CHAPTER 1

Perception, action, and consciousness

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1.1. Introduction

In the last couple of decades the cognitive sciences and the philosophy of mind have witnessed growing challenges to a basic assumption about the nature of mind and cognitive states. A grounding premise of early cognitive science was the hypothesis that perception arises by the experiencing subject acting as a passive recipient of sensory stimuli. Acceptance of this assumption conferred to the subject of experience a considerably passive role in the generation of experiential states. It was deemed possible to study cognition and perception by abstracting away from the details of the embodiment and situatedness of the experiencing subject. David Marr's (1982) theory of vision is an extremely influential example of such an approach and became the meta-theory for classical information-processing theories of perception and cognition (Kosslyn and Maljkovic, 1990, Palmer, 1999). However, there have always been a few dissenting voices pointing out the limitations of a conception of experience as the output of a purely abstract computational level of description (e.g. Gibson, 1966, 1979; Turvey et al., 1981, Varela et al., 1991) but it is only recently that there has emerged an identifiable research paradigm which takes the ideas of embodiment and situatedness as fundamental to understanding the nature of cognition and consciousness.[1]

Perceptual experience, in particular, presents one of the cognitive domains where the new paradigm has found its greatest support (Hurley, 2001). The new paradigm encourages a radical rethinking of the nature of perceptual states and the subject of experience. However, even among theories which agree that perception nontrivially involves an embodied and situated subject there are major disagreements regarding the exact nature of perceptual experience. It is a fact that the embodied perceiver is situated in a relation of dynamic sensorimotor engagement with her environment. However, how far do sensorimotor dynamics enter the content of perceptual experience? Is it possible to acknowledge dynamic sensorimotor interaction as a major causal factor in perceptual experience while at the same time viewing perception and action as two distinct domains of our cognitive life?

The chapters in this volume discuss the relation between perception and action from a variety of interdisciplinary perspectives ranging from theoretical discussion of concepts to reporting original empirical data from recent studies. Along with presenting diverse ways of relating perception and action, the contributions in this volume take a range of positions with respect to the view that perception is an achievement by an agent acting in a complex environment. Another related issue is

[1] For a review of the development of the embodied and situated cognition approaches see Anderson (2003) and Gallagher (in press).

whether or not sensorimotor dynamics of agent-environment interactions constitute an essential ingredient in perceptual experience.

Much of this volume is devoted to a particular debate within the general research on action and perception. The volume brings together two apparently opposing positions: the action-oriented theories of visual perception, on the one hand, and the dual-visual systems hypothesis on the other. Action-oriented theories champion the role of sensorimotor dynamics in perceptual awareness and the dual-visual systems hypothesis favours a functional dichotomy between perception and action. At least on the surface, these two approaches to visual perception are in conflict. The action-oriented approach emphasizes the interdependence of action and perception, while the dual-visual systems hypothesis suggests that action and perception are functionally distinct.

In this introduction we shall present the general issues discussed in the chapters and bring out the various themes that have emerged from the discussions of the relations between perception and action. They include, but are not limited to, the following topics:

- What is action in perception?
- Does empirical evidence support the functional dichotomy between perception and action?
- What constitutes the content of perceptual experience?
- Bringing together the competing views on the interaction between perception and action.

Before entering into the central issues, let us start with a summary of the two competing approaches to perception addressed in this volume, namely, the dual-visual systems views and the action-oriented theories. One of the earliest discussions of the dual-visual systems view is presented by Trevarthen (1968) who proposed that 'vision of space' and 'vision of object identity' are subserved by anatomically distinct brain mechanisms. Schneider (1969) describes two visual pathways in the mammalian brain enabling the location of objects and the identification of objects respectively. The two visual systems view received further attention with Ungerleider and Mishkin's (1982) neurophysiological evidence for 'what' and 'where' streams in the primate visual system, streams which process different aspects of the visual world. In recent times one of the most influential and elaborate discussion of the dual-visual systems hypothesis is presented by the cognitive neuroscientists M.A. Goodale and A.D. Milner (Goodale and Milner, 1992; Milner and Goodale, 1995; Goodale and Milner, 2004; Milner and Goodale, this volume). Motivated mostly by cases of cortical damage in humans, they describe the functions of the two visual streams as 'vision for perception' and 'vision for action', respectively. Vision for perception is suggested to be subserved by processing in the ventral stream, which projects from the primary visual cortex to the inferior temporal cortex. Vision for action, on the other hand, is thought to be subserved by the dorsal stream, which projects from the primary visual cortex to the posterior parietal cortex. Vision for perception is involved in recognition and identification of objects and events whereas vision for action is involved in the programming and online control of visuo-motor actions such as reaching and grasping. The evidence for a functional dichotomy between vision for perception and vision for action mainly comes from claims of double-dissociation observed between the conditions exhibited by visual form agnosic and optic ataxic patients (Milner and Goodale, 1995, this volume). A second source of evidence is derived from studies suggesting that visuo-motor actions such as grasping are immune to illusions, e.g. the size-contrast studies by Aglioti et al., (1995), whereas perceptual awareness easily falls prey to them.

The neuroscientific analysis of the two visual streams has generated interdisciplinary interest and is defended and elaborated by philosophical and psychological literature in the field. Jacob and Jeannerod (2003) adopt the functional dichotomy between vision for perception and vision for action in their philosophical and psychological study of the two visual systems model. They propose that the same visual information undergoes two distinct types of processing depending on whether the information is used for guiding motor acts or for enabling perceptual beliefs. They label the first type of processing 'pragmatic processing' of visual information and the second type of processing 'semantic processing' of visual information. Matthen (2005, this volume) presents a philosophical study of the functional difference between the two visual streams. He argues that one type of

visual stream subserves 'descriptive vision', which is imagistic characterizations of objects allowing storage and recall, and the other type of visual stream underlies 'motion-guiding vision', which is visual information enabling fine motor control for visuo-motor tasks.

Theories of visual perception adhering to a dual-visual systems model vary on finer details, especially concerning how the two visual streams interact, and we shall bring out some of their differences in the course of this introduction. However, they are united in their claim that the boundaries between perception and action are rather tight. On the one hand, perceptual awareness proceeds via a type of processing of visual information that does not require coding in terms of the perceiver's ability to act, and on the other hand conscious visual experience does not enter the control of visuo-motor actions; a significant amount of our goal-directed engagement with the world can proceed independently of conscious awareness.

