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Conscious vision guides motor action—rarely

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ABSTRACT
According to Milner and Goodale's dual visual systems (DVS) theory, a division obtains between visual consciousness and motor action, in that the visual system producing conscious vision (the ventral stream) is distinct from the one guiding action (the dorsal stream). That there would be this division is often taken (by Andy Clark and others) to undermine the folk view on how consciousness and action relate. However, even if this division obtains, this leaves open the possibility that conscious ventral information is often transmitted to the unconscious dorsal stream and then used to guide action, a possibility seeming to preserve a significant role for consciousness in action. This article assesses this possibility. In course of doing so, we will review those arguments recently having been made against the DVS view on how visual consciousness and action relate (ones due to, e.g., Briscoe and Schwenkler, or Schenk and McIntosh). What we will find is that, if we properly analyze the data upon which these arguments are based, we are still left with the impression that the DVS view is largely correct; i.e., it is only rarely that visual experience guides action.

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1. Introduction

Arguably, our pre-theoretical understanding of conscious vision gives it a vital role to play in precise actions such as catching a ball or threading a needle. There is, perhaps, good reason for doing so. Consider the following observation, due to Briscoe and Schwenkler:

> Given the accuracy with which the spatial properties of objects in personal space are normally represented in conscious visual experience and the frequency with which human beings must manipulate or otherwise interact with these objects, it is natural to suppose that motor control systems should often avail themselves of consciously encoded visuospatial information in determining the spatial parameters of visually guided behavior (2015:1436).

Indeed, this thinking echoes the reasons for which many commentators have thought that visually based motor action will be guided by the seemingly fine-grained representations found within visual consciousness

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(O'Shaughnessy, 1992; Clark, 2001; Grush, 1998; Peacocke, 1992; Wallhagen, 2007),[1] an idea sometimes dubbed the "Hypothesis of Experience-Based Control" (or "EBC"; Clark, 2001). Though intuitive, this view on how consciousness and action relate is not easily reconciled with results from vision science.

There is, for example, the case of patient DF, whose brain damage abolished her ability to consciously perceive an object's shape, but not to perform precise motor actions like grasping it (Milner & Goodale, 2006, Chapter 5). And there are the numerous experiments in which visual illusions are shown to have a significantly smaller effect on action than they do on conscious perception (Jacob & Jeannerod, 2003, Chapter 3). These kinds of dissociations gave rise to the currently preeminent approach to understanding primate vision, Milner and Goodale's *dual visual systems theory*, according to which a functional schism exists between visual perception and action (1995/2006). More specifically, the theory hypothesizes there to be two semi-autonomous processing pathways, a conscious *ventral stream*, which provides the identity of objects to goal-oriented cognition, and an unconscious *dorsal stream*, which provides the visual information used in action. Suffice to say, the dual visual systems model (hereafter, DVS) stands in stark contradiction to any commonsense intuition according to which visual consciousness and action are intimately related (Clark, 2001; Kozuch, 2015a; Mole, 2013; Wallhagen, 2007).

This issue here is significant: Were it shown that visual consciousness played no role in motor action, this significantly advances the gradual extrication of consciousness from action that cognitive science has effected over the last few decades: It was in 1983 that Libet conducted his infamous (and still controversial) experiments seemingly showing consciousness to arrive too late to produce voluntary action. Were it now also true that visual consciousness plays no role in guiding motor action, consciousness becomes an epiphenomenon of not just the decision to act, but also the action itself. What role would be left for consciousness in action? Perhaps, not much.[2]

There already exist strong arguments for a key tenet of DVS, this being that the visual system producing conscious representations is anatomically distinct from the one guiding motor action (Milner & Goodale, 2010; Mole, 2013, see, esp. Kozuch, 2015a). Were this true, then the idea that the representations found within visual consciousness might sometimes *directly* guide action (Mole, 2009, 2013; Wallhagen, 2007) must be false. However, this neuroanatomical division leaves untouched another possibility, which is that information within visual consciousness is nonetheless frequently (if indirectly) used to guide action (Shepherd, 2015b; Briscoe & Schwenkler, 2015; Mole, 2009; Wallhagen, 2007). The idea here would be that the conscious ventral stream often exports information to the dorsal stream, and that this information is then used to guide action. If this happened frequently enough, it might justify saying that consciousness plays some important role in action.

In this spirit, many commentators (e.g., Shepherd, 2015b; Briscoe & Schwenkler, 2015; Schenk & McIntosh, 2010) have recently appealed to psychophysical and lesion data to argue that visual experience plays a larger role in visual experience than is countenanced by DVS. This being the case, it would be timely to investigate the issue of how often – and in what ways – visual experience contributes to action. And so what this article presents is an up-to-date – if tendentious – review of the arguments and data that have been (or might be) used to argue that visual experience and motor action are closely associated – more closely than is held in DVS. Along the way, several often-held views are challenged, including the ideas that visual illusions influence actions under a wide range of circumstances (Briscoe & Schwenkler, 2015; Ferretti, 2019; Schenk & McIntosh, 2010), that the minor motor deficits possessed by DF reveal visual consciousness to actually have an expansive role in action (Briscoe & Schwenkler, 2015; Hesse et al., 2012), and that some dorsal representations are conscious (e.g., Brogaard, 2012; Ferretti & Zipoli Caiani, 2019; Gallese, 2007; Prinz, 2012, Chapter 2).

The article is laid out as follows: Section 2 more precisely describes what is at issue, this being how *frequently* information from visual experience is used to guide action; Section 2 also reexamines (and embellishes) the empirical evidence usually offered against EBC, seeing how well it works against specifically the idea that visual experience frequently (if indirectly) contributes information to action. Section 3 addresses conceptual and background issues, such as what counts as an instance of visual experience “guiding” action. Sections 4 through 7 critically examine the arguments and data that have been recently offered (or could be offered) against DVS, with one section each being dedicated to psychophysical, brain lesion, dorsal stream, and interstream interaction evidence.

2. Are motor actions typically guided by visual experience?

This article has two general goals. Its primary goal is to review and critique arguments recently made for visual experience guiding motor action more frequently than is supposed by DVS; this requires addressing conceptual issues (e.g., what counts as “guidance by visual experience”), but a more advantageous time for doing so appears below. The secondary goal of this article is to examine how much support these recently offered anti-DVS arguments give to the thesis of EBC (i.e., Experience-Based Control), with the focus being on a particular subthesis of it, this being the idea that action is *typically* guided by visual experience. The first part of this section zeroes in on this subthesis. After this, we reexamine (and supplement) the evidence usually offered against EBC, seeing how strongly it counts against this specific subthesis of EBC.

