Is action-guiding vision cognitively impenetrable?

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Abstract

The aim of this paper is to argue that action-guiding vision is not cognitively impenetrable and arguments that suggest otherwise rely on an unjustified identification between action-guiding vision and dorsal vision – a functional and an anatomical way of describing the mind. The examination of these arguments show the importance of making a distinction between the functional and the anatomical level when addressing the problem of cognitive penetrability.

Keywords: Cognitive impenetrability; dorsal vision; action-guiding vision; perception and action; multimodal perception; top-down influences on perception

The impenetrability of conscious versus unconscious perception

There are notorious ambiguities in the formulation of the cognitive penetrability debate. Some of these has been acknowledged and (more or less) resolved, like the one about the various senses in which a mental process could be considered to be cognitively penetrable (Fodor 1983). A seemingly simpler but often unacknowledged ambiguity is not about the predicate of the claim that perception is cognitively impenetrable, but its subject.

It seems that when philosophers and psychologists talk about the cognitive penetrability or impenetrability of perception, they mean very different things by ‘perception’. Some (mostly philosophers) mean conscious perceptual experience (Lyons 2011, Siegel 2011), some others (mostly psychologists) mean perceptual processes in general, conscious or unconscious. As perception can be conscious or unconscious, even if it is true that conscious perceptual experience is cognitively penetrable (or impenetrable), this should not be generalized to unconscious perception and, as a result, to perception in general.

This distinction is especially important if we consider the following possibility. Many philosophers and psychologists now assume some version of the claim that conscious experiences are cognitively penetrable. But this leaves open the question whether unconscious perceptual states are cognitively penetrable. More specifically, this leaves open whether the most compelling cases for unconscious perceptual processes, namely, the ones that guide our goal-directed actions, are cognitively impenetrable.

According to a more and more influential view, the unconscious perceptual, or, more precisely, visual, processes that guide our goal-directed actions, which we can call ‘action-guiding vision’ is cognitively impenetrable (Milner 2008, Goodale & Wolf 2009, Raftopoulos 2001, 2005, Norman 2002, Goodale 2011, Jacob & Jeannerod 2003, Jeannerod & Jacob 2005, Jacob 2005, Milner & Goodale 1995, 2008, Goodale & Milner 2004, Rizzolatti & Matelli 2003). For many philosophers and psychologists, the last refuge of the cognitive impenetrability thesis is unconscious action-guiding vision.

My aim is to argue that action-guiding vision is not cognitively impenetrable and arguments that suggest otherwise rely on an unjustified identification between action-guiding vision and dorsal vision – a functional and an anatomical way of describing the mind. The examination of these arguments show the importance of making a distinction between the functional and the anatomical level when addressing the problem of cognitive penetrability.

Action-guiding vision

I call ‘action-guiding vision’ those, mainly unconscious, processes in visual perception that help us to perform the goal-directed movements of our actions. But why should we assume that there is such processes? And why should we think that they are unconscious?

The main reason for thinking that there is such a thing as unconscious action-guiding vision is that in certain circumstances, our conscious visual experiences represent the world differently from the way the perceptual processes that help us to perform goal-directed actions do (see, e.g., Loach et al. 2008, Xu et al. 2012). The most important examples for this comes from the study of optical illusions.

A number of optical illusions mislead our perceptual experience but not (or much less) our action-guiding vision. One such example is the three dimensional Ebbinghaus illusion. The two dimensional Ebbinghaus illusion is a simple optical illusion. A circle that is surrounded by smaller circles looks larger than a circle of the same size that is surrounded by larger circles. The three dimensional Ebbinghaus illusion reproduces this illusion in space: a poker-chip surrounded by smaller poker-chips appears to be larger than a poker-chip of the same diameter surrounded by larger ones. The surprising finding is that although our perceptual experience is incorrect – we experience the first chip to be larger than the second one –, if we are asked to pick up one of the chips, our grip-size is hardly influenced by the illusion (Aglioti et al. 1995, see also Milner & Goodale 1995, ch. 6 and Goodale & Milner 2004). Similar results can be reproduced in the case of other optical illusions, like the Müller-Lyer illusion (Goodale & Humphrey 1998, Gentilucci et al. 1996, Daprati & Gentilucci 1997, Bruno 2001), the ‘Kanizsa compression illusion’ (Bruno & Bernardis 2002), the dot-in-frame illusion (Bridgeman et al., 1997), the Ponzo illusion