Challenging the rigid boundaries between perception and action are theories which champion the idea of perceptual experience as an achievement by an active perceiver. According to this school of thought, perception and action are interdependent processes and being a perceiver is, at some level of description, inseparable from being an agent. This group of theories presents an emerging research paradigm which we shall call 'action-oriented' approaches to perception. The most discussed and elaborately defended action-oriented approach in recent philosophy of mind and cognitive science is the sensorimotor theory of perception (O'Regan and Noë, 2001; Noë, 2004; Hurley, 2008). The theory has been described under a variety of names such as the sensorimotor theory of visual consciousness (O'Regan and Noë, 2001), enactivism (Noë, 2004), and actionism (Noë, this volume). Hurley (1998) presents one of the pioneering accounts of an action-oriented theory of perception in contemporary philosophy of mind and cognitive science. In her bid to unify perceptual awareness (and consciousness in general) and action Hurley (1998) writes,

> The idea of having a *perspective* or point of view is part of our concept of what it is to be conscious. Unity is a basic feature of the perspectival aspect of consciousness. But so is agency. At the personal level, having a perspective means that what you experience and perceive depends systematically on what you do, as well as vice versa.
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> (Hurley, 1998: 86)

Adopting a somewhat similar approach,[2] the sensorimotor theory of O'Regan and Noë (2001) and Noë (2004) defends an action-oriented theory of perceptual awareness by maintaining that perceptual content is a function of the implicit sensorimotor knowledge exercised by an active perceiver by way of exploring the environment. The action-oriented theories include neuroscientific accounts which argue against the dual-visual systems view by claiming that the functional dissociation between vision for perception and vision for action is not one that easily allows strict anatomical mapping onto specific brain regions (Rossetti et al., this volume, Vallar and Mancini, this volume). However, there is considerable difference of opinion among the action-oriented approaches regarding the role of action in perception and indeed regarding how we are to understand the notion of action in the first place. Section 1.2 addresses this issue focussing on the internal debates between the action-oriented approaches represented in this volume and between the action-oriented approaches and theories supporting a dual-visual systems view. Section 1.3 discusses the debate centring on the empirical evidence for the functional dichotomy between perception and action. Section 1.4 focuses on the various theories and issues regarding the content of perceptual experience and Section 1.5 brings together the competing views on the interaction between perception and action.

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[2] For importance differences between Hurley's (1998, 2008) account of the relation between perception and action and that defended by O'Regan and Noë, (2001) and (Noë 2004) see Gangopadhyay and Kiverstein (2009).

1.2. What is action in perception?

There is considerable ambiguity among the action-oriented theories regarding the notion of action in perception. The sensorimotor theorists write,

> ... seeing is an exploratory activity mediated by the mastery of the sensorimotor contingencies. That is seeing is a skill-based activity of environmental exploration. Visual experience is not something that happens *in* individuals. It is something they *do*.
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> (Noë and O'Regan, 2002: 567)

Faced by recent challenges (e.g. Block, 2005; Clark, 2006), the sensorimotor theorists have put forth an account of what they have in mind when they say perception is something that a perceiver does. Noë clarifies his position on incorporating action as a necessary element in perception by drawing a distinction between action and movement (real-time sensorimotor behaviour). In his actionist view of perception, perceptual experience is active in the sense of requiring the exercise of the skilful perceiver's implicit knowledge of the sensorimotor laws governing the relation between movement and change of stimuli. In Noë's theory perception is *not* active, '... in the sense that it requires that one move. What is required is that one understand the relevance of movement to action. What is required is that one knows what would happen if one were to move. Perception is active, according to the actionist, in the same way that thought is active'[3] (Noë, this volume). O'Regan (this volume) upholds a similar position arguing that nothing in the sensorimotor theory requires action in the sense of real-time ongoing movement as constituting perceptual content at any given time. What is necessary for perception to be active is the skilful perceiver's access to and exercise of her implicit knowledge of how perceptual content could vary as a function of her movement or the movement of the object.

Schellenberg's (this volume) proposal of how perceivers grasp the intrinsic properties of objects finds a place in the action-oriented camp. Her 'capacity view', however, proposes to be an alternative to actionism and similar sensorimotor approaches. Schellenberg contends that while sensorimotor approaches usually ground their theories on token actions (past, present, future, or counterfactual) the capacity view builds up on the perceiver's practical knowledge that the object of perception can be perceived from other spatial perspectives. In spite of the apparent disagreement between the sensorimotor views and the capacity view, they seem to be unanimous in claiming that the way to link perception and action is not by referring to *movements*, that is, the actual execution of sensorimotor behaviour.

Psychological and neuroscientific action-oriented theories of perception have proposed a more radical relation between perception and action in a manner avoided by both the sensorimotor theory and the capacity view. A number of cognitive neuroscientists connect action, in the sense of ongoing sensorimotor behaviour, and perception by offering evidence to show that the two share common neural processing areas. Rossetti et al. (this volume) focus on specific instances of visuo-motor behaviour to argue against a double-dissociation between perception and action. The double-dissociation is claimed to be supported by studies on optic ataxia and visual agnosia and forms the

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[3] This marks a point of departure between the sensorimotor theory proposed by O'Regan and Noë (2001) and subsequently defended by Noë (2004, this volume) and Hurley's action-oriented theory of perception (1998, 2001, 2008). Hurley contends that real-time physical interaction with the environment is necessary for furnishing the content of experience. She writes,

> Perhaps the received tradition has focussed too much on the internal aspects of perception and ignored the external aspects. But we can correct this bias and take on board the role of movement in making information available, without going to the opposite extreme of denying that the brain processes information at all .... The right response to Gibson is ecumenical: both movement through real environments by whole organisms and brain activity play essential roles in extracting information from the environment and enabling a creature to have a perceptual perspective.
>
> (Hurley 2001: 20)

basis of the dual-visual systems hypothesis (Milner and Goodale, this volume). Rossetti et al., contend that a careful examination of cases of optic ataxia reveals that not all aspects of visuo-motor behaviour are controlled by the dorsal stream but share common processing areas with perception. Perception and action do not belong to water-tight cognitive domains as they share common processing areas, such as the areas between the ventral and the dorsal streams, and thereby enable visuo-motor behaviour by their ongoing dynamics. Therefore, a tight coupling between perception and action is justifiable on the basis of the sensorimotor (and neural) dynamics underlying the execution of certain visuo-motor actions or real-time movements. A similar line of thought is expressed by Vallar and Mancini (this volume) in their study of the neurofunctional streams underlying the neglect syndrome. Establishing action-oriented views of perception by referring to visuo-motor behaviour is an avenue explored by a considerable amount of literature in the field. Although only some of the action-oriented approaches in this volume make a brief reference to it, analysing the nature of the specific types of sensorimotor behaviour which are executed as part of the process of seeing, for example saccadic eye movements, also offers promising ways of linking perception and action.[4] This is not to say that there must be an isomorphism between perceptual content and token movements. Instead, the evidence indicates that ongoing sensorimotor dynamics impose a real-time constraint on perceptual content.

Noë (this volume) offers a taxonomy of four distinct ways of relating perception and action. These are: (1) actionism, which claims that exercise of implicit sensorimotor knowledge constitutes perceptual content, (2) 'the movement view', which states that actual motor movement is necessary for perceptual experience, (3) 'seeing is for acting', which proposes that the role of perceptual awareness is to subserve action, (4) the dual-visual systems view, which maintains that perception and action are two autonomous domains. An analysis of these different ways of relating perception and action reveals that 'action' is used in at least the following different senses by various theories. First, according to the sensorimotor view, 'action' stands for the exercise of implicit sensorimotor knowledge which may, but does not necessarily, include reference to the actual ongoing sensorimotor behaviour. This view maintains that it is possible to link perception and action without falling back on the real-time sensorimotor behaviour of the perceiver. Second, 'action' in what Noë dubs the 'movement view' can be spelt out as including real-time sensorimotor behaviour. In this view it is not only the perceiver's possession of implicit sensorimotor knowledge but also her exercise of that knowledge in the form of engaging in real-time sensorimotor behaviour which yields the sensorimotor dynamics necessary for coupling perception and action. In this view the nature of perceptual experience remains unexplained without reference to actual motor movements. Third, in the 'seeing is for acting' view 'action' stands for everyday motor behaviour as discussed, for example, by Gibson (1966, 1979). This view maintains that the content of perceptual experience is made up of the perception of potential movements with regard to the object. This view has close affinities with the sensorimotor theory of perception in highlighting the role of sensorimotor knowledge in perceptual content. However, the sensorimotor theorists do not claim that the only purpose of perceptual experience is the guidance of motor movements. Finally, in the dual-visual systems view, 'action' refers to at least three distinct elements in motor behaviour, namely, planning the motor movement in accordance with the goal to be achieved, programming the required parameters for executing the movement, and the online control of the movement (Milner and Goodale, this volume). The dual-visual systems theorists argue that the role of conscious perception is limited only to the first (the planning stage) of these three elements in action or motor movement. In this view, conscious perceptual experience and action come together in planning motor movements but conscious perception and action part ways in the later stages of programming and online control of motor behaviour.

