For almost thirty years now, the growing program of embodied cognition has tried to elevate the importance of the body in explaining cognitive activities. Embodied theorists claim that the body has a crucial significance in how and what the organism thinks and feels. Paradoxically, most of the time there is no description of bodily experiences in embodied theories, with few exceptions (e.g. Gallagher, 2005). While putting so much emphasis on the role of the body for many cognitive functions, embodied theorists tend to neglect the body for its own sake. Part of the reasons for this neglect is that the body is the *explanans*, not the *explanandum*. But one cannot ground cognition in the body if one has no understanding of what it means to have a body. In this sense, it is important to step back from speculations about the possible roles of the body for the mind and to start at the very beginning by asking the following question: How does one experience one’s body? One may then wonder whether one can give an embodied account of bodily awareness that does not fall into triviality (bodily awareness explained by the body), namely, a sensorimotor account. But to what extent and in what manner can action account for bodily awareness?

**The space of the body**

According to Merleau-Ponty, bodily space is a space of action. The action needs not be performed, but can remain virtual. In his words, the lived body consists in an “I can” (1945, p. 137). For instance, he claims that phantom limbs are merely the consequence of the preserved readiness to move the amputated limbs. More generally, Merleau-Ponty argues in favor of the constitutive role of action for consciousness. As such, he can be considered as one of the ancestors of the recent enactive view, which claims that conscious experiences are inseparable from bodily activities (Siewert, 2005; O’Regan and Noë, 2001; O’Regan, 2011; Noë, 2004; Hurley, 1998; Thompson, 2005). On this view, what we feel is determined by what we do and what we know how to do. Proponents of the enactive view thus argue for a relation of constitutive interdependence between perception and action. Perception is not merely a means to action and action a means to perception. Instead, perceptual content, especially in the perception of spatial properties, constitutively depends on law-like relationships that hold between sensory input and
motor output. Perceptual experiences are thus said to be inseparable from the perceiver’s bodily activities. Although it is vision that has received the most attention, the enactive view has been generalized to other perceptual experiences, including bodily experiences:

For example, when something tickles you on your arm, you can move your other hand and scratch the tickled location … What we mean by feeling something in a particular place in our bodies is precisely that certain sensorimotor laws apply. (O’Regan, 2011, pp. 157–58)

However, the enactive view of bodily experiences raises empirical and conceptual worries (for further details see de Vignemont, 2011). The first difficulty arises from the existence of double dissociations between bodily know-how (i.e. how to reach the bodily location that was touched and how to move it) and bodily awareness. If bodily awareness consisted in bodily know-how, then one could not have one without the other. Yet, it has been recently found that the possession of accurate bodily know-how does not guarantee that one consciously feels touch or feels where the touch occurs. For instance, patients with numbsense have no tactile awareness, but retain a surprising ability to point to where they were touched: “But, I don’t understand that. You put something there; I do not feel anything and yet I got there with my finger. How does that happen?” (in Paillard, Michel, and Stelmach, 1983, p. 550). A further dissociation can be found in two patients, KE and JO, who can both consciously feel a touch (Anema et al., 2009).

Surprisingly, JO can indicate on her hand where she was touched, but not on a pictorial representation of her hand. By contrast, KE can localize the tactile stimulus on the hand drawing, but not on his own hand. Although he knows where he was touched, he is unable to get to the right location of the touch on his hand. This latter case is especially interesting because it shows that bodily know-how is not a necessary condition for experiencing touch on one’s hand.

The second difficulty that the enactive view faces is conceptual. In a nutshell, action cannot account for bodily experiences, because they do not take place in the same spatial frame of reference. Let us consider the following example. A spider lands on the back of my right hand. It tickles me. According to the enactive view, my ticklish sensation consists in the expectation that I can move my other hand and remove what is tickling me. I then wave my hand hoping that the spider will fall, but I fail. All through my movement, I still feel the sensation on my right hand. I experience my hand moving but I do not experience my sensation moving. Yet, the specific bodily movement for my left hand to reach my right hand has changed. One may then conclude that the tactile-motor law has changed, although the localization of my ticklish sensation has not. Consequently, according to the enactive view, the localization of my bodily experience should have moved. Since it has not moved, feeling sensation in a particular body part does not consist in such sensorimotor laws.

