PART 6

Boundaries of the agent

CHAPTER 15

Extended vision

Robert A. Wilson

Abstract

Vision constitutes an interesting domain, or range of domains, for debate over the extended mind thesis: the idea that minds extend physically beyond the boundaries of the body. In part this is because vision (and visual experience more particularly) are sometimes presented as a kind of line in the sand for what we might call *externalist creep* about the mind: once all reasonable concessions have been made to externalists about the mind, visual experience marks a line beyond which lies a safe haven for individualists. Here I want to put a little more pressure on such a view of visual experience, as well as to offer a more constructive, positive argument in defence of the idea of extended vision.

15.1. Vision, visual experience, and the extended mind

Vision is a domain in which two sets of competing considerations clash. On the one hand, the notion of a perceptual *system* is relatively well entrenched in the cognitive sciences, and even some of the most trenchant critics of the extended mind thesis (e.g. Adams and Aizawa, 2008, 2009) are prepared to allow that cognitive systems may be extended. Since the version of the extended mind thesis I favour is most naturally expressed in terms of the extension of cognitive systems beyond bodily boundaries (Wilson, 1994, 2004, chapters 4–8), perceptual domains in general seem to be pre-adapted (as it were) as likely domains for which the extended mind thesis is defensible. On the other hand, not every aspect of cognition and cognitive processing is extended. Perceptual *phenomenology* in general, and the phenomenology of visual experience in particular, has been the first port of call for those with individualistic intuitions about the mind (*sensu* Burge, 1979, 1986). The idea that my perception of the world, *how the world seems to me from the inside*, might be *exactly as it is*, even were I not the embodied, world-enmeshed being that I actually am, but merely a brain in a vat (or were Descartes' evil demon hypothesis true), has both motivated and sustained individualistic thinking about the mind since before the time that there were individualists as such (see also Wilson, forthcoming).

I have argued previously (Wilson, 2004, chapter 9) that at least some of the various phenomena collected under the rubric of consciousness (higher order thought, introspection, and some aspects of attention) fall under the umbrella of the extended mind thesis, and that at least some aspects of visual experience should be viewed likewise (ibid., 232–38). There I also resisted what I called *global externalism*, the view that the extended mind thesis is true across the board for all mental phenomena, opting for a kind of pluralistic view of the mind vis-à-vis the debate over individualism, whereby individualistic and externalist views of cognition divide the mind between them. This moderate externalist view allows that some cognitive systems are individualistic; I have suggested previously (ibid., pp. 238–40) that the nociceptive system that realizes pain is a likely example.

In this chapter, I want to reconsider such pluralism, and to put a little more pressure in particular on an individualistic treatment of visual systems and visual experience in light of that reconsideration. I shall offer a more constructive, positive argument in defence of the idea that vision is extended, aiming to shift the balance of power in any pluralistic coalition further towards externalism. As part of this discussion of the question of whether visual systems and the experiences they generate are extended, I will also take up the question of whether they are embodied. Some individualists about visual experience (e.g. Block, 2005; Aizawa, 2007) have denied the embodiment of vision in anything but a fairly weak sense, e.g., we happen to have bodies that are causally important to vision in the actual world.

I have indicated that visual experience has been a sort of first port of call for individualists. More recently, however, visual experience has become the last refuge for individualism about the mind: visual experience has been taken to be a phenomenon that, after all reasonable concessions have been made to externalists, remains a safe haven for individualists. Ned Block captures this individualistic view of visual experience neatly in a recent, prominent review of Alva Noë's *Action in Perception* in considering the claim that perceptual experience is essentially embodied. Block denies this claim, saying that 'the minimal constitutive supervenience base for perceptual experience is the brain and does not include the rest of the body' (Block, 2005, p. 271). The intuition that Block's own claim about perceptual experience draws on is: that whatever the precise material realization of perceptual experience consists in, it does not extend beyond the brain. This intuition expresses a widely accepted 'embrained view' of the mind, and such *embrainment* is incompatible with the *embodiment* of the mind. Moreover, if perceptual experience is not embodied because its material realization does not extend beyond the brain into the body, then it would also seem that the mind is not extended for that very same reason.

I will try to show not only why I think that Block's claim here is false, but why this, in turn, provides reason to view perception not only as embodied but also as extended. In short, rather than argue (along with Block) that the failure of perceptual experience to be embodied implies that it is not extended, I will argue that precisely because perceptual experience is embodied, it is also extended. In fact, if the line of argument that I am developing is on track, then the physical embodiment and physical extension of at least some forms of perception are tightly entwined facts about how the corresponding perceptual systems operate (cf. Gallagher, 2005; Myin and O'Regan, 2009; Noë, 2009).

Whether this is true *only* of perception because of specific ways in which perception is embodied, or true more generally (e.g. of consciousness; cf. Prinz, 2009; Clark, submitted), is something that I leave open here. In fact, my concern will be almost exclusively with *visual perception* and *visual experience*, bringing in other perceptual modalities only insofar as they shed light on vision. Discussions of vision that are partially cast in terms of broader notions, such as perception or even consciousness, can sometimes be misleading, especially when probing into what it is that vision *requires* or what it is that is necessary or sufficient for *visual* experience.

15.2. **Loosening the skullcap**

In order to loosen the screws on the individualistic skullcap about perception, consider two kinds of cases, one concerning perceptual *systems*, the other perceptual *experience*.