[4] See Findlay and Gilchrist (2003) for one of the most influential accounts of how motor movements can constitute perception.

It is apparent that 'action' in both action-oriented approaches and dual-visual systems views covers a wide range of elements involved in an embodied agent's ongoing interactions with the environment, from highly complex cognitive components like planning and decision-making to the fine-grained control of motor behaviour. Such wide range, and at times ambiguous, uses of the term 'action' (e.g. referring to either motor movements or sensorimotor knowledge), further complicates the debate between the action-oriented and dual-visual systems accounts. For instance, consider the following issue on which the two camps disagree: How direct is the route between perception and action? While actionism (Noë, this volume) argues that action directly enters the picture in the form of the perceiver's implicit sensorimotor knowledge, in the absence of which there would be a corresponding absence of perceptual content, the dual-visual systems hypothesis advanced by Milner and Goodale (this volume) maintains that the relation between perception and action is only 'indirect and flexible … in which cognitive operations such as memory and planning play a crucial role'. As the dual-visual systems view does allow some interaction between perception and action at the cognitively demanding stage of action planning, Noë contends that far from being an opposing view to the dual-systems view, actionism is in fact a necessary building block for a strong dual-systems account. Noë argues that actionism and the dual-visual systems view are not in conflict because by 'action' actionism refers to the complex cognitive level of the perceiver's implicit understanding of sensorimotor laws, rather than to the fine-grained ongoing sensorimotor behaviour. Thus the way to secure the interaction between perception and action is in terms of the higher level cognitive component in the form of sensorimotor knowledge.

However, actionism's proposal of securing the interaction between perception and action in terms of the perceiver's implicit sensorimotor knowledge is rivalled by dual-visual systems views which offer their own explanation of how the two distinct domains of perception and action interact in everyday life. Focussing on the real-time execution of visuo-motor behaviour, Jacob and de Vignemont (this volume) contend that what really guides visuo-motor action in everyday life is not necessarily conscious perception but rather the unconscious pragmatic processing of visual information. They claim that perceptual experience involving object recognition is a function of processing in an allocentric frame of reference whereas visuo-motor actions require coding in egocentric frames. While proponents of this account object to a tight coupling between perception and action, this account has some affinities with the action-oriented account presented by Schellenberg (this volume). In Schellenberg's 'capacity view' perception of intrinsic properties of objects requires transcending an egocentric frame of reference by exercising the spatial know-how of the possibility of other spatial perspectives on the object.

Does the strategy of chalking out different frames of reference for the coding of perception and action really resolve the issue of their interaction? Schellenberg admits that it is an open empirical question as to how spatial know-how of different perspectives actually combines ego-centric and allocentric frames. In the account proposed by Jacob and de Vignemont it remains to be discussed how far the outputs of the two visual streams are available to consciousness, especially whether egocentric coding by the dorsal stream is totally encapsulated from conscious perceptual experience. Clark (this volume) raises concern on this issue and proposes that conscious experience could be best conceived of as a multifaceted phenomenon and points out that a major challenge facing any account of perception is that there is to-date no established criteria by which to assess what counts as conscious experience. This point shall be taken up for further discussion in the context of the various proposals of the interaction between the two visual streams (Section 1.5).

The disagreements between action-oriented approaches and the dual-visual systems views are also importantly based on the interpretation of the empirical evidence cited in favour of the dual-visual systems hypothesis. In particular, the debate builds upon two main sources of empirical evidence. These are: (1) the claims of double-dissociation between the conditions exhibited by a visual agnosic patient such as D. F. (Goodale and Milner, 1992) and those found in patients with optic ataxia and (2) the interpretation of studies which suggest that visuo-motor actions like grasping etc. are impervious to illusions which affect conscious visual experience (Aglioti et al., 1995). Action-oriented views of perceptual experience question the extent to which these studies establish perception and action as

mutually encapsulated domains. The following section takes up the debate between action-oriented approaches and dual-systems views on the issue of empirical evidence for the functional dichotomy between perception and action.

1.3. Debates on empirical evidence for the functional dichotomy between perception and action

The dual-systems view of vision for action and vision for perception is based on the anatomically distinct cortical pathways of visual processing, namely, the dorsal and the ventral stream. From this anatomical fact Milner and Goodale (1995, Goodale and Milner, 1992) develop their model of the functional dichotomy between perception and action deriving support from two main sources. First they claim to find a double-dissociation between the conditions exhibited by D.F., the visual form agnosic patient and the conditions observed in cases of optic ataxia. The second source of evidence comes from studies which indicate that certain visual illusions (e.g. Aglioti et al., 1995), deceive conscious perception but not visually guided grasping.

Milner and Goodale propose that there is significant evidence for establishing a double-dissociation between visual form agnosia and optic ataxia, the former arising due to impairment in the ventral processing stream and the latter due to impairments in the dorsal processing stream. What does a double-dissociation signify? Double-dissociation is a tool often employed by cognitive neuroscientists to demonstrate that specific structures or systems are responsible for specific functions. Identifying specific brain systems as solely responsible for specific functions by the method of double-dissociation has been criticized (Passingham et al., 2002; Pisella et al., 2006) but is nonetheless widely used as a method of localizing cognitive functions to specific brain structures. The aim of the present discussion is not to assess the methodological merit of double-dissociation in attributing cognitive functions to brain systems but mainly to raise two issues. First, has a double-dissociation actually been established between the conditions observed in visual agnosic patients and those found in optic ataxic ones? Second, what are the implications of the debate surrounding the evidence of double-dissociation between visual agnosia and optic ataxia on the relation between perception and action?

