

Dislocation, Not Dissociation: The Neuroanatomical Argument Against Visual Experience Driving Motor Action

BENJAMIN KOZUCH

Abstract: Common sense suggests that visual consciousness is essential to skilled motor action, but Andy Clark—inspired by Milner and Goodale’s dual visual systems theory—has appealed to a wide range of experimental dissociations to argue that such an assumption is false. Critics of Clark’s argument (e.g. Wallhagen, Mole) contend that the content driving motor action is actually within subjects’ experience, just not easily discovered. In this article, I argue that even if such content exists, it cannot be guiding motor action, since a review of current visual neuroscience indicates that the visual brain areas producing conscious representations are distinct from those driving motor action.

1. Introduction

At first glance, it might just seem obvious that the rich information found in visual experience is indispensable to fine-tuned motor actions, things like carrying a brimming cup of coffee or catching a ball. Consider what it is like to descend a rocky trail. Picking your way through the obstacles, your visual experience seems to contain metrically precise representations of things like the pitch of the ground and the position of rocks. Because these representations are detailed, they look ideal for guiding the fine-tuned motor actions needed to safely cross the ever-changing terrain. It is observations like this one that brought some philosophers (O’Shaughnessy, 1992; Peacocke, 1992; Cussins, 1998; Grush, 1998) to hypothesize that visual experience is what *guides* skilled motor action, a view Andy Clark (2001) dubbed the thesis of *experience-based control*, hereafter EBC.¹

Clark has argued against EBC by appealing to a large body of experiments in which the content guiding motor action seems missing from visual experience

The author would like to thank Uriah Kriegel, Brian Fiala and Shaun Nichols (as well as the editors and referees of *Mind & Language*) for insightful comments on earlier drafts of this article.

Address for correspondence: Philosophy Department, University of Arizona, 213 Social Sciences, P. O. Box 210027, Tucson, AZ 85721-0027, USA.

Email: bigben@email.arizona.edu

¹ When Clark originally presented the hypothesis of EBC, it was a conjunction of three claims: (1) Visual experience ‘presents the world to the subject in a richly textured way, a way that presents fine detail’; (2) visual experience ‘is, in virtue of this richness, especially apt for ... the control and guidance of fine-tuned, real-world activity’; and (3) visual experience is in fact ‘typically utilized’ in such control and guidance (2001, p. 496). Since Clark introduced the hypothesis of EBC, the debate has largely narrowed to just the third claim, this also being what we will be concerned with here.

(2001, 2007, 2009; cf. Milner and Goodale, 1995/2006). There is the well-known case of patient DF, whose brain lesion seems to affect only her ability to visually experience an object's shape, but not her ability to grasp it (Milner and Goodale, 1995/2006, ch. 5). Then there are the numerous experiments in which subjects' motor actions appear unaffected by consciously experienced visual illusions (e.g. Aglioti, DeSouza and Goodale, 1995). The sum of these and other data is a formidable case against EBC.

If Clark is right, and visual experience is only distantly related to motor action, this looks like one more in a string of rebukes recently served to folk psychology, just as in the case of our commonsense understanding of introspection (Nisbett and Wilson, 1977), rationality (Tversky and Kahneman, 1983), and conscious intention (Wegner, 2002). The falsity of EBC also stands to extirpate a budding approach to understanding consciousness, so-called *enactive* theories (O'Regan and Noë, 2001; Noë, 2005), since such theories are predicated on a tight link between consciousness and motor action (Clark, 2006; Brogaard, 2011a). Much appears at stake, then, when it comes to EBC.

Key to Clark's argument against EBC is it really being the case that, in the experiments that he appeals to, the visual content driving motor action is absent from subjects' visual experience. It has been argued, however, that such content is not absent, just unreportable or otherwise hard to discover (Wallhagen, 2007; Mole, 2009). Not surprisingly, it has proven difficult to rule out this hard-to-discover content, and I argue below that Clark's attempts (2007, 2009) to do so are unsuccessful.

Nonetheless, there merely being such content in subjects' experiences is not enough to help EBC; for this, we need reason to think that this content is actually *driving* motor action. In this article, I argue that a review of the relevant neuroscience reveals this probably is not the case. More specifically, there appear to be no representations in the visual system that both are conscious and feed directly into motor action, something that we would expect if EBC were true. The good news here: to pass verdict on EBC, we need not first resolve difficult issues concerning the possibility of conscious but unreportable content.

The rest of the article is as follows: in Section 2, I examine the thesis of EBC, and review the lesion and psychophysical evidence marshaled against it. In Section 3, I look at how advocates of EBC have undermined this evidence, and argue that Clark's main response to this undermining is unsuccessful. In Section 4, I review the neuroscientific data relevant to EBC, arguing that they show there to be no areas in the visual system producing representations both conscious and directly used in motor action. In Section 5, I consider objections.

2. The Dissociation Argument

EBC hypothesizes a tight link between visual experience and skilled motor action, but what is the nature of this connection? In the philosophical debates concerning the relationship between visual experience and motor action, there is no one

formulation of EBC universally and explicitly adopted.² Nonetheless, we can base a formulation around the key features it is usually taken to have (see, e.g., Clark, 2007; Wallhagen, 2007; Briscoe, 2009). This looks as follows:

EBC: The content of visual consciousness is what is typically used to directly guide visually based motor actions

A few remarks: First, there are two ways to understand EBC. It can be regarded as a philosophical hypothesis, one based on the idea that the rich, detailed kind of content found in visual experience seems well suited to guiding visuomotor action. But EBC is also often regarded as an expression of the commonsense view of the relation between vision and action (the one that cognitive science looks in danger of overturning). Hold this thought.

Now notice that, since EBC says that the guidance of motor action by visual experience is both typical and direct, we can think of EBC as having both a *typicality clause* and a *directness clause*. The question now arises as to whether EBC qua the commonsense view requires typicality and/or directness. Another issue concerns how we are to say, in practice, what counts as being ‘direct’ or ‘typical’ guidance. These matters are addressed at more advantageous times.

Finally, there is the question of what is meant by ‘consciousness,’ this being a term variously understood (Chalmers, 1995). Listening to participants in the debate, a natural interpretation emerges according to which EBC is a thesis concerning *phenomenal* consciousness (Nagel, 1974; Block, 1995; Chalmers, 1995). A mental state is phenomenally conscious if and only if there is ‘something it is like’ to have that mental state, if it is *experiential*. We can understand EBC, then, as saying that it is the content of visual *experience* that guides motor action.

There appears to be a significant empirical case against EBC. This section surveys the relevant evidence, and looks at how it has been used to cast doubt on EBC. First, though, we look at the inspiration for empirical arguments against EBC, dual visual systems theory.

2.1 Dual Visual Systems Theory

When light stimulates receptors in the retina, the receptors mostly send their signals to the lateral geniculate nucleus of the thalamus (a subcortical structure often known as the sensory ‘relay station of the brain’), and from there on to the primary visual cortex. Upon leaving the primary visual cortex, the visual system divides into two semi-autonomous pathways known as the ventral and dorsal streams, the first projecting to the temporal cortex, the second to the parietal cortex (Morel and Bullier,

² Here, I am taking philosophers such as Mole (2009, 2013) and Wu (2013, 2014) to be a part of the debate over EBC, even though they often only explicitly engage with what they call the ‘zombie action hypothesis.’ The zombie action hypothesis is—for all intents and purposes—just the denial of EBC. (For discussion, see Wu, 2013, pp. 1–2.)

1990; Young, 1992; but see Prinz, 2012, ch. 6). The discovery of multiple pathways in the visual system gave rise to a series of *dual visual systems theories*, which attribute different functions to the distinct processing streams (Schneider, 1969; Ungerleider and Mishkin, 1982; Ungerleider and Haxby, 1994). The currently ascendant dual visual systems theory is that of Milner and Goodale (1995/2006; cf. Jacob and Jeannerod, 2003), who hypothesize the ventral stream to be associated with perception and goal-oriented cognition, and the dorsal stream to provide the information used in visuomotor action (but see Pisella *et al.* 2006, 2009; Schenk and McIntosh, 2010). Milner and Goodale's theory also involves a less widely accepted claim, which is that *conscious* visual perception is confined to the ventral stream.

This last claim is of course important to evaluating EBC. Were it correct, it looks like EBC's directness clause is unfulfilled: Any influences that visual experience had upon motor action (however typical) would be *mediated* by whatever areas actually directly guide visuomotor action. And so one promising way to build a case against EBC is to argue that the areas in the brain where conscious visual representations are produced are anatomically distinct from those where visuomotor representations are produced. Let us call this the *neuroanatomical argument* against EBC.

The most well-developed argument against EBC, due to Clark (2001, 2007, 2009; see also Milner and Goodale, 1995/2006; Koch and Crick, 2001), is not best characterized as a neuroanatomical argument.³ Instead, Clark's approach is to describe a number of instances in which skilled visuomotor action seems to come apart from visual experience, and argue that the best explanation of these dissociations is that visual experience does not typically or directly guide motor action. Call this the *dissociation argument*.⁴ It is to this that we now turn. Later, I develop a version of the neuroanatomical argument.

2.2 The Dissociation Argument Against EBC

Clark has enlisted two lines of evidence in building his dissociation argument: the first is the effects of lesions to the visual system, the second is psychophysical experiments involving visual illusions. We examine each in turn.

Lesions to the ventral and dorsal streams provide striking examples of dissociations between visual experience and visuomotor action. One disorder thought to present particularly strong evidence against EBC is *visual form agnosia*, an inability to perceive object shape (Heider, 2000). There are a few recorded cases of visual form

³ The work of Milner and Goodale can be viewed as including a neuroanatomical argument against EBC (see esp. 1995/2006, 2008), one that I aim to improve upon below.

⁴ What I here refer to as the 'dissociation argument' should not be confused with the *double dissociation* arguments offered on behalf of dual visual systems theory (Milner and Goodale, 1995/2006; Jacob and Jeannerod, 2003). These arguments use some of the same data discussed below to argue for a related conclusion, which is that the systems in charge of visually guided behavior are functionally distinct from those carrying out perceptual tasks (such as object identification).

agnosia (Benson and Greenberg, 1969; Efron, 1969; Campion, 1987), but the one most thoroughly studied is that of DF, a Scottish woman with ventral stream damage resulting from carbon monoxide poisoning. DF's lesion appears to have caused deficits in her conscious perception of things like the shape and position of an object, but left her ability to perform visuomotor actions unaffected. In what is called the 'posting task', a subject is asked to fit an envelope into a narrow slot of varying orientations. DF can perform this task with facility, but at the same time is unable to report the orientation of the slot (Goodale *et al.*, 1991; Milner *et al.*, 1991). She can also easily step over obstacles the height of which she cannot estimate (Patla and Goodale, 1996). Examples of DF displaying similar dissociations abound (Milner and Goodale, 1995/2006, pp. 128–33). Dorsal lesions, on the other hand, bring about an opposite pattern of deficits (Perenin and Vighetto, 1983, 1988). Some subjects with dorsal damage, for instance, can discriminate the orientation of lines correctly, but are unable to perform the kind of motor actions involved in the posting task. All in all, the results of lesions to the ventral and dorsal streams seem to act as compelling evidence against EBC.

