The Body Schema as a Condition of Possibility of Action*

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Outline:

1. Introduction: Dissociating Body Representations

The body is the self – is the subject. Thus, it might be thought that the subject in representing itself must represent its body. In that case, it would seem that body representation is a form of self-representation. Indeed, in agents with self-consciousness, body representations may be a primordial form of self-consciousness (Rochat 2011, Peacocke 2014). I want to approach these issues by way of reflecting on the functional architecture of body representations. In particular, I will focus on body representations which support action: the body schema. My aim is to defend

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the coherence and utility of the notion of the body schema as *body representations for action*.

How should one approach the functional architecture of body representations? A powerful way to do this is to look at dissociations in healthy and diseased individuals. We know from experimental work on dissociations between perception and action that successful action is possible even when conscious perception is illusory, as is familiar from dissociations in the visual system (Milner and Goodale 2006, Jeannerod 1997). These dissociations characterising vision have inspired applications of the perception/action model of functional dissociations to other sensory modalities, such as the bodily senses (Paillard 1999, Dijkerman and de Haan 2007).

The basic starting point for dissociating body representations is the dichotomy between body representations for perception as opposed to those for action (Paillard 1999, Dijkerman and de Haan 2007). Let us understand 'body representations' to be whatever representations are needed to characterise the functioning of the bodily senses. Body representations for perception are known as the 'body image', whilst body representations for action are known as the 'body schema'. The body image is a representation of one's overall body form that can be manifest in consciousness through perception or imagery. It is an explicit representation of body form, which may include the conscious awareness of current postural configuration. It is "given by the description or drawing or model one would assemble in order to say how the body seems to one at a certain instant" (O'Shaughnessy 1980: 241). In contrast, the body schema is a dynamic representation of the relative position of body parts that is employed in the control of action and the maintenance of posture. Haggard and Wolpert (2005) characterise the body schema as follows: "*Body schema* refers to a representation of the positions of body parts in space, which is updated during body movement. This typically does not enter into awareness, and is primarily used for spatial organization of action. The body schema is therefore a central representation of the body's spatial properties that includes the length of limb segments, their hierarchical arrangement, the configuration of the segments in space and the shape of the body surface." This basic dissociation between body image and body schema is widely accepted, though the exact characterisation of each body representation is a subject of dispute (de Vignemont 2010, Longo et al. 2010, Dijkerman and de Haan 2007, Paillard 1999, Gallagher 1986).

One relatively uncontroversial way to demonstrate a dissociation between these two kinds of body representations is to consider scenarios where the conscious body representation is illusory, but action is successful despite this. Given that action needs to draw on accurate bodily parameters, the bodily parameters used to control action cannot be those given by the conscious body representation, since these are illusory. It follows that there are body representations for action control (body schema), and that these are distinct from the ones for conscious body perception (body image). A number of different experiments could be used to illustrate this, but let us consider the following one.

Kammers and colleagues (2009) studied the effects of the rubber hand illusion (RHI) on action. In the standard RHI setup (Botvinick and Cohen 1998), a subject sits with their arm resting on a table but hidden behind a screen. A rubber hand is placed in front of the subject, in a position anatomically congruent with the subject's hidden hand. If both the rubber hand and the subject's hidden hand are synchronously stroked for about a minute, a large portion of subjects report that (1) they feel the touch to be where they see it – i.e. on the rubber hand – and that (2) they feel that the rubber hand is part of their body. This has the effect of inducing a proprioceptive drift of the position of the subject's affected hand toward the position of the rubber hand. None of these effects are found in the control condition when the rubber hand and the subject's hand are stroked asynchronously.

Kammers and colleagues examined whether the illusory position of one's hand in the RHI affects acting on and acting with the affected hand. As usual, the induction of the RHI was accompanied by a mislocation of the stimulated hand toward the rubber hand. But they found that this proprioceptive illusion had no effects on the ballistic reaching responses of both the stimulated and unstimulated hands. Furthermore, the proprioceptive illusion of hand location persisted even after the reaching responses. Thus, we find a dissociation between the spatial parameters determining conscious perception of hand location and spatial parameters used in the control of action (both as target of the action and as effector). This provides an instance of the dissociation between body representations for perception – the body image – and body representations for action – the body schema.

Do dissociations like this provide adequate support for positing a dichotomy between body image and body schema? In particular, do functional dissociations suffice to carve out a coherent notion of the body schema?