Milner and Goodale's (1995) hypothesis regarding the functional dichotomy between perception and action was based on a series of studies conducted on the visual form agnosic patient D.F. who showed a striking contrast in her performance in visuo-motor tasks and in perceptual judgement tasks involving the same stimuli. For example, D.F. can accurately carry out the visuo-motor task of passing her hand or a hand-held plaque through a slot in a disc which is placed at different orientations in front of her but she is unable to report (including manual report) the orientation of the slot. Milner and Goodale (1995) argue that the remarkable disparity in D.F.'s performance in visuo-motor and perceptual judgement tasks is evidence for the functional dichotomy between perception and action subserved by anatomically distinct cortical pathways. To further establish the hypothesis of functional dichotomy between perception and action, Milner and Goodale (this volume) claim that a double-dissociation is clearly observed between visual form agnosia and optic ataxia in the context of demonstrating the effect of delay introduced between presentation of stimuli and a pointing response. The task assesses spatial processing in peripheral vision in both visual agnosic patient D.F. and optic ataxic patient A.T. With the introduction of the delay D.F.'s performance deteriorated while that of A.T. improved. Milner and Goodale argue that the results indicate that with the introduction of the delay there is demand on D.F.'s impaired ventral processing which leads to the corresponding drop in performance accuracy. Similarly, the delay engages A.T.'s intact ventral processing thereby improving performance. On the other hand, without the delay D.F. successfully completes the task by relying on her unimpaired dorsal processing whereas A.T.'s performance is poor because of her impaired dorsal processing. Moreover, Milner and Goodale maintain that double-dissociation is also reported in central vision between patients with optic ataxia and visual agnosic patient D.F. when they were tested for grasping accuracy and perceiving the dimension of the objects.

Optic ataxic patients revealed deficits in scaling grip aperture but not in perceiving the dimensions of the objects whereas D.F. showed the opposite pattern of impairment.

Rossetti et al. (this volume) challenge Milner and Goodale's claims of double-dissociation between optic ataxia and visual agnosia. They argue that the double-dissociation lacks sufficient evidence in a number of ways. They contend that the tasks may not have been performed in identical conditions in visual agnosia and optic ataxia patients. While D.F.'s reaching performance has mainly been studied for central vision, studies with optic ataxic patients is focussed on peripheral vision. Rossetti et al., propose that the possibility of optic ataxic patients having intact reaching abilities in central vision cannot be ruled out in which case there would be no double-dissociation.

Also, the double-dissociation is challenged on the ground that there is a difference in the lesions reported in visual agnosia patient D.F. and optic ataxic patients. The former reveals bilateral lesion whereas the latter usually manifest unilateral lesions. Rossetti et al., propose that the lack of sufficient evidence for double-dissociation between visual agnosia and optic ataxia casts a general doubt on whether or not the dorsal stream is solely involved in action. They suggest that it may be more appropriate to conceive of the function of the dorsal stream as subserving peripheral vision rather than vision for action. They contend that the data for double-dissociation supports a dissociation between processes in peripheral and central vision rather than between vision for action and vision for perception. They conclude that the double-dissociations on which the dual-visual systems hypothesis is built do not support a strict separation between perception and action.

Milner and Goodale (this volume) concede that the available data on double-dissociations between visual form agnosia patient D.F. and optic ataxic patients is not beyond doubt and does indicate some incompleteness. Nonetheless, they defend their model of the functional dichotomy between perception and action against Rossetti et al.'s criticism with the following point: even if the conditions found in visual form agnosic patient D.F. and optic ataxic patients do not, to date, conclusively establish a strong double-dissociation between visual agnosia and optic ataxia, this does not imply that the functions of the dorsal and the ventral streams cannot be doubly dissociated. Crucially, Milner and Goodale point out that optic ataxics show a deficit in reaching in peripheral *as well as* central vision.

If a double-dissociation were to be established between the functions of the dorsal and the ventral streams, could it be taken as conclusive evidence for the proposed functional dichotomy between perception and action? For example, consider the recent studies by Schenk (2006) which offer an alternative explanation of D.F.'s impairment. In a series of studies Schenk explored the possibility that D.F. retains her abilities to make perceptual judgments when the object is coded in an egocentric frame of reference. Schenk reports the following results: (1) there is no significant difference in D.F.'s performance and that of controls in egocentric motor tasks. (2) D.F. is seriously impaired in any allocentric task, motor, or perceptual, and (3) D.F. is better at egocentric perceptual tasks than at any allocentric task. Schenk's studies raise a puzzle for the functional dichotomy between perception and action based on the functions of the ventral and dorsal streams. D.F. has impairments in her ventral processing, but why does she perform poorly in an allocentric *motor* task which in the dual-visual systems model is subserved by the dorsal stream? Moreover, if vision for perception and vision for action neatly map onto processing in the ventral and dorsal streams respectively then how is it that D.F.'s performance in egocentric perceptual tasks is better than that in her allocentric motor task despite her impairment in ventral processing? Schenk proposes that D.F.'s impairment does not justify the hypothesis of separate processing for perception and action but rather that she is unable to encode spatial information in an allocentric frame irrespective of the nature of the task (motor or perceptual).

Milner and Goodale (this volume) discuss the puzzle raised by Schenk's studies and reply that the studies do not test what they have in mind while discussing vision for action. The tasks in which D.F. performs poorly are not motor tasks in any sense but are simply a form of reporting a perceptual judgement. Given that she has impaired ventral processing it is not surprising that she performs below average on a variety of perceptual judgment reporting tasks. Jacob and de Vignemont (this volume) provide a detailed theoretical justification for the line of response offered by Milner and Goodale arguing that the tasks in which D.F.'s impairment is revealed in Schenk's studies do not probe visuo-motor processing but her ability to report perceptual judgment. However, if D.F. manages to perform well in egocentric perceptual tasks, how far is it reasonable to conclude that perceptual experience is subserved by processing in the ventral stream? Speculations of such nature fuel the further debate of whether or not processing for action seeps into conscious awareness to make a considerable difference in the quality of our perceptual experience. This point will be further discussed in the following section.

The second source of evidence in favour of a functional dichotomy between perception and action comes from studies demonstrating that visuo-motor processing is significantly immune to visual illusions which deceive conscious experience (Aglioti et al., 1995). However, controversy surrounds the issue of absolute and consistent immunity of visuo-motor processing to illusions which affect perceptual awareness. Melmoth et al. (this volume) present an original study examining the effect of the Poggendorf illusion on both perceptual experience and the visuo-motor response of pointing. Their study reveals that the visuo-motor response is significantly affected by the illusory stimuli which also affect perceptual judgement. Milner and Goodale (this volume) discuss the possible reasons for visuo-motor actions being occasionally affected by illusory stimuli. They argue that the role of the dorsal stream in visuo-motor tasks is best revealed only under very specialized conditions. One such condition would be highly practiced skilful actions directed at targets that are directly visible and do not require drawing from memory or perceptual representations encoded by the ventral stream. However, this seems to narrow down the highly specialized role of dorsal stream in action to a rather small repertoire of visuo-motor behaviour. How far does such limited role of dorsal stream processing in action support the broad functional dichotomy between perception and action? Rossetti et al. (this volume) offer an alternative explanation of why certain cases of visuo-motor behaviour are immune to visual illusions. Optic ataxic patient I.G., studied by Rossetti et al., exhibits patterns of response similar to controls in visuo-motor tasks with illusory stimuli. The authors infer that I.G.'s performance points towards the possibility of visuo-motor behaviour being controlled by systems other than the dorsal stream, for example, by the inferior parietal lobule. Vallar and Mancini (this volume) draw parallels from their study of the neglect syndrome to support the claim that visuo-motor behaviours can be planned and executed independently of the dorsal stream and possibly via the route suggested by Rossetti et al.