Also counting against EBC are dissociations revealed in experiments involving visual illusions. In the Titchener illusion, two interior circles are surrounded by annuli of either smaller or larger sized circles, which causes subjects to misjudge the relative size of the interior circles (e.g. judge two circles of the same size to be different). Aglioti and colleagues (1995) constructed an interactive Titchener illusion using wooden disks placed on a table, asking subjects to both pick up and judge the size of the two central disks. Though subjects reported the disks to be differently sized, their grip aperture was largely unaffected by the illusion (see also Haffenden and Goodale, 1998). While these particular experiments are somewhat controversial (Franz *et al.*, 2001), numerous similar dissociations between visual consciousness and visuomotor action have been found in experiments utilizing the Ponzo illusion (Brenner and Smeets, 1996; Ellis, Flanagan and Lederman, 1999), the Roelofs effect (Bridgeman, Peery and Anand, 1997), the hollow face illusion (Kroliczak, 2005), and various forms of induced illusory motion (Bridgeman *et al.*, 1979; Bridgeman, Kirsch and Sperling, 1981; Wong and Mack, 1981; Goodale, Pelisson and Prablanc, 1986).

It is natural to think that the best explanation of these numerous dissociations is that visual experience is not what typically and directly guides visuomotor actions. Such, at least, is the conclusion of the dissociation argument.

This conclusion should be clarified in two ways. First, the dissociation argument is meant only to rule out visual experience from being what typically plays a *direct* role in guiding motor action. Thus it is often granted by the critic of EBC (Milner and Goodale, 1995/2006; Goodale, 1998; Clark, 2001, 2007) that visual experience plays indirect roles, such as the *selection* of objects toward which a motor action is to be performed. Second, the dissociation argument should not necessarily be taken to say that visual experience *never* plays a direct role. As we will see below, there is evidence that it might do so under certain circumstances, such as when motor actions are delayed (Hu, Eagleson and Goodale, 1999; Hu and Goodale, 2000). But

the conclusion of the dissociation argument *does* say that visual experience fails to play the kind of central and direct role in motor action that would be suggested by untutored intuition, in that ‘conscious visual experience is not, despite appearances, in the business of providing the information used to control most daily visuomotor action’ (Clark, 2007, p. 570).

3. Responses to the Dissociation Argument

In the dissociation argument, one argues against EBC by pointing out instances where the content driving motor action appears missing from, or mismatched with, the content of subjects’ experiences. Accordingly, responses on behalf of EBC have consisted of arguments that such content actually *is* with the experience of subjects, just unreportable or otherwise hard to discover. In this section, I look at these responses, along with Clark’s rejoinder. I argue that Clark’s rejoinder is inadequate, meaning efforts to undermine the dissociation argument have succeeded.

As just said, the advocate of EBC responds to the dissociation argument by arguing that there is, within the experience of subjects, content matching the content driving motor action. Wallhagen claims that visual form agnostic DF must experience the form⁵ of an object, since she experiences color and texture, and ‘if color and texture are present, then ... features such as shapes ... must be present as well—minimally, as the boundaries of colored, textured regions’ (2007, p. 557; but see Mole, 2009, pp. 1004–5). DF’s inability to report the form of objects is not due to a lack of shape experience, contends Wallhagen, but rather an inability to bring her form experiences under concepts, as would be necessary for report. Similarly, Mole hypothesizes that, in the posting task, DF’s visual experience has *demonstrative* content (like ‘*this way round*’) that correctly represents the orientation of the slot (2009; see also 2013). But because this content is conscious ‘when (and only when) an action is in play’ (2009, p. 1007), it is discoverable only under certain experimental conditions (such as those obtaining in Schenk and Milner, 2006; but see Goodale and Milner, 2010). Wallhagen and Mole resist the visual illusion data in like fashion, arguing that there are multiple, inconsistent contents within the experience of subjects in these experiments, some of which match the content driving motor action (cf. Smeets and Brenner, 2001).

Let us refer to the idea that there is, within the experience of subjects, content matching the content driving motor action as the *presence thesis*. While Clark argues against the presence thesis in various ways (see also Wu, 2013), his centerpiece response is the ‘argument from agency’ (2007, 2009; cf. Clark and Kiverstein,

⁵ Responses to the dissociation argument so far have concentrated on showing that there are *form* experiences being used in visuomotor action. The term ‘form,’ as it has been used in these debates, refers to a few related object properties, such as shape, size, and orientation—all those properties that DF appears unable to experience.

2007).⁶ Start by observing that each of the scenarios Wallhagen and Mole describe involves (phenomenally) conscious content for which it is difficult to find evidence; let us say that such content is *arcane*. Assuming such content exists, its being arcane is due to the subjects themselves appearing to not know of them. DF, for example, reports that objects ‘seem to run into each other,’ it being difficult to segment objects within her visual field (Milner, personal correspondence). But we would not expect reports such as these if DF knew of her (purported) form experiences. Similar observations could be made about the visual illusion data, in that the subjects’ behavior gives us no reason to suppose that they know of any multiple, inconsistent contents in their experience.

In the argument from agency, it is claimed that arcane content of the sort described cannot be conscious. Borrowing from Evans (1982), Clark argues that we should consider content conscious only when it is of potential use to the agent, ‘when [it] is poised ... for direct and non-inferential use in the guidance of ... rational action’ (2009, p. 1465; see also Clark, 2007; Clark and Kiverstein, 2007). Let us refer to this as the *agency requirement*. The thrust of Clark’s argument is that the arcane content hypothesized by advocates of EBC does not satisfy the agency requirement, and therefore is not conscious.

There are, however, some difficulties that Clark’s argument faces. For one thing, there is reason to doubt that the agency requirement is relevant to the present issue, given the kind of support that Clark provides for it. Consider that the presence thesis is a *metaphysical* claim, a claim concerning whether or not something *exists*: the presence thesis hypothesizes there to be certain experiential states (namely, phenomenally conscious states), ones possessed by subjects in the experiments, and whose content matches the content driving motor action. But Clark appears to justify the agency requirement with nothing but *conceptual* claims; specifically, descriptive or normative claims concerning how our concepts do or should operate. In various places, Clark seems to argue that arcane states cannot or should not be considered conscious because our commonsense concept of consciousness would not classify them as such,⁷ because having a concept of consciousness that allows them would create irresolvable disputes,⁸ or because the concept of a conscious state not available

⁶ Since the papers in which Clark develops the argument from agency predate Mole’s arguments on behalf of EBC, Clark has not used the argument from agency to rebut Mole’s arguments in particular. Nonetheless, the argument from agency has been Clark’s main response to the presence thesis in its previous forms (O’Regan and Noë, 2001; Nudds, 2007; Wallhagen, 2007), so we can guess that he would employ it in the case of Mole’s version as well.

⁷ Write Clark and Kiverstein: ‘... the *notions* of conscious experience and reasoned agency ... are deeply intertwined ... [such that] there are non-negotiable links between ... conscious awareness and the ... sweep of deliberate actions and choices available to a reasoning subject’ (2007, p. 503; italics mine).

⁸ Writes Clark: ‘Such a critic, by endorsing the idea of experience as that which is somehow phenomenally present to what I dubbed the “bare agent,” places the discursive goalposts in a most inaccessible position’ (2007, p. 589).

for rational control of action is incoherent.⁹ It is, however, unclear how conceptual considerations like these help to answer the metaphysical question with which we are concerned; viz., whether subjects *really are or are not* in the hypothesized experiential states (those whose content matches the content driving motor action).¹⁰

Nonetheless, even if the agency requirement were relevant to evaluating the presence thesis, it might yet fail to rule out much of the arcane content from being conscious. The agency requirement says, roughly, that some state is conscious only if it is available for rational control of action. Key here is the idea that content need not actually be *accessed* for use in rational control of action, only *accessible*, 'at least momentarily poised in a way that makes it apt for use (though it need not actually be used) in ... personal level reasoning, planning and ... deliberate and goal-driven selection [of] action' (2009, p. 1466). Thus Clark does not rule out the possibility of visually conscious states the content of which the subject fails to report upon (even when prompted), since it is possible 'elements that we don't attend to or notice in our visual experience can be thus poised' (*ibid.*, p. 1465).

Understood this way, the agency requirement is too weak to rule out many of the arcane states from being conscious. Perhaps the form content Wallhagen attributes to DF does not satisfy the agency requirement: If such content cannot, as Wallhagen hypothesizes, be conceptualized by DF, then plausibly it is also inaccessible for use in rational control of action. However, most of the arcane content is better construed as accessible (if not yet accessed). Mole (2009), for example, claims that DF, under certain experimental conditions, *can* access (and report upon) the hypothesized form experiences (viz., if she is asked to name the shape of an object that she is currently reaching for, as she was in Schenk and Milner, 2006). Mole also goes out of his way to explain how a subject in the Titchener illusion experiment might miss there being multiple, inconsistent contents in her experience, claiming that conflicts in content need not be obvious to the subject if some of the contents are demonstrative; but of course no such explanation would be needed if the contents were inaccessible. Similarly, Wallhagen's hypothesizing of multiple, inconsistent contents appears, at the least, uncommitted to the idea that such contents are inaccessible. In sum, the agency requirement looks too weak to rule out many of the hypothesized arcane contents from being conscious, since most of them look accessible, if not yet accessed.

⁹ Clark argues that allowing for arcane experiences (like those considered above) 'is to allow experience to occur in ... informationally isolated islands within the overall agent-economy,' saying we 'should ask ourselves whether this idea really makes sense' (2007, p. 588). Elsewhere he writes 'can we really make sense of ... free-floating experiences, of ... isolated islets of experience ... not even potentially more widely available ... as fodder for a creature's rational choices and considered actions?' (2009, p. 1466).