The first are cases in which organisms generate a sensory field that they then move through in order to achieve basic biological goals, such as mating and prey-detection. Bats and electric fish are two of the better-known examples of such creatures. Where is the boundary of *their* sensory systems, given that their self-generated sensory fields are located beyond their bodily boundaries? At first glance, their sensory systems, and indeed the sensory processing they engage in, do not begin and end at their bodily boundaries, since they use their bodies to generate electromagnetic or sonic fields beyond those bodies. In any case, exploring just how such creatures function successfully in the world is relevant to answering the questions. Attention to the mechanistic and computational details of that functioning push against, I shall later argue, at least some of the individualistic intuitions behind Block's claim (Section 5). What they suggest specifically about perceptual *experience* is something I will return to.

The second are cases that are more directly relevant for thinking about perceptual experience, and they help to frame issues about *visual* experience in a particular way. Consider not perceptual experience in general but *tactile* experience in particular. Does the minimal constitutive supervenience base for tactile experience include only the brain and exclude the rest of the body? Precisely the same question could be asked of *orgasmal experience* or the experience of *physical pain* (that associated with breaking one's leg). All three kinds of experience seem to be more intimately related to the body than are visual, auditory, and olfactory experience, as reflected in common reference to them as *bodily* experiences. The experience, in each case, is *felt in the body*, and the material realization of the experience as it actually occurs involves sensors in, on, and nerves that run through, the body. (Whether the appearances in ordinary cases are merely apparent, or this is true of *all* bodily experience, such as in cases of pain felt in phantom limbs, I leave aside here.) If at least some kinds of perceptual experiences are bodily experiences, in this sense, then the embodiment of perceptual experience more generally, and of visual experience in particular, is cast in a new light (see section 15.7).

These cases are introduced here as suggestive screw-looseners, but it is worth saying a little more about which screws on the individualistic skullcap about perception they aim to loosen. I take the first kind of case, involving apparently extended sensory fields, to suggest that whether the corresponding perceptual system ends at the body is in part an empirical question, and the second kind of case, involving bodily experience, to suggest the same about the issue of whether *all* experience supervenes only on the brain to the exclusion of the rest of the body. Ultimately, I shall argue that such suggestions not only loosen the skullcap on thinking about perception and perceptual experience; they also provide the bases for an argument for the extended vision thesis. The full defence of that argument will require showing how it avoids some of the now-standard objections to arguments for the extended mind thesis, or their analogues for perception, such as a putative 'coupling/constitution fallacy', and a failure to consider the significance of the distinction between cognitive *systems* and cognitive *processes* (Adams and Aizawa, 2008, 2009; Block, 2005). For now, it is enough if these suggestions challenge non-externalists to entertain the prospect that individualism about perception and perceptual experience is not as secure a position as is often assumed. This is a kind of *externalist creep* (I've been called worse). I want to turn next to briefly recount a broader and perhaps more familiar externalist creep in philosophy of mind over the past 35 years or so, primarily for those unfamiliar with the trajectory of the debate over individualism and externalism in the philosophy of mind.

15.3. **Externalist creep**

Contemporary externalist thinking about the mind originates in the work of Hilary Putnam (1975) and Tyler Burge (1979). The arguments of Putnam and Burge appeal, respectively, to the attribution of 'meaning' or belief in counterfactual circumstances. Both Putnam and Burge acknowledge the debt of their views to earlier works, including their own, on the causal theory of reference, particularly as it applied to both proper names and natural kind terms in natural languages. Here we have our first instance of externalist creep: from the philosophy of language to the philosophy of mind. Given this starting point, two individualistic responses which concede that the Putnam-Burge thought experiments show some form of externalism about mental representation to be true, are natural.

The first kind of individualistic response (Field, 1978; Loar, 1981; McGinn, 1982) was to argue for 'two factor' theories of mental content, where one factor is externalist (or 'wide'), the other individualistic (or 'narrow'). The most common ways to develop an account of narrow content have been either as a form of conceptual role semantics, or by analogy with David Kaplan's notion of *character* in his semantics (see Wilson, 1995, chapter 9 for discussion).

The second kind of individualistic response (Fodor, 1982) was to argue that while conceptual content is externalist, *non-conceptual* content, as exemplified in unarticulated perceptual experience, is individualistic. As philosophical attention shifted its focus from the problem of intentionality to the problem of consciousness during the 1990s, more sophisticated defences of the idea that phenomenology (especially *visual* phenomenology) was individualistic have appeared (e.g. Loar, 2002, 2003; Horgan and Tienson, 2002). While the focus here is squarely on the first-person phenomenology of our mental states, these efforts are an attempt to reinvigorate the narrow content programme about intentionality by arguing that 'phenomenal intentionality' was individualistic. The basic idea of these views is that there is a kind of intentionality, phenomenal intentionality, determined by one's phenomenology (how the world seems to one at a given time) that is individualistic. Although the view is intended to apply to mental states more generally, sensory experience has been presented as a paradigm of where one could locate phenomenal intentionality (see Wilson, 2003, 2004, chapter 10 for discussion).