2. Scepticism about the Body Schema

De Vignemont (2010) answers 'no' to both questions. She argues that the familiar distinction between body image and body schema is inadequate. First, she argues that there appear to be no systematic grounds for restricting the kinds of body representations to two. If we were to introduce distinct body representations based on every dissociation discovered, we would have to introduce too many body representations because the dissociations appear to be task dependent. Second, she argues that it is unclear how to classify certain pathological cases based on the familiar dichotomy.

De Vignemont is correct that there are no systematic grounds for restricting the kinds of body representations to two. Based on dissociations between apraxia, autotopagnosia, and body-specific aphasia, researchers have proposed a trichotomy of body representations: the body schema, the body structural description, and body semantics (Sirigu et al. 1991, Schwoebel and Coslett 2005). This trichotomy still maintains a divide between body representations that are for action (the body schema) and those that are not (the body structural description, which contains topographical information about how the body is articulated into parts, and body semantics, which contains information about different aspects of the semantics of body parts, including their function). If the problem were simply that we had to switch from a dichotomy to a trichotomy, the situation would be less worrying. But there appear to be far more dissociations that we can find based on the tasks we already have. If we posit a new body representation for each dissociation discovered, then the many different kinds of body representation posited would lack explanatory power, as they would appear to reflect task differences and not genuine differences in functional architecture (de Vignemont 2010).

I agree with De Vignemont that the distinction between the body image and the body schema is not exhaustive and exclusive, and that the dichotomy is not sufficient for classifying the full range of body-related pathologies. The question is whether this robs the distinction between body representations which are for action and those which are not of any explanatory value. I contend that it does not. This is not to deny that a full catalogue of the varieties of body representation would need to draw on more distinctions, and that there remain critical questions about how best to interpret dissociations in neuropsychology.[1]

There is wider scepticism about the notion of body schema, partly because of widespread terminological confusion. This would appear to be a superficial problem, unlike those that De Vignemont raises. Researchers need only regiment their labels. However, there is a deeper worry, which is that the notion fails to be explanatory because it is not well defined. Expressing this concern, Maravita, Spence and Driver write: "the 'body schema' has often been invoked as an explanatory concept, when it should perhaps rather be considered as a label for a set of problems still requiring explanation" (2003: 531). In order to earn the right to use the body schema as an explanatory notion, we need to answer these sceptical doubts. I will argue that the body schema is crucial for understanding action and that if we are to uncover the conditions of possibility of bodily action, we need a serviceable notion of the body schema.

[1] For a review of different kinds of body representation, see Longo's essay in this volume. For a discussion of issues concerning the interpretation of double dissociations, see Davies (2010).

3. The Body Schema

3.1. Functional Arguments for the Body Schema

I will reply to the scepticism about the body schema by providing a functional characterisation of the body schema and then providing some arguments for it. My strategy is to argue that there must be some body representation that fulfils a certain role and to understand the body schema as that which does this. I will provide three arguments for the body schema: (1) from reflection on Bernstein's degrees of freedom problem in motor control, (2) from perception/action dissociations, and (3) from observations about tool use.

Bernstein's (1967) degrees of freedom problem is that if the information processing system were involved in the production of all decisions about each of the muscles involved in a motor act, this would be computationally much too expensive. *Why?* The motor system has too many degrees of freedom. For even simple movements, there are numerous joints and muscles involved. This would lead to an impossible situation for the central nervous system if it had to control all these degrees of freedom separately (Bernstein 1967, Greene 1972, Whiting 1984).

What Bernstein shows is that there are too many parameters to control individually. These control parameters need to be organised hierarchically, so as to reduce degrees of freedom. On a hierarchical model of action, actions are organised in a tree-like structure, with the overarching goal of the action at the top of the hierarchy, followed by sub-goals under, and different levels of the hierarchy, eventually terminating in individual muscle activations. The idea is that if certain action units are grouped together and hierarchically controlled, control of nodes higher up the hierarchy programs the operation of nodes lower in the hierarchy. For example, plans allow the agent to orient his behaviour in some general way, and a descending hierarchy of systems implement these plans ever more specifically as we descend the control hierarchy. This hierarchical organisation allows for effective control of action by reducing the degrees of freedom of the motor system.