(Jackson & Shaw 2000, Gonzalez et al. 2008) and the 'hollow face illusion' (Króliczak et al. 2006).[1]

What makes it possible for us to reach for the chip with the (more or less) appropriate grip size is action-guiding vision – the visual processes that help us to perform goal-directed actions. Our conscious experience represents the size-property of the chip one way (incorrectly) and our action-guiding vision represents it a different way (more or less correctly). Hence, action-guiding vision is different from our conscious perceptual experience. We cannot explain this behavior without postulating action-guiding vision. And as action-guiding vision represents the size-property of the chip differently from the way conscious perception does, it must do so unconsciously.

I call the representations of action-guiding perceptual processes 'action-oriented representations' (Nanay 2012, Clark 1997, Mandik 2005). In the 3D Ebbinghaus case, it is the action-oriented representation that guides our action: it attributes, unconsciously, the (more or less) correct size-property to the poker-chip – in spite of our very misleading conscious experience.

This focus on action-oriented representations as the mental states that mediates between perception and action provide a more and more popular third alternative to both classic computationalism/propositionalism and anti-representationalism/enactivism. The mind is to be understood in terms of representations, but these representations are not all propositional, linguistically structured or uniquely human. Some are better compared to the mental representations of the predator that make it possible for it to catch its prey. These representations are simple, supposedly non-propositional, and maybe perceptual, representations and they are also inherently action-oriented (Norman 2002, Hummel et al. 2001, Grush 2004, Gendler 2008, Jeannerod 1997, Millikan 1995, 2004, Pacherie 2011, Jeannerod & Jacob 2004, Clark 1997, Mandik 2005, Nanay 2011, 2012, 2013, in press).

It is not universally agreed upon that action-oriented representations can be considered to be perceptual states – although there are some arguments for this conclusion (Bach 1978, Nanay 2011, 2012, 2013). But those accounts of action-guiding vision this paper is about, the ones that consider action-guiding vision to be cognitively impenetrable, invariably do consider representations that mediate between perception and action to be perceptual states (Jeannerod & Jacob 2003, Jacob & Jeannerod 2005, Jacob 2005, Jeannerod 1997, Milner & Goodale 1995, 2008, Goodale & Milner 2004, Norman 2002).

So far, I treated action-guiding vision as a genuinely philosophical or theoretical category. But this philosophical way of raising the question may puzzle neuroscientists. They have long been studying the link between perception and action and we have a lot of empirical evidence about the nature of the processes that mediate between perception and action. And this body of evidence points to the dorsal visual subsystem. The dorsal visual subsystem is a genuine part of the perceptual system of mammals and its function is widely acknowledged to be the guiding of goal-directed actions.

In the light of the similarities between the dorsal visual subsystem and action-guiding vision, a very tempting suggestion would be to say that action-oriented representations must be the representations of the dorsal visual subsystem (see, e.g., Jacob & Jeannerod 2003, Jacob 2005, Norman 2002, see also Matthen 2005 for a more cautious claim). The dorsal system guides action and represents the world in such a way that would help us perform actions – this sounds exactly like what action-guiding vision is supposed to do.

I will argue that we should resist this temptation to equate 'action-guiding vision' with 'dorsal vision'. And, more specifically, we should not identify action-oriented representations, the representations, posited on the functional level, with the representations of the dorsal stream. The dorsal stream plays an important role in the implementation of action-guiding vision, but it is unlikely that it plays the only role. We should be careful not to conflate the functional and the neural level.

Dorsal vision

Humans (and other mammals) have two visual subsystems that use different regions of the central nervous system, the ventral and dorsal streams. To put it simply, the ventral stream is responsible for identification and recognition, whereas the function of the dorsal stream is the visual control of our motor actions. In normal circumstances, these two systems work together, but if one of them is removed or malfunctions, the other can still function relatively well (see Milner & Goodale 1995, Goodale & Milner 2004).