This section has reprised briefly a central strand to the individualist–externalist debate, one that has focused on mental representation, intentionality, and content. The central question here, as it pertains to vision, has been something like this: is the content of visual experience, or our visual phenomenology, individuated individualistically? Aficionados of the individualism–externalism debate will have followed discussions of this kind of question in the context of Marr's theory of vision, where there has been sustained attention to the question of whether Marr's theory was externalist (Burge, 1986; Shapiro, 1997) or individualistic (Segal, 1989) or neither (Egan, 1992; Chomsky, 1995) about content. Here we can note another kind of externalist creep: from externalist claims about folk psychology (e.g. belief) to externalist claims about cognitive science (e.g. zero-point crossings and 2.5 D sketches in Marr's theory; see also Wilson, 2004, chapter 7). Yet none of these views have considered the question that is now at the forefront of contemporary debate between individualists and externalists: does the mind itself extend physically beyond the physical boundary of the body? Those who answer affirmatively (Clark and Chalmers, 1998; Clark, 2007, 2008, in press; Hurley, 1998; Wilson, 2000, 2004, in press; Wilson and Clark, 2009) defend the *extended mind thesis.* Those who answer negatively (Adams and Aizawa, 2001, 2008, 2009; Rupert, 2004; Prinz, 2009) view that thesis as resting on one or more errors. They hold, instead, that the 'vehicles' of cognition are bound by the head. The *extended vision thesis* is an instance of the extended mind thesis that applies to vision; an early version of it was defended in my 'Wide Computationalism'"through discussion of the multispatial channels theory of form perception and of work on animal navigation systems (Wilson, 1994. See also Wilson, 1995, chapter 3). It is to an argument for this thesis that I now turn.

15.4. **An argument for the extended vision thesis**

One general consideration that opens up ground for taking the extended vision thesis seriously is that cognitive systems that have evolved through world-mind constancies are good candidates for extended cognition (Clark, 1989, 1993, chapter 6; Wilson, 1995, chapter 4). Together with what Andy Clark (1989, p.64) has called the *007 Principle* for organisms engaged in costly internal processing – 'know only as much as you need to know to get the job done' – this consideration suggests that we should expect to find cognitive systems designed to rely on world-mind constancies to perform their function, rather than form and compute complex internal representations, when such constancies are there to exploit. Visual systems are often in just this position.

Over the past 15 years, a number of new accounts of visual processing have taken up a question that is very much in the background of such general considerations, and in so doing, have made the extended vision thesis more plausible. That question concerns the global function of vision: what it is that vision, as a whole, *is for*. Answering questions about the global function of any biological structure, capacity, or behaviour are far from straightforward, turning at least in part on organismal and lineage history, current utility, and the relationship between them. But at least one defensible epistemic handle on this question is to ask what it is that vision allows organisms who have it to do that those without it either cannot do, or at best do in a much more constrained and cumbersome way. The particular argument for the extended vision thesis that I shall discuss appeals, in the first instance, to the global function of visual systems.

To a large extent, the question 'What is vision for?' has not been centre-stage in traditional theories of perceptual processing. When it has been asked, the answer given has been something like this: vision is for recording some kind of raw imprint of the world, which then gets processed 'downstream' to arrive at a reconstruction of the world in terms of concepts and categories (in organisms that have such tools) that are employed either consciously or unconsciously. Human vision in particular, and human perception more generally, is 'for' cognition: vision extracts information from the world to deliver inputs to various cognitive processes. Insofar as access to visual information results in a massively enriched database on which cognitive processes can operate, vision is for the enhancement of cognition and, eventually, action.

A range of recent theories of vision (including O'Regan and Noë's [2001] sensorimotor theory of perception, Ballard's [Ballard et al., 1987] animate vision programme, Milner and Goodale's [1998] dual systems account of visual perception, and Matthen's [2005] action-oriented account of perception as sensory sorting) have provided variants of a different answer to this question (see Wilson, 2006). They all hold that *vision is for guiding action*. While this is not the only function performed by every visual system, including those that humans have, it is the 'big thing' that vision is for. The global function of vision is to allow individuals to get around in the world. Only mobile organisms have vision, and the visual systems that organisms are equipped with, when those systems are working as they ought to, ultimately guide their action. More specifically, the overarching function of vision is to guide action via the processing of a certain kind of information: visual information.

If the guidance of action is the ultimate function of visual systems, then what follows? To answer this question, consider another: how is it that visual systems achieve this function of guiding action through distal visual information? One way to do so would be to make an internal, encoded representation of what is in the world, and then, combining this with other internal representations, use internally stored computational rules to deliver outputs that serve as inputs to internal motor programmes that, in turn, generate action. This presents what we might call a *flow through* model of visual representation and visually guided action, whereby visual representations are formed internally and flow through the agent's cognitive system to generate, eventually, actions and behaviours.

Such flow through models have dominated how visual representation has been conceptualized, perhaps because such models fit so tidily with the conception of vision as a feeder process that delivers raw 'sensation-like' representations to cognition central and with standard computational views of vision (Marr, 1982). They also instantiate what Susan Hurley has called the *Input-Output* picture of perception and action, which 'conceives of perception as input from the world to the mind and action as output from the mind to the world' (1998, p. 288). To be sure, flow through models have not been articulated with the conception of visual systems as being for the guidance of action in mind, but instead within a framework that holds that what vision is for is the provisioning of cognitive processing. Perhaps not surprisingly then, on these models, most attention has been focused on the nature of the encoding from world to mind, and to the character of the resulting internal representations. However, flow through models are not the only way to think about how visual systems operate, and they are not all that plausible as general models of how visual systems achieve their goal of guiding action. In part, this is because in the absence of basic bodily actions, such as physiological nystagmus and saccadic eye movement, many visual systems do not operate at all, or do so only in degraded or radically modified ways. As Steve Palmer notes with regard to the absence of the former, '[I]f a patterned stimulus is presented to the eyes without any retinal motion whatsoever for more than a few seconds, the pattern completely disappears!' (Palmer 1999, p. 521). Moreover, in part, this is because the kinds of rich, internal structures that flow through models require do not seem to be as ubiquitous in vision as researchers had assumed they were. On flow through models, all that bodily actions can do is to re-position the organism to produce novel inputs, or stabilize the perceiver so that inputs remain fixed over time. On these models, representations themselves cannot be enriched through later stage processes, such as motor output, except in such 'indirect' ways.