2.1 The Typicality Clause

As usually understood, EBC elucidates the folk view on how visual experience and action relate (Clark, 2001; Wallhagen, 2007). Whether this is truly the case is an issue going beyond confines of this article (but discussions appear in Clark, 2001; Kozuch, 2015a; Shepherd, 2015a; Wallhagen, 2007), so we will just assume that the folk view on how consciousness and action relate is something close to EBC. As a formulation of EBC, we adopt one due to Kozuch (2015), one shown to be in tune with what many researchers consider to be at issue in this debate (e.g., Briscoe, 2009; Clark, 2001; Wallhagen, 2007)[3]; the formulation looks as follows:

> EBC: Visually based motor action is typically and directly guided by visually conscious representations

Notice that EBC has both a "Directness Clause" and a "Typicality Clause," the first hypothesizing that visual experience *directly* guides motor action, the second that it *frequently* guides motor action (Kozuch, 2015a). Many commentators (Kozuch, 2015; Clark, 2007; Mole, 2009; Wallhagen, 2007) seem to interpret the folk view on how visual experience and action relate to include the Directness Clause (hereafter, simply "Directness").[4] There have, however, been strong arguments offered for only ventral representations being conscious, and only dorsal representations directly guiding action (Milner & Goodale, 1995/2006; Goodale & Milner, 2010; see, esp. Kozuch, 2015a), in which case Directness fails.[5] But this leaves open the possibility that information within visual experience is *indirectly* used to guide action: It could be that conscious ventral representations often pass their content onto unconscious dorsal representations,[6] where this donated content is then used to guide action.[7,8] Were this to occur frequently enough, we could consider the Typicality Clause of EBC to be true, and the folk view vindicated.[9]

This being the case, an adequate understanding of how visual experience and action relate probably requires knowing the degree to which Typicality is true. And so, an aim of this article will be to assess Typicality. When doing so, we pay special attention to the above-mentioned arguments recently offered against DVS, seeing if they help to boost the plausibility of Typicality. Right now, we briefly examine the issue of how strong the empirical case is against Typicality in particular.

2.2: DVS and Typicality

While much empirical data has been offered against EBC (e.g., Milner & Goodale, 2006; Clark, 2001, 2007; Kozuch, 2015a), a question not yet investigated is how well these data undercut Typicality in particular. In this section, we survey (and supplement) the data used to cast doubt on EBC, examining it to see how well they work against Typicality. Take note: Presenting a comprehensive empirical case against Typicality is something going beyond available space, and so accomplishing this is not among the article's goals. Instead, the article mainly focuses on evaluating data recently used to argue against the DVS view on how visual experience and action relate, with a subsidiary goal being to see how well these data support Typicality. And so this section does not try to present a comprehensive case against Typicality, but rather just enough of a prima facie case to motivate investigating how advocates of Typicality might respond to it.

Now we look at the evidence that is usually used against EBC. It mainly consists of lesion studies concerning ventral or dorsal damage, and psychophysical studies utilizing visual illusions. We look at each in turn.

Damage to the ventral stream causes perceptual deficits, including ones in color perception (Damasio et al., 1980; Zeki, 1990), face recognition (Damasio & Damasio, 1983; Gross & Sergent, 1992), and object identification (Farah, 1992). It also sometimes results in *visual form agnosia*, the inability to consciously perceive the orientation, position, or shape of an object (Heider 2000). Much of our knowledge of visual form agnosia comes from patient DF, whose ventral stream was damaged by carbon monoxide poisoning. Remarkably, DF's inability to perceive the shape or position of objects does not prevent her from successfully performing actions toward them. For some examples: DF can easily place an envelope into a slot that varies in orientation (the "posting task") while being at chance when reporting its angle (Goodale et al., 1991), can pick up small, variously shaped objects without being able to say what shape they are (Goodale, Jakobson et al., 1994), and successfully performs numerous other actions (Goodale & Milner, 2004, esp. Chapters 2, 9; Milner & Goodale, 2006, pp. 128–33). More recent data show V1 damage to produce a similar dissociation, one in which a subject's visuomotor system manages to maintain object size constancy, though their reports are more influenced by the object's retinal size (Whitwell et al., 2020).

Moving on to the psychophysical evidence: Here, it consists of studies where illusions affect visual experience more strongly than they do action. One widely discussed experiment involves the familiar Titchener illusion in which two same-sized disks appear differently sized because of the addition of rings of small or large circles. Aglioti et al. (1995) created an interactive version of this illusion by placing disks on a table, asking subjects to both judge the relative size of the two central disks, and to pick them up. The experimenters found that, while subjects reported the two equal-sized disks to differ substantially in size, their grip aperture when picking each up was close to identical (see also, Haffenden & Goodale, 1998). While the validity of these particular studies are contested (Franz et al., 2001; Franz & Gegenfurtner, 2008; Kopiske et al., 2016; but see, Whitwell & Goodale, 2017), there have been numerous other experiments in which a visual illusion differentially affects visual experience and action; these include studies where subjects use the same grip force for two identically sized objects, though a Ponzo ("railway") illusion makes one appear larger (Brenner & Smeets, 1996; Ellis et al., 1999; Jackson & Shaw, 2000; Westwood et al., 2000), and studies where subjects accurately point at a stationary target, though they report it to have moved (Bridgeman et al., 1997; Wong & Mack, 1981). More recent experiments demonstrate subjects to accurately flick targets off of a target that they perceive as being farther than it is (Króliczak et al., 2006); to have their actions adapt to a visual illusion after just a few trials, though this does not happen to their conscious perception (Whitwell et al., 2016); and to be able to aptly grasp an object, though there are crowding stimuli causing a misperception of its size (Chen et al., 2015).

It has been argued, however, that some of these studies suffer from confounds (Franz et al., 2001; Pavani et al., 1999), the idea here being that the dissociations between visual experience and action can be explained as coming from, not a lack of conscious ventral influences on action, but rather from one of a few alternative sources, such as from object avoidance caused by the target being closely crowded (Kopiske et al., 2016), from online adjustments made in response to the visual feedback that becomes available during the action's performance (Bruno & Franz, 2009), or from haptic feedback gained from trial to trial (Schmidt et al., 1989). However, there was a study recently conducted by Whitwell et al. (2018) in which each of these proposed confounds was controlled for, and dissociations were still found. For example: Because a nonsymmetrical visual illusion was used (the Sanders illusion), this meant that the figure could be rotated from trial-to-trial, something that would allow any effects coming from object avoidance to be factored out. And the possibility of visual feedback being used during action performance was prevented by goggles that became translucent when the subject began the grasping motion. Given that the Whitwell et al. study simultaneously addresses many or all of the proposed confounds, it seems to not only give us a particularly compelling instance of a consciousness/action dissociation, but also to lend more credibility to those earlier dissociation studies that were alleged to suffer from these confounds.

As discussed above, the kind of ventral lesion and psychophysical data just reviewed are taken to count strongly against EBC. It seems especially potent against Typicality in particular, since it presents many instances in which the content guiding action appears *missing* from visual experience: In the psychophysical evidence, the subject's visual experience represents a disk as being one size, while the system guiding the grasping represents it as another; in the ventral lesion evidence, the subject successfully performs actions requiring information about an object's shape, orientation, or position, though her visual experience fails to represent these properties at all. The fact that the content guiding action is missing from visual experience suggests that it is not visual experience guiding the actions performed in these studies. But it would be unexpected if, though actions performed with ventral damage or toward visual illusions are guided unconsciously, ones performed under other circumstances (i.e., no brain damage or visual illusion) were guided consciously. So, it seems that the ventral lesion and psychophysical data provide strong prima facie reason to think that actions are, in general, probably not guided by conscious representations, i.e., Typicality is false.