A proponent of the enactive view might agree and claim that the tactile-motor law is only the general fact that reaching the hand that is touched with the other hand will stop the tactile signal, no matter the specific trajectory between the two hands. But even then it is not certain that one gains a clear understanding of the bodily location. One may say that sensorimotor laws are body-part specific, and as such provide the bodily location. It is only if I reach my right hand, and not any other body part, and remove the spider on it that I can expect the tactile signal to stop. But how do I know that it is my right hand that must be the target of my movement? In order to act upon a body part, one needs first to be able to single it out, and this cannot be done on the basis of sensorimotor laws for threat of circularity. One needs a prior and independent way of singling out the relevant body part that is in contact with the object in order to avoid a circular account of bodily experiences.
Rather than enactivism, I defend a representationalist approach to bodily awareness. On this view, phantom limbs do not reveal a preserved readiness to move. Actually most patients feel that they cannot move their phantom limbs. Rather, as noted by Schilder (1935), phantom limbs are the clearest pathological expression of the existence of the representation of the body in the mind. Patients can feel sensations in a limb that no longer exists thanks to the body representation that still includes the amputated limb. The body senses, including the sense of pressure, the sense of posture and the sense of balance, do not directly carry information about the shape of the various parts of the body, their spatial configuration and their size. In order to compensate for their insufficiencies, bodily information needs to be spatially organized by a representation of the configuration and metrics of the body segments, what I call a body map. It is thanks to the body map that sensations are experienced as being at more than an isolated body point. The body map gives a spatial frame of reference to bodily experiences. In visual experiences, visual properties are ascribed to specific locations within the visual field. In bodily experiences, bodily properties are ascribed to specific locations within the body map. The body map is the background on which bodily sensations are experienced. Thanks to the body map, all bodily experiences over an extended period share the same spatial content of the structural shape of the body (O’Shaughnessy, 1980).

The body map thus accounts for the spatiality of bodily experiences in association with spatial information carried by body senses. But what are the origin and the format of the body map? Action may then come back by a side door by shaping the body map.1 For example, we know that young infants engage in repetitive actions on their own body and explore visual-proprioceptive correspondence (Morgan and Rochat, 1997). Later on, one can gain knowledge about the size of one’s limbs thanks to the somatosensory feedback one receives when acting. For instance, if I knock my head on the shelf, it means that I am taller than the height of the shelf. Evidence also indicates that the body map can adjust to incorporate artificial extensions like tools. For instance, Sposito and colleagues (Sposito, Bolognini, Vallar, and Maravita, 2012) found that after tool use, participants mislocalized the center of their arms as if their arms were longer. But if tools can be incorporated in the body map just because one exerts control over them, then it seems that action must play a role for the body map. On this new version of the sensorimotor approach, one takes oneself to have two arms and two legs, of such respective size on the basis of past sensorimotor experiences. If so, one can expect the body map to represent body parts in terms of the possibilities of movement they afford, that is, in terms of bodily affordances (O’Shaughnessy, 1980; Bermúdez, 1998; Smith, 2009; Wong, 2009). The fact is that tactile localization is improved close to anatomical landmarks with functional salience like joints (Cholewiak and Collins, 2003). As joints have a special significance for action, there is only one step to conclude that the body map is endowed with a motor format.

Clearly, representations of bodily affordances are essential for planning action. They prevent one from attempting to move in biologically impossible or painful ways and from over- or under-reaching when trying to get an object. Still one may wonder whether these representations are fine-grained enough for bodily experiences. In a nutshell, if someone touches my forearm, the sensation is quite focal, localized in one specific area in a specific body part. By contrast, when I move my forearm, my hand and fingers follow. Parts of the body are brought together, unified by their functional role for action. How then can a rough-grained body map account for the focality of bodily experiences? In order to illustrate this worry, let us consider a study on the segmentation of the body into parts (de Vignemont, Majid, Jolla, and Haggard, 2009). We found that two tactile stimuli felt farther apart if they were applied on two distinct body parts across the wrist than within a single body part. This indicates that the body map that spatially organizes bodily experiences is structured into well-segmented body parts delineated by
the joint. We then asked participants to move their hand by rotating their wrist several times just before being touched. We found that the effect was reduced, although one might have expected the reverse. This result suggests that the relative overestimation of cross-joint distances cannot itself be a motor effect. On the contrary, action brings body parts together into functional units. The notion of functional unit actually appears as early as in the primary motor cortex, which is not as well segregated and segmented as that in primary somatosensory cortex (Hlustik, Solodkin, Gullapalli, Noll, and Small, 2001). To conclude, bodily experiences are framed by a representation of well-segmented body parts, representation that is of little use for action.