The chief alternative to viewing visual information as flowing through from perceptual to cognitive (then to motor) systems is to take the systems that process such information as *feedback systems*. In such systems, information is fed back *to the very same system in completing that system's* *task processing*. Such feedback can take place entirely at the level of encoding, but it can also involve feedback that does not form such an internal loop. The kind of representation that such boundary-crossing feedback systems traffic in can be partial and improvisational, including cases in which visual representation is a form of what I have elsewhere (Wilson, 2004, chapter. 8) called *exploitative representation* (see also Shapiro, 1997). Rather than taking a representational fix on the world, and then having those representations transformed internally as they flow through the organism to generate visually guided action, in exploitative visual representation, the activity of representing exploits whatever resources it can to generate the appropriate action. Importantly, exploitative representation can rely on *the body's own structures and behaviours* in its activity of representing, with relevant bodily actions (in the first instance, eye-movements of various kinds, foveation, head-turning, squinting)constituting, and not simply causing, a key part of an overall perception–action cycle that manifests not informational flow through, but informational feedback.

To summarize this point: I have been drawing a contrast between two views of vision that give different answers to two questions. Concerning the question *what is vision for?*, the traditional view holds that vision is for encoding information from the world for downstream cognitive processing, while recent views that cluster under the heading of embodied approaches hold that vision is for guiding action via visual information. Concerning the question *how does vision operate?*, traditional views offer what I called flow through models, while embodied views suggest that vision functions via boundary-crossing feedback mechanisms that link perception to action. As I have indicated, traditional encoding, flow through views of vision can adapt in the direction of action-oriented views of the function of vision, but there is somewhat of an awkward fit here with the overall separability of perception and action. Likewise, such views could attempt to incorporate feedback as part of how visual systems operate, but again this adjustment to traditional views leads to positions with some instability to them. Either kind of move pushes one from separating perception and action as distinct, determinable, cognitive natural kinds towards the view that perception and action are more intimately related than such a view allows.

Susan Hurley's *Consciousness in Action* was a watershed in breaking the grip that the flow through view of perceptual representation has had on philosophers and cognitive scientists alike. One of its important contributions was in arguing against individualists about perception on very much their own turf. In doing so, Hurley provided at times a painstaking critical review of thought experiments (e.g. Twin Earth, Inverted Earth) that had been used in support of individualistic conclusions about perceptual content, and introduced discussion of actual experiments (e.g. work with inverted lenses by Ivo Kohler and by James Taylor; Paul Bach-y-Rita's development of tactile-visual substitution systems). While the negative point of Hurley's discussion was to call into question some of the large-scale frameworks in terms of which perception (and consciousness) had been conceptualized, the alternative, positive perspective on vision as involving dynamic perception-action cycles suggests a view of perception and action as being integrated much more tightly than often depicted by both philosophers and cognitive scientists. On the view that Hurley shares with many others who take the function of vision to be the guidance of organismic action, it is not simply that our visual systems are causally hooked up to (the rest of) our brains/bodies, or that these systems deliver sensory outputs to (the rest of) the brain/body, which then executes motor routines. Rather, what is usually thought of as the human visual system (starting at the retina and terminating in one or another area of visual cortex) is *coupled integratively* with the non-neural body via a sequence of bodily actions. This use of the body, this body-in-action, creates and stabilizes a chain of representations tied directly to actions.

Although I have said that visual systems are embodied 'in a fairly strong sense', it is important to note that this is not the strongest possible sense in which one might speak of the embodiment of vision. The claim is not that visual systems are *necessarily* parts of bodies, or that it is impossible to have functioning visual systems that are removed from, or even temporarily causally disengaged from, the rest of the body. Both of these stronger claims seem to me to be clearly false. This is not, however, because the body merely provides causal inputs to perception through its actions, nor because bodies (for some reason) fail to realize visual processing. Rather, it is chiefly because of general facts about how complex, modularly decomposable systems operate. Such systems in general do not have *any* parts that are strictly necessary, since one can substitute functionally equivalent parts for any given part. That, I think, is one of the implications of functional decomposition, however constrained actual substitutions might be given actual circumstances. Yet since this is true as much of 'brain parts' as of 'bodily parts', it does little to soften the claim that vision is embodied. Physical bodily parts need not be subject to theses that are stronger than those that hold true of physical neural parts; neural parts are, after all, just body parts with a particular location, composition, and range of functions.

I hope to have said enough about the starting points of the argument for extended vision that I am making now to lay out the whole argument more explicitly. The argument runs as follows:

1. The function of some visual processes is to guide action via visual information.

2. A primary way to achieve that function is through the active embodiment of visual processing (in a fairly strong sense).

3. Visual processes are actively embodied (in that same fairly strong sense) just if in their normal operation in natural environments, these processes are *coupled* with bodily activities so as to form an *integrated system* with *functional gain*. But

4. Visual processes that are actively embodied, in this sense, are also extended.

Some visual processes, and the visual systems those processes physically constitute, are extended.