On the other hand, the dorsal stream evidence is ineffective against Typicality: Dorsal damage can result in *optic ataxia*, a disorder mirroring visual form agnosia, in that optic ataxics can successfully report things like the orientation, position, and shape of objects without being able to perform actions such as the posting task (Perenin & Vighetto, 1983, 1988). Optic ataxia has been thought to be vital to the case for dual visual systems theory, since it along with visual form agnosia forms a double dissociation between perception and action (Milner & Goodale, 2008; but see, Rossetti et al., 2017). It is also often thought to be integral to the case against EBC (e.g., Clark, 2001), but this is incorrect in the case of specifically Typicality,[10] since the idea that visual experience frequently guides action is easily reconciled with there being motor deficits in absence of conscious deficits: This is explained as occurring, not because conscious ventral content never guides action, but rather because its content is no longer being transmitted to motor areas, since the ventral stream's usual conduit to them (i.e., dorsal areas) is no longer available.[11]

Putting this aside, it seems that the ventral lesion and psychophysical data alone still constitute a strong prima facie case against Typicality, given the numerous instances that they provide in which the content guiding action is absent from visual experience.[12] The question arises now as to whether there are any arguments or data counteracting this prima facie case against Typicality. However, before investigating this issue, some conceptual matters need to be addressed.

3: What counts as "guidance by visual experience"?

This article's primary purpose is to evaluate data and arguments recently offered to try to show that visual experience plays a greater role in guiding motor actions than is supposed by DVS. This being the case, the question arises as to when we should take visual experience to have "guided" a motor action.

According to one intuitive-sounding standard, visual experience is considered to have guided an action if and only if "it provides the *information* used by the motor system in developing motor instructions" (italics mine, Wallhagen, 2007, p. 543; see also, Briscoe & Schwenkler, 2015, p. 1436; Clark, 2001, p. 570). Here, "information" is most profitably understood in terms of *representational content* (cf., Dretske, 1988, Chapter 3), as this illuminates a key determinant of whether any given action counts as being guided by visual experience, which is whether there is a match in content between visual experience and the motor systems (Mole, 2013; Wu, 2013). This method of *content-matching* (cf., Kozuch, 2015b; Noë & Thompson, 2004) is expanded upon below. For now, let us take with us the following idea, one that we adopt as a seemingly plausible assumption: We should consider "guidance" to have occurred if and only if the content of visual experience was (in some sense) used to direct the action.

Here is a further way in which "guidance" should be understood, given this article's aims: Remember that the primary goal of this article is to determine whether recent anti-DVS arguments compel us to accept the idea that the class of actions guided by visual experience needs to be expanded relative to what DVS takes it to be; let us refer to this thesis as "Expansion." What is central to the debate over Expansion can be brought to light by considering Milner and Goodale's tripartite distinction between types of motor control (Milner & Goodale, 2010): The first is *planning*, which involves specifying, in abstract terms, the action to be performed (e.g., pick up the cup of coffee), and setting the general parameters for the action (such as "the selection of the class of hand postures appropriate to the particular task at hand" (ibid., p. 4)); the second type of motor control is *programming*, which involves setting the specific parameters that will govern the action (things like the grip aperture to be used to grasp the cup's handle, and the precise direction in which one's hand is to be moved); and the third is *online control*, which involves adjustments made to the action after its initiation (e.g., modulating the speed with which one is raising the cup, to prevent spilling).

According to DVS, the ventral stream's role in action is nearly always limited to motor planning, with the dorsal stream directing both programming and online control (Clark, 2001, Milner and Goodale, 1995/2006; Clark, 2007; Milner & Goodale, 2010). However, a number of commentators have argued for Expansion by providing evidence meant to show that visual experience is involved in motor programming in many cases beyond those accepted by DVS (e.g., Briscoe & Schwenkler, 2015; Ferretti, 2019; Schenk & McIntosh, 2010). Given that this is where a major line is drawn in the debate, it makes sense to consider "guidance" to have occurred just in those cases where visual experience actually participates in motor *programming*.

Let us combine this with the thesis discussed above, the one concerning the content of visual experience, so as to give us this (rough) formulation of "guidance":

> Some action A is guided by visual experience if and only if its content was used in the programming (or online control) of that action

Complications will arise when implementing this formulation, but these are more efficiently addressed below.

Before moving on, I should point out that DVS accepts there to be cases – albeit rare – in which the ventral stream might influence motor programming, like when an action is delayed (Hu & Goodale, 2000; Hu et al., 1999; Milner et al., 2001, 1999), or when an object's texture suggests something about its weight (e.g., if its shininess suggests that it is made of heavy metal; Jackson & Shaw, 2000; see also, Milner & Goodale 2006, Chapter 8). Importantly, DVS also holds that slow, deliberate actions can be used as a measure of the content of one's visual experience, e.g., when one uses the spread between two fingers to indicate an object's perceived size. Doing this is common practice in psychophysics (examples include Aglioti et al., 1995; Dyde & Milner, 2002; Freud et al., 2016; Haffenden & Goodale, 1998; Hu et al., 1999; Króliczak et al., 2006).

Given that DVS includes the idea that visual experience contributes to motor programming in these ways, what we will be concerned with below is not whether anti-DVS arguments show that visual experience sometimes programs actions, but rather whether the circumstances in which they show this to occur go beyond those already countenanced by DVS; that is, we will be concerned with whether (and to what degree) the thesis of Expansion is true. Of course, the results of this investigation directly connect back to Typicality, in that whatever support is found for Expansion probably translates directly into support for Typicality.

Sections 4–7: Review of anti-DVS evidence

Having laid the necessary foundations, we can now examine and critique arguments and data recently presented against DVS. The data is of four types, which includes evidence for visual illusions affecting action (Sect. 4); for visual agnosic patient DF possessing motor deficits (Sect. 5); for there being conscious representations in the dorsal stream (Sect. 6); and for there being ventral-dorsal interactions (Sect. 7). The presentation will be business-like: Each of the next three sections starts with a review of the relevant anti-DVS evidence and arguments, to be followed by a critique.

4: Psychophysical evidence

4.1 The evidence

Something that anti-DVS theorists often stress is that, in some of the psychophysical studies, it is not that the visual illusion has *no* effect on action, rather just *less* than the one on visual experience (Briscoe, 2008; Briscoe & Schwenkler, 2015; Ferretti, 2016, 2021a; Schenk et al., 2011). For instance, in the Aglioti et al. study discussed above, the illusion affected subjects' actions roughly half as much as it did their visual experience. Other studies show comparable results (Caljouw et al., 2011; DiLorenzo & Rock, 1982; Haffenden & Goodale, 1998; Króliczak et al., 2006). Briscoe and Schwenkler in particular believe that it is a significant oversight that philosophers (e.g., Clark, 2001) sometimes present these studies as showing illusions have *no* effect on action, since the effects shown in these studies act as "evidence that consciously encoded spatial information will make measurable contributions to motor programming … even when action is performed under ideal conditions for dorsal control" (2015:21; see also, Briscoe, 2008). Briscoe and Schwenkler also assert that actions are "fully susceptible to the effects of visual illusions" (ibid., p. 21; see also, Briscoe, 2008) except under very specific circumstances, namely, only when an action is well-practiced (Gonzalez et al., 2008), performed rapidly (Carey, 2001; Króliczak et al., 2006; Rossetti et al., 2005), right-handedly (Gonzalez et al., 2006), *and* with binocular vision (Goodale & Milner, 2004; Marotta et al., 1998).