¹⁰ Perhaps Clark means to use the incoherence of the concept to argue that such states could not occur, but no argument is given for this purported incoherence; moreover, that such a concept would be incoherent seems belied by the ongoing (and apparently substantive) debate over whether phenomenal consciousness occurs in absence of access consciousness (see three paragraphs below).

In response to this, the agency requirement could be strengthened, so that content counts as conscious only if it is actually *accessed*. Construed this way, the agency requirement may well exclude all of the arcane contents from being conscious, since subjects seem to not know of them. But it is a matter of ongoing debate whether content needs to be accessed before it can become phenomenally conscious (Dennett, 1995; Block, 2007, 2011; Brown, 2011; Cohen and Dennett, 2011)¹¹ a debate probably not resolved soon. And so a strengthened agency requirement does no better a job at showing the hypothesized arcane content to be not conscious.

I conclude that the argument from agency makes no significant dent in the presence thesis. Interpreted one way, the agency requirement is too weak to rule out a majority of the arcane content hypothesized by the advocate of EBC; interpreted another way, it becomes controversial. In addition, it is unclear whether the agency requirement is relevant to evaluating the presence thesis, since the presence thesis is a metaphysical claim, and the agency requirement is grounded on conceptual claims.

Now, while the argument from agency is Clark's central argument against the presence thesis, it is not his only argument.¹² Unfortunately, we cannot consider all his arguments here. Nonetheless, let us assume (as I think is the case) that the cumulative force of Clark's arguments at least fails to *refute* the presence thesis. If so, there is room for a stronger case to be made against EBC. Building such a case is what I try to do next.

4. The Neuroanatomical Argument Against EBC

It is frequently thought that, if EBC is true, then it should be the case that visual experience *directly* guides visuomotor action. This, at least, is an assumption commonly adopted,¹³ and one that I adopt as well. But let us consider one reason for thinking that EBC contains what I above called a 'directness clause.'

¹¹ See also Block 1995; Kouider, de Gardelle and Dupoux 2007; de Gardelle, Sackur and Kouider 2009; and commentary on Block's 2007.

¹² For instance, Clark argues that even if there is arcane content in the experience of subjects, such conscious information may not be in the proper format for use in visuomotor action (2001, pp. 505–8; but see Briscoe, 2009, pp. 19–20). Clark also rebuts Wallhagen's suggestion that we should take DF's visuomotor capabilities to indicate that she has form experience, arguing that if such reasoning were good, 'all manner of assembly line robots and other apparently non-conscious devices ... would need to be admitted ... to the ranks of the conscious perceivers' (2007, p. 585).

¹³ Clark, for example, intends to debunk EBC by arguing that 'conscious processes of seeing, willing, and intending ... are at work *only at one remove* from most cases ... of world-engaging action' (2007, p. 571, italics mine). Similarly, it is Wallhagen's intention to defend EBC against the claim that 'conscious visual perception is part and parcel of a cognitive system ... [that is] only *indirectly* associated with systems controlling the detailed execution of selected actions' (2007, p. 546, quoting from Clark, 2001, p. 517, italics mine). And Mole (2013, p. 2) and Wu (2013, p. 1) agree that what is at issue is the frequency with which the 'visual representations that *directly* control and guide mundane bodily actions are unconscious' (italics mine).

Remember that the thesis of EBC does double duty: it can be taken as a philosophical hypothesis, or as an attempt to express the commonsense view. EBC as a philosophical hypothesis of course contains a directness clause, as a matter of stipulation. But what about EBC as the commonsense view? Without extended investigation, it is difficult to say much with *certainty* about the folk view on the relation between conscious vision and action. Still, it is reasonable to suppose that the folk view takes conscious vision to be *indispensable* to fine-tuned motor action. There being this assumption explains why the case of DF was met with such sensation: her normal visuomotor abilities in absence of normal visual experience appeared to be a thorough debunking of the indispensability assumption. Now, suppose that, whenever conscious visual information influenced motor action, it did so only by first being routed through unconscious visuomotor systems ('zombie systems', as they are called). It seems that this would, in some sense, make DFs of us all (if you will), in that our visual experience would seem to play no larger role in our motor actions than they do with DF. And so there appears at least *prima facie* reason to think that EBC (qua commonsense view) contains a directness clause.

What, however, should serve as a criterion for whether a visual state *directly* guides a motor action? One way of understanding this would be to say that a visual state directly guides motor action if and only if that visual state's influence on motor action is unmediated by another mental state.¹⁴ However, all guidance of motor action by vision is probably mediated at least by motor states, making this criterion too restrictive. A better one can be built around a fundamental difference between visual and motor states, which is that the former have a mind-to-world direction of fit, and the latter a world-to-mind direction of fit (cf. Jacob and Jeannerod, 2003, ch. 8).¹⁵ Such a criterion looks as follows:

Visual state *S* *directly* guides some motor action *M* if and only if:

- (a) *S* causally influences how *M* is carried out, and
- (b) *S*'s influence is not mediated by some mental state *S**, where *S** has a mind-to-world direction of fit.

Notice that this criterion has the intuitive result of seeming to label, as directly guiding motor action, just those visual states sitting on the *cusp* of where perception meets action. At any rate, this way of understanding directness seems plausible enough to justify our tentatively adopting it.

¹⁴ This understanding of directness is extracted from some of the ways in which EBC has been understood. Mole, for example, has thought that vindication of the commonsense view requires not just that visual experience make a 'causal contribution to the guidance of movement,' but rather that 'movement control and conscious experience are the work of one and the same system' (2009, p. 1002).

¹⁵ A visual state has a mind-to-world direction of fit insofar as it (ideally) conforms to whatever the world is actually like, whereas a motor state has a world-to-mind direction of fit insofar as it is meant to bring about a state of affairs in the world (one in accord with the motor plan).

Now we return to EBC and the directness clause. In the last section, we saw how the dissociation argument was undermined by the possibility of there being, within the visual experience of subjects, content matching the content driving motor action. But the directness clause can be used to build an argument against EBC not susceptible to this kind of undermining. Consider that, if EBC is true, there should be, somewhere in the visual system, representations that both are conscious, and directly guide motor action; let us refer to these as the *conscious, (motorically) efficacious representations*. In this section, I argue that a look at contemporary visual neuroscience reveals there to be no such conscious, efficacious representations.

I use an argument from elimination. I start by dividing up the cortical visual system into three general areas: the ventral stream, dorsal stream, and early visual areas (the latter being those cortical areas tributary to both the ventral and dorsal streams).¹⁶ Then I argue that none of these general areas produce the conscious, efficacious representations needed by EBC.¹⁷ The conclusion: even if we were to grant the advocate of EBC that there is, within the experience of subjects, content matching the content driving motor action, this does not help EBC, since any such representations do not feed directly into motor action.

Before beginning, I note that given the incomplete state of neuroscientific knowledge, some data appealed to below are tentative and/or open to interpretation. As such, they are sometimes unable to provide decisive considerations against EBC. Nonetheless, looking at the data as a whole, a picture emerges in which current neuroscience seems to stand in opposition to EBC; and this, I think, gives good reason to believe that EBC is probably false.

4.1 The Ventral Stream Does Not Produce the Conscious, Efficacious Representations

While the ventral stream probably produces conscious representations, these representations appear to not feed directly into motor action. There are two lines of support for this. The first is the indirect and limited effects that ventral lesions have

¹⁶ I am considering (the major components of) the ventral stream to comprise areas V2, V3, V4, LO, IT, STS, and TEO. I am considering the dorsal stream to comprise areas V3a, V7, IPS, SPL, and IPL. (It has been recently argued that the dorsal stream actually consists of two sub-streams, the ventro-dorsal and dorso-dorsal [Gallese, 2007], but we can lump them together for present purposes.) I am considering the early visual areas to comprise V1 and MT. By grouping MT (also known as V5) in with early visual areas, I follow the lead of Milner and Goodale, who argue that MT should be considered an early visual area specializing in motion processing (1995/2006, p. 218–19; see also Schenk and McIntosh, 2010, p. 53; and below [Section 4.3]).

¹⁷ One might wonder whether this argumentative strategy still works if what Prinz has argued is correct (2012, ch. 6), and there are too many cross-connections between what are considered the ventral and dorsal visual areas to fruitfully think of them as constituting two distinct streams. All that is required for the present strategy, however, is that there be distinct *brain areas*, since the strategy is to show that the directness clause of EBC is not satisfied by showing that there are no brain areas producing representations both conscious and efficacious.

on visuomotor action. The second is neuroimaging evidence that reveals a lack of correlation between ventral activity and visuomotor action. We look at each in turn.

Damage to the ventral stream produces a variety of deficits in visual consciousness, and so it is likely that the ventral stream produces conscious representations. Subjects with ventral damage, depending on the precise lesion location, might experience a deficit of color perception (Damasio *et al.*, 1980; Zeki, 1990), form perception (Heider, 2000), face identification (Damasio and Damasio 1983; Gross and Sergeant, 1992), or object recognition (Sacks, 1985). There are, however, few reports of visuomotor deficits resulting from ventral lesions, and those that do only manifest in conditions that agents rarely (if ever) encounter outside the laboratory. Unfortunately, studies of ventral lesions infrequently involve testing for visuomotor deficits, likely because ventral patients neither present with nor complain of motor difficulties. There has, however, been more interest in investigating the visuomotor abilities of DF, since her case is thought an important source of support for Milner and Goodale's dual visual systems theory. A closer look at DF's visuomotor abilities reveals a role for the ventral stream in visuomotor action, but one falling far short of vindicating EBC.

As discussed above, DF reports an inability to experience things like the shape, position, and orientation of objects. At the same time, her everyday capacity for visuomotor action appears normal (Goodale and Milner, 2004, ch. 2). This assessment is supported by numerous studies: Among other things, DF has been shown to be able to pick up objects of various shapes and sizes (Goodale *et al.*, 1994), perform the 'posting task' (Milner and Goodale, 1995/2006), and step efficiently over obstacles of various heights (Patla and Goodale, 1996). However, DF presents with visuomotor deficits in certain situations (see Schenk and McIntosh, 2010). DF is less accurate than controls when tested in paradigms where the light is shut off before the motor action is initiated (Rossetti *et al.*, 2005; Himmelbach and Karnath, 2005), where the motor actions are delayed until five seconds after the target is removed (Milner, Dijkerman and Carey, 1999), or where the motor actions are performed with a patch over one eye (Dijkerman, Milner and Carey 1996, 1999).