Interestingly, even for the body map used for action, it is not clear that it is built up exclusively on the basis of action. Sensorimotor feedback can give only a rough estimate of one’s body metrics. For example, bumping my head does not indicate the respective size of my head, torso, and legs. Active exploration of each body part by haptic touch seems to fare better and to be more specific. However, this involves complex tactile–proprioceptive processing, and that in turn requires taking into account the size of the exploratory body parts (e.g. fingers). One should not believe that building up a representation of the body on the basis of action is a fast and costless solution. Rather, research in robotics indicates that it requires hundreds of interactions (Bongard, Zykov, and Lipson, 2006). Arguably, action helps to develop and calibrate a multimodal representation of one’s own body. But it cannot be the only source of information. On the one hand, there must be an innate rough specification of the human body (such as two arms and two legs) (Melzack, Israel, Lacroix, and Schultz, 1997). If not, how could one explain phantom limbs in individuals with congenital limb deficiency? On the other hand, vision, which is the sense of space par excellence, is needed in order to fill in the specific details of the body map, such as body metrics. It is indeed the only sense that can directly and reliably process size information (Longo and Haggard, 2010). In particular, several studies show that the body map adjusts on the basis of visual information. For instance, one can induce an illusory distortion of the size of your hand, which affects both how you move your hand and how you feel touch (Taylor-Clarke, Jacobsen, and Haggard, 2004; Marino, Stucchi, Nava, Haggard, and Maravita, 2010). Even more surprisingly, the body map can incorporate an extraneous object that is only visually perceived, though one has no control over it, like in the rubber hand illusion (Botvinick and Cohen, 1998): if one looks at a rubber hand, while one’s own hand is hidden, and both the rubber and the real hands are synchronously stroked, one reports feeling as if the rubber hand were part of one’s body and one mislocates one’s hand toward the rubber hand. Mere vision can thus alter the body map.

To conclude, I have explored two paths the sensorimotor approach to bodily awareness can take and showed that neither is satisfactory. First, one may claim that bodily experiences consist in sensorimotor laws. I argued that bodily know-how fails to account for the localization of bodily experiences in specific parts of one’s body. Alternatively, one may claim that the body map that is required to account for the spatiality of bodily experiences is ultimately grounded in action and represents bodily affordances. I argued that the way one spatially represents the body differs in motoric and in non-motoric contexts. Should one then conclude that action plays no major role for bodily awareness? Not yet. There is indeed a further path a sensorimotor approach can undertake. So far I have focused on the experience of the space of the body. But as noted by O’Shaughnessy (1980), bodily experiences are “sensations-at-a-part-of-body-at-a-point-in-body-relative-space.” Typically, when you feel your arm moving to the right, not only do you feel that it is your arm that is moving, but also that your arm is moving over to the right. Any account of bodily awareness must thus account both for the fact that one feels sensations in a specific part of the body and for the fact that one feels sensations in external space.
One may then suggest that action plays a role for the experience of the body in space, if not for the experience of the space of the body.

**The body in space**

Close your eyes and cross your hands. If you are touched briefly on the left hand and then rapidly after on the right, you will have difficulties in localizing in which hand the first touch was applied (Yamamoto and Kitazawa, 2001). This effect results from the conflict between two spatial frames of reference in which tactile experiences are encoded. If tactile experiences were located only relative to the body map, then bodily posture should make no difference. A touch on the right hand remains on the right hand no matter where it is located. The difficulties that you experience here, however, show that (i) the relative location of body parts matters and (ii) the location in the body map can be in conflict with the location in external space (for instance, a right hand on the left side of the body). The external frame of reference can be said to be egocentric: you locate the location of your hand in relation to you (on your left). Now a dominant view in philosophy is that the origin of the egocentric format of perceptual experiences can be found in action. For example, Evans (1985) defines egocentric space as the space of action, what he called a “behavioral space.” Since Evans, a number of philosophers have taken egocentric perceptual experiences as evidence for the implication of action in perceptual awareness (Brewer, 1997; Peacocke, 1992; Briscoe, 2008). It is true that egocentric frames are essential for action. In order to act toward an object, one needs to locate it relative to oneself. However, does this entail that sensorimotor processes are involved in bodily experiences?

