A multimodal conception of bodily awareness

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Abstract: One way to characterize the special relation that one has to one's own body is to say that only one's body appears to one from the inside. Although widely accepted, the nature of this specific experiential mode of presentation of the body is rarely spelled out. Most definitions amount to little more than lists of the various body senses (including senses of posture, movement, heat, pressure, and balance). It is true that body senses provide a kind of informational access to one's own body, which one has to no other bodies, by contrast to external senses like vision, which can take many bodies as their object. But a theory of bodily awareness needs to take into account recent empirical evidence that indicates that bodily awareness is infected by a plague of multisensory effects, regardless of any dichotomy between body senses and external senses. Here I will argue in favour of a multimodal conception of bodily awareness. I will show that the body senses fail to fully account for the content of bodily experiences. I will then propose that vision helps compensate for the insufficiencies of the body senses in people who can see. I will finally argue that the multimodality of bodily experiences does not prevent privileged access to one's body.

One way to characterize the specific relation that one has to one's body is to say that only one's own body appears to one from the inside. Although widely accepted in philosophy and psychology (see for instance, Bermúdez et al. (eds), 1995), the nature of this specific experiential mode of presentation of the body is rarely spelled out. Most definitions of 'the body from the inside' amount to little more than lists of the various body senses (including senses of posture, movement, heat, pressure, and balance) (Bermúdez, 1998; Brewer, 1995; Evans, 1982; Gallagher, 2005). Indeed, through body senses, one has a privileged informational access to one's own body that one has to no other bodies. Body senses are then classically contrasted with external senses such as vision, which can take many bodies as their objects.

But can one reduce bodily awareness to body senses? The difficulty arises when one takes into account recent empirical evidence indicating that bodily awareness is infected by a plague of multisensory effects, regardless of any dichotomy between body senses and external senses. I will argue in this paper that the body senses fail to fully account for the content of bodily experiences, and that bodily awareness is constitutively multimodal—and in particular, that bodily awareness is constitutively visual. I will then deal with objections to this account that derive from the fact that those who lack sight have bodily experiences. I will finally argue that the multimodality of bodily experiences does not prevent privileged access to one's body.

1. The puzzles of bodily experiences

Let us start with considering the experience of one's arms being crossed. One can see them being crossed, but one can also *feel* them being crossed. What is the basis of such apparently simple experiences of the body from the inside? The physiological basis of the sense of bodily posture, or proprioception, is well known. It includes muscle spindles, which are sensitive to muscle stretch, Golgi tendon organs, which are sensitive to tendon tension, and joint receptors, which are sensitive to joint position. The question then arises: how does one obtain reliable proprioceptive information about posture and movement on the basis of raw signals about muscle stretch, tendon tension, and joint angle? But this is not the only puzzle. One also needs to derive full-fledged bodily experiences from proprioceptive information. The body senses then suffer from two main problems: the limits of their reliability and the limits of their informational scope.

When you lie in bed at night without moving at all, you may sometimes feel unsure of the exact location of your limbs. Proprioceptive signals are weak when one is not moving (Rossetti et al., 1994; van Beers et al., 1998, 1999; Helms Tillery et al., 1991). Proprioception is then only of limited accuracy; even a few minutes of complete stillness can make you lose your body, so to speak. In order to be the most reliable about the location of one's limbs, one must be moving. But even then the accuracy of proprioception is limited. More precisely, it decreases with the number of joint angles that must be computed. The more distal the body part, the more complex the computations are. For example, information about the location of one's fingertip in space requires taking into account information from many receptors on many joints, muscles and tendons, each of them sending noisy signals, the noise increasing in proportion to the degree to which the body part is distal.

The second problem with the body senses is that they do not directly carry information about the shape of the various parts of the body, their size, and their spatial configuration. For example, the facts that we have two arms, that they are cylinder-shaped, that they are of a certain length, and that they are connected to the torso on one end and to the hands on the other end, cannot be easily derived from the body senses. It is true that one receives somatosensory feedback when acting, which can carry information about the size of the limbs. But this can give only a rough estimate. In particular, to know how far one can reach with one's hand does not indicate the respective size of one's fingers, palm, forearm and upper arm. 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). Hence, the scope of information that the body senses directly carry is limited. Yet, information such as body metrics is needed in order to locate body parts in space. For instance, the arms can be crossed or not with the very same joint angles depending on their size and on the width of the shoulders.

One century after Sherrington (1906) introduced the notion of proprioception, neurophysiologists and psychologists no longer believe that the body senses can suffice to fully account for the spatiality of bodily experiences (e.g., Helms Tillery et al., 1991; van Beers et al., 1998).

> We found that subjects were unable to synthesize a reliable estimate of the locations of their hands in space using only kinaesthetic [proprioceptive] cues. (Helms Tillery et al., 1991, p. 771)

> There is ... no afferent [somatosensory] signal, or combination of afferent signals, analogous to a global positioning system (GPS) signal. (Longo and Haggard, 2010, p. 658)

In order to compensate for the insufficiencies of the body senses, bodily experiences need to be structured by a representation of the configuration and metrics of the body segments. This hypothesis can be tracked back to Bonnier (1905), who first introduced the notion of a body schema to refer to the spatial organization of bodily sensations. Head and Holmes (1911) also posited the existence of what they called a superficial schema, which is the model of the skin surface of the body used for localizing bodily sensations. More recently, Schwoebel and Coslett (2005) have postulated the existence of what they call a body structural description, which is impaired in patients suffering from autotopoagnosia: these patients are not able to correctly localize where they are touched, nor can they identify the various parts of their body. But it is O'Shaughnessy (1980, 1989, 1995) who best argues in favour of a dual specification of the spatial content of bodily experiences:

> At instant t1 one seems to be aware of a flexed arm because in general (and in fact over a period of decades) one takes oneself to be a being endowed with an arm which can adopt postures like stretched, flexed, etc.; and because of the operation of postural sensations, etc., at t1. (O'Shaughnessy, 1995, p. 184)

O'Shaughnessy contrasts *short-term body images*, which consist in the perception of the posture and location of the body 'here and now', and the *long-term body image*, which represents the long-term spatial properties of one's body, including the spatial configuration and the metrics of body parts. Short-term body images determine the content of bodily experiences.[1] O'Shaughnessy defends the view that their spatial content (what body part instantiates the bodily property) cannot be exclusively provided by body senses. Rather, it is also inherited from the long-term body image, which explains how the spatial content of all bodily experiences share the same

[1] O'Shaughnessy distinguishes between three types of short-term body images: (α), (β) and (γ). This distinction will play no role here and I shall leave it aside.

anatomical shape of the body over an extended period. The long-term body image plays a structural role in spatially shaping short-term body images. 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 long-term body image. One can experience sensations in a phantom limb thanks to the long-term body image that still represents the amputated limb. Likewise, one can experience sensations at the tip of a tool, like Descartes' blind man with his cane, due to the fact that the long-term body image has incorporated the cane. O'Shaughnessy (1995) further argues that if the long-term body image misrepresented the body as being octopus shaped, then the spatial content of short-term body images, and henceforth of bodily experiences, would be within the reference frame of the octopus shape. In other words, one would feel one's tentacles crossed.

‘Long-term body image’, ‘superficial schema’, and ‘body structural description’, all refer to more or less the same notion, that is, the representation of the spatial configuration and the dimension of the body that is required to shape bodily experiences. Here, I adopt O'Shaughnessy's terminology, although I will argue against some of the claims that he makes about bodily experience. O'Shaughnessy argues for a dual specification of short-term body images, both in terms of body senses and in terms of a long-term body image. But is that all there is to bodily awareness? Can the long-term body image suffice to compensate for the insufficiencies of body senses? And what is the origin of the long-term body image? The discovery of the Rubber Hand Illusion, along with other recent empirical findings on multisensory interaction, may offer some replies to these questions. They raise fascinating new questions for bodily awareness about the consequences of seeing one's body. Here I shall argue that multisensory mechanisms can help solve the puzzles of bodily experiences. I shall then evaluate to what extent and in what manners bodily experiences may be constitutively multimodal.

2. The Multimodality Thesis

Much research on perception has focused on each sensory modality in isolation. However, not only do we experience the world through multiple senses at the same time, but those senses can influence each other. Information from one modality then affects information in another modality. For example, in the famous ventriloquism effect, the absence of seen lip movements displaces the apparent location of speech sounds. Multisensory effects can be found between most modalities, but I shall exclusively analyse how proprioception and touch are affected by visual and auditory information, thus leading to multimodal bodily experiences.[2]

Let me start with two striking bodily illusions involving erroneous multisensory integration: the Rubber Hand Illusion and the Parchment Skin Illusion. In the classic set-up of the Rubber Hand Illusion, participants sit with one arm resting on a table, hidden behind a screen. They are asked to visually fixate on a rubber hand presented in front of them, and the experimenter simultaneously strokes with two paintbrushes both the participants' hand and the fake hand. The illusion occurs after a couple of minutes, but only if the two hands are in congruent position and synchronously stimulated (Botvinick and Cohen, 1998; Tsakiris and Haggard, 2005). Most participants then report feeling as if they were touched on the rubber hand and as if the rubber hand were their hand. After the stroking, both the rubber hand and the

[2] One can distinguish between the interaction among body senses (for instance, proprioception influences touch) and the interaction between external senses and body senses (for instance, vision influences proprioception). I will focus on this latter type of interaction. For sake of simplicity, I will use the notion of multimodality only to refer to the interaction between external senses and body senses.

biological hand are hidden from sight and subjects are asked to indicate on a ruler where they feel their hand to be. Results show that they mislocate their hand as being closer to the rubber hand than it is. Furthermore, when they see the rubber hand hit by a hammer, subjects react vividly, as if their own hand were hit (Ehrsson et al., 2007). The Rubber Hand Illusion illustrates how visual information about a rubber hand being stroked can alter tactile and proprioceptive signals, so that one feels touch on the rubber hand and feels one's hand as being closer to where the rubber hand is. The Parchment Skin Illusion, by contrast, highlights the role of auditory information for bodily experiences. In this illusion, the sounds produced by the participants' hands rubbing back and forth are recorded and played back to the participants through headphones. When the recorded sounds are distorted and the high frequencies accentuated, participants report feeling their skin dry, almost like parchment (Jousmaki and Hari, 1998).

The resolution of conflict between somatosensory information and visual/auditory information leads here to illusory experiences. But most of the time the presence of external information improves the reliability and accuracy of bodily experiences. For instance, viewing the body part that is touched (without viewing the object that is touching it) enhances tactile acuity so that one’s judgements about tactile sensations are both faster (Tipper et al., 1998) and more accurate (Kennett et al., 2001). The link between bodily experiences and visual/auditory information can sometimes be so tight that the mere presence of the latter can automatically induce the former. We are all familiar with the unpleasant bodily sensation triggered by the sound of fingernails scratching a chalkboard. It was also found that when participants saw the light from a laser pointer 'stroking' a rubber hand, more than half of them reported that they felt the touch of the laser on their skin (they said that it felt 'warm', for example), even though their own hand was not stroked (Durgin et al., 2007). Some individuals with what is known as mirror-touch synaesthesia even report experiencing tactile sensations on their own body when they see someone else being touched. For example, when they see another individual being touched on their right cheek, they report feeling touch on their own left or right cheek. Their reports were confirmed by activation in somatosensory areas in their brains (Blakemore et al., 2005).