If the dorsal stream is malfunctioning, the agent can recognize the objects in front of her, but she is incapable of manipulating them or even localizing them in her egocentric space (especially if the perceived object falls outside the agent's fovea). This is called *optic ataxia*. If the ventral stream is malfunctioning, a condition called *visual agnosia*, the agent can perform actions with objects in front of her relatively well, but she is incapable of even guessing what these objects are.

The three dimensional Ebbinghaus illusion I mentioned above is normally explained as a nice demonstration of the dissociation between the dorsal and ventral visual subsystems in healthy human adults: the ventral subsystem is fooled by the illusion, but the dorsal is not. The other

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[1] I will focus on the 3D Ebbinghaus illiusion because of the simplicity of the results, but it needs to be noted that the experimental conditions of this experiment have been criticized recently (Pavani et al. 1999, Franz 2001, 2003, Franz et al. 2000, 2003, Gillam 1998, Vishton 2004 and Vishton & Fabre 2003, but see Haffenden & Goodale 1998 and Haffenden et al. 2001 for a response and Briscoe 2008 for an overview. I focus on the 3D Ebbinghaus experiment in spite of these worries, but those who are moved by Franz et al. style considerations can substitute some other visual illusion, namely, the Müller-Lyer illusion, the Ponzo illusion, the hollow face illusion or the Kanizsa compression illusion, where there is evidence that the illusion influences our perceptual judgments, but not our perceptually-guided actions.

examples in which optical illusions deceive the eye, but not the hand (Ponzo, Müller-Lyer, Kanizsa-compression, hollow face, etc) are analyzed in the same way. Sometimes our ventral visual subsystem attributes a different property to an object from the one the dorsal subsystem does.

The most important characteristics of the dorsal stream from the point of view of this paper is that it is taken to be informationally encapsulated from the rest of the brain. The original picture (in Milner & Goodale 1995) was that dorsal processing is quick, automatic and insensitive not only to higher order mental processes, but also to processing in the ventral stream. While it has been very much debated whether the dorsal stream is insensitive to processing in the ventral stream (see below), the claim about the insensitivity of dorsal processing to higher order mental processes remains more or less uncontroversial even in the works of those who argue for various interactions between the dorsal and the ventral streams (see, e.g., Jeannerod and Jacob 2005, Rizzolatti & Matelli 2003, Kravitz et al. 2011, Rossetti & Pisella 2002).

Back to action-guiding vision. A very tempting suggestion would be to say that action-guiding vision is just dorsal vision and action-guiding representations are the representations of the dorsal visual subsystem. The dorsal system guides action, just like action-guiding vision. The dorsal system represents the world in such a way that would help us perform actions and so do action-oriented representations. Shouldn't we then just say that it is the dorsal stream that mediates between perception and action? If we were to accept this claim, it would follow that action-guiding vision is cognitively impenetrable. In fact, the proponents of the idea of the cognitive impenetrability of action-guiding vision take the informational encapsulation of the dorsal stream to be the main evidence for their claim (see esp. Goodale & Wolf 2009, see also Jeannerod & Jacob 2003, Norman 2002, Milner & Goodale 1995, 2008, Raftopoulos 2001, 2005).

My aim is to carefully detach claims about action-guiding vision from claims about the dorsal stream. Action-guiding vision is not the same as dorsal vision. Whatever the neural implementation of action-guiding vision is, it surely includes the dorsal visual subsystem. But it cannot be restricted to the dorsal visual subsystem, for the following three reasons.

Interactions between the dorsal and the ventral subsystems

First, the anatomical distinction between the dorsal and the ventral visual subsystems is not as neat and clear-cut as it was originally thought. It seems that there are interactions between the two streams at various point of perceptual processing (see, e.g., Jeannerod 1997, Franz & Gegenfurtner 2008, Franz et al. 2000, Schenk & McIntosh 2010, Rosetti & Pisella 2002).