A consequence is that the operation of various action units lower down the hierarchy will be automatic. Though the agent does not monitor the operation of these units, the successful operation of these action units still requires that the motor system possesses accurate information about the relevant bodily parameters. Without having a body schema this would not be possible.

The imposition of the motor hierarchy requires both automaticity and the body schema, and it is the coming together of the two that shows how control of a complex motor system with numerous degrees of freedom, in real time and with limited computational resources, is possible. There is a deep link between automaticity and the body schema that deserves further exploration. But I have said enough to show that the current positions of body parts relative to other body parts have to be registered in order to make motor control in real time possible.

As noted earlier, we know from experimental work on dissociations between perception and action that successful action is possible even when the conscious perception is illusory. Together with the degrees of freedom problem, this suggests that there must be some representations employed for action which are automated and which are accurate. We can identify these as the appropriate body representations for action which play the functional role which we have identified for the body schema: the provision of accurate parameters for the control of action. Thus there are grounds for thinking that the architecture of motor control requires a hierarchical model of action where there are automated parameters figuring in representations for action control. These same representations are isolated when we encounter successful action under conditions of illusory perception.

We now have basic architectural grounds for positing the body schema for action. A further architectural reason comes from reflecting on how we act with tools. Insofar as tools can function like limb effectors in action, body representations for action have to be sufficiently plastic so as to allow for the incorporation of foreign objects into the representation of one's body. Thus some forms of tool use require the body schema. When Head and Holmes introduced the notion of 'body schema' in 1911 they explicitly noted the importance of the notion of a body schema where tools could be incorporated:

> It is to the existence of these "schemata" that we owe the power of projecting our recognition of posture, movement and locality beyond the limits of our own bodies to the end of some instrument held in the hand. Without them we could not probe with a stick, nor use a spoon unless our eyes were fixed upon the plate. Anything which participates in the conscious movement of our bodies is added to the model of ourselves and becomes part of these schemata… (Head and Holmes 1911: 188).

Evidence that tool use requires the body schema comes from two directions. We can examine the effects of tool use on perception and on action. On the perceptual side, it has been shown in monkeys that when they learn to use a tool, there is an extension of the bimodal receptive fields to the reaching area of the tool (Iriki et al. 1996, Maravita and Iriki 2004). The peripersonal space around the hand expands to cover the extent of the tool.

Furthermore, there is behavioural evidence from performance on temporal order judgment tasks that the somatosensory system treats tools like arm extensions. Yamamoto and Kitazawa (2001a) asked subjects to judge the order in which their hands are touched without vision. If we compare the performance of subjects when their hands are crossed over the midline of the body (left hand on the right side of space, and vice versa), as opposed to when their hands are in an uncrossed position (left hand on the left side of space, etc.), we see a dramatic drop in performance. In the hands-crossed condition, we are slower and less accurate in judging which hand was touched first without the help of vision. Similar effects are observed with tool use (Yamamoto and Kitazawa 2001b). If a subject's hands are uncrossed, but tools held in his hands are crossed over his midline, then performance in temporal order judgement tasks in sighted individuals drops, like in the hands-crossed condition. There is a similar drop in performance if the subject's hands are crossed but the tools are uncrossed.

These studies support the idea that tools are perceptually treated as body extensions, as Head and Holmes (1911) anticipated. These results provide perceptual evidence for body schema extensions with tools. Is there evidence from action that tools are treated as part of one's body?

Cardinali and colleagues (2010) showed that the kinematic profile of reaching and grabbing with a tool is just like that of having a lengthened limb. Jeannerod (1999) analysed the kinematics of reaching and grasping hand movements, and showed that these could be divided into a transport and a grip component. Cardinali and colleagues asked subjects to perform pointing and grasping tasks with and without a 40 cm long mechanical grabber. Subjects first performed free hand movements, followed by grasping movements with the grabber, and then the same free hand movements as before. They found that the kinematic profile of the free hand pointing and grasping movements made after tool use showed differences in the transport component that are best explained by a modification of the somatosensory representation of the subject's arm. The arm is represented as being longer than it is, which is a residual effect of tool use. This was corroborated by evidence from comparing stimulus localisation judgements through blindfolded pointing on landmarks on the hand before and after tool use.[2]

[2] Evidence from the effects of tool use on action is vital since it is controversial whether the perceptual effects of tool use are best explained by an extension of the body schema. Holmes and Spence have challenged this standard interpretation of the results from Iriki and colleagues (Holmes et al. 2004, Spence 2011, Holmes 2012). They suggest, instead, that the perceptual effects of tool use may involve a projection of the space around the hand to the space around the tips of the tools used. A body schematic extension would predict some gradient of perceptual effects distinctive to the hand along the length of the tool, as the tool is supposedly represented as an arm extension in the body schema – indeed, this is what we find in the case of biological arms. However, they found that the effects were restricted to the tips of the tools. Even so, Holmes and Spence's point does not bear on the action effects of tool use.