It looks, then, as if visuomotor deficits accompany ventral damage only infrequently, and in what seem rather artificial conditions. And even in circumstances where the ventral stream appears to participate in visuomotor action, arguably it is still be the dorsal stream that directly guides motor action: Himmelbach and colleagues (2009) tested normal subjects in the same delayed action paradigm used to examine DF (discussed just above), using fMRI to measure the subjects' brain activity. The task was found to cause increased activity only in dorsal (and not ventral) areas. All in all, while the results of ventral lesions support the idea that the ventral stream sometimes contributes to motor action, these contributions seem neither direct nor typical.¹⁸

¹⁸ Recently it has been argued (Himmelbach, Boehme and Karnath, 2012) that while DF performs motor actions with facility, she does not actually perform at the level of controls in some of the

Reinforcing this conclusion are other fMRI studies in which visuomotor action brings no concomitant increase in ventral stream activity. In (James *et al.*, 2003), fMRI was used to measure activity in DF's visual areas while she performed actions like those involved in the posting task. Only dorsal areas showed increased activity. In another study (Culham *et al.*, 2003), subjects were asked to either reach for and grasp a lever (known as the 'grasparatus'), or simply reach for it. The reaching and grasping condition produced significantly more dorsal activity than the reaching-only condition (presumably because of increased cumulative task demand in the former condition), but the level of ventral activity was the same. Were it the case that the ventral stream produced those representations directly used in motor action, it is likely fMRI studies would reveal correlations between the ventral stream and visuomotor action. But neuroimaging experiments such as these (see also Prado, 2005) fail to do so.

There is a further problem here for the advocate of EBC, concerning DF in particular. Most of the arguments in favor of the presence thesis have advocated specifically for the possibility of there being conscious representations of object *shape* guiding her motor actions. It looks, however, as if DF's ventral stream cannot produce shape representations at all: the locus of DF's damage is in the lateral occipital cortex (LO). A number of experiments have shown LO to have increased activation when subjects are presented with colored or grayscale images of objects rather than scrambled versions (Malach *et al.*, 1995; Kanwisher *et al.*, 1996; Kourtzi and Kanwisher, 2000, 2001). In addition, the increased activation LO shows in response to an object does not vary with changes in object position or size (Grill-Spector *et al.*, 1999; Malach *et al.*, 1998), nor does its response to object silhouettes vary according to whether the silhouette is defined by luminance, texture, or motion (Grill-Spector *et al.*, 1998). Such data seem to indicate that LO plays an important role in the conscious representation of object shape (Milner and Goodale, 1995/2006:210; Fankhauser and Kwasniewska, 2009). Given DF's ventral damage is centered on LO, her ventral stream probably cannot produce any experiences of shape DF might have.

In this subsection, we have seen reasons to think that the ventral stream could not produce the conscious, motorically efficacious representations hypothesized by the defender of EBC. First, lesion and neuroimaging evidence reveal the ventral stream to probably not produce the representations that directly or typically guide visuomotor action. Second, in the case of DF, it is particularly unlikely that her ventral stream could produce conscious *shape* representations, since the locus of her lesion encompasses the area in the ventral stream where object shape is represented.

tasks that Milner and Goodale used to originally examine DF. But even if it turned out that DF has minor visuomotor deficits, this would probably not count as evidence for the ventral stream playing an expanded role in visuomotor action: MRI scans of DF's brain (James *et al.*, 2003; Bridge *et al.*, 2013) have found shrinkage of gray matter in DF's dorsal stream (also due to the carbon monoxide poisoning). And so any minor motor deficits that DF might have uncovered would most likely be the result, not of DF's severe ventral damage, but rather her less serious dorsal damage.

4.2 The Dorsal Stream Does Not Produce the Conscious, Efficacious Representations

Unlike the ventral stream, there is no reason to doubt that the dorsal stream produces representations that feed directly into motor action. Producing such representations is thought one of its primary functions (see, e.g., Milner and Goodale, 1995/2006; Jacob and Jeannerod, 2003). But, as I argue now, the motorically efficacious representations that the dorsal stream produces (and perhaps *all* dorsal representations) are probably not conscious.

In the dorsal stream, the representations feeding directly into motor action are often thought to be produced in the posterior parietal cortex (the terminus of the dorsal stream), in two areas known as the intraparietal sulcus (IPS) and superior parietal lobe (SPL) (Milner and Goodale, 1995/2006, ch. 2). One reason to think this comes from fMRI studies that reveal correlations between visuomotor action and activity in the IPS and/or SPL (hereafter IPS/SPL). The aforementioned ‘grasparatus’ study (Culham *et al.*, 2003) provides one such example, since in this experiment increased motor demands produced increased IPS/SPL activity (see also Binkofski *et al.*, 1999; James *et al.*, 2003). Further reason to think this comes from the close association between IPS/SPL damage and optic ataxia. I will explain.

We start by considering the *specificity* of deficits resulting from IPS/SPL damage. Damage here brings about optic ataxia, defined as a deficit in visuomotor action (in, e.g., the grabbing of an object) in absence of any *primary* visual or motor deficits (such as blindness, or paralysis of the arm). In so-called *pure* cases of optic ataxia, where damage is restricted to IPS/SPL, the deficits occur in absence of any other visual deficits (Perenin and Vighetto, 1983, 1988; but see Pisella *et al.*, 2009). Optic ataxia also results *only* from IPS/SPL damage: lesions outside IPS/SPL do not cause deficits confined to visuomotor action. That the specific deficits constituting optic ataxia result from, and only from, IPS/SPL damage suggests that it constitutes the final stage in visuomotor processing, and is where visual information is transformed into a format suitable for motor action. And so IPS/SPL appears to be where motorically efficacious representations are produced in the dorsal stream. The question, then, is whether such representations are conscious.

In approaching this issue, let us consider a different question: If IPS/SPL representations were conscious, which of the conscious visual representations that compose our visual experience would we expect it to be responsible for? Probably, it would be those conscious visual representations the content of which looks potentially useful for motor action. The kind of information largely important for visuomotor action is information about the direction, distance, shape, and orientation of objects, where these properties are represented in an *egocentric* (viewer-centered) frame of reference (Milner and Goodale, 2008). Indeed, visual experience appears to contain representations of these types, in that objects in visual experience are typically represented (egocentrically) as having a certain direction, distance, shape, and orientation (cf. Briscoe, 2009). Because these conscious representations are candidates for use in visuomotor action, let us say that they are *potentially motorically*

efficacious. Now here is the point that I want to make: If IPS/SPL representations were conscious, we would expect IPS/SPL to produce these conscious, potentially motorically efficacious representations. But this appears not to be the case.

Recall that lesions confined to IPS/SPL produce *pure* cases of optic ataxia (i.e. optic ataxia occurring without any other visual deficits [and not just primary visual deficits]). A number of pure cases were studied by Perenin and Vighetto (1983, 1988; see also Garcin *et al.*, 1967). While subjects in these experiments suffered from those deficits in reaching and grasping that constitute optic ataxia,¹⁹ they seemed to have normal experience of object shape: they could easily find a specific shape among distractors, and could deftly recognize faces and other objects, these all being skills probably requiring the conscious perception of object shape.²⁰ The optic ataxics could also discriminate the direction and orientation of stimuli, even when presented peripherally and for intervals of less than 200 milliseconds. In addition, they could indicate the distance and position of objects. It appears, then, that IPS/SPL lesions do not produce deficits in those types of conscious representations that appear potentially motorically efficacious. Indeed, when considering the researchers' failure to find *any* conscious deficits in optic ataxics, the Perenin and Vighetto studies might allow a further conclusion (if perhaps with less confidence), which is that IPS/SPL lesions do not produce deficits in visual experience *at all*.

It appears, then, that the dorsal stream probably does not supply the conscious, motorically efficacious representations needed by the advocate of EBC: If it did, we would expect to find conscious representations in those parts of the dorsal stream that produce efficacious representations. But IPS/SPL lesions fail to produce deficits in those types of visual experience that are potentially motorically efficacious; in fact, IPS/SPL lesions appear to produce no deficits in consciousness at all. And so while representations in IPS/SPL are motorically efficacious, they are likely not conscious.²¹

Just above, I argued that those dorsal areas that directly drive motor action do not produce conscious representations. This, however, might very well be true of *all* dorsal areas (Milner and Goodale, 1995/2006; Brogaard, 2011a, 2011b). Subjects

¹⁹ I am omitting from the discussion complications concerning the precise extent of the deficits involved in optic ataxia. For instance, Glover (2003) has argued optic ataxia is a deficit specific to the *online guidance* of visuomotor actions, it not affecting the accuracy of the initial movement involved. Others (Rossetti *et al.*, 2003; Pisella *et al.*, 2006, 2009) have argued optic ataxia only involves deficits in the performance of visuomotor actions toward peripherally located objects. Interested readers should see the just-cited papers, along with Milner and Goodale's criticisms of these views (1995/2006, ch. 8; 2008).

²⁰ That these abilities would require conscious perception of shape is evidenced by the difficulty such tasks present for DF, who relies on cues such as color and texture to identify an object, and the sound of a person's voice to identify him or her (Steeves *et al.*, 2006).

²¹ One might object here that optic ataxics actually have deficits of consciousness, but they remain undetected because they are deficits in a subtle (demonstrative?) kind of conscious content. This objection (along with some others) is answered in Section 5.

with generalized damage to the dorsal stream exhibit *Bálint's syndrome* (Bálint, 1909; see also Holmes, 1918; Moreaud, 2003), which consists not just of optic ataxia, but also oculomotor disorders such as gaze paralysis (AKA 'sticky fixation'), and problems with fixating or visually pursuing targets. So far, none of these are disorders of consciousness *per se*. But if the lesion producing Bálint's syndrome extends into the inferior parietal lobe (IPL), it can produce *hemispatial neglect* (Driver and Vuilleumier, 2001), an inability to notice objects in the contralesional visual field. Some have thought that hemispatial neglect is a deficit of consciousness (Driver and Vuilleumier, 2001; Vosgerau and Newen, 2008; Briscoe, 2009; Prinz, 2012, ch. 3), but others believe it better explained as a mere deficit of attention (e.g. Lamme, 2006; Block, 2007; Jacob and de Vignemont, 2010; Brogaard, 2011a, 2011b; Kozuch, 2014).²²

Let us assume, however, that hemispatial neglect is a deficit of consciousness. Even so, it would not provide evidence for IPL activity being constitutive of the *contents* of consciousness. Consider that damage to IPL brings about no impairment in any *specific* type of visual experience: It is not, for example, a disorder specifically of color, motion, or shape experience (these result rather from damage to visual areas V4, MT, and LO, respectively). Hemispatial neglect—if it is a disorder of consciousness—is an inability to experience *any* of an object's properties (color, motion, form, whatever) in the contralesional visual field. Now, it is certainly *possible* that this pattern of deficits arises because IPL produces some of the representations that are found in visual experience. But the more natural explanation would be that the conscious representations in question are located elsewhere (e.g. V4, MT, and LO), and that IPL activity is merely somehow necessary for these representations becoming conscious.²³ Thus, even if hemispatial neglect were a deficit of consciousness (and not merely attention), this only provides reason to think that IPL is closely connected with visual experience, but not that it produces conscious *representations*.