Further, to make things even more complicated, it has been argued that instead of two visual subsystems, we need to talk about three: the ventral, the ventrodorsal and the dorsodorsal. To simplify matters considerably, what has been taken to be one single dorsal subsystem should be divided into two: one responsible for manipulating objects (dorsodorsal) and one responsible for localizing in egocentric space (ventrodorsal) (Rizzolatti & Matelli 2003).

Even more recently it has been suggested that what was originally taken to be the dorsal stream is in fact the ensemble of three different visual subsystems (Kravitz et al. 2011). To talk about the dorsal stream as an independent chunk of the brain and to talk about action-oriented representations as the representations of this unified and independent bit of mental processing would be misleading to say the least.

Is dorsal vision necessarily unconscious?

Second, there is a major debate both in vision science and in philosophy of cognitive science about whether dorsal vision is necessarily unconscious. The original proposal was that ventral visual processing may be conscious or unconscious, but dorsal processing is always unconscious. (see esp. Milner & Goodale 1995, Goodale & Milner 2004). But this view has been criticized both on empirical and on conceptual grounds (see Dehaene et al, 1998, Jeannerod 1997, Jacob & Jeannerod 2003).

This debate does not seem to go away (see Brogaard 2011, Briscoe 2008, Milner & Goodale 2008, Jeannerod & Jacob 2004, Goodale 2011, Clark 2009, Kravitz et al. 2011). As action-oriented representations can be conscious or unconscious (although they are typically unconscious), if we were to equate action-oriented representations with dorsal perceptual processing, we would have to take sides in this grand debate, which proponents of the action-oriented representation approach would be well advised to avoid.

Multimodality

The third reason why action-oriented representation is not to be identified with the representation of dorsal perception is the multimodality of perception. There is a lot of recent evidence that multimodal perception is the norm and not the exception – our sense modalities interact in a variety of ways (see Spence & Driver 2004, Vroomen et al. 2001, Bertelson & de Gelder 2004, O'Callaghan 2008). Information in one sense modality can influence the information processing in another sense modality at a very early stage of perceptual processing (often in the primary visual cortex in the case of vision (e.g., Watkins et al. 2006).

A simple example is ventriloquism, which is an illusory auditory experience caused by something visible (Bertelson 1999, O'Callaghan 2008). The auditory sense modality identifies the ventriloquist as the source of the voices, while the visual sense modality identifies the dummy. And the visual sense modality modifies the way we auditorily experience the scene. But there are more surprising examples: if there is a flash in your visual scene and you hear two beeps while the flash lasts, you experience it as two flashes (Shams et al. 2000).

Now, action-oriented representations are not necessarily visual: they can occur in any sense modality. But the dissociation between the dorsal and ventral subsystem is a distinction in the visual sense modality. Some have suggested a similar dissociation for speech perception (see, e..g, Hickock & Poeppel 2007) and for touch (Reed et al. 2005), but the evidence for dissociations similar to the one in the case of vision is far from clear in audition, olfaction and the other sense modalities. Tying action-oriented representations to the dorsal visual subsystem would make it difficult to talk about action-oriented representations in sense modalities other than vision.

Further, the literature on the multimodality of perception clearly shows that our perceptual states in one sense modality are influenced by the information we receive in other sense modalities. And there are some recent behavioral experiments supporting the multimodality of action-oriented representations (see esp. Stein et al. 2004, Gentilucci et al., 1995). How about the dorsal stream? Although it seems clear that the dorsal stream is also multimodal (see, e.g., Battaglia-Mayer & Caminiti 2002), but the exact extent of the crossmodal influences on dorsal processing has been debated (see, e.g., Lewis & Van Essen 2000, Rozzi 2008). Again, it seems that the neural correlate of action-oriented representation has a lot to do with the dorsal stream, but the current empirical evidence on multimodal perception does not quite support the claim that it is identical to, or fully exhausted by, the dorsal stream.