The argument begins, at (1), with a claim about the function of some visual processes, and is based on my discussion of the more general global function of vision. Premise (2) purports to identify the active embodiment of visual processing as *one way*, albeit an important way, in which this function is achieved, at least in human beings and other mobile material beasts with which we are familiar. The third makes more precise what I mean by the active embodiment of vision, while the fourth draws a link between active embodiment and extended vision. Yet (3) requires further explication, not least of all because it is cast in terms of a notion that I have mentioned but not explained so far, that of *functionally gainful, integrative coupling*. And (4) has not been discussed at all. To work!

15.5. External sensory systems: Back to bats and electric fish

Let us return first to some of the cases mentioned in section 15.2: those of organisms, such as bats, which use self-generated sonic fields for navigation and prey detection, and electric fish, which generate weak electric fields for the same purposes. Just as the examples of inverting lenses and tactile visual substitution systems provide the basis for viewing perception as embodied in a fairly strong sense, these examples provide grounds for taking perception to be *extended* in that same fairly strong sense. In such cases, organisms expend energy in creating a field (acoustic or electric in these cases) that they then interact with through motion in order to hunt, feed, mate, or navigate. I suspect that it would be at best very strained to argue that these fields do not physically constitute part of the sensory system of these organisms (and are, instead, say, simply resources used by, or inputs to, bodily-bounded sensory systems) as a broader consideration of their sensory ecology and evolution implies. These sensory systems are, in Richard Dawkins's (1982) terms, *extended phenotypes* of the organism; they are adaptations that have been selected for, much as their *internal* sensory physiology has. In at least these cases, sensory systems are extended, and they provide examples of a fairly radical form of 'vehicle externalism' about the mind, one that does not appeal to intuitions about mental content, or claims about what happens on Twin Earth (or if there is an evil demon). In such cases, a slab of sensory processing, some of which is almost certainly computational, takes place outside of the body of the organism, as MacIver (2009) has argued recently. Still, might all the computation that underpins bat echolocation be going on solely in the bat's brain?

One function of such extended sensory systems is to ease the 'in-the-head' computational and representational load, much as is the case of sensory off-loading where *non-sensory* body parts, such as the forelimbs of the legs of crickets, are recruited as part of an overall sensory function (in this case, phonotaxis). By redistributing computation beyond the nervous system, adaptive behaviour is clearly facilitated, as a closer look at any of the above examples reveals. Moreover, in all of these cases, it is not just aspects of the self-generated environment that are recruited as sensory resources, but parts of the organism's own body. In many cases, and in more distinctly philosophical terms, the body becomes part of the *realization base* for the computations that allow the organism to perform its cognitive functions. MacIver (2009) refers to such computation as *morphological computation*: computation that uses the organism's own morphology as part of computing machinery in play (see also Paul, 2004; Pfeifer and Bongard, 2006). This recruitment of one's own body as a computational resource can make itself visible over evolutionary time, as the variation one finds in bat pinnea suggests, as MacIver also suggests. The shape and character of the ear itself is a morphological adaptation that forms part of the more complex behavioural adaptation of the echolocatory visual-motor system, both of which have been the object of natural selection over many generations. As MacIver says, the 'conformation of skin and supporting tissue of the ear in the bat forms a computational device that solves a key problem in the localization of prey in three-dimensional space' (2009, p. 488).

To take an example closer to home ground, consider the optic flow, the pattern of apparent motion of objects and features in a visual scene that is created when an organism, such as a vertebrate, moves through space. When the optic field flow expands, it indicates, in conjunction with the organism's movement, that it is approaching some fixed point, while contracting optic flows indicate a growing gap between organism and object (Gibson, 1979, p. 227). Optic flow also crosses the divide between vertebrates and invertebrates. Recent research in invertebrate neuroethology on the visual systems of flies has focused on ways in which flies detect self-propulsion in order to stabilize their flight pattern. Facts about the geometry and physiological wiring of the fly's photoreceptors simplify the computation of optic flow (see Egelhaaf et al., 2002). For example, the dendrite of a tangential cell (VS6) likely integrates the input from sensors that detect optic flow patterns. The sensors (the ommatidia) that feed the neuron detecting a fly's rolling motion (as when it tips to one side) are located in a row that lies parallel to the pattern of optic flow. Given that the change in optic flow characteristic of rolling is typically caused in the fly's usual environment by the fly's own motion, activity in this neuron indicates self-motion to the fly. Both of these physiological set-ups contribute to simplifying the neural computation of optic flow in ways that connect the fly's visual system more effectively to action. They do so by distributing the overall computation over brain and body, not brain alone.

This kind of example provides the connection between what we might regard as the exotic cases of paradigmatic extended sensory systems (the echolocating bat, the electrically sensing fish) and more familiar and mundane examples of sensory systems. For *lots of creatures, including us*, operate visually in part through optic flow, and through a variety of other means whereby aspects of the organism's environment and their interaction with and manipulation of it are crucial to the visual tasks that they undertake. This is just what we should expect if sensing is a kind of doing, a kind of activity, a way in which organisms extract and exploit information from their environments through their bodily interactions with it. To connect this up directly with the earlier discussion of the embodiment of human vision: eye movements, foveation, saccading, head-turning and other forms of head movement, and even squinting are all familiar ways in which organisms like us adjust their bodies with respect to their environments in order to improve their visual performance. Once sensory systems are conceptualized in dynamic terms, such that we consider not only their in-the-head functional decomposition but also their in-the-world functional role, there is pressure to see more and more of their activity as extending beyond the brain into the body and, as I shall argue, into the world. More externalist creep.