These effects are only a few among a long list of multisensory interactions. One may conceive of them as mere side effects of the way the brain is hard-wired with no bearing on the nature of bodily experiences. However, I will argue that the presence of interaction between body senses and external senses, especially vision, has fundamental implications for bodily awareness. More particularly, I will argue that bodily experiences are multimodal. The notion of multimodality has become of interest to philosophers only recently (O'Callaghan, 2011; Macpherson, 2011; Spence and Bayne, forthcoming). Unfortunately, there is already little agreement in philosophy on the way to individuate the modalities themselves, let alone on how to understand multimodality. One might be tempted to directly derive the definition of multimodality from empirical evidence of multisensory effects, but any such attempt would be undermined by the fact that multisensory effects do not form a homogeneous category. Distinctions need to be made between conversion (i.e. recoding into the format of another modality) and convergence (i.e. recoding in a common amodal format), between short-term and long-term effects, and between perceptual, attentional, and cognitive effects.[3] If one's aim is to assess the multimodal nature of bodily experiences, one must focus on perceptual multimodality, that is, the

[3] I use the term “multisensory” to refer to the backstage mechanisms at the subpersonal level and the term “multimodal” for the personal level. Further useful distinctions can be found in Macpherson (2011) and Spence and Bayne (forthcoming).

multimodality of perceptual experience, to the exclusion of attentional and cognitive levels. This is not to say that attentional multimodality and cognitive multimodality are of no interest, but rather that they have no direct relevance for understanding the fundamental nature of bodily experiences.

Just to take an example of multisensory interaction with no bearing on the understanding of the nature of bodily experience, let us consider the neuropsychological syndrome of tactile extinction. After right-hemisphere lesion, some patients have no difficulty in processing an isolated tactile stimulus on the left side of their body. However, when they are simultaneously touched on the right hand, they are no longer aware of the touch on their left hand. Interestingly, the same is true when they merely *see* a visual stimulus near the right hand: the visual stimulus on the right side extinguishes the tactile stimulus on the left side so that they fail to detect the touch (Di Pellegrino et al., 1997). A version of the same type of tactile extinction has been found in healthy participants. The presentation of a visual stimulus close to a body part dominated (or even extinguished) tactile sensations when participants had to respond as quickly as possible to both elements of the visuo-tactile target (Hartcher-O'Brien et al., 2008). This indicates that vision and touch can be in competition for the same attentional resources. Visuo-tactile extinction illustrates how the mere presence of multisensory effects, no matter how pervasive they are, does not suffice to show that tactile experiences *per se* are multimodal. One has to show that those multisensory effects directly result from the nature of bodily experiences themselves (rather than from the nature of attention for instance).

In this paper I will not take upon the ambitious task of defining multimodality in general.[4] Rather I will simply spell out in what way bodily experiences can be conceived of as multimodal, granting that there may be other forms of multimodality. I propose that bodily experience qualifies as multimodal in virtue of its etiology. More particularly, I claim that the etiology of multimodal experience includes what I call *multisensory binding*. Multisensory binding should be understood on the model of visual binding. A typical example of visual binding is the integration of shape and colour of a seen object into a unified visual experience. This requires two conditions to be met: the parsing condition and the integration condition. First, information resulting from distinct sensory sub-processes, such as colour processing and shape processing, must be singled out as being about the same object or event. Second, the information that has been selected must be integrated into a unified content. The content is unified if one cannot normally retrieve the original information derived from each sensory sub-process. For example, one cannot experience the colour of an object without experiencing its shape, except in some rare neurological disorders.

Likewise, multisensory binding requires the parsing and the integration conditions to be met. First, multisensory binding is of use only when the signals carry information about a particular property of the same object or event. Multisensory binding thus requires selecting the information that comes from a common object or event, and segregating that information from the information that concerns distinct objects or events. If the parsing is successful, then only information about the same property instantiated by the same object or event is selected. I will come back to the implication of the parsing condition in section 5. Once the different types of information are assigned to the same object or event, they can be integrated into a

[4] See Vignemont (forthcoming) for a more general definition of multimodality.

unified content. A typical example of erroneous multisensory binding can be found in the Rubber Hand Illusion: visual information and proprioceptive information are – wrongly – taken to be about the location of the same hand and they are integrated in such a way that one cannot experience separately the proprioceptive location and the visual location of the hand.

It is then of little controversy that some bodily experiences are multimodal thanks to their specific etiology, which involves multisensory binding.[5] This fact, which has often been neglected, is already interesting. But I want to make a bolder claim, what I call the *Multimodality Thesis*. On this view, bodily experiences are *constitutively* multimodal. Another way to put it is to say that multisensory binding is a constitutive component of the etiology of bodily experience. The Multimodality Thesis seems to immediately face the following objection: blind individuals, even when they were born blind, have bodily experiences; hence, vision can hardly play a constitutive role for bodily experiences. However, I do not defend a strong constitutive thesis for multimodality according to which one could not have bodily experiences if one were blind. This is obviously false. Rather, I suggest drawing a distinction between a strong and a weak version of constitutive explanations. Here I defend only a weak constitutive thesis of multimodality according to which one would experience one's body differently if one were blind.