To sum up, these findings all point in the direction of a theoretical framework where it is clear that the dorsal stream plays an important role in the implementation of action-guiding vision, but it is unlikely that it plays the only role. Whatever the neural implementation of action-guiding vision is, it surely includes the dorsal visual subsystem. But we have strong reasons to doubt that it is restricted to the dorsal visual subsystem.

Is action-guiding vision cognitively impenetrable?

We are finally in the position to assess the claims about the cognitive impenetrability of action-guiding vision. The proponents of the idea of the cognitive impenetrability of action-guiding vision take the informational encapsulation of the dorsal stream to be the main evidence for their claim (see esp. Goodale and Wolf 2009, see also Jeannerod & Jacob 2003, Norman 2002, Milner & Goodale 1995, 2008, Raftopoulos 2001, 2005). But as I argued, action-guiding vision and dorsal vision should not be conflated. As a result, the argument from the informational encapsulation of the dorsal stream will bear no direct implications for the cognitive impenetrability of action-guiding vision.

But we have even stronger reasons to mistrust the suggestion that action-guiding vision is cognitively impenetrable. We have some positive evidence that action-guiding vision is sensitive to various top-down factors, like the subject’s affective life (Morgado et al. 2011), her language skills (Pulvermuller et al. 2005) and her expectations or knowledge. The example I will be focusing on is the following: two very widely used brand of matches in the UK are ‘Swan Vestas’ and ‘Scottish Bluebell’. The box of Swan Vestas is 25% larger than that of Scottish Bluebells. And it turns out that the brand of the match boxes influences our grip size when grasping them (McIntosh & Lashleya 2008). When the subjects were grasping the 1.25-scale replica of the Scottish Bluebell box, their grip size was smaller than it was when grasping the normal Swan Vestas of the same size. And when they were grasping the 0.8-scale replica of Swan Vestas box, their grip size was larger than it was when grasping the normal Scottish Bluebell box. Hence, the brand of the match boxes (but at the very least, the recognition thereof) influences grip size: it influences our action-guiding vision.

Dorsal vision may or may not be informationally encapsulated. But action-guiding vision, as the McIntosh and Lashleya experiment shows, is cognitively penetrable. Then this finding can be used as an independent evidence for the claim that dorsal vision and action-guiding vision are different and they should not be confused.[2]

But there is a more general lesson to be learned from the controversy about the cognitive impenetrability of action-guiding vision. Dorsal vision is an anatomical concept – it is identified by means of anatomical criteria. Action-guiding vision is a functional concept – it is identified by means of functional criteria. To confuse the two is to confuse the functional and the anatomical ways of describing the mind.

And this confusion is especially dangerous when it comes to the cognitive impenetrability debate. The proponents and opponents of the cognitive impenetrability of perception agree that whatever is meant by perception in this debate, for example, whether it is conscious experience or some unconscious perceptual process, it is to be identified by means of functional criteria. But then we should be suspicious of using anatomical data in support of, or against, the cognitive impenetrability claim.

If we are to keep the functional and the anatomical levels of describing the mind separate, then using anatomical data to bear directly on the cognitive impenetrability debate is a methodological mistake. The example of using the anatomical data of the dorsal stream to argue for the cognitive impenetrability of action-guiding vision is a good case study of this.

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[2] The distinction between the anatomical and the functional level also works in the other direction. The McIntosh and Lashleya experiment can be and has been taken to show that the dorsal stream is not informationally encapsulated (see Brogaard 2011 for analysis). But the experiments are not about the dorsal stream; they are about action-guiding vision. Interpreting them as having damning implications for the dorsal/ventral distinction is based on the equivocation of dorsal vision and action-guiding vision.

References

Aglioti, S., DeSouza, J.F.X., & Goodale, M.A. (1995). Size-contrast illusions deceive the eye but not the hand. *Current Biology, 5*, 679-685.

Bach, K. (1978). A representational theory of action, *Philosophical Studies* 34, 361-379.

Battaglia-Mayer, A., & Caminiti, R. (2002). Optic ataxia as a result of the breakdown of the global tuning fields of parietal neurones. *Brain*, 125, 225–237.