Recently, some philosophers have argued that dorsal areas V3A and/or V7 might produce conscious representations. The most developed case for this is due to Wu (2014; see also Prinz, 2012, ch. 6), who argues that one or both of these areas produce conscious representations of object distance. Wu supports this claim by appealing to an imaging study in which V3A and V7 showed increased activity when subjects were asked to report on the egocentric distance of objects (Committeri *et al.*, 2004), and by describing a case where damage to these areas produced deficits

²² Another potential disorder of consciousness resulting from dorsal damage is *simultagnosia*, an inability to attend to more than one object at a time. The same points I make about hemispatial neglect below also apply to simultagnosia, and so, for sake of economy, I omit further discussion of it.

²³ Putting it another way, while IPL might be some kind of 'neural correlate of consciousness' (a term coined by Crick and Koch [1990]), it is not what Chalmers would refer to as a *content* neural correlate of consciousness, 'a minimal neural representational system ... such that representation of a content in [it] is sufficient ... [given certain background conditions] for representation of that content in consciousness' (2000, p. 31).

in the ability to estimate object distance (Berryhill, Fendrich and Olson, 2009). Notably, experience of object distance was among the types of visual experience that we classified above as *potentially* motorically efficacious. These data might be the beginning of a promising line of argument to be made on behalf of EBC.

There are, however, two further things needed before this is helpful to EBC. The first is reason to think that these areas actually *produce* conscious representations of object distance, since it could be that they merely support the ability of some other brain area to do so (Chalmers, 2000; see also discussion of V1 and MT in Section 5.3). The second thing needed is reason to think that V3A and/or V7 are involved in the (direct) guidance of motor action. That the studies just discussed do not imply this is something that Wu himself points out, perhaps because—as seen above—the relevant evidence indicates that it is representations of IPS/SPL that feed directly into motor action. Nonetheless, the advocate of EBC should note that V3A and V7 look among the more promising candidates for possibly producing conscious, efficacious representations.²⁴

In summary, while the dorsal stream produces those representations feeding directly into motor action, it is unlikely that these representations are ever conscious. Most notably, lesions to those dorsal areas that directly guide motor action fail to bring about deficits in visual consciousness. But there is even a tentative case to be made for the dorsal stream producing no conscious representations at all. Overall, then, the dorsal stream is not a good candidate for producing the conscious, efficacious representations hypothesized by the advocate of EBC.

4.3 Early Visual Areas Do Not Produce the Conscious, Efficacious Representations

In the case of the two early visual areas, V1 and MT, the representations they produce are probably not processed enough to be ready for direct use in motor action.²⁵ In addition, V1 is commonly thought to not produce conscious representations. We look at each area in turn.

²⁴ Prinz (2012, ch. 6) has argued that dorsal areas are conscious by appealing to the case of SB, who retains some ability to have visually conscious experiences though his ventral stream is badly damaged (Lé *et al.*, 2002). But, as the study's authors point out, SB presents 'a completely unique case' (p. 72), one probably best explained as an instance in which normally unconscious dorsal contents have 'become accessible to perceptual awareness' (p. 58). And so not much can be inferred from the case of SB when it comes to whether dorsal areas are conscious in normal subjects.

²⁵ That V1 produces DF's experiences of form is the hypothesis for which Wallhagen shows predilection, because 'V1 is more likely to be associated with low-level (i.e. nonconceptual) sensing' (2007, p. 557). The idea here is that, because V1 is at a level of processing at which perceived properties have not yet been brought under concepts, V1 is a good place to locate the inaccessible experiences Wallhagen hypothesizes DF to have. While it is true such processing is pre-conceptual, it is also probably prior to the level at which robust motor representations are produced, as I explain below.

The representations in V1 are too elementary for direct use in motor action. V1 constitutes the first stage of cortical visual processing, its job being to construct something along the lines of what Marr referred to as the ‘primal sketch’ (1982): Information within V1 mostly consists of a 2D representation of the intensity and wavelength of light arriving from each part of the visual field, though some cells here (due to lateral connections) respond to edges, motion, and binocular disparity (Hubel and Wiesel, 1968, 1998). Importantly, V1 is at a level of processing prior to where things like an object’s distance, shape, or size are represented—it is even prior to where the visual field has been segmented into objects. But what is required for motor action are robust representations like those just described, ones that represent an object as an object, and represent things like an object’s distance, shape, or size. Plausibly, then, V1 is at too early a stage of processing for its representations to be ready for use in visuomotor action.

In any case, V1 representations are probably not conscious. This is the view of most contemporary visual neuroscientists, and some compelling data support this claim (Rees, Kreiman and Koch, 2002; Prinz, 2012, ch. 2). It has, however, been argued that activity in V1 is crucial for visual consciousness (Pascual-Leone and Walsh, 2001; Tong, 2003), on the basis of experiments in which visual experience appeared to require the establishing of feedback loops between V1 and a downstream brain area (Bullier, 2001; Pascual-Leone and Walsh, 2001). But given the copious evidence against V1 being conscious, the role V1 plays here is most naturally interpreted not as one in which it produces conscious representations, but rather in which it enables representations to become conscious elsewhere; namely, in the downstream brain area. In sum, in the case of V1, there is reason to think that its representations are neither conscious nor motorically efficacious.

Next we turn to MT (also known as V5), an area believed to specialize in processing motion information (Born and Bradley, 2005). It is also an area a number of researchers have taken to be where conscious motion representations are produced (Zeki, 2003; Schenk and McIntosh, 2010; Prinz, 2012, ch. 6; Wu, 2014), and many studies support this conclusion (see Block, 2007, p. 496). Among other things, increased MT activity correlates with the conscious perception of motion (Heeger *et al.*, 1999), and MT lesions²⁶ produce deficits in motion experience (Zihl *et al.*, 1983; Walsh *et al.*, 1998). It should be noted, however, that the arguments made in support of MT producing conscious representations have thus far failed to rule out the leading alternative, which is that motion information does not become conscious until it arrives in the ventral stream (Milner and Goodale, 1995/2006, ch. 8; Goodale and Milner, 2010). Nonetheless, probably our best guess at this time is that MT produces conscious representations of motion.

²⁶ I use ‘lesion’ loosely here, so that it refers both to instances of brain damage, and to the ‘temporary lesions’ induced by transcranial magnetic stimulation, a technique in which brain areas are taken ‘off-line’ with bursts of magnetic energy.

What is more doubtful is that MT representations are motorically efficacious. Initially, MT representations appear to be candidates for use in visuomotor action, since acting upon an object in motion will require information about its motion. Milner and Goodale, however, have argued that MT should be classified as ‘an “early” visual area, one that has the same relationship with the two streams as [V1], but which is specialized for motion processing’ (1995/2006, p. 219). In support of this picture, Milner and Goodale point out how both MT and V1 have substantial projections to the ventral and dorsal streams (Felleman and Van Essen, 1991), and how lesions to MT or V1 result in both perceptual and visuomotor deficits (Zihl *et al.*, 1983; Walsh *et al.*, 1998; Schenk *et al.*, 2005). If Milner and Goodale are right, and MT occupies a similar position in the visual processing hierarchy as does V1, then MT probably does not produce those motion representations used directly in visuomotor action, for the same reason that V1 probably does not: The representations would need further processing before they were ready for use in motor action.

Overall, it looks unlikely that the early visual areas could supply the conscious, efficacious representations hypothesized by the advocate of EBC. In the case of MT, it is a poor candidate for producing efficacious representations; in the case of V1, it is a poor candidate for producing efficacious *or* conscious representations. It should be acknowledged that the case against MT producing conscious, efficacious motion representations is not decisive: The idea that MT is properly classified as an early visual area is newer and therefore not yet widely accepted, so it might be hasty—at this point—to conclude that MT does not produce conscious, efficacious representations of *motion*. But even if it did, this offers only the most limited kind of vindication of EBC: representations of object motion are but one of the many types of representation needed for successful visuomotor action, with representation of things like an object’s direction, distance, orientation, and shape also being necessary. But, as seen above, there are probably no representations of these types that are both conscious and efficacious.

In Section 3, we saw how advocates of EBC cast doubt on the dissociation argument arguing that there is, within the experience of subjects, content matching the content driving motor action. It was hard to rule out the possibility of such content, in no small part because it is said to be unreportable or otherwise hard to discover. But what we saw in this section is that even if such content exists, it probably does not play a direct role in motor action, since it appears that there are no areas in the visual system producing representations both conscious and efficacious (with caveats in the case of motion).

5. Objections

In the last section, I presented the neuroanatomical argument against EBC. There are three prominent objections to the argument, each of which I answer in this section.

5.1 Do Newer Optic Ataxia Data Show it to Involve Deficits in Consciousness?

As discussed above, optic ataxia is classically understood as involving only visuomotor deficits. But some newer data suggest optic ataxics might also have perceptual deficits. In a study carried out by Pisella and colleagues (2009; see also 2006), optic ataxics were less accurate than controls at detecting changes in size, position, or orientation of peripherally located stimuli. The advocate of EBC could argue that these results are due to deficits in the ability to consciously perceive peripherally located objects. Were this correct, the Pisella *et al.* study would act as evidence for optic ataxics having deficits in visual experience, and therefore also as evidence for IPS/SPL producing conscious representations.²⁷

However, one would think that if optic ataxics had deficits in conscious perception of object size, position, and/or orientation, there would be a more direct sort of evidence for these deficits, like what is available in achromatopsia (a deficit in conscious color perception; Damasio *et al.*, 1980; Zeki, 1990), or akinetopsia (a deficit in conscious motion perception; Zihl *et al.*, 1983). Subjects with these disorders are not merely unable to *detect changes* in object color or motion, they cannot report on object color or motion *at all*.²⁸ But with optic ataxia, there is no similarly direct evidence for subjects having deficits in conscious perception of orientation, position, or size. Perhaps such evidence will appear in the future; pending its appearance, we should prefer whatever other, more plausible explanations are available.