The debates surrounding the issue of strong empirical evidence in favour of a strict functional dichotomy between vision for perception and vision for action brings to the fore further and deeper issues. First, it becomes clear that—far from being a homogenous phenomenon—action covers a wide range of visuo-motor behaviours. In addition, it is debatable whether action, as a whole, is fully controlled by the dorsal stream or whether explaining some actions necessarily implies blurring the dichotomy between perception and action. Second, the complexity of the nature of visuo-motor responses as well as that of perceptual judgements may necessitate a more complex model than that proposed by the dual-visual systems account. In the following section we shall look at the nature and content of perceptual experience to discuss its degree of immunity from processing which subserves action.

1.4. The content of perceptual experience

The empirical literature on the dual-visual systems pays considerable attention to the nature of visuo-motor actions. They are understood as the product of automatic processing by the largely

unconscious dorsal stream. However, when it comes to the tricky problem of conscious awareness, the empirical literature on the dual-visual systems views enters the realm of philosophical theories. In this section we shall discuss the nature and content of perceptual experience and its relation to processes subserving action.

As previously discussed in the context of the notion of action in perception, action-oriented theories of perception maintain that perceptual awareness is largely inclusive of processes that subserve action. Thus, for instance, actionism (Noë, this volume) defends the view that the perceiver's knowledge of the lawful relations between movement and change of stimuli constitutes the content of perceptual experience. In the absence of such knowledge there is corresponding absence of perceptual content. While Noë dedicates his chapter to the discussion of the notion of action in perception and the compatibility of actionism with the dual-visual systems view, Kiverstein (this volume) takes up the issue of how sensorimotor knowledge contributes to perceptual experience. Kiverstein maintains that perception, which is characterized by the feeling of seeing the whole of three-dimensional objects and details of the scene, is enabled by the perceiver's exercise of sensorimotor knowledge by way of forming sensorimotor expectations. Many such expectations may never reach consciousness but nonetheless constitute the content of perception as the 'background of experience'. Kiverstein defends the constitutive role of sub-personal sensorimotor expectations in perceptual content by arguing that the sensorimotor expectations are a necessary constitutive element in perceptual experience as long as the skilful perceiver has a sense that such expectations, although not reaching full-blown consciousness, are potentially available to be accessed. The role of sensorimotor expectations in Kiverstein's account is also extended to explain how perceivers grasp the intrinsic properties of objects. Intrinsic properties of perceptual objects are not apprehended from any particular spatial viewpoint adopted under any particular viewing conditions. They exceed the foreground of experience in the same way as in the case of the three-dimensionality of objects and the feeling of perceiving a detailed visual scene. It is sensorimotor expectations alone that furnish the perceiver with a sense of the object's intrinsic properties. Thus in Kiverstein's view the content of perceptual experience, far from being encapsulated from the perceiver's ability to act, is constituted by those very capacities. The content of perceptual experience is sensorimotor in nature.

Now compare this view with Schellenberg's (this volume) account of an action-oriented approach to perception. Schellenberg is of the opinion that perceptual experience presents the perceiver with two kinds of properties, situation-dependent properties and intrinsic properties. Perception of intrinsic properties is epistemically dependent on perception of situation-dependent properties. Grasping the intrinsic properties of objects requires abstracting away from the perceiver's current point of view. However, such abstraction does not lead the perceiver to draw on her knowledge of how the perception of the object would co-vary with movements because the perceiver's self-location, from which the abstraction proceeds, can be secured merely by her capacity to act and does not rely on sensorimotor expectations. Representation of intrinsic properties simply requires that the perceiver has the practical knowledge that the object is perceivable from other view-points which are similarly conceived of as spatial positions from which perceivers can both perceive and act on objects. In Schellenberg's account the content of perceptual experience is in no way constituted by sensorimotor knowledge or expectations, neither for situation-dependent properties nor for intrinsic ones. Yet the content of perception is not impervious to action. It relies on the perceiver's ability of self-location which is constituted by her capacity to act. Is there any reason to prefer either of these accounts of action-oriented perceptual content over the other? We take up this question in the following section in the context of discussing the interaction between the two visual streams and ultimately between perception and action.

Matthen (this volume) offers an account of perceptual content which is influenced by the hypothesis of the functional dichotomy between perception and action, but nonetheless champions the idea that our ability to interact with the object of perception ushers in a non-trivial difference in the qualitative feel of the experiential state. Matthen centres the discussion on the notion of 'feeling of presence' and asks why and how it is that our normal scene vision carries with it a distinct cognitive feeling, the feeling of presence, which marks a sharp contrast between it and pictorial vision.

The issue is as follows: given the similarity of the retinal image how does the perceiver distinguish between an actually present and a depicted object? Matthen introduces the distinction between 'descriptive vision' and 'motion-guiding vision' to provide an account of the feeling of presence accompanying the perception of real objects. Descriptive vision enables the perceiver to characterize, store and recall objects whereas motion-guiding vision is deployed in the precise control of motor movements. Descriptive vision corresponds to Milner and Goodale's (1995, this volume) concept of vision for perception and motion-guiding vision resembles vision for action. Matthen contends that visual consciousness is largely a matter of descriptive vision whereas motion-guiding vision may never enter consciousness due to its being totally or almost automatic. Importantly, though, motion-guiding vision is what secures the feeling of presence accompanying our normal scene vision and the perception of real, rather than depicted, objects. Only real objects engage the perceiver's motion-guiding vision by presenting the possibilities of interaction with the object. Thus although descriptive vision is the key element in visual consciousness, motion-guiding vision is responsible for the cognitive feeling which plays the decisive role in grasping the nature of the perceptual object. In Matthen's view, the content of perceptual experience is constituted by descriptive vision, but the nature of the cognitive feeling of the perceptual state is fixed by the possibilities of interaction with the object. Matthen's account offers a way in which an indirect relationship between perception and action is established by analysing the phenomenological characteristics of a perceptual state. The content of perception is not based on action, but the distinct 'feel' accompanying a perceptual state is decided by the possibilities of interaction offered by the perceptual object.

Clark (this volume) discusses some recent challenges to the dual-visual systems views and the implications these might have on the claim that the content of visual experience is exclusively determined by the operations of the ventral stream. The first of these challenges comes from the studies by Schenk (2006) which have been discussed in the preceding section. A second source of worry is that a theoretical analysis of the nature of visual experience reveals that visual experience may prove to be too heterogeneous to be attributed in its totality to particular brain mechanisms or to be understood in all its nuances as enabled by any particular cognitive process.