The defence of this thesis requires some discussion of the thorny issue of the boundary between a weak constitutive thesis and a merely causal thesis. One may

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[5] Multisensory binding involves short-term perceptual convergence effects. It is the main source of multimodality in bodily experiences. But it is not the only one. We shall see in section 4 that bodily experiences can be multimodal in virtue of a different type of multisensory processing, what I call multisensory translation, which involves long-term perceptual conversion effects. However, it is worth noting at this point that the definition offered here disqualifies cases in which, for instance, I see the colour of my nails and feel their sharp edge as involving multimodal experience. The experience results from multisensory combination of information about *distinct* properties of the same object.

indeed challenge that there is a substantive difference between the two. Still I think that this distinction calls for a more thorough examination. How does a weak constitutive thesis differ from the claim that input in one modality has a causal impact on experiences in another modality? Arguably, there are specific situations in which it may be difficult to determine whether a relationship is weakly constitutive or merely causal. This is the case of flavour perception for instance. It is well known that gustatory experiences are strongly influenced by olfaction and that food tastes differently when we have a cold (Auvray and Spence, 2008). But it is difficult to qualify exactly the relation between olfaction and flavour (Smith, 2007, Macpherson, 2011). On the one hand, one may hesitate before claiming that flavour consists in olfaction, for we retain some gustatory experiences even during the worst cold. On the other hand, we do not want to claim that olfaction is just one among many other factors that can influence flavour. Although it has been found that hearing the sound of the ocean makes oysters taste better (Blumenthal, 2008), the contribution of audition to gustatory experience is hardly equivalent to the contribution of olfaction. The relationship of olfaction to gustatory experience thus typically seems to be neither fully constitutive nor merely causal. I will now argue that the relationship of vision to bodily experience falls in the same grey zone.

At first sight, the fact that blind people have bodily experiences may be taken as evidence that vision (and multisensory binding) is *not* necessary for bodily awareness. This is true if one defines bodily awareness as the awareness as of having a body. But one may want to refine this definition. In particular, one may offer a teleological account of bodily experiences, according to which the etiology of bodily experience is partly determined by its function. Arguably, bodily experiences evolved to reliably track bodily states. Their function is to afford a *veridical* rendering of bodily properties (O'Shaughnessy, 1980). It is fulfilled if and only if bodily experiences are reliably correlated with bodily states that they are designed to indicate. The question has now become whether vision is necessary to the veridical rendering of bodily properties. And the answer is that it is indeed necessary. We have seen how body senses fail to fully account for bodily experience. Further information is needed to compensate for these flaws, and in particular visual information, which is characterized by its spatial richness and reliability. As claimed by Stein and Meredith (1993, p. 6), "the sensory modalities have evolved to work in concert". The same can be said of vision and body senses. Their interaction improves the likelihood of detecting, localizing and identifying bodily events and properties. It is thus beneficial to combine different sources of information in order to achieve the best perceptual judgments. In other words, the more information the better.

This is not to say that any information that influences bodily experience plays the same role. For example, we know that individuals with anorexia nervosa have disrupted awareness of the boundary of their bodies. Arguably, the etiology of their bodily experience is influenced by the affective attitudes they hold towards their body. Yet, it is not clear in what sense these affective attitudes could contribute to the function of bodily awareness. By contrast, multisensory binding is required in order for bodily experiences to fully realize their function of reliably tracking bodily states. It has been selected by evolutionary pressure because it is required by the very nature of bodily experiences. Consequently, the contribution of vision to bodily experiences is not a mere causal accident. On my account, certain types of causal relations and dependencies can amount to constitutive relations when they have been selected to contribute to the fulfilment of a given function. I qualify these relations as *weakly constitutive*. In this sense, bodily awareness is constitutively visual. It is, however, only *weakly* constitutive because its contribution to the etiology of bodily awareness is not of the same type as the contribution of body senses. For example, if one receives no information from the body senses, then one experiences no bodily sensation, as shown by peripheral deafferentation. Following an acute neuropathy, some patients have no tactile and proprioceptive experiences below the neck. The only sensations they have are thermal and painful sensations. If they close their eyes, they do not know where their limbs are. For the first three months after his disease, one of these patients, IW, reported feeling alienated from his body, almost as if he were only a head (Gallagher and Cole, 1995). His case vividly illustrates the difference between vision and body senses. As we shall see in the next sections, the loss of vision does not lead to such extinction of bodily awareness. None the less, we shall also see that it does not go without major consequences. In particular, I will argue that bodily experiences would not have the same type of spatiality if one were born blind. It is also worth noting that vision can partially compensate for the loss of proprioception and touch in deafferentation. As soon as IW had learnt to rely exclusively on visual information, he became able to control his movements and he regained some awareness of his body (Cole, 1991).[6]

To recap, I propose that an experience is multimodal in virtue of its specific etiology, that is, if its etiology consists in multisensory binding. I further claim that the function of bodily experience determines its etiology. As argued, body senses are insufficient for a veridical rendering of bodily properties. By contrast, vision is especially reliable for spatial properties. Hence, vision has been selected to work in

[6] The Multimodality Thesis primarily concerns bodily awareness, but it can be easily generalized to the representation of the body exploited for action, what is sometimes called the *body schema* (Vignemont, 2010). Actually, O'Shaughnessy does not draw any functional distinction between body representations involved in bodily awareness and body representations involved in action. Whether this functional distinction is valid or not, it remains the case that similar arguments can be used to highlight the importance of seeing one's body for action.

concert with body senses to fulfil the function of bodily experience. Thus, the etiology of bodily experience consists in the binding between body senses and vision. To defend the Multimodality Thesis, I shall now analyse bodily experiences respectively in sighted individuals and in blind individuals. I will show that they are of a different kind.