Similarly, Shepherd appeals to certain psychophysical studies when presenting support for visual experience making a "critical causal contribution" to action (2015b). The first is a study in which the experimenters altered a visual illusion when subjects were midway through performing an action, something that resulted in the visual illusion more strongly affecting the action (Caljouw et al., 2011). The second is a study showing that the amount of time that a golfer visually fixates the hole while putting positively correlates with making the shot (Vine et al., 2013). Since this longer "quiet eye duration" (Mann et al., 2007) might be construed as a successful allocation of attention (something perhaps associated with consciousness; but see 3.2.2), this study could present an instance in which visual experience contributes to the success of action. These two studies are of particular interest, since they might be taken to show that visual experience sometimes participates in the *online* guidance of action, something that even ardent critics of DVS often do not take to occur (e.g., Rossetti et al., 2003).

4.2 Evaluation of the psychophysical evidence

I present three criticisms of the arguments just given, each in its own subsection.

4.2.1 Minor effects on motor action from visual illusions

The first criticism concerns the contention that if actions are affected in any way by visual illusions (even if this effect is less than the one on visual experience), then this means that visual experience can be said to have guided the action. Something important to point out here is that these motor effects are not evidence for visual experience guiding action unless there is reason to think that they actually come from visual experience. In the next section, ample reason will be given to doubt this. But even if these partial effects *did* come from visual experience, they are best interpreted as presenting something less than instances in which visual experience has "guided" action. I will explain.

The criterion established above said that guidance occurs only when the content of visual experience was used to program that action. The question is whether we should consider guidance to have occurred in those cases where visual experience only *partially* determines the content driving motor. There is precedent against this: Researchers on both sides of the debate have taken it to be the case that the visual illusion studies cast doubt on EBC unless there is an actual *match* in content between the system guiding action and the system creating conscious perception. Thus, both Mole (2013) and Wu (2013) agree that what is essential to the debate over the Titchener illusion studies is not whether the motor systems represent the objects' sizes *accurately* (in the Titchener studies, they do not), only whether the motor systems represent them *differently* from how visual experience represents them.[13] As I explain now, there seems to be good reason for this.

Remember the motivation for EBC, this being that the rich, detailed content found within visual experience seems ideal for guiding precise actions. However, the content guiding action and the content within visual experience cannot be the same if they are not (type-) identical,[14] in which case a content mismatch is enough to show that the kind of scenario described by EBC – one in which it is the content that is found within visual experience that is guiding action – does not obtain. If so, these partial motor effects should not be considered to count significantly in favor of Typicality. Similarly, we should not consider these partial effects to count significantly against the DVS view on how visual experience and action relate (or to count significantly in favor of Expansion), given that the conscious influences occurring in these cases are of a much weaker sort than those that would be in play in cases where the content of visual experience fully determined the content driving action. To mark the difference, we can say that in cases where visual experience has just partial effects on action, visual experience has (merely) "modulated" the action, reserving the term "guidance" for when visual experience provides the very content used to guide an action.

But remember now that these effects on action by a visual illusion can be considered to support Expansion/Typicality only if it is thought that they actually come from visual experience. As seen next, there is reason to doubt this.

4.2.2 Alternative explanations of effects on motor action

As discussed above, commentators have recently argued against DVS by appealing to data in which visual illusions have a (full or partial) effect on action, the idea being that these effects should be attributed to visual experience. Schenk and colleagues in fact take these effects to "rule out a strong version of [DVS], according to which visually guided actions always bypass the content of conscious perception" (Schenk et al., 2011, p. 813). But this is too quick.

This is because there are plausible explanations according to which the motor effects arise without any input from visual experience. Instead, the effects might arise because the visual illusions affect processing in early visual areas (e.g., the primary visual cortex), areas tributary to both the dorsal and ventral stream (see, e.g., Dyde & Milner, 2002). In such a case, the conscious ventral stream is entirely bypassed, with the effects on action instead arising because representations in early visual areas – representations that are unconscious (Prinz, 2012, Chap. 2; Rees et al., 2002) – are what provide the visual content used by the unconscious dorsal stream to guide the inaccurate action. This might occur because the nature of the visual illusion is such that it is prone to arise within early visual areas (Dyde & Milner, 2002; Milner & Dyde, 2003), or because of top-down effects from higher areas (Fang et al., 2008; Murray et al., 2006), where these effects are possibly the result of a modulation by attention (Fischer & Whitney, 2009; Ito & Gilbert, 1999; Somers et al., 1999; Tootell et al., 1998). Indeed, it is plausible enough that actions that are performed monocularly, slowly, or without practice (i.e., the kinds of action appearing in the studies to which Briscoe and Schwenkler appeal) would require extra attention and therefore result in these kinds of top-down effects;

perhaps this is why Shepherd attributes the motor effects observed in the Vine et al. putting study to attention. And yet another alternative is that the effects in question arise because the dorsal areas themselves are affected by the illusion (de la Malla 2019).

Two responses could be made here. The first is that top-down effects occurring as a result of attention *are* instances where visual experience is guiding action, since consciousness is identical to attention (Prinz, 2012). There are, however, powerful arguments and data speaking against both the necessity (Lamme, 2003; Koch & Tsuchiya, 2007; Kozuch, 2018; Tsuchiya & Koch, 2008) and sufficiency (Kentridge, 2011; Norman et al., 2013) of attention for consciousness, thus this response looks weak. The second response is that the top-down effects might come from ventral areas, in which case they could be attributed to visual experience; however, even if they do (we just saw reasons to doubt this), not all ventral representations are conscious (Milner & Goodale, 2010; Schenk & McIntosh, 2010), meaning it would still be unclear whether the effects could be attributed specifically to visual experience.

It seems, then, that a visual illusion having (partial or full) effects on action is not enough to show that visual experience guided (or modulated) an action – not until it can be shown that conscious ventral representations are responsible for the effects.

4.2.3 Studies where visual illusions purportedly affect visual experience and motor action equally

As seen above, Briscoe and Schwenkler argue that visual illusions affect action less than visual experience only under "specific conditions" (Briscoe & Schwenkler, 2015, p. 1454), viz., when an action is performed rapidly, binocularly, right-handedly, and is well practiced (see also, Briscoe, 2009). Briscoe and Schwenkler (see also, Ferretti, 2019) take this to contradict the "deep and abiding dissociation between the contents of conscious seeing . . . and the resources used for . . . visuoaction" (Clark, 2001, p. 495). However, as discussed above, advocates of dual visual systems theory (e.g., Milner & Goodale, 2006; Clark, 2001, 2007; Goodale, 1998) already take some types of action to be potentially guided by visual experience (e.g., actions that are delayed). What I argue now is that Briscoe and Schwenkler do not succeed in expanding this list in any significant way (i.e., they give little support for Expansion).