Bertelson, P. & de Gelder, B. (2004). The psychology of multimodal perception. In C. Spence & J. Driver (Eds), *Crossmodal Space and Crossmodal Attention*, Oxford: Oxford University Press.

Brand, M. (1984). *Intending and Acting*. Cambridge, MA: MIT Press.

Bridgeman B, Peery S. & Anand S. (1997). Interaction of cognitive and sensorimotor maps of visual space. *Perception & Psychophysics* 59, 456 - 459.

Briscoe, R. (2008). Another look at the two visual systems hypothesis. *Journal of Conscious Studies* 15, 35-62.

Brogaard, B. (2011). Are there unconscious perceptual processes? *Consciousness and Cognition* 20, 449-63.

Bruno, N. (2001). *When* does action resist visual illusions? *Trends in Cognitive Sciences 5*, 385-388.

Bruno, N. & Bernardis, P. (2002). Dissociating perception and action in Kanizsa’s compression illusion. *Psychonomic Bulletin & Review 9*, 723-730.

Clark, A. (1997). *Being There*. Cambridge, MA: MIT Press.

Clark, A. (2009). Perception, action, and experience. *Neuropsychologia*, *47*, 1460–1468.

Daprati, E. & Gentilucci, M. (1997). Grasping an illusion. *Neuropsychologia 35*, 1577-1582.

Dehaene, S., Naccache, L., Le Clec'H, G., Koechlin, E., Mueller, M., Dehaene-Lambertz, G., van de Moortele, P.F. & Le Bihan, D. (1998). Imaging unconscious semantic priming. *Nature, 395,* 597-600.

Dijkerman, H. C., & De Haan, E. H. F. (2007). Somatosensory processes subserving perception and action. *Behavioral and Brain Sciences, 30*, 189–201.

Fodor, J.A. (1983). *The Modularity of Mind.* Cambridge, MA: MIT Press.

Franz, V. (2001). Action does not resist visual illusions, *Trends in Cognitive Sciences*, 5, 457–59.

Franz, V. (2003). Manual size estimation: A neuropsychological measure of perception?, *Experimental Brain Research*, 151, 471–77.

Franz, V. & Gegenfurtner, K. (2008). Grasping visual illusions: consistent data and no dissociation. *Cognitive Neuropsychology* 25, 920-50.

Franz, V. , Bülthoff, H. & Fahle, M. (2003). Grasp effects of the Ebbinghaus illusion: obstacle avoidance is not the explanation. *Experiental Brain Research 149*, 470-477.

Franz, V., Gegenfurtner, K., Bülthoff, H. & Fahle, M. (2000). Grasping visual illusions: No evidence for a dissociation between perception and action, *Psychological Science*, 11, 20–25.

Gendler, T. (2008). Alief in action (and reaction) *Mind & Language*, 23, 552–585.

Gentilucci, M., Cheiffe, S., Daprati, E., Saetti, M. C. & Toni, I. (1996). Visual illusion and action. *Neuropsychologia 34*, 369-376.

Gentilucci, M., Daprati, E., Toni, I., Chieffi, S., & Saetti, M. C. (1995). Unconscious updating of grasp motor program. *Experimental Brain Research*, 105, 291–303.

Gillam, B. 1998 Illusions at Century's End. In J. Hochberg (Ed.), *Perception and Cognition at Century's End*. San Diego: Academic Press.

Gonzalez, C., Ganel, T., Whitwell, R., Morrissey, B. & Goodale, M. (2008). Practice makes perfect, but only with the right hand, *Neuropsychologia*, 46, 624–631.

Goodale M.A. (2011). Transforming vision into action. *Vision Research* 51, 1567-87.

Goodale, M.A. & Humphrey, G.K. (1998). The objects of action and perception. *Cognition* 67, 181-207.

Goodale, M.A. & Milner, A.D. (2004). *Sights Unseen.* Oxford: Oxford University Press.

Goodale, M.A. & Wolf, M. (2009). Vision for action. In D. Dedrick & L. Trick (Eds.), *Computation, Cognition, and Pylyshyn*. Cambridge, MA: MIT Press.