One such explanation is that it is merely *attentional* deficits causing optic ataxics' inability to detect the changes in the peripherally presented stimuli (Striemer, 2007; Pisella *et al.*, 2009; McIntosh *et al.*, 2011). Dorsal areas play an important role in directing visual attention. This is especially true of its inferior areas (e.g. IPL), but other dorsal areas, including IPS/SPL, also participate (Striemer, 2007). It is thought that damage to IPS/SPL (and perhaps, to a more limited degree, areas just below IPS/SPL) causes attentional deficits for peripheral parts of the visual field. Plausibly, attentional deficits for the periphery leads to an insensitivity to changes in the periphery, whether there were deficits in consciousness or not. And so perhaps what is preventing optic ataxics from detecting changes in peripherally located stimuli is merely a shortage of attentional resources, and not any purported deficits in visual consciousness.²⁹

²⁷ Also relevant, if not as directly so, is a study carried out by McIntosh and colleagues (2011), in which an optic ataxic (subject IG) was slower than controls in indicating the direction in which a target stimulus had moved. The same observations I make below about the Pisella *et al.* study could also be made about this study.

²⁸ This could be put more carefully: Since these disorders are often localized to some specific part of the visual field, it will not, strictly speaking, be that they cannot report (e.g.) object color *at all*, but rather that they cannot report object color in the affected part of the visual field at all.

²⁹ Note that, in the present explanation, I am not hypothesizing that the peripheral changes are missed because *no* attention is able to be devoted to the peripherally located object, but rather because there is not *enough* attention devoted to it. And so the explanation that I am giving here

Overall, the explanation of the Pisella *et al.* data according to which optic ataxics have conscious deficits should probably be rejected: If there were such deficits, we would expect direct evidence for them (something more direct than an inability to detect a change), but so far there is no such evidence. This provides grounds for preferring the alternative interpretation of these deficits, according to which attentional deficits alone are responsible for optic ataxics' inability to detect the changes.³⁰

5.2 Do Optic Ataxics Have Undetected Deficits in Visual Experience?

Above, I presented evidence for IPS/SPL lesions not producing deficits in consciousness. But one might argue that such deficits exist, they are just as yet undiscovered. As discussed above (in Section 3.1), Mole hypothesizes there to be *demonstrative* form content within visual experience, content said to be used in motor action, and which is available only when actually performing a motor action. One might be tempted to argue that it is this demonstrative content (or something like it; see Nudds, 2007; Schenk and McIntosh, 2010) that is absent from the experience of optic ataxics. Note that this proposal comes with a ready explanation as to why there is thus far no evidence of such deficits: Since such content is fleeting and subtle, perhaps its absence would neither be noticed by the optic ataxic, nor discovered in the course of an examination. And so, the objection concludes, perhaps optic ataxics have deficits in visual experience after all.

If optic ataxia involved deficits in visual experience (even in 'subtle' content), it is probable that there would be evidence—at least anecdotal—of such deficits, given the extent to which optic ataxia has been studied (for review, see Jackson *et al.*, 2009). Still, this consideration falls short of *ruling out* there to be deficits in the hypothesized subtle content. But even if there were, it is questionable whether they would be relevant to evaluating EBC. I will explain.

Notice that what is key to this objection is the idea that the content in question is, because it is fleeting and subtle, not *prominent* in one's experience. But remember the original motivation for EBC as a philosophical hypothesis: The rich, detailed representations that we seem to find in visual experience—representations of things like an object's direction, distance, or shape—look well-suited for guiding skilled motor action. Note now that the conscious representations referred to here are *prominent* within visual experience: Anyone reflecting upon their visual experience easily finds the rich, detailed visual representations that served as inspiration for EBC as a philosophical hypothesis. Likewise, EBC as the commonsense

is consistent with the view that attention is necessary for consciousness (Simons and Chabris, 1999; Prinz, 2012).

³⁰ It should be noted that some of the Pisella *et al.* results act as evidence against IPS/SPL producing conscious *shape* representations, since optic ataxics performed at the level of controls when asked to detect changes in the shape of peripherally located stimuli.

view is plausibly construed as concerning the same prominent features of visual experience.

If so, the present objection might well constitute a change of subject: The content that EBC hypothesizes to be driving motor action is prominent within visual experience, but the content said to be missing from the experience of optic ataxics is subtle; so subtle that even the optic ataxics do not realize that they lost it. And so, even if such content exists, it might not be relevant to evaluating EBC.

5.3 Should Brain Lesions Be Used to Determine Whether or not a Brain Area Produces Conscious Representations?

In Section 4.2, we saw how IPS/SPL lesions fail to bring about deficits in visual experience, and from this it was inferred that IPS/SPL probably does not produce conscious representations. However, Chalmers has argued that it is ‘methodologically dangerous’ to use lesions to determine the location of conscious representations in the brain (2000, p. 32). The problem is that ‘lesions change the architecture of the brain, and it is quite possible that changes to brain architecture can change the very location of the [conscious representations]’ (2000, p. 29). What Chalmers is worried about here is *neuroplasticity*, the brain’s ability to reorganize its structure in response to damage or experience (Grafman, 2000). Because of neuroplasticity, sometimes some of the function lost because of a lesion is regained by a brain area neighboring the lesion. And so one might claim that conscious deficits have not been observed in conjunction with IPS/SPL lesions not because IPS/SPL representations are never conscious, but rather because other parts of the brain take on the job of producing conscious representations if IPS/SPL is disabled.

There are, however, a few reasons to think that the phenomenon of neuroplasticity does not undermine the IPS/SPL lesion data. For one thing, neuroplasticity rarely provides full recovery, and takes a long time when it does (Grafman and Litvan, 1999; Grafman, 2000; Frost *et al.*, 2003). This makes it very likely that the optic ataxics would still have had *some* deficits in visual experience when they were examined, were it the case that IPS/SPL produced conscious representations. But let us look more closely at the scenario that we are considering. In it, the optic ataxics underwent a remarkable recovery in their ability to produce conscious representations, and yet they still suffer from visuomotor deficits (to no small degree). The recovery here appears improbably localized, since it is unlikely that the optic ataxics would have a dramatic recovery in one ability without also having an at least moderate recovery in the other. More importantly, if optic ataxics still have visuomotor deficits, this means they probably have not regained their ability to produce visuomotor representations. But if the optic ataxics regained their conscious representations without regaining their visuomotor representations, the two were probably never the same to start with. It looks, then, as if neuroplasticity does not undermine the IPS/SPL lesion data.

6. Conclusion

The dissociation argument uses apparent divergences between the contents of visual experience and motor action to argue that visual experience does not play the kind of central role in visuomotor action that we might have pre-theoretically thought. Advocates of EBC have responded by arguing that the dissociations are merely apparent, with the content driving visuomotor action being present within subjects' experiences, just hard to discover. Clark attempted to rule out such content by arguing that it lacks any proper connection to agency, but his argument fell short of showing such content to not exist. I have argued, however, that even if such content does exist, it likely does not directly guide visuomotor action, since current neuroscience fails to support the idea that there are conscious, motorically efficacious visual representations. If this is correct, EBC still faces a compelling empirical threat.

In closing the article, let us reflect on a strength and a weakness of the neuroanatomical argument against EBC. Recall that EBC has not only a directness clause, but also a typicality clause. There is some evidence available appearing to move EBC closer to having its typicality clause fulfilled. This evidence consists of studies in which motor action appears influenced by content that is conscious and/or of a type usually associated with the ventral stream.³¹ It has been demonstrated, for instance, that the illusory (Franz *et al.*, 2001; Gonzalez *et al.*, 2008) or remembered (McIntosh and Lashley, 2008) size of an object affects motor action under certain circumstances. More intriguingly, some recent experiments suggest that consciously experienced visual illusions can even influence the *online* control of motor action (Caljouw *et al.*, 2011), a type of motor control usually thought the exclusive province of the dorsal stream (even by critics of dual visual systems theory).

This brings us to a weakness of the neuroanatomical argument: say there is, in the future, an accumulation of these studies demonstrating correlations between conscious/ventral content and the content driving motor action. This could be used to argue that the typicality clause is satisfied. And, if so, this is nothing that the neuroanatomical argument could gainsay, since it only argues that the consciousness-producing system is distinct from the action-guiding system, but is more or less silent on the question of the frequency or degree to which the former influences the latter.

On the other hand, once it is established that the brain areas directly driving motor action are neuroanatomically distinct from those that are conscious, any number of such correlations between consciousness and motor action cannot help fulfill the directness clause. The problem is that these correlations can be interpreted as instances in which conscious visual information influences motor action only by first being routed through a non-conscious action guiding system.

³¹ For reviews of some of the more interesting data, see Schenk and McIntosh, 2010; Shepherd, 2015.

This interpretation, moreover, becomes compulsory with the success of the neuroanatomical argument. And so the strength of the neuroanatomical argument is that it presents a particularly resilient case against the directness clause of EBC being fulfilled.

One issue that we have not had time to look at in this article is the relative importance of the typicality and directness clauses to EBC. Still, as explained above, we have at least *prima facie* reason to think that EBC includes a directness clause. It would be notable, then, if there is a good case to be made for it not being fulfilled, something I hope to have done in this article.

*Philosophy Department
University of Arizona*

References

- Aglioti, S., DeSouza, J. and Goodale, M. 1995: Size-contrast illusions deceive the eye but not the hand. *Current Biology*, 5(6), 679–85.
- Bálint, D. 1909: Seelenlähmung des ‘Schauens’, optische Ataxie, räumliche Störung der Aufmerksamkeit. *European Neurology*, 25, 51–66.
- Benson, D. and Greenberg, J. 1969: Visual form agnosia: a specific defect in visual discrimination. *Archives of Neurology*, 20, 82.
- Berryhill, M.E., Fendrich, R. and Olson, I.R. 2009: Impaired distance perception and size constancy following bilateral occipitoparietal damage. *Experimental Brain Research*, 194(3), 381–93.
- Binkofski, F. *et al.* 1999: A parieto-premotor network for object manipulation: evidence from neuroimaging. *Experimental Brain Research*, 128, 210–13.
- Block, N. 1995: On a confusion about a function of consciousness. *Behavioral and Brain Sciences*, 18, 227–87.
- Block, N. 2007: Consciousness, accessibility and the mesh between psychology and neuroscience. *Behavioral and Brain Sciences*, 30(5), 481–98.
- Block, N. 2011: Perceptual consciousness overflows cognitive access. *Trends in Cognitive Sciences*, 15(12), 567–75.
- Born, R. and Bradley, D. 2005: Structure and function of visual area MT. *Annual Review of Neuroscience*, 28, 157–189.
- Brenner, E. and Smeets, J.B. 1996: Size illusion influences how we lift but not how we grasp an object. *Experimental Brain Research*, 111(3), 473–6.
- Bridge, H. *et al.* 2013: Structural and functional changes across the visual cortex of a patient with visual form agnosia. *The Journal of Neuroscience*, 33(31), 12779–91.
- Bridgeman, B., Kirsch, M. and Sperling, A. 1981: Segregation of cognitive and motor aspects of visual function using induced motion. *Perception and Psychophysics*, 29, 336–42.