The necessity of egocentric content for action does not show that the egocentric space in perceptual experiences is a space of action. Even if it primarily evolved for action, it may have detached itself from action and evolved differently when used in perceptual experiences. It is actually not even clear whether the same type of egocentricity is at stake in perception and in action. For instance, there is evidence that one can localize one’s body in two distinct egocentric frames. In the rubber hand illusion, we found that participants mislocalized their hand at a location close to the rubber hand. Yet, when asked to move it, their movement indicated that the motor system correctly localized it at its actual location (Kammers, de Vignemont, Verhagen, and Dijkerman, 2009). The egocentric location of one’s hand in bodily experiences can thus differ from the egocentric location used by the motor system. Furthermore, it was found that the effect of bodily posture due to the conflict between the bodily frame and the egocentric frame when the hands are crossed is erased when one is congenitally blind, but not when one becomes blind later in life (Röder, Rösler, and Spence, 2004). It thus seems that the key factor is not whether one can (or could) act or not. Obviously congenitally blind people can scratch their leg when it is itching. It is rather that one has had visual experiences during childhood. Only then can one acquire the egocentric frame upon which one can automatically remap one’s bodily experiences.²

Does it mean that action does not contribute to bodily awareness? Matthen (2005, p. 304) asks: “What would seeing – conscious vision – be like if we lacked motion-guiding vision?” He claims that it would lack a feeling of presence. Likewise, I will now argue that bodily experiences would be devoid of feeling of bodily presence if one lacked sensorimotor processing. When something brushes your face, not only do you feel a tactile sensation on your face, you also become suddenly aware of the presence of your face, which before remained at the background. Bodily sensations carry with them a sensation of physical presence or reality. The feeling of bodily presence has two distinctive features, what I shall call “externality” and “globality.”
First, when one is visually aware of an object as present in a scene, one experiences it in the external three-dimensional world. Likewise, one is aware of one’s body as present in the external world. Another way to put it is that the body is not only an inner space. As Martin (1993, p. 211) says, it is experienced as being part of a “larger space, which can contain other objects.” In visual experiences, externality is given by the fact that one can have different perspectives on the object. But one cannot feel one’s body from different spatial perspectives. Rather, the feature of externality requires relating one’s body to other objects or other bodies, upon which one can have different perspectives. In this sense, the feeling of bodily presence is relational. The second feature of the feeling of presence is its globality. In visual experiences, one is aware of the object as a whole, including its unseen sides. In the same way that objects have unseen sides, the body has unfelt regions. The feeling of bodily presence then consists in the awareness of the body part, including its unfelt regions. For example, although one feels sensations at a rather specific location on the body part (for example, in the middle of the left cheek), the feeling of bodily presence is more global, at the level of the whole body part (the head for instance), and possibly even beyond. It is not restricted to the limited area of the body in which one localizes the sensation.

Matthen (2005) argues that the origin of the feeling of presence can be found in the involvement of the dorsal stream of visuomotor processing for visual experiences of a visual scene. By contrast, he argues that visuomotor processing is not involved in visual experiences of a pictorial representation, which are thus devoid of feeling of presence. Roughly speaking, one feels the objects as present thanks to the fact that one knows one can act on them. Now the question is whether the same is true of bodily experiences.

I will now argue that the feeling of bodily presence is grounded in the sensorimotor processing of peripersonal space, that is, the space immediately surrounding one’s body. When a threatening object enters a spatial margin of safety around the animal’s body, animals engage in a range of protective behaviors. As Graziano and Gross (1993, p. 107) described it, the peripersonal space is like “a gelatinous medium surrounding the body that deforms whenever the head rotates or the limbs move.” For example, in humans it was found that neutral visual stimuli close to a part of the body interfere with tactile experiences, if the location of the visual stimuli is incongruent with the location of the tactile stimuli (Spence, Pavani, and Driver, 2004). Interestingly, objects in peripersonal space are endowed with a special significance for the body. They may be perceived as potential threats or obstacles. One may then defend a sensorimotor interpretation according to which peripersonal space is defined in terms of the movements one can or should perform in relation to the objects perceived in peripersonal space. In Evans’ terms, one can claim that peripersonal space is a “behavioral space.” How is this notion of peripersonal space then related to the feeling of bodily presence?