One natural response to this point is to acknowledge a role for both body and world in easing perceptual computation and generating perception, but dispute that either body or world have a *constitutive* role in perception. To counter such a response, and to respond in turn to related objections to premises in the argument, I shall elaborate on the notion of active embodiment and its relation to extended vision.

15.6. Integrative coupling, embodiment, and extended vision

I have been arguing that vision is embodied in a fairly strong sense (section 15.4), a conclusion reinforced and connected to the extended vision thesis by consideration of the active, extended sensory systems of creatures like bats and electric fish, and reflection on the connection between such exotic cases and those that are more familiar (section 15.5). However, more needs to be said about the notion of embodiment itself in play, which brings us back to Premise (3):

> (3) Visual processes are actively embodied (in a strong sense) just if in their normal operation in natural environments, these processes are *coupled* with bodily activities to form an *integrated system* with *functional gain*.

I introduce *functionally gainful, integrative coupling* as a technical notion that can be explained in terms of the three component notions that it contains.

First, two processes are *coupled* just if there are reliable causal connections between them. Since reliable causal connections between x and y entail a strong correlation between the presence of x and the presence of y, but (notoriously) correlation does not entail causation: coupling is a *stronger* notion than mere correlation. The processes leading to the growth in height of the summer annuals planted in various parts of my garden are correlated but not coupled. Second, two processes form an *integrated system* just if there are contexts in which they operate as one, as a whole, in the causal nexus, with causes affecting the resultant system as a whole, and the activities of that system as a whole producing certain effects. Although causal coupling need not produce an integrative system (two annuals planted very close together in my garden might have processes that are reliably coupled without those processes forming an integrative system), integrative systems result typically from causal coupling, and when they do, we have *integrative coupling*. What bridges the gap between mere reliable coupling and the formation of integrative systems is the sharing of parts and activities. Third, an integratively coupled system shows *functional gain* just when it either enhances the existing functions of its coupled components, or manifests novel functions relative to those of any functions possessed by those components.

Before considering special features of the active embodiment of visual processing, note that functionally gainful, integrative coupling is a general phenomenon that is commonplace in biological and social processes (see Wilson, 2005, chapters 3–4 and 6–7). Consider human digestion, which involves the causal coupling of the activities of human body parts, such as the stomach, and the activities of microorganisms, like *Escherichia coli*, that find a useful habitat in those parts. The resultant, integratively coupled system, the human digestive system, has evolved over time to process foods more effectively than do any of its constituent processes alone, and so that system shows functional gain. Although the process of human digestion incorporates non-human components, such as those processes undertaken by *E. coli*, note that these still take place in the digestive system *of a human being* whose trajectory in the world is affected by these processes. The relevant processes (and, I think, systems) here are one kind of entity; the human being whose behaviour is governed, in part, by those processes, is another.

To take an example from the social domain, consider the process of pairwise cooperation as facilitated through explicit agreements to cooperate. I say 'I'll scratch your back, if you scratch mine' and you say 'Sure'. Here such agreements causally couple the activities of distinct individuals, who thus come to engage in pairwise cooperation. When things go well, this results in a dyadic cooperative system, one sustained by internalized and externally imposed sanctions, that shows functional gains in terms of problem-solving and desire satisfaction in certain contexts (e.g. those in which a pair of backs are to be scratched), as classic discussions of prisoner's dilemma and other game-theoretic scenarios indicate. The fact is that there is a functionally gainful, integratively coupled system is compatible with the existence of identifiable parts, each with its own integrity and functions, and with the decomposition of that integrative system into those functional parts.

As these examples perhaps suggest, functionally gainful, integrative coupling can result in systems of various levels of durability and robustness over time and circumstance (cf. Wilson and Clark, 2009, pp. 64–68). It does not require any form of lawful or other necessary connection between the constituent components to the integrated system, or at least none more than reliable causation itself requires. For this reason, it is irrelevant whether there is integrative coupling, that there are possible (even actual) circumstances in which the constituent processes come apart, or in which there can be (or are) alternative constituent processes. For example, that bacteria other than *E.coli* might play the role in digestion that *E.coli* actually play does nothing to undermine the claim that stomachs and *E.coli* are (together with much else) integratively coupled in the process of digestion as it actually occurs. Likewise, the vulnerability of an integratively coupled system to dissolution – as is pairwise cooperation through cheating and external threat – does not itself call into question whether there is integrative coupling when those threats are absent or non-effective.

Returning to visual processing and bodily activities, it seems that *everyone* who is party to the debate over the embodiment of vision grants that there is causal coupling between (some aspects of) vision and (some aspects of) action, just as everyone who is party to the debate over the extended mind thesis grants that there is causal coupling between (some aspects of) cognition and (some aspects of) the beyond-the-skin environment. The real question, in both cases, is of the significance of such causal coupling. In the case of the active embodiment of visual processing, this is of significance just when such coupling between visual processing and bodily activity produces integratively coupled systems and those systems manifest functional gain, in the senses just explained, through their normal operation in their natural environments. Such systems are often called *visuo-motor systems* or *modules* (e.g. Ballard, 1996; Milner and Goodale, 1998a and 1998b). If the overarching function of vision is the guidance of action through visual information, then such systems or modules have functional gain with respect to the functions of the constituent processes in such systems.