Consider, for instance, the phenomenological nature of the impairment observed in visual form agnosia patient D.F. Milner and Goodale (1995, this volume) construe the impairment observed in D.F. as a lack of phenomenal awareness of the shape of visual objects presented to her. However, Wallhagen (2007) offers an alternative conception of the impairment observed in D.F. He argues that instead of lacking phenomenal awareness of shapes, D.F.'s impairment can coherently be described as her failing to conceptualize and report these elements which are perceptually experienced by her. Thus, rather than impaired visual experience, D.F. has impaired *reporting* of her perceptual experience. This interpretation comes at a price for the dual-visual systems model. It implies that the ventral stream may no longer underlie all aspects of visual experience. If D.F. does have visual awareness of shape in spite of her severely impaired ventral processing then it is considerably difficult to rule out processing in other visual streams including the dorsal as playing a role in perceptual awareness. The deeper problem underlying Wallhagen's interpretation of D.F.'s impairment is how to understand conscious experience in the first place. When are we justified in attributing conscious experience to a perceiver? Clark (this volume) offers an answer by appealing to the notion of action while at the same time suggesting a defence of the basic functional dichotomy between dorsal and ventral stream processing. He contends that in order for a perceiver to claim ownership over a conscious experience the information delivered by it must be 'poised for the control of rational action'. He further suggests that ventral stream information qualifies as conscious experience by satisfying this requirement. A considerable amount of dorsal stream processing, on the other hand, yields information that is not available to the perceiver as a rational agent in the guidance of action and consequently does not count as an element in conscious experience. Thus even if one abandons the criterion of reportability for conscious experience all is not lost. However, Clark goes further to propose that conscious experience itself need not be, and in fact most probably is not, a unitary entity. The 'Mere Motley' model of conscious experience which presents consciousness as complex,

jumbled, and at times highly dissociable, capacities comprising multiple layers and streams of processing may just be the best available description of conscious experience. In this picture, action enters the content of perceptual experience only in an indirect way. The content of perceptual experience gains its status from being poised for rational action although much of the processing for the control and online guidance of action escapes the perceiver's awareness.

Jacob and de Vignemont (this volume) take up the puzzle of unreportable visual experience to offer an account of the nature of perceptual content that is consistent with the dual-visual systems hypothesis, which attributes the contents of conscious experience to the processing in the ventral stream. Taking up the challenge presented by Wallhagen's alternative interpretation of the nature of D.F.'s impairment, Jacob and de Vignemont argue that Wallhagen's conjecture at best leads to a stalemate in the debate of the nature of D.F.'s impairment. Wallhagen's arguments raise serious doubts about the lack of phenomenal awareness of shape in D.F. but they do not conclusively demonstrate its presence as a part of D.F.'s perceptual experience. Ascribing phenomenal awareness of shape to D.F. may require grounding her perceptual awareness of shape on the visuo-motor processing in the dorsal stream. However, Jacob and de Vignemont contend that mere processing by the dorsal stream may not suffice for the information to be a part of perceptual content. Visuo-motor processing by the dorsal stream may not play an automatic role in enabling the perception of full blown visual features of objects (such as their shapes) but rather compute features of objects that are immediately relevant for the task at hand. Jacob and de Vignemont argue that experimental evidence strongly indicates that D.F.'s success in visuo-motor tasks relies on her computing the width rather than the shape of objects. For example, she performs at chance when presented with a square and a rectangle of equal width. So does the processing by the dorsal stream enter into perceptual content? This would require the distinct unbound features of an object relevant for visuo-motor tasks, as processed by the dorsal stream, to be found in conscious experience and for the dorsal stream to have access to an iconic memory buffer. Jacob and de Vignemont's treatment of perceptual content makes it highly unlikely for information at the service of action to directly constitute perceptual experience. The point will be discussed in detail in the following section on the interaction between the two visual systems.

Action-oriented views of perception counteract claims regarding the nature of perceptual content as distant and at best indirectly linked to action. Some action-oriented accounts argue that a major attraction of their approach lies in the methodological remedies they offer for central issues in consciousness studies. O'Regan (this volume) defends an action-oriented approach to perception which generalizes to a broad theory of consciousness. Sensory experience presents us with puzzling features which philosophers and cognitive scientists have sought to explain for decades. Sensory experiences are ineffable, have certain structures, and are generally accompanied by something it is like to undergo the experience in question. Does adopting a functional dichotomy between perception and action take us any closer to accounting for these puzzling features of sensory experience? O'Regan contends that these essential characteristics of a sensory state are due to the perceiver's mastery of the sensorimotor laws of interaction with the environment. Abandoning the contribution of action in enabling perceptual content leads to a sort of radical neuro-reductionism with no explanatory advantage. O'Regan argues that the hard problem of consciousness remains unresolved on a 'passive' view of perception where perceptual experience proceeds by the perceiver passively receiving the sensory stimuli which are then somehow organized into meaningful perceptual experience by sub-personal neural mechanisms. In the passive view of perception an explanatory gap between the phenomenological aspect and the physical mechanism persists because there is nothing intrinsic about neural mechanisms that can account for the particular feel accompanying a perceptual state. On the other hand, the perceiver's particular sensorimotor mode of engaging with the environment when undergoing a sensory experience offers an objective and verifiable characterization of the puzzling phenomenological features of sensory experience. It is in virtue of being directly enabled by sensorimotor processes of interaction with the environment that conscious experience acquires its familiar phenomenology.

The discussion of the nature of perceptual content in action-oriented and dual-visual systems views allows us to form certain hypotheses about the nature of interaction between the two visual

systems as well as about the nature of the interaction between perception and action. Let us now see how we can tackle the tricky issue of bringing together these two major components of our cognitive life.

1.5. Bringing it all together: interaction between perception and action

The goal of the conference on Perception, Action and Consciousness, which resulted in this volume, was to encourage dialogue between what appeared to be two opposing schools of thought on the nature of perception and cognition in general. Action-oriented approaches strongly defend perception as an achievement by an active perceiver whereas dual-visual systems theories are in favour of maintaining a functional dichotomy between perception and action. However, it is a fact that in normal everyday cognitive behaviour the two visual streams, the ventral and the dorsal, interact. In the remaining part of the introduction we shall explore the issue of interaction between the two visual streams and discuss whether or not an account of the interaction also leads to a resolution of the debate between the two schools of thought.

One way in which the action-oriented approaches have sought to reconcile their approach with the dual-visual systems views is by suggesting that in dual-visual system theories one must make use of an action-oriented theory of perception in order to account for the interaction between the two streams. Noë (this volume) offers a reconciliation of actionism with the existence of the dual-visual systems by arguing that conscious perception influences visuo-motor behaviour not only in the planning of the latter but in the general guidance of this behaviour as well. This claim finds support, for example, in the case of optic ataxics who appear to perform normally in everyday activities. The evidence of fine online adjustment to visuo-motor behaviour proceeding without the agent's awareness could be seen as a challenge to the idea of perception as an active engagement of the perceiver with the environment. However, Noë argues that this evidence is not incompatible with action-oriented theories: the role of the agent's awareness can well be limited to fixing the target of action without interfering with the low-level parameters of online adjustment of the visuo-motor behaviour. What is crucial for securing an adequate account of the interaction between the two visual streams is abandoning a 'picture-theory' of perception where perceptual awareness merely registers the visual scene in an allocentric frame without encoding the possibilities of interaction with the perceived objects.