3. Seeing one's body

> Look up at the ceiling while your right arm is moved to the right. Attempt to recapture the original uninterpreted experience (…) Then you cannot in doing so help mentioning that they [the feelings] were in your arm, which was over to the right, poised like such and such, near to such and such a part of the body (O'Shaughnessy, 1980, I, p. 157)

As hard as we might introspect, we cannot experience a raw bodily sensation devoid of any spatiality. Furthermore, the spatiality of bodily sensations is dual. In O'Shaughnessy's terms, we experience sensations "at-a-part-of-body-at-a-point-in-body-relative-space". For instance, when we feel touch on our hand, not only do we experience the pressure in a specific location within our long-term body image (e.g., our right hand), we also experience this part of our body in a specific location in the external world (e.g., on the right). As we have seen in section 1, somatosensory information does not suffice to fully account for the dual spatiality of bodily experiences. I shall now argue that vision plays an essential role in building up the long-term body image and in grounding short-term body images.

How are we aware that it is our *arm* that is moving to the right? And how are we aware of the size of our arm? I have argued that the information is supplied by the long-term body image, which consists in the topological and geometric map of the body. But this answer may be just pushing the question one step back. What is the origin of the long-term body image? O'Shaughnessy offers the following answer:

> I hypothesized the existence of three kinds of origin-properties: changeless-innate (e.g. fingers), developmental-innate (e.g. growing), and experience-acquired (e.g. hump, corpulence). (O'Shaughnessy, 2000, p. 648)

The main evidence in favour of O'Shaughnessy's innate hypothesis can be found in the case of aplasic patients (with congenital limb deficiency) who experience phantom limbs despite the absence of those limbs since birth. This can be explained if an innate representation encodes the rough specification of a human body (such as two arms and two legs), regardless of the physical body one was born with (Melzack et al., 1997). The role of experience is thus minimal on O'Shaughnessy's view. The long-term body image adjusts only slowly to changes thanks to the proprioceptive and tactile feedback that one receives when acting (the hand reaching where it could not reach before, for example). His conception of the long-term body image is mainly tactile rather than visual: "the body image must be the image of what would reveal itself in tactile encounters" (O'Shaughnessy, 1989, p. 56).[7]

However, we shall see later that other explanations of phantom limbs in aplasic patients are possible. Furthermore, some recent results indicate that even if some aspects of the long-term body image are innately determined, others are shaped by

[7] O'Shaughnessy (1995, 2000) defends the view that proprioception is fundamentally different from vision. If this is true, one may then wonder whether those differences could prevent multisensory integration. However, we know that the Rubber Hand Illusion could not exist if visuo-proprioceptive integration were impossible. Furthermore, there are differences not only between vision and proprioception, but also among all sensory modalities. Again, this does not prevent their integration. This only raises a complex computational problem, known as the 'recoding problem' in the multisensory literature (Pouget et al., 2001). For further discussion of the recoding problem, see Vignemont (forthcoming).

experience, and more particularly by visual experience. Let us go back to the Rubber Hand Illusion. I have argued that one feels sensations within the frame of reference provided by the long-term body image. Thus, if one can feel sensations *in the rubber hand*, it must be because the rubber hand has been integrated into the long-term body image.[8] What is interesting here is that the long-term body image has adjusted to incorporate a rubber hand that was only *seen*, and only for a couple of minutes. This seems to indicate that the so-called *long-term* body image can be quickly updated on the basis of visual information. Other studies have found that the visual distortion of the size of body parts can affect tactile experiences and bodily action. For instance, if you are touched on two spots on your finger after observing the image of a smaller version of your hand, you will experience the distance between the two tactile stimuli as relatively smaller (Taylor-Clarke et al., 2004). If you observe an enlarged version of your hand, you will pre-shape your hand to grasp an object as if your hand were bigger (Marino et al. 2010). But it is only when one considers how we are aware of the size of the various segments of our body that one realizes how essential is vision for the veridicality of the long-term body image. Arguably, the length of each segment of the body, and even more their width, cannot be entirely genetically determined. Furthermore, we have seen that the body senses do not directly carry information about body metrics. Only vision can directly and reliably (though not perfectly) process size information (Longo and Haggard, 2010). Vision is thus needed in order to fill in the metric details of the long-term body image.

[8] There are several recent findings that indicate that the long-term body image is altered by the Rubber Hand Illusion. For example, it was found that if the rubber hand that was stroked was bigger than the real hand, then participants judged their hand bigger (Pavani and Zampini, 2007). Another recent illusion, the Supernumerary Limb Illusion, shows that when participants can see both their real hand and the rubber hand, they can feel sensations in the two hands (Guterstam et al., 2011).

Yet, one may be tempted to discount such results because they apply to body parts that can be seen, like the hands. But there are other parts of the body that are not directly visually available, such as the back. The representation of these parts thus cannot be multimodal. This, however, is not a fatal objection. Although not directly visually accessible, our back is represented in relation to other body parts that are visually accessible. The long-term body image represents the body as a whole, and it is as such that it can be conceived as multimodal. Furthermore, even if we cannot see our own back, we see other people's backs. There is no body part that is not visually available one way or the other. Visual information about other people's backs may supplement the representation of the configuration of our own body. For example, Price (2006) suggests that phantom limbs in aplasic patients with congenital limb deficiency can be explained by the fact that they constantly see other bodies with two arms and two legs. This enables them to generate a body template, which supplements their own long-term body image. If this is true, then one does not need to postulate an innate long-term body image in order to explain their phantom experiences. Vision of other bodies can play a role in shaping one’s own long-term body image.