George Orwell in his novel 1984 nicely illustrated how important the potential threat of an outside enemy is to strengthening the awareness of a country’s borders (Orwell, 1949). Likewise, one may argue that one is aware of one’s body as a single bounded object among others thanks to the processing of potential threat in peripersonal space. We have seen that the feeling of bodily presence is characterized by its “externality” and its “globality.” I claim that peripersonal space can account for both features. On the one hand, the body part feels present in the external world in virtue of the fact that peripersonal space defines the relation between one’s body and other objects. The fact that objects in peripersonal space are located relative to the same bodily frame of reference as bodily experiences creates a line between the inside and the outside, and thus leads to awareness of one’s body as a bounded object. On the other hand, the body part feels present as a whole, including its unfelt regions, in virtue of the fact that the representation of peripersonal space is organized relative to the body map used for action.
Therefore, the part of the body that feels present in bodily experiences corresponds to the holistic functional segmentation of the body map for action. The feeling of bodily presence is thus traceable to sensorimotor processing of peripersonal space.\(^3\)

One can then make two empirical predictions. On the one hand, patients who lack the feeling of bodily presence should have motor abnormalities. On the other hand, patients who have motor abnormalities are susceptible to loss of feeling of bodily presence. This has never been directly investigated, but some findings point in this direction in depersonalization disorder and in ideomotor apraxia. Patients with depersonalization disorder complain about abnormal bodily experiences, and in particular feelings of unreality. Typically they report “I have to touch myself to make sure that I have a body and a real existence” (Sierra and Berrios, 2000). In short, they lack the feeling of bodily presence. Interestingly, they also report abnormal action awareness, as if they had no control over their body. The psychiatrist Pierre Janet actually insisted that the disorder of depersonalization does not result from a sensory disorder, but rather from a motor disorder: “the feeling of emptiness is a trouble of action, not of sensation or misunderstood consciousness” (Janet, 1928, p. 101). Unfortunately, this has not been directly tested. I would predict for example that patients with depersonalization should have difficulties in motor imagery tasks and that they should have abnormal processing of peripersonal space.

Let us now consider the case of ideomotor apraxia, which clearly demonstrates motor disorder. Typically apraxic patients cannot imitate meaningless gestures or imagine movements in motor imagery tasks (Buxbaum, Giovannetti, and Libon, 2000). Interestingly, their introspective reports also reveal abnormal bodily experiences: “All the participants experienced to some degree that their hands had to be searched for, found, put in the right place and ‘monitored’ through the action” (Arntzen and Elstad, 2013, p. 69).

To conclude, I have argued in favor of a duplex conception of bodily experiences. Bodily experiences are localized in specific parts of the body thanks to a well-segmented body map. This body map, however, does not exhaust the spatiality of bodily experiences. When one feels sensations in a specific part of the body, one feels this body part as present thanks to the sensorimotor processing of peripersonal space. Consequently, the spatial content of bodily experience consists both in a relatively fine-grained perceptual spatial content and in the way our bodily experience presents parts of the body in relation to objects that surround it.

**Conclusion**

Bodily awareness is a multifaceted phenomenon, which can hardly be summarized in so short a contribution. Although bodily awareness and action seem to be intimately linked, it is actually hard to pinpoint the exact role of action for bodily awareness. I distinguished two main aspects of bodily awareness, the awareness of the space of one’s body and the awareness of the body in space. I argued against a sensorimotor approach of the bodily space. Action plays only a limited role in calibrating the mental representation of one’s body that spatially structures bodily experiences. On the other hand, I argued in favor of a sensorimotor approach of the body in space. More precisely, one is aware of the boundaries of one’s body in its relation to other objects thanks to sensorimotor peripersonal space.

**Notes**

1 Although there are some embodied theorists that reject the notion of mental representations, this does not need to be (Shapiro, 2011).

2 This is not to say that congenitally blind individuals have no egocentric reference frame in general. It only shows that they have different types of bodily experiences. Further evidence confirms this view,
including the fact that they do not experience the non-visual version of the rubber-hand illusion (Petkova, Zetterberg, and Ehrsson, 2012). For further detail, see de Vignemont (in press).

3 Now one may object that many animals have peripersonal space. Does one want to assume that they share this specific dimension of bodily awareness with humans? There is no reason why they should not. The feeling of bodily presence does not involve a first-personal component. It may be a condition for a sense of bodily ownership, but it is not a sufficient condition. At least, an animal can be aware of one’s body as a bounded object without being aware of one’s body qua one’s own.

References