Kiverstein (this volume) frames the issue of interaction between the two visual streams in terms of the 'communication problem'. How is it possible to establish communication between two systems which, if the functional dichotomy proposed by dual-visual systems theories is correct, encode information in different frames of reference? The solution proposed by Kiverstein's sensorimotor theory of consciousness is to conceive of the contents of perceptual experience as encoded in an egocentric frame of reference. Crucially, this frame of reference represents the possibilities of entering into sensorimotor engagement with an object as the object of both perception and action. While Kiverstein resolves the communication problem between perception and action by proposing egocentric coding for both, Schellenberg's (this volume) capacity view argues that allocentric encoding for perceptual awareness needs to be preserved if the theory is to explain the perception of intrinsic properties of objects. A challenge for Schellenberg is that representing the possibilities of action in terms of the perceiver's spatial know-how involves egocentric encoding. Schellenberg's view leads to the issue of how appreciating different perspectives by way of apprehending the intrinsic properties of objects allows for egocentric and allocentric encoding to fuse together. While Schellenberg leaves it an open-empirical question, studies by Delevoye-Turrell et al. (this volume) provide an empirical approach to solving the puzzle of combining different frames of reference in perception and action by invoking the role of motor-imagery in perceptual judgements. Delevoye-Turrell et al., argue that spatial know-how is not a uni-modal cognitive ability but that spatial know-how requires fusing perceptual information about the location of the object with action representations of possible

visuo-motor interactions with it. Insofar as motor representations contribute to the visual judgement of what is reachable, or possible targets of visuo-motor behaviour, egocentric encoding does appear to make up part of perceptual content concerning our spatial know-how.

In disagreement with the action-oriented approaches, the dual-visual systems theories deny it is necessary to introduce elements of action into perceptual awareness in order to account for the interaction between the two visual streams. One of the strongest resistances to an action-oriented conception of perception is offered by Jacob and Jeannerod (2003) and taken up by Jacob and de Vignemont (this volume). Jacob and Jeannerod (2003) present one of the earliest objections to an over-simplistic dichotomy between the functions of the ventral and the dorsal visual streams. They propose a hierarchical model where the one and the same stimulus can undergo two different types of processing along several levels of complexity. The pragmatic processing of visual information by the dorsal stream at first delivers visuo-motor representations as a low-level component and the processing gradually increases in complexity till it delivers input for more conceptually demanding aspects of visuo-motor behaviour such as skilful use of tools, planning future actions, etc. On the other hand, semantic processing of the visual stimuli by the ventral stream similarly proceeds in several layers with the lower levels processing for non-conceptual outputs which gradually increase in complexity to inform the perceiver's complex perceptual judgements.

According to Jacob and Jeannerod (2003), however, the output of processing by the ventral stream does not interact with motor intentions. Thus perception and action remain distinct as cognitive operations but this does not prevent the theory from accounting for aspects of our visuo-motor behaviour of which we are aware. Instead of offering an account of a simple interaction between two broadly characterized visual systems, Jacob and Jeannerod (2003) and Jacob and de Vignemont (this volume) aim to explain the peculiarities of visual perception and visuo-motor behaviour by postulating a complex hierarchy for each of two distinct types of processing. These two types of processing usually work in tandem but the impairment in one does not affect the essential nature of the output delivered by the other. Thus perception and action usually interact but are not co-constitutive. Clark (this volume) tackles the issue of interaction between the two visual streams in a similar fashion by arguing in favour of a complex and non-homogenous conception of conscious experience itself. In Clark's account the interaction between the two streams of visual processing and between perception and action is required only at an 'agent-level' description. The interaction is established in terms of content, visuo-motor or perceptual, which is poised for being accessed for rational action. Perception and action usually interact causally, but the interaction is indirect and flexible allowing ample room for conscious experience to proceed without motor input from action guiding systems and vice versa.

While the theoretical approaches of the dual-visual systems views have provided conceptual analyses of the notions of perception and action for breaching the gap between the two, the proponents of the dual-visual systems' functional dichotomy offer a sequence of refinements of their views which build up on the complexity of the underlying anatomy. They maintain that the links between perception and action are indirect but the two usually interact on the basis of sharing a common retinotopic area in the primary visual cortex. The functional interaction between vision for perception and vision for action is explained via cognitive operations of memory and action planning. The quest for a common cortical system for integrating the functions of the dorsal and the ventral visual streams has occupied neuroscientific studies of the dual-visual systems for decades. Milner and Goodale's (1995) proposal of the strict functional dichotomy between the dorsal and the ventral visual streams added more fuel to this quest with many claiming it to be an oversimplification of the anatomical and functional bases of perception and action which is unable to accommodate a considerable volume of empirical literature in the field (Viviani, 2002; Rizzolatti and Matelli, 2003; Pisella et al., 2006; Gallese, 2007).

Does an account of neurophysiological interaction between the two visual streams sway the debate in favour of action-oriented theories of perception? While Milner and Goodale (this volume) maintain that a complex account of the functional and anatomical interactions between the two visual streams would nonetheless preserve the basic hypothesis of the functional dichotomy of perception and

action, neuroscientific accounts which have attempted to explain the interaction between the two visual systems often argue that preserving a strict functional dichotomy may well be impossible. Consider, for example, Gallese's use of evidence from lesion studies and single neuron studies for establishing a case in favour of multiple pathways subserving perception and action (Gallese, 2007). These multiple pathways make at least certain categories of visual perception, for example, spatial perception and perception of action, reliant on processing for action. In place of a broad dichotomy between the ventral and the dorsal visual streams, Gallese defends the view that visual processing is in fact conducted along three streams, the ventral stream, the ventro-dorsal stream, and the dorso-dorsal stream. The ventro-dorsal stream, which involves projections from the inferior parietal lobe to the pre-frontal and pre-motor areas, serves as the main interaction zone for the ventral and dorsal streams where the coupling between perception and action is seen in one of its most robust forms.

Similarly, from their claims of incomplete dissociation between perception and action Rossetti et al. (this volume) hypothesize the existence of multiple pathways that make it highly improbable for perception and action to proceed as independent phenomena, not only in normal subjects but also in case of visual agnosics and optic ataxics. One of the likely reasons why a neat double-dissociation between visual agnosia and optic ataxia is yet to be established to date is because the neural structures underlying our capacities of perception and action are too intertwined to allow either to proceed totally unaffected when there is an impairment in the other. As a possible solution to the issue of interaction between the two visual streams, Rossetti et al., highlight the role of the areas lying between the ventral and the dorsal stream with special focus on structures like the inferior parietal lobe which seem to be involved in the control of action outside the dorsal stream. In a similar vein, the neuroscientific analyses by Vallar and Mancini (this volume) suggest that the dual-visual systems only partially capture the essential elements in perception and action. They highlight the role of what they term the 'dorso-ventral stream'. Vallar and Mancini discuss in detail the role of the dorso-ventral stream in both visual and motor spatial awareness. They argue that the phenomenon of unilateral spatial neglect offers a challenge to the simple dichotomy of dorsal and ventral streams because the phenomenon cannot be attributed exclusively to impairment in either. Milner and Goodale (1995) consider unilateral spatial neglect to result from impairment in the ventral stream but Vallar and Mancini argue against this conclusion on grounds that the impaired and preserved characteristics in neglect syndrome differ significantly from those of visual agnosia. Unilateral spatial neglect indicates the role of the dorso-ventral stream in combining perceptual and motor elements leading to perceptual awareness of space as well the execution of motor behaviour directed at objects situated in the perceived space.

What are we to conclude from the above neuroscientific claims of the interaction between the dorsal and the ventral streams involving structures that appear to subserve the crucial functions for both perception and action? If these claims are taken at face value then perception and action appear to be coupled, anatomically and functionally, especially at low levels of description.