I have argued that there are architectural reasons why there should be something like a body schema, so as to solve the degrees of freedom problem. The presence of such a schema is borne out by the possibility of action control under conditions of illusory body perception. Furthermore, such a schema can explain how it is possible that we can perform skilled actions with tools. The body schema allows that tools can be incorporated as limb effectors into one's body representations for action. All this shows that the body schema is a condition of possibility of action.

3.2. The Multimodal Body Schema

A consequence of my functional characterisation of body schema as those body representations needed for the control of action is that the body schema is multimodal. The body schema is a dynamic representation of the relative position of body parts that is employed in the control of action and the maintenance of posture. Since the body schema is crucial for online control of action, it has to be constantly updated with bodily movement as the action unfolds (Wolpert et al. 1998, Schwoebel and Coslett 2005). Because of constraints on accuracy, it is plausible to think that body representations for action will draw on a range of different sources, including vision, touch, proprioception, the vestibular system, and the motor system, so as to provide the most optimal information for the control of action. This will involve both sensory combination and sensory integration from multiple sources of information about bodily parameters required for action (Ernst and Bülthoff 2004). On this picture, there are architectural and computational grounds for thinking that the body schema must be multimodal. The multimodality of the body schema naturally derives from the need for optimal information for online motor control.

But we can distinguish two questions about the multimodality of body schema. One is whether the body schema should be multimodal. My answer is 'yes', based on the need for optimal bodily information for motor control. Another question is whether the body schema is multimodal. If my functional argument for the body schema is on track, then the answer is also affirmative.

All three points I used to argue that the body schema is required for tool use illustrate the multimodality of the body schema. The updating of one's body schema when tool extensions are involved is naturally construed multimodally. We do not have proprioception in tools. The expanded receptive fields in Iriki and colleagues' monkey studies were of bimodal neurons sensitive to visual and tactile input.

I have already alluded to the experiments on temporal order judgements of tactile stimulus done by Yamamoto and Kitazawa (2001a). Using the same paradigm, Röder and colleagues (2004) found that the difference in task performance between the hands-uncrossed and hands-crossed conditions was found in sighted and non-congenitally blind people, but not in congenitally blind people. This behavioural difference is best explained through a process of remapping stimulus information from a body part centred, somatotopic frame of reference to a visual frame of reference that is absent in congenitally blind individuals. The finding in the hands-crossed condition indicates that the body representations underlying touch are different in kind in sighted (and late blind) people as opposed to congenitally blind people, since in the latter case it is centred on the body parts involved rather than on the visual frame of reference. Similarly, in experiments done with the same paradigm with tools, there is a drop in performance when either the subject's hands or the tools were crossed (but not both). Interestingly, if the subject's hands are crossed but the tools are also crossed (so that the tips of the tools would be roughly where they would be if neither hands nor tools were crossed), then task performance goes back to the same level as the hands-uncrossed condition (Yamamoto and Kitazawa 2001b). The recovery in performance in this final condition to levels in the hands-uncrossed condition suggests that the processing of tools as part of one's body in external space is anchored to visual frames of reference rather than to a somatotopic one.[3]

[3] Here I am extending de Vignemont's (2014) argument for a multimodal conception of bodily awareness based on Yamamoto and Kitazawa (2001a).

Finally, the modification of the body schema through tool use in the study by Cardinali and colleagues is clearly multisensory. Visual, somatosensory, and motor information is feeding into the updated representations of limb length for online control. Thus there are powerful grounds for the claim that there are body representations for action and that these are multimodal.[4]

4. A Double Dissociation between Numbsense and Deafferentation?

Now that I have adumbrated a conception of the body schema, I want to return to consider and dispute an influential way of arguing for the distinction between body image and body schema. Paillard has argued that the contrast between peripherally deafferented patients and numbsense patients presents a double dissociation between the body image and the body schema (Cole and Paillard 1995, Paillard 1999).