Taken all together, these results argue in favour of a multimodal long-term body image in sighted people (e.g., Mancini et al., 2011). Visual information about one’s own (and possibly other people’s) body parts shapes the long-term body image that spatially structures bodily experiences and bodily actions. Vision is as essential as body senses for a veridical rendering of body configuration and metrics. The various sources of information – innate, visual, somatosensory – are integrated together into a unified multimodal representation such that one cannot normally retrieve the original information derived from each source.

Bodily experiences are thus spatially structured by a multimodal long-term body image. I will now argue that bodily experiences are also multimodal because of the role of vision in determining the content of short-term body images. 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*. Proprioception carries information about the posture and the location of body parts. Yet, as argued in section 1, it does not suffice for reliable correspondence between the location of the body in the external world and short-term body images.

Short-term body images thus require other sources of information, both to supplement for informational limits (such as information about the length of the segments connecting the joints and the width of each body part) and to improve their accuracy. Vision is then a good candidate to fulfil both functions because it provides highly accurate and rich spatial information. In general, vision offers more reliable information about spatial properties than touch and proprioception, and it often dominates over them when there is a conflict.[9] It is thus optimal to combine visual information with proprioceptive information in order to achieve the most accurate perceptual estimate of bodily location (van Beers et al., 1999).

This is well illustrated by prismatic adaptation (Welch and Warren, 1980). When participants wear prismatic goggles that displace the visual field laterally by a fixed amount (typically, 10-16°), the visual system carries information about the location of their hand that is incongruent with somatosensory information. After a while, the visual deviation affects not only where the participants see and judge their hand to be, but also where they *feel* their hand to be. Two interesting facts are worth noting here.

[9] However, in some perceptual contexts, proprioception is more accurate than vision. For instance, the weight of proprioceptive information can be larger than the weight of visual information when the hand is actively moving and for certain spatial directions (e.g., depth) (Van Beers et al., 2002).

First the hand is usually localized closer to the visually perceived position than to the position perceived proprioceptively. In this sense, one may claim that the short-term body image is more visual than proprioceptive. Second participants can no longer retrieve the ‘pure’ proprioceptive location of the hand independently of the influence of the prisms. They have adapted so well to the prismatic deviation that they cannot help but feel their hand close to the visually perceived position. Proprioceptive information and visual information are bound together. Prisms bring to light the multimodal nature of short-term body images because of the artificial conflict. But the conclusion can be generalized to many of our bodily experiences, which involve the binding of somatosensory and visual information to optimize perceptual reliability.

The involvement of visual information in bodily experiences is indeed more pervasive than one might expect in people who can see. Let us consider again the Rubber Hand Illusion. After the stroking, participants are asked to indicate where their hand is on the table. If the biological hand and the rubber hand were stroked synchronously, participants mislocalize their hand toward the rubber hand. Interestingly, they have no current visual experience of either hand when they are asked to make the report. Yet, their bodily experience is determined by the location of the rubber hand, which was only visually accessible. As argued earlier, the rubber hand is integrated into the long-term body image, which determines the spatial content of the short-term body image. The short-term body image then takes into account visual information about the location of the rubber hand. In other words, the experience of the participants' hand location is determined by the multimodal short-term body image constructed during the illusion. This multimodal short-term body image persists beyond the lack of online visual input. Indeed, it has been found that even if participants move their hand after the stroking and then return to the same location, they still mislocalize their hand toward the rubber hand (Kammers et al., 2009). Their bodily experience is determined by the multimodal short-term body image despite the proprioceptive update.

It has also been found that short-term body images can result from the integration of current proprioceptive information and visual *prediction* of hand location (Smeets et al., 2006). In one study, participants were asked to move a cube between four positions with and without visual feedback from their hand movement.[10] According to the authors' computational model of optimal integration, the hand should drift over a distance equal to the difference between the combined visual and proprioceptive estimates. The analysis of the drift allowed them to evaluate to what extent the visual estimate was taken into account. They found the following results. When the light was turned off, participants still located their hand where they had seen it even when the current position differed. More surprisingly, when they started moving in the dark, they still used the visual estimate of their hand location, which was updated on the basis of their intention to move. It was only after several movements that participants relied less on their visual estimate because each movement of the unseen hand added uncertainty to their visual estimate. The results thus show that when one moves one's hand, one anticipates the sensory consequences of one's movements, including the expected visual location of the hand. Furthermore, they show that the short-term body image, which represents the location of the hand, can be updated on the basis of visual expectation, even when one is in the dark. Hence, the involvement of visual information in short-term body images is not restricted to cases in which one actually sees one's body. It persists even after one can no longer see one's body and even after

[10] Unfortunately, participants were not asked to report where they *felt* their hand to be. The conclusions are thus drawn exclusively on the basis of their movements.

one has moved. The importance of vision in the absence of online visual signals argues in favour of an essential role for vision with respect to short-term body images.

Yet, one may be tempted to discount all the results described in this section because they do not show that bodily experiences are *constitutively* multimodal, even in the weak sense. True, the long-term body image and short-term body images are strongly influenced by vision, even in the absence of online visual input, which is already an interesting fact. But one needs further arguments to show that vision plays more than a causal role in fixing the content of bodily experiences. In the next section, I will show that there are fundamental differences between bodily experiences in those who see and in those who have never seen: (i) blind individuals are not sensitive to the same bodily illusions; (ii) they do not use the same strategy to compensate for the flaws of somatosensory information; and (iii) they do not exploit the same spatial frames of reference. [11] Without vision, bodily experiences cannot fulfil their function to the same extent and in the same way.