Grush, R. (2004). The emulation theory of representation, *Behavioral and Brain Sciences* 27, 377–442.

Haffenden, A. & Goodale, M.A., (1998). The effect of pictorial illusion on prehension and perception. *Journal of Cognitive Neuroscience* 10, 122–136.

Haffenden, A. M., Schiff, K. C., & Goodale, M. A. (2001). The dissociation between perception and action in the Ebbinghaus illusion. *Current Biology* 11, 177–181.

Hickock, G. & Poeppel, D. (2007). The cortical organization of speech processing. *Nature Reviews Neuroscience*,8, 393-401.

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding. *Behavioral and Brain Sciences, 24*, 849-878.

Jackson, S. & Shaw, A. (2000). The Ponzo illusion affects grip-force but not grip-aperture scaling during prehension movements, *Journal of Experimental Psychology HPP*, 26, 418–23.

Jacob, P. (2005). Grasping and perceiving an object. In A. Brooks & K. Akins (Eds.), *Cognition and the Brain*. Cambridge: Cambridge University Press.

Jacob, P. & Jeannerod, M. (2003). *Ways of Seeing.* Oxford: Oxford University Press.

Jeannerod, M. (1994), The representing brain: Neural correlates of motor intention and imagery, *Behavioral and Brain Sciences*, 17, 187-245.

Jeannerod, M. (1997). *The Cognitive Neuroscience of Action.* Oxford: Blackwell.

Jeannerod, M. & Jacob, P. (2005). Visual cognition: a new look at the two-visual systems model. *Neuropsychologia*, 43, 301-312.

Kaas, J. H., & Hackett, T. A. (1999). ‘What’ and ‘where’ processing in auditory cortex. *Nature Neuroscience*, *2*, 1045–1047.

Kravitz, D. J., Kadharbatcha S., Saleem, S., Baker, C. I. & Mishkin, M. (2011). A new neural framework for visuospatial processing. *Nature Neuroscience 12*, 217-230

Króliczak, G., Heard, P., Goodale, M.A. & Gregory, R.L. (2006). Dissociation of perception and action unmasked by the hollow-face illusion. *Brain Research*, 1080, 9-16.

Lewis, J. & Van Essen, D. (2000). Corticocortical connections of visual, sensorimotor and multimodal processing areas in the parietal lobe of the macaque monkey. *Journal of Comp. Neurology,* 428, 112-37.

Loach, D., Frischen, A., Bruce, N. & Tsotsos, J.K. (2008). An attentional mechanism for selecting appropriate actions afforded by graspable objects. *Psychological Science*, 19, 1253-57.

Lyons, J. (2011). Circularity, reliability and the cognitive penetrability of perception, *Philosophical Issues* 21, 289-311.

Mandik, P. (2005). Action oriented representation. In A. Brook & K. Akins (Eds.), *Cognition and the Brain: The Philosophy and Neuroscience Movement*. Cambridge: Cambridge University Press.

Matthen, M. (2005). *Seeing, Doing, and Knowing: A Philosophical Theory of Sense-Perception*. Oxford: Clarendon Press.

McIntosh, R.D., & Lashleya, G. (2008). Matching boxes: Familiar size influences action programming. *Neuropsychologia*, 46, 2441–2444.

Millikan, R.G. (1995). Pushmi-pullyu representations. *Philosophical Perspectives, 9,* 185-200.

Millikan, R.G. (2004). *Varieties of Meaning*. Cambrdige, MA: The MIT Press.

Milner, A.D. (2008). Conscious and unconscious visual processing in the human brain. In L. Weiskrantz & M. Davies (Eds.), *Frontiers of Consciousness*. Oxford: Oxford University Press.

Milner, A.D. & Goodale, M.A. (1995). *The Visual Brain in Action*, Oxford: Oxford University Press.

Milner, A.D., & Goodale, M.A. (2008). Two visual systems re-viewed. *Neuropsychologia*, *46*, 774–785.

Morgado N., Muller D., Gentaz E., & Palluel-Germain R. (2011). Close to me? The influence of affective closeness on space perception. *Perception, 40,* 877-879)

Nanay, B. (2011). Do we see apples as edible? *Pacific Philosophical Quarterly,* 92, 305-322.