Of what sorts of visual process might this be true? Some might suggest, following Milner and Goodale (1998a and 1998b), that such processes are restricted to those subserved by the dorsal stream of visual processing, the *where system* in primate visual systems, including motion perception and spatial orientation. This would leave those subserved by the ventral stream, the *what system*, such as object recognition, beyond the reach of the kind of active embodiment thesis being used here to defend extended vision. While the distinction between dorsal and ventral streams of visual processing has been articulated both functionally and anatomically in increasing detail over the past 40 years since Schneider (1969) first postulated the distinction based on work with hamsters, and Ungerleider and Mishkin (1982) developed it further on the basis of work with primates, I am sceptical that the distinction can serve adequately to demarcate (or contain) actively embodied visual processing in the manner suggested here. Many of the common types of visual processes that are invoked in theories of vision (visual attention, depth perception, shape perception, image change detection, even motion perception and objection recognition themselves) involve aspects or dimensions that fall under *both* kinds of system. Accounts of these processes that approach empirical adequacy for the range of phenomena that each encompasses will almost certainly appeal to *both* what and where systems (cf. also Hurley, 1998, pp. 180–183). All require eye movements and associated bodily adjustments, for example in how they normally operate in natural environments.

To say that visual processes are actively embodied, then, is to say much more than that they are causally coupled, or to infer directly from the causal coupling of vision and action to their active embodiment, committing what some, following Adams and Aizawa (2001, 2008, 2009), call the *coupling-constitution fallacy* (e.g. Block, 2005; Prinz, 2009). To elaborate on this second point, we need to be more explicit about precisely what this fallacy is. Often when Adams and Aizawa (2008, pp. 93–99; 2009, pp. 81–83) ascribe this fallacy, they attribute to proponents of the extended mind thesis the following inference pattern:

a. Y is a cognitive process

b. X is causally coupled to Y.

c. X is part of a cognitive process

where X = activities involving some environmental structure, such as a notebook, and Y = some specific in-the-head processing, such as memory retrieval. Whatever one thinks of Adams and Aizawa's claim to find such an inference pattern almost ubiquitously in the work of those defending the extended mind thesis, the preceding argument contains no inference of this form, modified so that X = bodily actions or activities and Y = some specific in-the-head visual processing, such as the computation of depth from disparity or shading in visual cortex. Rather, the claim is that the causal coupling between visual processing and bodily activities *builds an integratively coupled system that is a causal entity in its own right, both subject to, and an agent of, causal influence*. This is parallel to the way in which the causal coupling between body parts (like stomachs) and bacteria (like *E. coli*) builds an integratively coupled system that digests, and that between individuals, facilitated by explicit agreements, builds a dyadic group that cooperates pairwise to achieve particular goals. My view is that only by denying integrative coupling as a general phenomenon, or that it is a phenomenon that one finds in perception, can one challenge Premise (2) in the argument I have offered, but that would be to offer something other than the charge that the argument trades on a 'coupling/constitution fallacy'.

Although Adams and Aizawa sometimes identify that fallacy as I have above, they also employ that term more broadly to pick out a larger family of faulty inferences that they believe proponents of extended cognition make. Prominent amongst these are defences of the extended mind thesis that involve an inference from claims about extended *systems* to conclusions about extended *processes* (e.g., Adams and Aizawa, 2008. chapter 7; 2009, pp. 83–5). One might think that this is precisely the form that the coupling-constitution fallacy takes in the argument I have offered for the extended vision thesis, since that argument is cast explicitly in terms of the notion of integrated *systems*. To link this transparently to the preceding schema, we might characterize this version of the putative fallacy as follows:

A. Y is a cognitive (perceptual) process

B1. X is causally coupled to Y.

B2. X and Y form an integrated system (with functional gain).

C. X is part of a cognitive (perceptual) process.

However, there are two reasons why this argument does not instantiate this fallacious pattern of inference. The first is that it does not begin with a premise like (A); in fact, it does not even contain a premise like (A); cf. my premises (1)–(4). The second is that it does not conclude with a conclusion like (C). Rather, it begins with a claim about a function of vision and how that function is achieved, and concludes with a claim about not the character of any component of the resulting system but with a claim about the character of that system itself. In offering a conception of visual processes as actively embodied, it depicts visual processing as a kind of *building* or *construction*, whereby bodily resources are recruited to enhance and even create visual functioning of various kinds.

Having spent some time articulating and defending (3) (and (2)) in the argument for extended vision, which takes us only to the claim that vision is actively embodied, not extended, what of the remaining premise, (4), that completes the argument?

(4) Visual systems that are embodied, in this sense, are also extended.

Given the conception of active embodiment that I have defended, (4) is less of a leap than it may sound initially, since the resultant integratively coupled system is one tracing an arc that reaches beyond the body of the organism. While proprioception and kinesthesia provide two sources for causal couplings between visual processing and bodily activities that remain within the bodily envelope, simple visual observation of one's own body and its movements over time provides a kind of feedback from vision to action that goes beyond that boundary. Much like the extended sensory systems of bats and electric fish, the visuo-motor systems with which we explore our visual world are not contained fully within the bodily boundary. While their extended sensory systems are realized, in part, by sonic and electromagnetic fields that they generate through their bodily movements, our extended visual systems are realized, in part, by optic flow fields that we generate through *our* bodily movements. Neither the sonic, nor electromagnetic, nor optic flow fields that are used in perceptual processing, respectively, by bats, electric fish, or human beings, exist simply in the world independently of these organisms. Rather, they are created and sustained by the ongoing, active bodily engagement of those organisms with their environments. Since this form of embodiment involves causally coupling between organisms and physical structures that lie beyond the physical boundaries of those organisms, it is a kind of extended perception. In the case of human (and much other animal) vision, it is a kind of extended vision.