We start by considering one of the experiments that Briscoe and Schwenkler use to support the idea that visual illusions fully affect *slowly* performed actions (Króliczak et al.. 2006). The experiment utilized an illusion in which a concave face is made to look convex by lighting it from below (the "hollow face illusion"). In one condition, subjects were "asked to flick the small magnet off the face as quickly and accurately as they could" (p. 12), a task that they could perform easily, despite the face's illusory appearance. In a second condition, subjects were "instructed to point directly to the location where they perceived the target" (ibid., p. 12); here, the illusion significantly affected their actions. Apparently, Briscoe and Schwenkler's intention here is to use the second condition as evidence for slow action being affected by visual illusions. However, the "slow pointing movement" (as it is described by Króliczak et al. [p. 12]) that the subjects were instructed to carry out in this second condition is intended to be a "perceptual" measure (p. 11–12), i.e., a measure of the *content of visual experience*. As mentioned above, it is in fact quite common in psychophysics to use a patient, deliberate action like the pointing motion in this study to measure conscious perception (see Sect. 2 for references).[15] But it is of course no surprise if a measure of the content of visual experience reflects the effects of a consciously experienced visual illusion! And so the Króliczak study does not help Expansion.

The same is true of the other study meant to support visual illusions affecting slow actions. In this experiment (Rossetti et al., 2005), the task was to point at a target's location, but subjects were not cued to do so until several seconds after their visibility of the target was lost (the lights being shut off). However, it is hard to see how these actions would be correctly classified as being "slow," since (1) subjects were not asked to point slowly, and (2) the velocity of their actions was not measured. Additionally, actions performed under these conditions are typically not considered to be "slow," but rather "delayed," this being true not only in the present study, but also in many others (e.g., Hu and Goodale, 2000; Hu et al., 1999). In any case, these kinds of delayed action are already widely accepted as candidates for being guided by visual experience, including by DVS theorists (Milner & Goodale, 2006; Goodale, 1998; Clark, 2001, 2007), and so the Rossetti study also fails to help Expansion.

Next, we look at the Gonzalez et al. study (2006) meant to support left-handed actions being fully affected by visual illusions. In this experiment, the task was to grasp targets embedded in an Ebbinghaus or Ponzo illusion, and it was shown that actions performed left-handedly were more affected by the visual illusion than those performed right-handedly.[16] First, as the experimenters themselves discuss, the hand effect can be explained without hypothesizing it to have resulted from increased ventral and/or conscious influences, it instead occurring because of hemispheric asymmetries, perhaps due to the left hemisphere's specialization in tool use (Kimura, 1993). Indeed, the latter explanation is simpler, since the former explanation implies that, while right-handed actions are guided by conscious ventral representations, left-handed actions will be guided by unconscious dorsal representations, an odd and hard-to-explain asymmetry. Putting this aside, a more fundamental reason for which these studies are not evidence for action being *fully* affected by a visual illusion is that the study did not include a "perceptual" measure, i.e., a measure of the content of visual experience; given this, it is of course impossible to say whether the illusion affected visual experience and action *equally*. And so this study is also not an instance of an action being fully affected by a visual illusion.

Two of the other studies that Briscoe and Schwenkler cite (Carey, 2001; Goodale & Milner, 2004, p. 92) fail to establish their intended conclusion for reasons similar to those offered just above.[17] This leaves just two of the studies that Briscoe and Schwenkler cite – one each in the case of monocular and unpracticed actions – look as if they potentially present an instance of visual experience fully determining the content of an action; just "potentially" because they cannot count as such until the alternative explanations discussed in the last subsection (ones in which visual experience plays no role) are ruled out.

5: Neuropsychological evidence

Some commentators have pointed out recent studies in which DF presents with motor deficits, arguing that these give reason to think that visual experience and/or the ventral stream plays a greater role in motor action than is countenanced by DVS (Briscoe & Schwenkler, 2015; Schenk & McIntosh, 2010; Zipoli Caiani & Ferretti, 2017). This section describes and gauges the significance of these deficits.

5.1 The evidence

There are three new lines of neuropsychological evidence possibly supporting an increased role for visual experience in action. We examine each in turn.

The first concerns actions DF was previously thought to carry out without difficulty. Himmelbach et al. (2012) have argued that DF does not perform at the level of controls in some of the tasks that Milner and Goodale used when originally examining DF: A comparison of her performance in these original studies (Goodale, Meenan et al., 1994; Goodale et al., 1991) to data newly generated by Himmelbach et al. shows that, while DF's performance was at the level of controls when asked to grasp variously sized rectangles, she showed a minor impairment in the posting task, and a significant one when grasping irregular shapes. Himmelbach and colleagues conclude that "DF's performance … suggests an interaction between [the ventral and dorsal] systems up to a level that makes it difficult to speak of functionally dissociated pathways" (p. 143).

The second line of evidence includes deficits that DF displays when performing actions while looking through a prism (Mon-Williams et al., 2001), using just one eye (Carey et al., 1996; Dijkerman et al., 1998, 1999), or when directing them toward peripherally located objects (Hesse et al., 2012). Briscoe and Schwenkler draw broader lessons from these deficits, concluding that "even in those conditions where DF's actions appear fully normal, the strategies she uses to program her actions may be different from those of normal subjects with a functioning ventral stream" (2015:1448); they also point out how non-brain damaged subjects perform "relatively normally" under conditions where binocular depth cues are unavailable, something that indicates to Briscoe and Schwenkler that "there is some redundancy in the visual information ordinarily used for motor programming" (ibid.; see also, Himmelbach et al., 2012; Schenk & McIntosh, 2010).

The third line of evidence comes from experiments where DF has difficulty performing tasks involving geometrically complex shapes. More specifically, she appears unable to reliably fit a T-shaped object into a T-shaped slot, often rotating it to a position perpendicular to its proper orientation (Goodale et al., 1994). DF also shows insensitivity to the orientation of an X-shaped object when picking it up, in that she seems to orient her hand the same regardless of the object's rotation (Carey et al., 1996). In another study (Dijkerman et al., 1998), DF was asked to pick up disks with three holes cut in them; one hole sat in opposition to the others, making it a natural place to put one's thumb. In this task, DF often placed her fingers into the wrong holes, oriented her wrist incorrectly, or failed to fit each finger into a hole. DF's inability to perform these more complex tasks is sometimes taken to suggest that information within visual experience is required for effectively carrying them out (Briscoe & Schwenkler, 2015; Schenk & McIntosh, 2010).