- Bridgeman, B., Lewis, S., Heit, G. and Nagle, M. 1979: Relation between cognitive and motor-oriented systems of visual position perception. *Journal of Experimental Psychology: Human Perception and Performance*, 5, 692–700.
- Bridgeman, B., Peery, S. and Anand, S. 1997: Interaction of cognitive and sensorimotor maps of space. *Perception and Psychophysics*, 59, 456–69.
- Briscoe, R. 2009: Egocentric spatial representation in action and perception. *Philosophy and Phenomenological Research*, 79(2), 423–60.
- Brogaard, B. 2011a: Conscious vision for action versus unconscious vision for action? *Cognitive Science*, 35(6), 1076–1104.
- Brogaard, B. 2011b: Are there unconscious perceptual processes? *Consciousness and Cognition*, 20(2), 449–63.
- Brown, R. 2011: The myth of phenomenological overflow. *Consciousness and Cognition*, 21(2), 599–604.
- Bullier, J. 2001: Feedback connections and conscious vision. *Trends in Cognitive Sciences*, 9, 369–70.
- Caljouw, S.R., van der Kamp, J., Lijster, M. and Savelsbergh, G.J. 2011: Differential effects of a visual illusion on online visual guidance in a stable environment and online adjustments to perturbations. *Consciousness and Cognition*, 20(4), 1135–43.
- Campion, J. 1987: Apperceptive agnosia: the specification and description of constructs. In G. Humphreys and M. Riddoch (eds), *Visual Object Processing: A Cognitive Neuropsychological Approach*. Hillsdale, NJ: Erlbaum, 197–232.
- Chalmers, D. 1995: Facing up to the problem of consciousness. *Journal of Consciousness Studies*, 2(3), 200–19.
- Chalmers, D. 2000: What is a neural correlate of consciousness? In T. Metzinger (ed.), *Neural Correlates of Consciousness: Empirical and Conceptual Questions*. Cambridge, MA: MIT Press.
- Clark, A. 2001: Visual experience and motor action: are the bonds too tight? *Philosophical Review*, 110(4), 495–519.
- Clark, A. 2006: Vision as dance? Three challenges for sensorimotor contingency theory. *Edinburgh Research Archive*. Available at <https://www.era.lib.ed.ac.uk/handle/1842/1444>
- Clark, A. 2007: What reaching teaches: consciousness, control and the inner zombie. *The British Journal for the Philosophy of Science*, 58(3), 563–94.
- Clark, A. 2009: Perception, action and experience: unraveling the golden braid. *Neuropsychologia*, 47(6), 1460–8.
- Clark, A. and Kiverstein, J. 2007: Experience and agency: slipping the mesh. *Behavioral and Brain Sciences*, 30(5–6), 502–3.
- Cohen, M. and Dennett, D. 2011: Consciousness cannot be separated from function. *Trends in Cognitive Sciences*, 15(8), 358–64.

- Committeri, G. *et al.* 2004: Reference frames for spatial cognition: different brain areas are involved in viewer-, object- and landmark-centered judgments about object location. *Journal of Cognitive Neuroscience*, 16(9), 1517–35.
- Crick, F. and Koch, C. 1990: Towards a neurobiological theory of consciousness. *Seminars in the Neurosciences*, 2, 263–75.
- Culham, J. *et al.* 2003: Visually guided grasping produces fMRI activation in dorsal but not ventral stream brain areas. *Experimental Brain Research*, 153(2), 180–9.
- Cussins, A. 1998: Nonconceptual content, frames of reference and trails of information. Talk presented to the Symposium on Nonconceptual Content, APA, Eastern Division Meeting, Washington DC, January.
- Damasio, A. and Damasio, H. 1983: Localization of lesions in achromatopsia and prosopagnosia. In A. Kertesz (ed.), *Localization in Neuropsychology*. San Diego, CA: Academic Press, 331–341.
- Damasio, A. *et al.* 1980: Central achromatopsia: behavioral, anatomic and physiologic aspects. *Neurology*, 30(10), 1064–71.
- de Gardelle, V., Sackur, J. and Kouider, S. 2009: Perceptual illusions in brief visual presentations. *Consciousness and Cognition*, 18(3), 569–77.
- Dennett, D. 1995: The path not taken. *Behavioral and Brain Sciences*, 18, 252–3.
- Dijkerman, H.C., Milner, A.D. and Carey, D.P. 1996: The perception and prehension of objects oriented in the depth plane. *Experimental Brain Research*, 112(3), 442–51.
- Dijkerman, H.C., Milner, A.D. and Carey, D.P. 1999: Motion parallax enables depth processing for action in a visual form agnostic when binocular vision is unavailable. *Neuropsychologia*, 37(13), 1505–10.
- Driver, J. and Vuilleumier, P. 2001: Perceptual awareness and its loss in unilateral neglect and extinction. *Cognition*, 79, 39–88.
- Efron, R. 1969: What is perception? *Boston Studies in Philosophy of Science*, 4, 137–73.
- Ellis, R., Flanagan, J. and Lederman, S. 1999: The influence of visual illusion on grasp position. *Experimental Brain Research*, 125, 109–14.
- Evans, G. 1982: *The Varieties of Reference*. Oxford: Clarendon Press.
- Fankhauser, F. and Kwasniewska, S. 2009: Cortical mechanisms of normal and abnormal processing in the visual system, Part 1: Spatial vision, amblyopia, hyperacuity, modal assumptions: A review. *Technology and Health Care*, 17(2), 77–97.
- Felleman, D.J. and Van Essen, D.C. 1991: Distributed hierarchical processing in the primate cerebral cortex. *Cerebral Cortex*, 1, 1–47.
- Franz, V.H. *et al.* 2001: Effects of visual illusions on grasping. *Journal of Experimental Psychology: Human Perception and Performance*, 27(5), 1124–44.
- Frost, S. *et al.* 2003: Reorganization of remote cortical regions after ischemic brain injury: a potential substrate for stroke recovery. *Journal of Neurophysiology*, 89(6), 3205–14.

- Gallese, V. 2007: The 'conscious' dorsal stream: embodied simulation and its role in space and action conscious awareness. *Psyche*, 13, 1–20.
- Garcin, R., Rondot, P. and De Recondo, J. 1967: Ataxie optique localisée aux deux hémichamps visuels homonymes gauches. *Revue de Neurology (Paris)*, 116, 707–14.
- Glover, S. 2003: Optic ataxia as a deficit specific to the on-line control of actions. *Neuroscience and Biobehavioral Reviews*, 27(5), 447–56.
- Gonzalez, C. *et al.* 2008: Practice makes perfect, but only with the right hand: sensitivity to perceptual illusions with awkward grasps decreases with practice in the right but not in the left hand. *Neuropsychologia*, 46(2), 624–31.
- Goodale, M. 1998: Visuomotor control: where does vision end and action begin? *Current Biology*, 8(14), 489–91.
- Goodale, M., Meenan, J.P., Bühlhoff, H.H., Nicolle, D.A., Murphy, K.J. and Racicot, C.I. 1994: Separate neural pathways for the visual analysis of object shape in perception and prehension. *Current Biology*, 4(7), 604–10.
- Goodale, M. and Milner, A. 2004: *Sight Unseen: An Exploration of Conscious and Unconscious Vision*. Oxford: Oxford University Press.
- Goodale, M. and Milner, A. 2010: Two visual streams: interconnections do not imply duplication of function. *Cognitive Neuroscience*, 1, 52–62.
- Goodale, M., Milner, A.D., Jakobson, L.S. and Carey, D.P. 1991: A neurological dissociation between perceiving objects and grasping them. *Nature*, 349(6305), 154–6.
- Goodale, M., Pelisson, D. and Prablanc, C. 1986: Large adjustments in visually guided reaching do not depend on vision of the hand or perception of target displacement. *Nature*, 320, 154–6.
- Grafman, J. 2000: Conceptualizing functional neuroplasticity. *Journal of Communication Disorders*, 33(4), 345–56.
- Grafman, J. and Litvan, I. 1999: Evidence for four forms of neuroplasticity. In J. Grafman and I. Litvan (eds), *Neuronal Plasticity: Building a Bridge from the Laboratory to the Clinic*. Berlin: Springer, 131–9.
- Grill-Spector, K. *et al.* 1998: Cue-invariant activation in object-related areas of the human occipital lobe. *Neuron*, 21, 191–202.
- Gross, C. and Sergeant, J. 1992: Face recognition. *Current Opinion in Neurobiology*, 2(2), 156–61.
- Grush, R. 1998: Skill and spatial content. *Electronic Journal of Analytic Philosophy*, 6(6).
- Haffenden, A. and Goodale, M. 1998: The effect of pictorial illusion on prehension and perception. *Journal of Cognitive Neuroscience*, 10, 122–36.
- Heeger, D. *et al.* 1999: Motion opponency in visual cortex. *The Journal of Neuroscience*, 19(16), 7162–74.
- Heider, B. 2000: Visual form agnosia: neural mechanisms and anatomical foundations. *Neurocase*, 6, 1–12.