Perhaps this becomes clearer once we consider more explicitly the *dynamic* dimension to visual processing (Hurley 1998, chapter 10), acknowledging the fact that it is only through bodily movement over time, especially of the eyes through physiological nystagmus, saccadic eye movements, and smooth pursuit and vergence movements (Palmer, 1999, pp. 519–25), that there is a visual field with anything like the richness of our actual visual field at all. Visual representational cascades are built up dynamically over time, with repetitive feedback loops building the information that fills visual pathways, and that makes visual experience possible. Vision is a hungry constructive process, one that needs to be fed continually over time if it is to function as it is supposed to. While it feeds on inputs and produces outputs, those outputs themselves feed back over time into the system that produces them. The 'it' here is not a system that begins and ends in a part of the brain, nor even in the body. It involves a body that moves over time, and through a particular environment. Vision is extended.

15.7. **What of visual experience?**

This brings me back, finally, to visual experience, and the role that it has come to play as a last refuge for individualistic intuitions. Recall Block's claim that 'the minimal constitutive supervenience base for perceptual experience is the brain and does not include the rest of the body' (Block, 2005, p. 271). Even putting aside (4) in the argument for extended vision, if the premises (1)–(3) in that argument are true, then we can see why this claim is false, at least of much perceptual experience. Moreover, it is false for much the reason that the corresponding claim is false of tactile and orgasmal experience: the visual processing that underlies visual experience, like the sensory processing that underlies these paradigmatic forms of bodily experience, is coupled integratively with bodily activity.

Strictly speaking, what (1)–(3) imply most directly is the falsity of the claim that the minimal constitutive supervenience base for perceptual *systems* is the brain and does not include the rest of the body. Could one not concede that point, but insist, with Block, that perceptual experience is located firmly within the neural fold, inside not just the body, but the head, much in the way that one might allow that an air-conditioning *system* might extend throughout a house but insist that *the air-conditioning itself* is localized *right here* in a particular unit within that system, such as the compressor (cf. Adams and Aizawa, 2009)? *That's* where the air-conditioning is taking place, just as all of the computing in a computational system (which might include screens, printers, hard drives, wireless signals, and more) takes place in the *central processing unit*. In short, does not the explicit appeal in (1)–(3) in the argument to visual systems, an appeal that is then used to reach a conclusion about visual *experience*, commit a fallacy that falls under the broad head of the coupling-constitution fallacy?

To be clear on this: no, it does not. While there is an inference being made from a claim about the visual system to a claim about visual processing *and so visual experience*, the visual system just is the system in which visual processing takes place. Certainly, the neural pathways that subserve many aspects of vision are located in the head, and they will have some properties that are unique (and so not shared by other parts of the visual system) and not possessed by the system as a whole. Neurons fire; visual systems do so at best metaphorically or in some other sense. My claim is that *having visual experience* and *being the place where visual experience happens* are not amongst such properties. What is at issue is whether any amount or form of activity just in those pathways themselves is metaphysically sufficient for the full range of visual experience, or something suitably like our actual visual experience. For this reason, reports of some kind of experience or other in cases of partial paralysis of the body, or even of the more extensive paralysis brought on by the neuromuscular blockade of receptors for the transmitter acetyl choline (Adams and Aizawa, 2008, pp.166–72), offer no challenge to the argument I have offered, which is specifically about everyday vision and visual experience. The same is true of appeals to other cases, such as dreams, TMS stimulation to orgasm, or pain in phantom limbs, in which experience of some kind is putatively divorced from the kind of active embodiment that is extended. Whether a modification of the argument offered here can be defended for the full range of experience is an issue I leave for further discussion (see also Wilson 2004, chapter 9).

In fact, if visual processing itself is embodied actively in the way I have defined that notion here, it is hard to see how a feature generated by that processing in toto, visual experience, could fail to be embodied actively as well. To look to identify the realization base for visual experience in the brain would be more like aiming to locate digestion solely in the stomach, or fitness solely in the organism. Stomachs digest, and organisms have fitness, but at best they realize these properties partially. Sometimes we look inside organisms and their parts to identify what is metaphysically sufficient for the properties they possess, but sometimes we need to look to what those organisms, and those parts, in turn form a part of, as I have argued at length elsewhere (Wilson, 2004, chapters 5–6). Visual experience, I am claiming, is a property that falls into this latter category.

Since I have argued that visual processing is not simply actively embodied but also, in light of that, extended, I think that the same reasoning above implies that visual experience, as an outcome of some forms of extended visual processing, is also extended. At the outset I noted that I have previously argued that at least some of the various phenomena that fall under the rubric of consciousness – higher order thought, introspection, and some aspects of attention – fall under the umbrella of the extended mind thesis, and that at least some aspects of visual experience should be viewed likewise (Wilson, 2004, chapters 9–10). In appealing to the active embodiment of visual processing, and the link between that and extended vision, I have sought a way to reinforce that conclusion. Visual experience thus joins these other aspects of consciousness, processes of awareness, in further extending externalist creep from the intentional into the phenomenal. Thus, the space for individualistic refuge is smaller than many individualists have thought it is.

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