5.2 Evaluation of neuropsychological evidence

We first examine the Himmelbach et al. study, the one in which DF performs at a level below controls when carrying out the posting task and when picking up irregularly shaped objects. This might be taken to support an increased role for visual experience in action. However, it turns out that more recent MRIs of DF's brain have shown her to have not only ventral damage, but also dorsal damage (Bridge et al., 2013; James et al., 2003), and this is probably what explains the small motor deficits from which to suffers (Ganel & Goodale, 2017; Kozuch, 2015a; cf., Hesse et al., 2012; Briscoe & Schwenkler, 2015). More specifically, it appears as if DF has minor optic ataxia, since (a) her deficits resemble those found in this disorder (Perenin & Vighetto, 1983, 1988), in that they occur when an action is performed toward the periphery (Hesse et al., 2012), and (b) her dorsal damage is in the same area that causes optic ataxia, the intraparietal sulcus (James et al., 2003). Given this, the deficits revealed in the Himmelbach et al. study probably "do not contradict claims by the [dual visual systems] model, but serve as evidence for a functional deficit in DF's dorsal stream areas" (Hesse et al., 2012, p. 96), in which case these data do not support visual experience playing some significant role in action.

Next, we examine the studies where DF has difficulty performing actions monocularly or through a prism, or in handling geometrically complex objects. As seen above, Briscoe and Schwenkler take this as evidence for conscious ventral content being required, not only for these kinds of action, but also for more straightforward ones (e.g., actions not performed monocularly, or through a prism), and they believe that DF is able to perform at the level of normal subjects only by utilizing different strategies from normal subjects. Perhaps Briscoe and Schwenkler's idea here is that, while normal subjects use conscious ventral content to guide these straightforward actions, DF's ventral lesion means that she relies solely on dorsal content, with this being what causes her sometimes somewhat poor performance. But this again is just as well explained as occurring because of her dorsal damage: Perhaps the reason that she shows deficits in the case of (what we might call) "difficult" actions (e.g., handling geometrically complex objects) but not "straightforward" ones (e.g., grasping geometrically simple objects) is because damage to DF's dorsal stream is only bad enough to affect her difficult actions, but not her straightforward ones. This alternative explanation is particularly plausible given that DF's dorsal lesion appears relatively mild (James et al., 2003),[18] and also includes the area responsible for grip choice (Wood et al., 2017), something probably especially important when handling geometrically complex objects.

Additionally, it is difficult to reconcile Briscoe and Schwenkler's "Different Strategies" explanation with the psychophysical data: If in the case of mundane ("straightforward") actions, DF uses different strategies because of ventral damage, this implies that normal subjects typically use conscious ventral content to guide actions. But if this were the case, how are the psychophysical data to be explained? As we saw above (Sect. 3), the effects that visual illusions have on actions are rare, nearly always incomplete, and do not necessarily come from visual experience. Given this, it seems that the Different Strategies explanation might have to say that, though visual experience typically guides everyday actions, it suddenly has markedly less influence when actions are performed in situations involving visual illusions. This seems implausible.

Overall, the neuropsychological evidence in which DF displays motor deficits does not help Expansion much, in large part because her deficits are equally well explained by her dorsal damage.

6. Consciousness and the dorsal stream

As discussed above, a primary function of the dorsal stream is to prepare visual information for use in motor action. This means that if we had evidence for conscious representations in the dorsal stream, this might open the door to there being conscious representations guiding actions. This section assesses arguments that have been made in support of dorsal consciousness.

6.1 The dorsal stream evidence

It was recently argued that dorsal areas V3A and V7 produce conscious representations of object distance and motion (Prinz, 2012, Chap. 6; Wu, 2014a).[19] There are three studies to whichthese arguments appeal: an imaging study where V3A/V7 showed increased activity when subjects were asked to report on the egocentric distance of objects (Committeri et al., 2004); a study in which V3A/V7 damage produced deficits in estimating object distance (Berryhill et al., 2009); and a study where disrupting activity in V3A caused subjects to judge objects to be moving more slowly (McKeefry et al., 2008). Additionally, several commentators (Block, 2007; Prinz, 2012, Chap. 6; Schenk & McIntosh, 2010; Zeki, 2003) have argued that another area sometimes classified as part of the dorsal stream, area MT, produces conscious representations of motion, on the basis of correlations between consciousness of motion and activity in MT, demonstrated in both neuroimaging (Heeger et al., 1999) and neuropsychological (Walsh et al., 1998; Zihl et al., 1983) studies. Finally, Gallese (2007) uses the neuropsychological disorder of hemispatial neglect to support the idea of dorsal consciousness, arguing that it is a case in which damage to the dorsal stream has led to deficits of consciousness (Ferretti, 2016, 2021a; Nanay, 2013, Chapter 3).[20]

6.2 Evaluating the dorsal stream evidence

If the above studies support Expansion, they need to produce examples of conscious visual representations guiding action. For this, we need evidence showing that representations in V3A, V7, or MT are both (1) used in action and (2) conscious. So far, the evidence is incomplete (see also, Kozuch, 2015a).

In the case of (1), what needs to be shown is that representations in V3A, V7, or MT guide action. One would probably establish this by appealing to correlations between activity in these brain areas and action. Some evidence exists in the case of MT, since MT lesions can result in motor deficits (Schenk et al., 2000), but there is no similar evidence with V3A/V7.

Nonetheless, since V3A/V7 are located within the dorsal stream, and the dorsal stream is associated with action, the idea that V3A/V7 representations guide action has some plausibility.

In the case of (2), what needs to be shown is that representations in V3/V7 and/or MT are conscious. So far, the evidence supporting this is merely suggestive, since it consists of correlations between visual experience and consciousness. But these correlations can be accounted for without hypothesizing dorsal representations to be conscious. Consider the two things needing to be explained about these data: (a) why damage to these areas causes deficits in conscious distance or motion perception, and (b) why there is increased activity in these areas during conscious distance or motion perception. These data could be explained by activity in these areas producing conscious representations; however, they could also be explained by these areas merely being what supplies distance or motion information to some other brain area A (e.g., some ventral area), where A is what actually produces the conscious representations. So, for (2) to be truly supported, we need reason to think that there are no other candidates for producing conscious representations of these types. Providing such reason plausibly requires either (a) arguing that there are no probable alternative candidates for producing these conscious representations, or (b) first identifying plausible alternative candidates for producing such representations, then ruling out these alternative areas from actually producing them. In the case of the three areas we are considering, this is not yet done.

Now, it is true that the idea that MT produces conscious motion representations has often been endorsed. However, this idea should be reassessed: MT has been recently reclassified from being a mid-level to an early visual area (Milner & Goodale, 2006, Chap. 8; cf., Schenk & McIntosh, 2010), putting MT in the same category as the primary visual cortex, an area widely thought to operate unconsciously (Prinz, 2012, Chap. 2; Rees et al., 2002). Indeed, it has been convincingly argued that representations in general will not become conscious until they reach mid-level processing (Prinz, 2012, Chapter 2). Given all this, we must entertain the idea that content in MT is not conscious, but rather must be transmitted to another (probably ventral) area before becoming conscious (Goodale & Milner, 2010; Milner & Goodale, 2006, Chapter 8).

