of the system do not always correspond to macroscopic physical boundaries. If those features can be found in the causal interactions between brain, body, and environment in visual perception, then we can construct dynamicist models which will include body and environment as a part of the system.

What remains to be seen is whether our best models of vision will be these kinds of dynamicist models. The main alternative would be internalist mechanistic models of the visual brain. Proponents of mechanistic explanation have voiced some of the most important objections to dynamical systems models of the mind. Carl Craver (2007), for instance, has argued that neuroscientific explanations should be mechanistic, that differential equations alone leave out something essential for the explanation. Apart from general worries about explanation with dynamical systems, one might also object to the practice of using dynamical systems theory in order to motivate claims about the spatial boundaries of physical systems.

5. The embodied neuroscience of vision

There are at least two emerging themes in neuroscience which converge on themes from embodied approaches to visual experience. They are, first, the context sensitivity of neural processing, and, second, neural models which give a central role to prediction, or anticipation, in the cycle of action and visual perception. As an historical note, although both of these themes are now slowly entering the mainstream, both themes are central to the pioneering work of Walter Freeman, who has been defending them, in one form or another, for several decades (Freeman 1999).

The traditional understanding of the neuroscience of vision is in line with the objectivist view mentioned in the above section on enactivism. The objectivist maintains that the task of vision is to represent the objective world, without variation due to context or embellishment of other kinds. The neuroscientific tradition which most strongly supports this position dates back to the Nobel Prize winning work of David Hubel and Torsten Wiesel (1959). They used single-cell recording to demonstrate that particular neurons in the cat brain fired strongly in response to particular visual stimuli. This method has since been widely used in support of the idea that visual neurons function as feature detectors. If visual neurons are strictly in the business of representing objective features in the world, then objectivism looks to be correct.

But there is another way of understanding neural processing which has been gaining increasing acceptance in the last couple of decades. This alternative suggests that neural processing is strongly context sensitive. On this view, the response of visual neurons depends only partly on the nature of the visual stimulus. The response of visual neurons also depends on other factors such as the ongoing endogenous dynamics within cortex (Arieli et al. 1996, perhaps also including what is known as the "default mode network," Raichle et al. 2001), the task that the organism is trying to accomplish (Cohen and Newsome 2008), and bodily states of the organism (Horn and Hill 1969, Abeles and Prut

1996 as cited in Noë and Thompson 2004). Amos Arieli and colleagues illustrate the main idea in a widely cited study on this theme as follows: "Thus, the effect of a stimulus [on cortex] might be likened to the additional ripples caused by tossing a stone into a wavy sea" (1996: 1869).

Before moving on to the models of neural anticipation, I will make two quick comments about how context sensitivity might connect with some of the topics covered above. First, the ongoing dynamics of cortex could be used as support for premise (1) in my reconstruction of Hurley's argument for EVPS. Second, in the debate between objectivism and enactivism, the objectivist can appeal to the evidence which shows visual neurons to be feature detectors, and the enactivist can appeal to the evidence for context sensitivity in visual neuronal response.[5]

The second emerging theme in neuroscience relevant here is the idea that the brain predicts or anticipates the upcoming sensory stimulation. In the case of vision, it is anticipation of the sensory consequences of bodily movement. An overview of the neuroscientific evidence which motivates this theme can be found in Kestutis Kveraga and colleagues' (2007), in which they cover both neurophysiological evidence as well as mathematical models. The important neurophysiological features of cortex include two well-established facts. First, there are distinct visual pathways from the retina which process information at different speeds. This fact underlies the hypothesis that the faster processing enables anticipatory feedback to the slower pathway (Bullier 2001). Second, there is massive feedback connectivity in the mammalian visual areas (Rockland and Van Hoesen 1994). The traditional understanding of the feedback connections is that they are "merely" modulatory, but the newly emerging understanding of them is that they are predictive. There are a number of mathematical models of the visual brain which posit some kind of predictive processing (Rao and Ballard 1999, Friston and Kiebel 2009).

5 For a non-visual neurophysiological case against objectivism, see Kathleen Akins (1996), who focused on the human thermoreceptive system.

These models fit nicely with recent work in the philosophy of perception which suggest that visual anticipation occurs at the conscious level (Siegel 2006, Madary, forthcoming).

6. Future directions for embodied approaches to visual experience

This final section of the chapter raises three areas of future research for embodied approaches to visual experience. These areas involve the nature of visual consciousness, the role of the brain for embodied approaches, and the question of visual representation.

The first area of future research has to do with the nature of visual consciousness itself. The orthodox view in the philosophy of perception is that, if visual experience has any content at all, then it is propositional content of some kind (Siegel 2010). Often this content is described using natural language, as in Searle (1983: 41). It is not obvious that this way of describing visual content is compatible with some of the themes explored in this chapter. In particular, it is not clear that everyday linguistic reports can capture the content of visual experience if that content is anticipatory, closely bound up with action, dynamic, and enacted (as in sense-making from section 3). Future work will determine whether and to what extent there is a real tension here.

The second area for future research has to do with the role of the brain. Perhaps owing to the influence of J. J. Gibson, embodied approaches to vision have sometimes urged a limited role for neuroscience as a way of explaining vision (O'Regan and Noë 2001, Noë 2004, O'Regan 2011). On the other hand, as explained above, some current trends in neuroscience seem to converge on themes that are important to embodied vision researchers. Of particular interest here are Bayesian predictive coding models of neural processing (Friston and Kiebel 2009, Hohwy 2013, Clark 2013). Do these kinds of models support the theories of embodied vision researchers, or is will the charge remain that the brain is the wrong place to look for understanding conscious vision?

The third area for future research has to do with visual representation. Traditionally, a representation refers to an information state with correctness conditions (Fodor 1987, Drestke 1995). Will our best models of vision include representations? There are a number of related questions here. For instance, one might distinguish between personal and sub-personal representations. Does it make sense to posit representations at one level and not the other? There has been a good bit of debate over whether dynamical systems models of the mind involve representations (van Gelder 1995, Bechtel 1998). As long as we use dynamical systems to model vision, then this debate may be relevant. Similarly, the disagreement between objectivist and enactivist stances is relevant here. If the enactivist is correct that our visual experience is partly determined by our own interests and so forth, then can such an experience be described in terms of personal level representational content? In other words, can there be correctness conditions for content which is the result of enactivist sense making?

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