Nanay, B. (2012). Action-oriented perception. *European Journal of Philosophy*, 20, 430-446.

Nanay, B. (2013). *Between Perception and Action*. Oxford: Oxford University Press.

Nanay, Bence (in press). Success semantics: The sequel. *Philosophical Studies*

Norman, J. (2002). Two Visual Systems and Two Theories of Perception. *Behavioral and Brain Sciences*, 25, 73-144.

O'Callaghan, C. (2008). Seeing what you hear: Crossmodal illusions and perception. *Philosopical Issues*, 18, 316-38.

Pacherie, E. (2011). Nonconceptual representations for action and the limits of intentional control. *Social Psychology,* 42, 67-73.

Pavani, F., Boscagli, I., Benvenuti, F., Rabuffetti, M., and Farnè, A. (1999). Are perception and action affected differently by the Titchener circles illusion? *Experimental Brain Research*, 127, 95–101.

Pulvermuller, F., & Hauk, O. (2005). Functional links between motor and language systems. *European Journal of Neuroscience , 21*, 793-797

Raftopoulos, A. (2001). Is perception informationally encapsulated? The issue of the theory-ladenness of perception. *Cognitive Science*, 25, 423-451.

Raftopoulos, A. (2005). Perceptual systems and a viable form of realism. In A. Raftopoulos (Ed.), *Cognitive Penetrability of Perception*. Hauppauge: Nova Science.

Reed, C.L., Klatzky, R.L. & Halgren, E. (2005). What vs. where in touch: an fMRI study. *NeuroImage*, 25, 718–26.

Rizzolatti, G., & Matelli, M. (2003). Two different streams form the dorsal visual system: Anatomy and functions. *Experimental Brain Research*, *153*, 146–157.

Rossetti, Y. and L. Pisella 2002 Several 'vision for action' systems: a guide to dissociating and integrating dorsal and ventral functions. *Attention and Performance* 19: 62-119.

Rozzi, S., Ferrari, P. F., Bonini, L., Rizzolatti, G. & Fogassi, L. (2008). Functional organization of inferior parietal lobule convexity in the macaque monkey. *European Journal of Neuroscience* 28, 1569–1588.

Schenk, T. & McIntosh, R. D. (2010). Do we have independent visual streams for perception and action? *Cognitive Neuroscience* 1, 52-78.

Shams, L., Kamitani, Y., & Shimojo, S. (2000). What you see is what you hear. *Nature*, 408, 788.

Siegel, S. (2011). Cognitive penetrability and perceptual justification. *Nous* 46, 201-222.

Spence, C. & Driver, J. (2004, Eds.). *Crossmodal Space and Crossmodal Attention*, Oxford: Oxford University Press.

Stein, B.E., Stanford, T.R., Wallace, M.T., Vaughan, J.W. & Jiang, W. (2004). Crossmodal spatial interactions in subcortical and cortical circuits. In C. Spence & J. Driver (Eds.), *Crossmodal Space and Crossmodal Attention*. Oxford: Oxford University Press.

Vishton, P. (2004). Human vision focuses on information relevant to a task, to the detriment of information that is not relevant. *Behavioral and Brain Sciences*, 27, 53–54.

Vishton, P. & Farbe, E. (2003). Effects of the Ebbinghaus illusion on different behaviors, *Spatial Vision*, 16, 377-92.

Vroomen, J., Bertelson, P., & de Gelder, B. (2001). Auditory-visual spatial interactions. In B. de Gelder, E. de Haan & C. Heywood (Eds.), *Out of Mind,* Oxford: Oxford University Press.

Watkins, S., Shams, L., Tanaka, S., Haynes, J. D., & Rees, G. (2006). Sound alters activity in human V1 in association with illusory visual perception. *NeuroImage* 31, 1247-1256.

Xu, Y., O'Keefe, S., Suzuki, S. & Franconeri, S.L. (2012). Visual influence on haptic torque perception. *Perception* 41, 862 – 870.