Finally, we discuss Gallese's argument (Gallese, 2007): Damage to the right inferior parietal lobe (IPL) (an area sometimes classified as part of the dorsal stream) causes hemispatial neglect, a disorder in which the patient fails to notice items located in their left visual field (or, in a different variety, the left part of objects; Vuilleumier et al., 2001). However, neglect supports dorsal consciousness only if neglect actually involves deficits of consciousness, and while this interpretation is frequently assumed (Briscoe, 2009; Driver & Vuilleumier, 2001; Ferretti, 2016; Prinz, 2012, Chap. 3; Vosgerau et al., 2008), it is also frequently denied, in favor of the idea that it is merely a disorder of attention (Block, 2007; Brogaard, 2011a, 2011b; Jacob & de Vignemont, 2010; Kozuch, 2014, 2015a; Lamme, 2006), something made plausible by the IPL's participation in an attentional network (Bartolomeo et al., 2007; Mesulam et al., 1999). This latter explanation has parsimony on its side given that a neglect patient's inability to attend left-located objects alone would be sufficient for failing to report on them, whether or not the patient phenomenally experienced them (cf. Kozuch, 2018; Wu, 2014b, Chapter 5). Consider, additionally, that if right IPL damage caused an inability to consciously perceive left-located items, it seems strange that it is only rarely that damage to left IPL produces an inability to consciously perceive right-located items; even stranger is the fact that *bilateral* IPL damage never leads to an inability to consciously perceive objects in *both* visual fields (Pierrot-Deseilligny et al., 1986; Cazzoli et al., 2012).[21] Finally, even if neglect did include conscious deficits, this does not entail that there must be conscious dorsal representations, as the deficits are equally (if not more) plausibly explained by IPL merely enabling the consciousness of ventral representations, rather than IPL actually *having* conscious representations (Brogaard, 2011a, 2011b; Ferretti, 2019, p. 1292; Kozuch, 2015a).

Overall, while one might hope to support a larger role in motor action for visual experience by arguing for dorsal consciousness, the evidence so far looks merely suggestive.

7. Interstream interactions

Recent years have seen the appearance of evidence for ventral/dorsal interactions (for review, see, Cloutman, 2013), something that arguably implies that conscious ventral representations are sometimes used by the dorsal stream to program motor actions. Let us examine the case for this.

I start by noting the many theoretical arguments offered in favor of dorsal/ventral interactions (Briscoe, 2009; Chinellato & Del Pobil, 2016; Ferretti, 2016, 2019; McIntosh & Lashley, 2008; Zanon et al., 2010). These are often based on the idea that ventral-to-dorsal influences will be required for many actions, since just the ventral stream processes certain object-attributes required for the everyday interactions that we have with real-world objects (e.g., in the case of a coffee mug, things like "its weight, how full the cup is, and [its] temperature" (Briscoe, 2009, p. 431)). In similar spirit, Chinellato and Del Pobil (2016) offer a detailed theoretical model of how visuomotor action unfolds in the primate visual system, one in which the ventral stream influences dorsal processing in a few different ways.[22] One of their more relevant hypotheses is the idea that the (ventrally located) lateral occipital cortex (LO) influences activity in the (dorsally located) anterior intraparietal sulcus (AIP), providing AIP with information about things such as an object's estimated size, as learned from previous experience with that object (2016, Chap. 6; McIntosh & Lashley, 2008). Several other researchers endorse LO or some other higher ventral area playing such a role (Borra et al., 2008; Zanon et al., 2010), sometimes claiming that these ventral influences are conscious (Briscoe & Schwenkler, 2015). Other arguments for frequent ventral influences on everyday action have come from studies in which prior experience with an object has been shown to increase the effects that a visual illusion has on action (McIntosh & Lashley, 2008; but see, Marotta & Goodale, 2001).[23]

While these theoretical arguments for ventral-to-dorsal influences have intuitive plausibility, it is questionable how many of these potential ventral influences can be considered to be motor *programming* rather than *planning*. It has been argued, for example, that motor effects coming from prior experience (like those seen in the McIntosh and Lashley study mentioned above) reflect "a modulation of dorsal stream programming mechanisms by high-level ventral stream processing, rather than a ventral stream share in the motor programming itself" (Goodale & Milner, 2010, p. 66); the idea here is that ventral areas do not provide the parameters used to govern the action, but rather just indicate which preexisting motor representations should be activated (Chinellato & Del Pobil, 2016, p. 151). Putting this concern aside, the question remains as to how much empirical evidence backs up these theoretical arguments. As it turns out, not much.

While evidence exists for anatomical connections between ventral and dorsal areas (Borra et al., 2008; Fogassi & Luppino, 2005; Zanon et al., 2010), these connections do not tell us the nature of the interactions that they enable. And when we do examine the studies commonly cited in support of interstream interaction, what we find is that, in each case, they are not naturally interpreted as instances of ventral-to-dorsal interactions, but only the opposite: In a study by Zanon et al. (2010), what was shown was that TMS applied to the left parietal cortex (i.e., the dorsal stream) would cause activations in ventral areas (left middle temporal and fusiform gyri), something that of course suggests only *dorsal-to-ventral* influences. In another oft-cited study (Perry et al., 2014), the effects of an illusion on visual experience were reduced by providing cues processed by the dorsal stream,[24] a result again implying only dorsal-to-ventral influences. In one more study (Verhoef et al., 2011), neural synchrony was observed between AIP and the inferior temporal cortex (IT) during a 3-D shape discrimination task, a function carried out by ventral area LO; this is again most naturally interpreted as dorsal-to-ventral influences, since it appears that AIP is aiding LO in making the discrimination; additionally, the synchrony in question occurred only after "the system had stabilized to a particular perceptual state but not during active visual processing" (p. 2041), where the latter is what is probably needed if we seek evidence for ventral guidance of action.

Overall, there appears to be precious little evidence for ventral influences on action, let alone for motor programming. On the other hand, there is evidence against this idea, in the form of a failure to find correlations between the task demands of an action and the amount of activity in LO (Culham et al., 2003; see also, Prado et al., 2005; but see, Briscoe & Schwenkler, 2015, p. 1453). Of course, the lack of direct evidence for ventral-to-dorsal influences cannot be taken to mean that these influences are necessarily few in number, given the strength of the theoretical arguments considered above. But it does mean that we so far lack the kind of evidence needed to draw the conclusion that the ventral stream frequently participates in motor programming. Finally, we should not forget a point raised above, which is that not all ventral activity is conscious (Milner & Goodale, 2010; Schenk & McIntosh, 2010), in which case evidence for ventral-to-dorsal influences alone does not count as evidence for visual experience guiding action.

8: Conclusion

The theory of DVS takes visual experience to be involved in motor programming under only tightly circumscribed situations, such as when movements are delayed, or when one makes a deliberate gesture meant to indicate their perceptual state. In this article, we have considered a range of evidence thought to gainsay this, and found it to be lacking: In the psychophysical experiments, the effects caused by visual illusions are rare, nearly always partial, and are easily explained without giving a role for conscious ventral activity; in the case of DF's motor deficits, many of them are probably not occurring because of a lack conscious ventral activity, but rather from a mild optic ataxia coming from her dorsal damage; in the case of the dorsal stream, we really only found reason to consider V5 as a candidate for producing conscious representations, but V5 is probably best construed as not part of the dorsal stream proper; and in the case of interstream interactions, all we found were instances of dorsal-to-ventral influences, and not the opposite.