Paillard argues as follows. In numbsense, the somatosensory analogue of blindsight, patients suffer from a central deafferentation of a limb and are unaware of tactile and proprioceptive stimulation on the affected limb (Paillard et al. 1983, Rossetti et al. 1995, 2001). When tactile or proprioceptive stimuli are applied in the absence of vision, numbsense patients are at chance when verbally reporting the site of stimulation or when pointing on a diagram of the affected limb, but they are able to reliably point to the site of stimulation (or its position) on the affected limb with the unaffected hand. Peripherally deafferented patients have no touch or proprioception in affected parts of their body due to the destruction of large myelinated nerves in those parts; some deafferented patients have learnt how to act

[4] A further argument for the claim that the body schema is multimodal comes from the need to neutralise systematic distortions of the body model. The body model is a model of the metric properties of the body that is used to map primary afference from somatosensation to provide the position of body parts in space (Longo 2015). There is evidence from hand proprioception and touch that the body model suffers from systematic distortions (Longo and Haggard 2010, 2011, 2012a, 2012b). Insofar as proprioceptive afference needs to be mapped through the body model for action control, the systematic distortions need to be neutralised so that accurate motor control is possible. One way to achieve this is through multisensory integration of different sensory sources about bodily parameters. See Wong (2015) for discussion.

with parts of their body that they have no touch or proprioception in using visual feedback (Cole and Paillard 1995). In contrast to numbsense patients, if nociceptive or thermal stimuli are applied to peripherally deafferented patients in the absence of vision, they are able to identify the site of stimulation through verbal report or pointing on a picture of the body. (Though these patients have lost touch and proprioception, pain and temperature sensation are intact as the afferent nerves underpinning these functions are unaffected.) However, they are unable to point to the site of stimulation in the absence of vision. Thus Paillard claims that the body schema is intact in numbsense patients – because they can point to the site of stimulation without vision – and absent in peripherally deafferented patients – because they cannot point to the site of stimulation without vision. The situation is the reverse with the body image, which is intact in peripheral deafferentation but absent in numbsense.[5]

There is no question that there are significant differences between the two pathologies. But it is unclear that the two cases are appropriately complementary in a way that supports a double dissociation. The key point is that Paillard thinks that the body schema is absent in peripherally deafferented patients because they cannot point accurately in the absence of vision. I agree that there is an absence of proprioceptive input in the case of peripherally deafferented agents, and that this explains why they cannot point accurately in the absence of vision. But why does this entail that the body schema is *absent*?

Paillard's use of the inability to point in the absence of vision as criterial for the loss of the body schema presumes that proprioception is necessary for calibrating the body schema. This assumption is widespread (Cardinali et al. 2009, Paillard 1999, Cole and Paillard 1995, Gallagher and Cole 1995), but unwarranted.

[5] "Proprioceptive information is necessary for updating the postural body frame (or schema), whereas exteroceptive multimodal information, mainly visual, underpins the central representation and percept of the body image (Paillard 1982)" (Cole and Paillard 1995: 254).

What follows from this deficit is only that the body schema is typically calibrated by proprioception and that in the absence of proprioception or any substitute information channel its operation is defective. The natural response is that the body schema is compromised by peripheral deafferentation as a key source, or the key source of input, is now missing. I have argued that our best understanding of the body schema is as the multimodal body representations underlying action control. Thus, insofar as deafferented agents can act, they must have some intact body schema, though these will be lacking inputs from proprioception, but will rely heavily on vision. In relearning how to act after peripheral deafferentation, these agents are recalibrating their body schema to operate with vision.[6] The functional conception of the body schema I have advocated allows us to both reject the claim that intact proprioception is necessary for possession of a body schema, whilst recognising that proprioception is key to calibrating the body schema in healthy subjects.

5. The Body Schema as a Condition of Possibility of Action

I have defended a conception of the body schema as body representations for action. I want to end by considering the suggestion that the body schema is a condition of possibility of action. The language of conditions of possibility is Kantian. The question is whether there is a need to allude to the body schema to understand how action is possible. One way to approach the question is to ask whether the body schema is a constitutive or an enabling condition on action. The distinction between constitutive and enabling conditions is intuitive, but hard to explicate (Wong 2014). It is often employed after being introduced through example; ambient oxygen, for example, is an enabling condition for cognition. In this case the idea is that oxygen is part of the necessary background for cognition, but isn't in some sense central to cognition. Burge (2010) has recently proposed that we should understand constitutive conditions as conditions which elucidate a thing's nature or essence.