Such coupling between perception and action is often invoked for explanatory advantage when it comes to accounting for higher level cognition as well as for consciousness in general. In the previous section we saw how O'Regan's sensorimotor theory of perception proposes a methodological remedy for explaining the qualitative character consciousness. Other theories have also pointed out tricky methodological issues in studying conscious experience in general within the framework of a rigid functional dichotomy between perception and action. For example, Ballard (this volume) argues against the view that conscious experience can be localized within a system that seems to be relatively impervious to processing for action by considering the question: why are we conscious? Ballard compares the role of consciousness to the process of debugging a program run on a computer. He contends that consciousness shares the same neural hardware as that of 'zombie' systems, as can be seen for example in case of the activity of mirror neurons. Furthermore, the use of the same neural hardware for both consciousness and 'zombie' programs indicates that conscious experience relies on the same neural systems that are deployed in everyday interaction between the agent and the world. Interestingly, Milner and Goodale (1998) emphasize that the reason why perception evolved is '... to provide distal sensory control of the many different movements that organisms make'. Ballard's proposal of the role of consciousness may not be in direct conflict with Milner and Goodale's hypothesis about the reason for the evolution of perceptual abilities. Ballard's main contention

against the dual-visual systems view lies in the latter's attempt to localize conscious experience within a particular neural system that has at best indirect and highly flexible connections to systems responsible for the control of the organism's real-time behaviour and survival.

In the context of discussing the role of conscious visual experience in guiding action, Wilson (this volume) argues that such a role of conscious experience requires attributing to the body and the environment of the perceiver a constitutive role in enabling perceptual experience. According to Wilson, visual systems which have primarily evolved for the guidance of action are best understood as involving 'exploitative representations' or representations that rely on the body's structure and sensorimotor engagement with the environment. Wilson suggests that the consideration of a constitutive role of the body and its sensorimotor interaction with the environment in enabling perception makes a theory better able to account for basic elements involved in perception such as saccadic eye movements. Viewing vision as proceeding by dynamic feedback loops which cross the boundaries of skin and skull enables us to understand more fully the action-guiding nature of vision as well as the nature of vision as an extended cognitive system.[5]

The fact that perception and action interact in the everyday life of an organism situated in a complex environment is not disputed by any of the views that are discussed in this volume. The question is: how tight does the coupling between perception and action have to be in order to account for our perceptual awareness and motor behaviours? Action-oriented approaches to perception, both theoretical and empirical, have pointed out the inadequacies of a framework that views perception and action as only rather loosely connected in accounting for a significant amount of empirical studies in the field as well as for everyday perceptual experience and motor behaviour. On the other hand, the dual-visual systems theories have pointed out that postulating an inflexible and strongly co-dependent relation between perception and action does not go a long way in accounting for observed dissociations between the two and the existence of specialized functions. Unravelling the various components of perception and action reveals that there are lessons to be learnt from both camps. While not necessarily inseparable in all their nuances, the interaction between perception and action may turn out to be more than a marriage of convenience.

1.6. Conclusion

This volume results from the last international and interdisciplinary conference convened by the late Susan Hurley months before she passed away after her long and courageous battle with cancer. The conference on Perception, Action, and Consciousness: Sensorimotor Dynamics and Two-Visual Systems was organized as part of the CONTACT project funded by the Arts and Humanities Research Council under the European Science Foundation Eurocores Consciousness in Natural and Cultural Contexts (CNCC) scheme (grant number AH/E511139/1 of the AHRC). The goal was to bring together leading researchers in philosophy, psychology, neuroscience, and artificial intelligence in order to discuss the relation between perception and action, specifically whether perception required action or whether perceptual awareness was merely a matter of passively representing the visual world. Hurley's work in philosophy of mind and cognitive sciences covers an incredibly wide range of topics such as embodied cognition, the nature of consciousness, theories of imitation, theories of

[5] Readers may be familiar with Clark's similar suggestion that some cognitive systems are extended (Clark and Chalmers 1998, Clark, 2008). Wilson's claim of vision as constituting an extended cognitive system differs from Clark's. The constitutive relationship between perception and action served by feedback loops motivates Wilson's proposal of an extended cognitive system. In contrast, Clark's proposal of the extended mind is motivated by the 'parity principle'. The parity principle maintains that if external structures function as part of a process which if conducted exclusively by internal neural mechanisms would be considered as a cognitive process, then those external structures too constitute the cognitive process. Thus, unlike Wilson's hypothesis of vision as an instance of an extended cognitive system involving feedback loops, Clark's defence of the extended mind hypothesis does not rely on a tight coupling between perception and action.

perception, and social cognition to name a few. A common note running through Hurley's treatment of these diverse topics is her rigorous defence of the essentially active nature of our cognitive life. She repeatedly challenged the orthodox view of the mind which she dubbed the 'classical sandwich' because it conceives of the mind or cognition as sandwiched between the separate modules of perception and action; the former carries the input from the world to the mind and the latter carries the output from the mind to the world. In the decade between the publication of her two major works *Consciousness in Action* (1998) and 'The Shared Circuits Model' (2008) Hurley's approach was one of gradually unifying her views on social cognition with her thesis of the active nature of perception which eventually culminated in the framework of the shared circuits model where consciousness of oneself and of others arises from the dynamic perception-action coupling constituting the very core of our engagement with the world.

The dialogue between the two approaches, the action-oriented views of perception and the dual-visual system theories, presented in this volume brings out wider theoretical issues that underlie the research paradigm of cognitive sciences and philosophy of mind. These issues require critical deliberations and interdisciplinary efforts for laying the foundations of future research in the domain. For example, an important implication of the action-oriented views is that the notion of embodiment, which is crucial for understanding the notion of agency, must be wide enough to include the whole organism rather than just the brain. Consequently, some action-oriented approaches, for example the sensorimotor theories, tend to view the search for the neural correlates of consciousness with suspicion (Noë and Thompson, 2004). However, if the separation between perception and action is accepted as unavoidable for a systematic account of consciousness, such a separation implies that perceptual experience can be understood, at least to a nontrivial extent if not in its totality, by brain mechanisms dedicated to the generation of internal representations. The conference brought together leading exponents of the two approaches, renowned scholars offering a dynamic and interdisciplinary perspective of a number of fundamental issues in cognitive sciences and philosophy of mind, and aimed to take up modern challenges to classical issues from two powerful emerging perspectives while pointing out the direction of the current and future research in the domain.

The volume has been organized into six sections. The first section discusses methodological issues in a scientific study of consciousness with special focus on the role of sensorimotor dynamics (Ballard, O'Regan, Clark). The second section takes up an exposition of the two visual systems hypothesis along with discussions of empirical evidence (Milner and Goodale, Melmoth et al.). The third section discusses conceptual issues relating to the notion of agency and object perception. It includes works inspired by the dual-visual systems model (Matthen, Jacob and de Vignemont), and a work that offers a different take on an action-oriented approach to perceptual experience (Schellenberg). The fourth section presents studies in cognitive neuroscience that throw new light on the two-visual systems hypothesis (Rossetti et al., Vallar and Mancini, Delevoye-Turrell et al.). The fifth section addresses the role of action and sensorimotor knowledge from the perspective of the sensorimotor theories of perception and presents new developments in the sensorimotor theorists' conceptualization of the relation between perception and action (Noë, Kiverstein). In addition, Noë pays special attention to the relation between his action-oriented account of perception and the dual-visual systems hypothesis. The sixth and final section raises fundamental issues about the embodied situated agent and questions the traditional boundaries of the agent's embodiment (Wilson).

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