4. Blind bodily experiences

Let us return once again to the Rubber Hand Illusion, but with a different design that does not appeal to the vision of the rubber hand (Petkova et al., 2012). Participants are blindfolded during the whole experiment and never see the rubber hand. The experimenter moves the participant's left index finger so that it strokes the rubber hand, and simultaneously strokes the participant's biological right hand in synchrony. Sighted participants report feeling that they are touching their own right

[11] Most studies compare haptic perception of objects in blind and sighted individuals, and only few of them directly investigate bodily experiences in blind people. In the results I describe, blind subjects had no residual vision. At most, they could see if the light was on or off, but this did not affect their performance one way or the other. And it made no difference for them if their eyes were closed or open.

hand. When asked to point to their right index finger after the illusion, they mislocate it in the direction of the rubber hand. By contrast, blind participants are not sensitive to this non-visual version of the Rubber Hand illusion. This may seem surprising because there is no visual component in the illusion: the rubber hand is never visually available. The illusion involves the integration of only tactile, proprioceptive and efferent information. Consequently, one might have expected no difference between sighted and blind participants. Yet, blind participants do not report feeling as if they were touching their own hand, some even claim that it was 'absurd'. When asked to point to their hand, they show no proprioceptive drift.[12] As the authors conclude: "This finding suggests the existence of fundamental differences in central body representation between blind and sighted individuals." (Petkova et al., 2012, p. 8). But what are those fundamental differences?

First, one can note that individuals who are congenitally blind or have become blind in childhood have a partially distorted long-term body image. The tactile and kinesthetic information that they receive about their body metrics and configuration cannot fully compensate for the lack of visual information. In particular, without visual input, the long-term body image misrepresents the size of the various segments of the body to a greater extent than with visual input. For instance, Helders (1986) reported that their torso appears to blind individuals long and very narrow with disproportionately big arms and hands. Kinsbourne and Lempert (1980) also showed that blind individuals have a less accurate representation of the size of their body parts

[12] Blind subjects and sighted blindfolded subjects localized their hand equally well in a non-illusory set-up. The absence of proprioceptive drift in blind subjects thus could not be explained by better proprioceptive abilities.

compared to sighted individuals. This seems to result in some motor impairments (Levtzion-Korach et al., 2000).[13] As Kinsbourne and Lempert (1980, p. 37) conclude:

> When vision is unavailable for the construction of a geometrically accurate internalised space, the other spatial senses construct a body scheme which in general has topological validity but falls short of affording a veridical rendering of the properties of the human body.

The second interesting difference between sighted and blind individuals is revealed in their performance in localizing their body parts and their tactile sensations. Jones (1972) compared two conditions: participants (sighted and congenitally blind) could have their eyes open or closed. In the eyes-open condition, congenitally blind subjects were less accurate than sighted subjects. This confirms that visual information, when available, increases spatial accuracy. By contrast, in the eyes-closed condition, blind subjects outperformed sighted subjects.[14] These interesting findings indicate that the difference between sighted and blind bodily experiences cannot be reduced to the mere presence versus absence of online visual input. Indeed, even with eyes closed, the performance of blind subjects differs from that of sighted subjects. There are two reasons for this. On the one hand, we have seen that the processing of bodily information in those who can see is shaped by the almost constant involvement of visual information (based on online vision, visual memory, visual prediction), which provides highly accurate and rich spatial information. The side effect of this otherwise advantageous feature is that even in the absence of visual information, sighted

[13] Unfortunately, the few studies on action control in congenitally blind people do not directly address the question of size misperception. There are delays in early motor developments in congenitally blind children (Sonksen et al., 1984; Adelson and Fraiberg, 1974; Jan et al., 1975; Levtzion-Korach et al., 2000). However, there may be other factors influencing these impairments, which are not necessarily linked to the long-term body image.

[14] Further studies found that tactile acuity was enhanced in both early and late blind participants in studies where participants had their eyes closed (e.g., Goldreich and Kanics, 2003; Alary et al., 2009; Yoshimura et al., 2010).

individuals do not rely as much as they could on somatosensory information for short-term body images. On the other hand, blind individuals compensate for the lack of vision by dedicating more resources to somatosensory processing, which can improve the accuracy of their short-term body images (Yoshimura et al., 2010; Goldreich and Kanics, 2003). This is revealed by large-scale cortical reorganisation (for review, see Merabet and Pascual-Leone, 2010). For instance, tactile practice involved by reading Braille leads to an enlargement of the finger areas in the somatosensory cortex (Sterr et al., 2003). Furthermore, neurons that would normally respond to visual stimulation can be recruited by body senses when visual input is entirely absent. Finally, somatosensory inputs to multisensory areas that are recruited for spatial perception and attention increase thanks to the lack of competing visual input.

We have thus good evidence that the sensory processing of bodily properties is distinct between blind and sighted individuals. However, the most convincing evidence that the resulting bodily experiences are of two distinct kinds involves nothing more than the following simple manipulation. Close your eyes and cross your hands over your body midline. If your left hand is briefly touched, and then your right hand, you take longer and are less accurate in judging which hand was touched first than if your hands are uncrossed (Yamamoto and Kitazawa, 2001).[15] This effect has been observed both in sighted adults who have their eyes closed and in non-congenitally blind adults. But it is reduced when sighted adults cross their hands in a space that is not visually accessible like behind their back (Kobor et al., 2006). And it is absent in sighted young children and in congenitally blind adults (Röder et al., 2004; Pagel et al., 2009).

[15] Participants gave a motor response to avoid any verbal bias.