- Himmelbach, M. and Karnath, H. 2005: Dorsal and ventral stream interaction: contributions from optic ataxia. *Journal of Cognitive Neuroscience*, 17(4), 632–40.
- Himmelbach, M. *et al.* 2009: Brain activation during immediate and delayed reaching in optic ataxia. *Neuropsychologia*, 47(6), 1508–17.
- Himmelbach, M., Boehme, R. and Karnath, H.O. 2012: 20 years later: a second look on DF's motor behaviour. *Neuropsychologia*, 50, 139–44.
- Holmes, G. 1918: Disturbances of visual orientation. *British Journal of Ophthalmology*, 2, 449–506.
- Hu, Y. and Goodale, M. 2000: Grasping after a delay shifts size-scaling from absolute to relative metrics. *Journal of Cognitive Neuroscience*, 12(5), 856–68.
- Hu, Y., Eagleson, R. and Goodale, M. 1999: The effects of delay on the kinematics of grasping. *Experimental Brain Research*, 126, 109–16.
- Hubel, D. and Wiesel, T. 1968: Receptive fields and functional architecture of monkey striate cortex. *The Journal of Physiology*, 195, 215–43.
- Hubel, D. and Wiesel, T. 1998: Early exploration of the visual cortex. *Neuron*, 20(3), 401–12.
- Jackson, S.R. *et al.* 2009: There may be more to reaching than meets the eye: re-thinking optic ataxia. *Neuropsychologia*, 47(6), 1397–1408.
- Jacob, P. and de Vignemont, F. 2010: Spatial coordinates and phenomenology in the two-visual systems model. In N. Gangopadhyay (ed.), *Perception, Action and Consciousness: Sensorimotor Dynamics and Two-Visual Systems*. Oxford: Oxford University Press.
- Jacob, P. and Jeannerod, M. 2003: *Ways of Seeing: The Scope and Limits of Visual Cognition*. Oxford: Oxford University Press
- James, T. *et al.* 2003: Ventral occipital lesions impair object recognition but not object-directed grasping: an fMRI study. *Brain*, 126(11), 2463–75.
- Kanwisher, N. *et al.* 1996: Functional imaging of human visual recognition. *Cognitive Brain Research*, 5, 55–67.
- Koch, C. and Crick, F. 2001: The zombie within. *Nature*, 411(6840), 893.
- Kouider, S., de Gardelle, V. and Dupoux, E. 2007: Partial awareness and the illusion of phenomenal consciousness. *Behavioral and Brain Sciences*, 30(5–6), 510–11.
- Kourtzi, Z. and Kanwisher, N. 2000: Cortical regions involved in perceiving object shape. *The Journal of Neuroscience*, 20(9), 3310–18.
- Kourtzi, Z. and Kanwisher, N. 2001: Representation of perceived object shape by the human lateral occipital complex. *Science*, 293(5534), 1506–9.
- Kozuch, B. 2014: Prefrontal lesion evidence against higher-order theories of consciousness. *Philosophical Studies*, 167(3), 721–46.
- Króliczak, G. *et al.* 2006: Dissociation of perception and action unmasked by the hollow-face illusion. *Brain Research*, 1080, 9–16.

- Lamme, V. 2006: Towards a true neural stance on consciousness. *Trends in Cognitive Sciences*, 10(11), 494–501.
- Lê, S. *et al.* 2002: Seeing, since childhood, without ventral stream: a behavioural study. *Brain*, 125, 58–74.
- Malach, R. *et al.* 1995: Object-related activity revealed by functional magnetic resonance imaging in human occipital cortex. *Proceedings of the National Academy of Sciences*, 92(18), 8135–9.
- Marr, D. 1982: *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*. New York: Henry Holt and Co.
- McIntosh, R. *et al.* 2011: Correlated deficits of perception and action in optic ataxia. *Neuropsychologia*, 49, 131–7.
- McIntosh, R.D. and Lashley, G. 2008: Matching boxes: familiar size influences action programming. *Neuropsychologia*, 46(9), 2441–4.
- Milner, A. and Goodale, M. 1995/2006: *The Visual Brain in Action*. Oxford: Oxford University Press.
- Milner, A. and Goodale, M. 2008: Two visual systems re-viewed. *Neuropsychologia*, 46(3), 774–85.
- Milner, A. *et al.* 1991: Perception and action in ‘visual form agnosia’. *Brain*, 114, 405–28.
- Milner, A., Dijkerman, H. and Carey, D. 1999: Visuospatial processing in a pure case of visual-form agnosia. In N. Burgess, J. Jeffery and J. O’Keefe (eds), *The Hippocampal and Parietal Foundations of Spatial Cognition*. Oxford: Oxford University Press, 443–66.
- Mole, C. 2009: Illusions, demonstratives and the zombie action hypothesis. *Mind*, 118(472), 995–1011.
- Mole, C. 2013: Embodied demonstratives: a reply to Wu. *Mind*, 122(485), 231–9.
- Moreaud, O. 2003: Balint syndrome. *Archives of Neurology*, 60(9), 1329–31.
- Morel, A. and Bullier, J. 1990: Anatomical segregation of two cortical visual pathways in the macaque monkey. *Visual Neuroscience*, 4(6), 555–78.
- Nagel, T. 1974: What is it like to be a bat? *Philosophical Review*, 83, 435–50.
- Nisbett, R.E. and Wilson, T. D. 1977: Telling more than we can know: verbal reports on mental processes. *Psychological Review*, 84(3), 231–59.
- Noë, A. 2005: *Action in Perception*. Cambridge, MA: MIT Press.
- Nudds, M. 2007: Seeing how to move: visually guided action and the ‘directive’ content of visual experience. Draft manuscript available at: <http://homepages.ed.ac.uk/mnudds/papers/shtm.pdf>
- O’Regan, J. and Noë, A. 2001: A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences*, 24(5), 939–72.
- O’Shaughnessy, B. 1992: The diversity and unity of action and perception. In T. Crane (ed.), *The Contents of Experience*. Cambridge: Cambridge University Press.

- Pascual-Leone, A. and Walsh, V. 2001: Fast backprojections from the motion to the primary visual area necessary for visual awareness. *Science*, 292, 510–12.
- Patla, A. and Goodale, M. 1996: Obstacle avoidance during locomotion is unaffected in a patient with visual form agnosia. *NeuroReport*, 8, 165–8.
- Peacocke, C. 1992: Scenarios, concepts and perception. In T. Crane (ed.), *The Contents of Experience*. Cambridge: Cambridge University Press, 105–35.
- Perenin M. and Vighetto, A. 1983: Optic ataxia: a specific disorder in visuomotor coordination. In A. Hein and M. Jeannerod (eds), *Spatially Oriented Behavior*. New York: Springer.
- Perenin M. and Vighetto, A. 1988: Optic ataxia: a specific disruption in visuomotor mechanisms. *Brain*, 111(3), 643–74.
- Pisella, L. *et al.* 2006: No double-dissociation between optic ataxia and visual agnosia: multiple sub-streams for multiple visuo-manual integrations. *Neuropsychologia*, 44(13), 2734–48.
- Pisella, L. *et al.* 2009: Optic ataxia and the function of the dorsal stream: contributions to perception and action. *Neuropsychologia*, 47, 3033–44.
- Prado, J. *et al.* 2005: Two cortical systems for reaching in central and peripheral vision. *Neuron*, 48(5), 849–58.
- Prinz, J. 2012: *The Conscious Brain*. New York: Oxford University Press.
- Rees, G., Kreiman, G. and Koch, C. 2002: Neural correlates of consciousness in humans. *Nature Reviews: Neuroscience*, 3, 261–70.
- Rossetti, Y. *et al.* 2005: Visually guided reaching: bilateral posterior parietal lesions cause a switch from fast visuomotor to slow cognitive control. *Neuropsychologia*, 43(2), 162–77.
- Sacks, O. 1985: *The Man Who Mistook His Wife for a Hat and Other Clinical Tales*. New York: Summit Books.
- Schenk, T. and McIntosh, R. 2010: Do we have independent visual streams for perception and action? *Cognitive Neuroscience*, 1, 52–62.
- Schenk, T. and Milner, A. 2006: Concurrent visuomotor behaviour improves form discrimination in a patient with visual form agnosia. *European Journal of Neuroscience*, 24(5), 1495–1503.
- Schenk, T. *et al.* 2005: The role of V5/MT+ in the control of catching movements: an rTMS study. *Neuropsychologia*, 43(2), 189–98.
- Schneider, G. 1969: Two visual systems: brain mechanisms for localization and discrimination are dissociated by tectal and cortical lesions. *Science*, 163, 895–902.
- Shepherd, J. 2015: Conscious control over action. *Mind & Language*, 30, 320–44.
- Simons, D.J. and Chabris, C.F. 1999: Gorillas in our midst: sustained inattentive blindness for dynamic events. *Perception*, 28, 1059–74.
- Smets, J. and Brenner, E. 2001: Action beyond our grasp. *Trends in Cognitive Sciences*, 5(7), 287.

- Steeves, J. *et al.* 2006: The fusiform face area is not sufficient for face recognition: evidence from a patient with dense prosopagnosia and no occipital face area. *Neuropsychologia*, 44(4), 594–609.
- Sriemer, C. *et al.* 2007: Deficits in peripheral visual attention in patients with optic ataxia. *Neuroreport*, 18(11), 1171–5.
- Tong, F. 2003: Primary visual cortex and visual awareness. *Nature Reviews Neuroscience*, 4(3), 219–30.
- Tversky, A. and Kahneman, D. 1983: Extensional versus intuitive reasoning: the conjunction fallacy in probability judgment. *Psychological Review*, 90(4), 293–315.
- Ungerleider L. and Mishkin, M. 1982: Two cortical visual systems. In D. Ingle, M.A. Goodale and R.J.W. Mansfield (eds), *Analysis of Visual Behavior*. Cambridge, MA: MIT Press.
- Ungerleider, L. and Haxby, J. 1994: ‘What’ and ‘where’ in the human brain. *Current Opinion in Neurobiology*, 4(2), 157–65.
- Vosgerau, G. and Newen, A. 2008: Orthogonality of phenomenality and content. *American Philosophical Quarterly*, 45, 329–48.
- Wallhagen, M. 2007: Consciousness and action: does cognitive science support (mild) epiphenomenalism? *The British Journal for the Philosophy of Science*, 58(3), 539–61.
- Walsh, V. *et al.* 1998: Task-specific impairments and enhancements induced by magnetic stimulation of human visual area V5. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 265(1395), 537–43.
- Wegner, D.M. 2002: *The Illusion of Conscious Will*. Cambridge, MA: MIT Press.
- Wong, E. and Mack, A. 1981: Saccadic programming and perceived location. *Acta Psychologica*, 48, 123–31.
- Wu, W. 2013: The case for zombie agency. *Mind*, 122(485), 217–30.
- Wu, W. 2014: Against division: consciousness, information and the visual streams. *Mind & Language*, 29, 383–406.
- Young, M.P. 1992: Objective analysis of the topological organization of the primate cortical visual system. *Nature*, 358(6382), 152–5.
- Zeki, S. 1990: A century of cerebral achromatopsia. *Brain*, 113(6), 1721–77.
- Zeki, S. 2003: The disunity of consciousness. *Trends in Cognitive Sciences*, 7, 214–8.
- Zihl, J., Von Cramon, D. and Mai, N. 1983: Selective disturbance of movement vision after bilateral brain damage. *Brain*, 106(2), 313–40.