[6] Compare de Vignemont 2010: 675.

Employing Burge's understanding of constitutive conditions, my question becomes whether it is part of the nature of action that it requires the body schema.

Whether one looks at the science or the philosophy of action, the body isn't central, except as the effector. Rather the focus is on the prior motivational states, the intentions, plans or choices one makes before acting, or on the structures underpinning the motor planning and control. One can summarise the dominant picture of action by saying that intentions and/or motor representations – neural representations encoding the goal of an action which underpin the planning, initiation, and execution of bodily action – are considered to be key (e.g. Davidson 1980, Bratman 1987, Butterfill and Sinigaglia 2014, Jeannerod 2006). Certainly the operation of these states in action planning and execution will require computing over body representations for action. But it does not appear that we need to draw on body representations in order to understand the nature of these states. Does this mean that we should conceive of the body schema as an enabling condition on action?

I think not. An alternative picture comes from reflecting on the role of perception in action, such as in the debate concerning dissociations in the visual system (Milner and Goodale 2006). Is the role of body schema in action akin to that of perception in action? Action is often a response to perception, and perception is often used to guide action, both to present the target of action that one is acting on (e.g. the glass one reaches to grasp for) and also to provide feedback about how one is performing. Since my focus is on body representations for action, the issue is how one should conceive of the role of the body schema in acting *with* the body rather than in acting *on* some point on the body (say, scratching an itch or rubbing a bruise). One line is that we should think of perception in these cases as an enabling condition on action and knowledge of what one is doing even though perception plays a key role in control and feedback (Moran 2004, Falvey 2000). The thought is that perception is needed for action to achieve its goals, but it is not part of the nature of action itself. It is correct that action and perception are distinct capacities, but the interdependence of these capacities in any actual activity of an organism would seem to indicate that thinking of perception as merely an enabling condition – where this is understood to simply be part of the background conditions – is not quite right. Perhaps if we focus only on intention and its role in action, the role of the body schema is not apparent. But if we reflect on the sub-personal machinery required for the control of action, the role of the body schema will be apparent. The programming of the appropriate motor commands will draw on the body schematic representation of bodily parameters. Once the motor commands are issued, online motor control will employ a combination of sensory prediction and feedback that will again draw on the body schema. So the body schema is a critical aspect of the entire motor control loop. It should not be thought of merely as a background condition.

The centrality of the body schema is brought out further on a fuller notion of motor representation, not restricted to the encoding of goals. Besides the encoding of goals, Jeannerod emphasised that motor representations contain a "representation of the body as the generator of acting forces, and not only of the effects of these forces on the external world" (Jeannerod 1997: 95). Jeannerod also argued that motor representations encode various kinematic and biomechanical constraints, such as Fitt's law and certain asymmetries in the direction of ease of movement of human limbs. The central encoding of the body as generating acting forces and of biomechanical constraints that movement is subject to as part of motor representation would seem to require information about bodily parameters that are most plausibly thought to be represented by the body schema. Thus there are grounds for thinking that the body schema is much more central to action than is generally recognised.

6. Conclusion

In this essay, I argued for the coherence and utility of the notion of the body schema as body representations for action. I answered scepticism about the coherence of the body schema through providing a functional argument for the body schema. I argued that there are architectural reasons why there should be something like a body schema, which is needed in solving the degrees of freedom problem in motor control. There is evidence that such a schema explains action control under conditions of illusory body perception. Finally the body schema is needed to underwrite our ability to act with tools, by incorporating the tools in to a plastic representation of the body.

I began this essay with the thought that representing one's own body may be a form of self-representation. My defence of the coherence and utility of the notion of the body schema as body representations for action leaves open whether body representations are a primordial form of self-consciousness and whether self-consciousness is bodily in some sense. The body schema has complex connections with significant philosophical issues about body, self, and self-consciousness that remain to be explored (Merleau-Ponty 1945/1958, Longuenesse 2006, Cassam 1997, Carman 1999). But any substantive connection will be constrained by the centrality of the body schema to action, for there are powerful grounds for thinking that the body schema is a condition of possibility of action.

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