Since the anti-DVS evidence that we have considered in this article does not amount to much, this of course means that the theses being evaluated in this article, Expansion and Typicality, have correspondingly found little support: We have found neither reason to think that the list of types of action taken to be guided by visual experience needs expanded beyond what DVS takes it to be, nor reason to think that visual experience typically guides action (where this latter idea is arguably ta commitment of the folk view on how the two relate).

Perhaps future data will reveal an important role for visual experience in action, one in which its content is frequently used by dorsal areas to construct actions.[25] Until then, there appears to be a good case for saying that: If one investigates the issue of how often motor systems employ conscious visual information when guiding action, the answer seems to be: very rarely.

Endnotes

1. It is interesting to note that the "fine-grained nature" of visual experience that many of these researchers assume is belied to some degree by the poor acuity that we have in peripheral vision, a result of the diminishing numbers of photopic receptors found there.
2. For a review of the debates concerning DVS and the Libet data, and a discussion of how DVS and the Libet data both suggest a "local" form of epiphenomenalism, see Kozuch, 2020.
3. For textual evidence for these researchers supporting the formulation appearing just below, see Kozuch, 2015a, esp. 580–81.
4. For textual evidence for this claim, and for an argument that the folk view includes a Directness Clause, see Kozuch, 2015, esp. 580–81.
5. A detailed argument for the idea that this dissociation would falsify Directness, along with an analysis of Directness itself, is found in Kozuch, 2015, pp. 580–82. It should be noted, however, that whether this is the case is orthogonal to the aim of this article, which is to evaluate Typicality.
6. Arguments for dorsal representations not being conscious are found in Brogaard, 2011a, 2011b; see, esp. Kozuch, 2015a; one is also found below, in Sect. 6. The strongest argument to the contrary is probably found in Wu, 2014a.
7. I am considering *representations* to be mental states whose function is to indicate the presence of some property (e.g., redness or roundness), and *contents* to be whatever specific property a representation has as its function to indicate (e.g., redness or roundness; Dretske, 1988, Chap. 3; Tye, 1995, Chapter 4). Important here is the idea that ontologically distinct representations might have identical contents, as this makes it possible that visual experience might *indirectly* guide actions (see next footnote).
8. To clarify: The idea here is that there is an instantiation of content C in the conscious ventral stream (call this particular instance "C-v"), one which then causes an instantiation of content C in the dorsal stream (call this instance "C-d"), where C-d is then (directly) used to guide action. So, the contents of the ventral and dorsal streams would be of *type*-, but not *token*-, identity. Given this, we can distinguish Typicality from Directness by saying that the former requires just that that the contents driving action and those found in visual experience be type-identical, whereas the latter requires token-identity.
9. But even if it were not part of the folk view, it is still a component of an oft-advocated thesis, i.e., EBC (e.g., Mole, 2009; Peacocke, 1992; Wallhagen, 2007).
10. It *is* effective, however, against Directness; see Kozuch 2015a, esp. pp. 555–8.
11. Thus it turns out that establishing a double dissociation between visual consciousness and action is not necessary (or even useful) for casting doubt on Typicality; this seems to be an interesting way in which the dialectic shifts once the focus is not on evaluating EBC as a whole, but rather just Typicality.

12. Another line of argument that might be used against EBC is to say that conscious ventral representations cannot be used to guide action, since they are "allocentric" (object-centered) representations, whereas what is needed for guiding actions are "egocentric" (viewer-centered) representations (Milner & Goodale, 2006, Chapter 4). However, recent developments in the debate obviate the need for a pro-EBC response here, since DVS theorists recently clarified their position as being one in which it is allowed that ventral processing will use both allocentric and egocentric representations (Foley et al., 2015).
13. That this is the case quickly becomes evident if one reviews the formal arguments against EBC that Mole and Wu construct. For example, Wu's argument against EBC uses premises saying that "the visual representation controlling reach represents the disc as size x," and that the "conscious visual representation controlling report represents the disc as size y, where y does not equal x" (2013:7–8); similarly, Mole construes the argument against EBC to be one claiming that "the system controlling reaching represents the discs as different sizes," while "it is not the case that the system responsible for conscious awareness represents the discs as different sizes" (2009:997). Note that, in both cases, there is no claim that the representation controlling reaching is veridical.
14. Remember that type-identity is enough for Typicality to be supported, with token-identity being a more appropriate standard in the case of the Directness Clause (see 1.1, esp. fn. 8).
15. For instance, in the Aglioti et al. study, experimenters had subjects indicate how large they perceived a disk to be by using the distance between their thumb and forefinger.
16. Important to note is that this is not because of some kind of "practice effect" that the right-handed effect occurs: Both right- and left-handers express the effect in their right hand.
17. One does not involve visual illusions (Goodale & Milner, 2004, p. 92), and the other does not provide instances of an action being fully affected by visual illusions (Carey, 2001).
18. Her dorsal lesion being relatively mild can be inferred from her intraparietal sulcus showing normal levels of activity when performing actions.
19. While V3A and V7 are often considered dorsal areas, they provide input to ventral areas as well (Felleman & van Essen, 1991).
20. It was recently argued that we cannot know that dorsal representations lack consciousness, since the reports used to indicate this are just as easily explained by dorsal representations simply being inaccessible (Kozuch, 2015b; Wu, 2020). Unfortunately, addressing "skeptical"-style objections like these go beyond the scope of this article. It can be said, however, that such arguments are applicable to not just the dorsal stream, but to *any* brain area whose content we suspect might be inaccessible (V1, the thalamus, etc.). This is to say: Such arguments do not uniquely target what I am arguing for her, but rather *all* arguments aimed at showing a brain area is non-conscious.
21. One might respond to these objections by *identifying* consciousness with attention (Prinz, 2012), but something that we saw above is that this is contentious (see 3.2.2), even more so because crucial support for this identity comes from hemispatial neglect itself (Prinz, 2012, Chapter 1).
22. The ventral stream is hypothesized to do things such as provide estimates of the object's size, weight, distance, and roughness, and to possibly play a role in activating whatever motor coding might already be associated with the object (p. 151).

23. McIntosh and Lashley fabricated oversize versions of familiar objects (e.g., matchboxes), something that caused subjects to use grip apertures too small for the object.
24. In this case, cues involving variance in speed.
25. Something that might be thought to be more promising here would be the idea that conscious ventral representations contribute to types of action that are not yet skilled or performed with automaticity (e.g., Ferretti, 2021b), an idea that is in kinship with Briscoe and Schwenkler's Control Thesis, which holds that conscious ventral information is required for actions that are "complicated, delicate, or unfamiliar" (2015:1438).

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No potential conflict of interest was reported by the author(s).

Notes on contributor

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