The effect can be explained by the conflict between two spatial frames of bodily experiences: the frame of the body (left hand) and the frame of the external world (on the right). The location of the touch within the bodily frame is remapped into the external frame (e.g., the touch on your left hand is represented on the right when your hands are crossed). This effect corresponds to what I call *multisensory translation*, which is one of the subprocesses of multisensory binding. More exactly, visuo-tactile translation solves what can be called the Tower of Babel problem of multisensory binding. Each sensory modality is encoded in its own spatial frame (e.g., eye-centred vision, head-centred audition, skin-centred touch). In order for the information coming from different modalities to be integrated it must be translated into a common reference frame. This common frame can be amodal or the frame of one modality. But there can be translation only if one has been exposed to and learnt another language. Likewise multisensory translation requires past experiences in another modality in order to learn its specific format or structure such as its spatial frame of reference. Once the format is learnt, translation from one modality to another, including spatial remapping, is an automatic low-level perceptual process. Perceptual experiences in one modality during development can thus have long-term consequences on perceptual experiences in a different modality.

Here I argue that the common reference frame is primarily visual. The visual frame of reference is of special interest because the world with which one interacts is mainly given through vision. Location within a body-centred frame of reference used by touch is remapped into the eye-centred frame used by vision.[16] As a result of multisensory translation, one cannot separately experience the hand location within

[16] Multisensory translation is a necessary step to multisensory binding when the format differs among the modalities. However, it can occur in the complete absence of current visual information, as illustrated by the results above. There is then no binding, merely spatial remapping into the visual reference frame.

the tactile body-centred reference frame and within the visual eye-centred reference frame. In other words, one cannot help but take into account the two frames, even when they come into conflict.

If the common frame is visually grounded, as I argue, then one expects the effect to be diminished or erased when the hands are crossed in a space that is not visually accessible and when one is blind. Both predictions have been empirically confirmed. In particular, congenitally blind people and young children have no difficulty in judging where they were touched first when their hands are crossed: visuo-tactile translation does not occur. This reveals that in their case there is no conflict between the two spatial frames. This is not to say that congenitally blind individuals and young children have no external reference frame in general. It only shows that in their case tactile information is not automatically remapped into the frame in eye-centred coordinates because of the lack of visual experiences at crucial stages in development (Pagel et al., 2009). The lack of remapping into the visually grounded external frame also explains why blind individuals do not experience the non-visual version of the Rubber Hand Illusion. To bind together what one feels on one's hand with the rubber hand that one touches, one needs to remap one's tactile sensations in the external world where the rubber hand is. Without remapping, the space of one's tactile sensations and the space of the rubber hand remain distinct. Hence, blind individuals cannot feel touch on the rubber hand.

The difference between bodily experiences in those who can see and those who have never seen is thus not merely quantitative (more or less accurate). It is also qualitative. The *format* of the experience when a sighted individual or a late blind individual is touched is different from the format of the congenitally blind individual's experience. In particular, multimodal short-term body images enable one to remap what happens on the body into the external world, remapping that does not occur in congenitally blind people.

To conclude, the series of findings I have reviewed here argues in favour of the Multimodality Thesis. Processing of bodily information has been selected to guarantee that long-term and short-term body images correspond in some reliable way to the body. Both sighted and blind individuals have access to somatosensory information. But somatosensory information has some limitations, which have to be compensated for. The compensatory strategy is then of two different kinds, for those who see and those who do not see. Sighted individuals use visual information because of its spatial precision, even in the absence of on-line visual inputs. Blind individuals do not have the option to exploit the spatial determinacy of vision. Instead, they exploit at best what is available to them, namely, somatosensory information to which they dedicate more resources. They rely more heavily on body senses than sighted individuals, but this does not suffice for their bodily experiences to be identical to the body experiences enjoyed by sighted individuals. Not only is their long-term body image partially distorted, but their short-term body images are also in a different format, which prevents blind individuals experiencing the same difficulties in temporal order judgement and the same bodily illusion. Arguably, the multimodal strategy has been selected by evolution as guaranteeing the most reliable correspondence to the body in individuals endowed with vision. Both sighted and blind individuals have bodily experiences, but these bodily experiences are of different types because they are grounded in different types of sensory processing and they use different frames of reference.

5. The more multimodality, the less immunity?

The role of vision in bodily experiences is not restricted to a couple of bodily illusions. Rather, bodily illusions reveal a fundamental fact about bodily awareness, namely, its multimodality. One may, however, wonder whether the Multimodality Thesis is compatible with another fundamental fact about bodily awareness, the fact that it holds a privileged relationship to one's own body. In particular, it is widely accepted that bodily experiences can ground judgements that are immune to error through misidentification relative to the first-person (Evans, 1982; Bermúdez, 1998; Brewer, 1995; Dokic, 2003; Longuenesse, 2012; Peacocke, 2012; Recanati, 2007; Vignemont, 2012). Typically, it is said that when I feel my arms crossed, I can rationally doubt whether they are crossed or not, but I cannot rationally doubt that they are mine. The immunity to error of bodily judgements (hereafter bodily IEM) is classically explained by the special way of gaining knowledge about the body that is afforded by the body senses, which ensure, so to speak, that one's own body is the relevant body for the evaluation of the bodily property. One can thus dispense with self-identification of the type “the arms that I feel crossed are mine”.

Now what happens if bodily experiences are grounded not only in body senses, but also in vision? From some specific visuo-spatial perspectives, the only body one can see is one’s own. For instance, the nose I see at the foreground when I close one eye can only be mine. As such, vision can guarantee bodily IEM and its involvement in bodily experiences can only reinforce their special link to the body. However, this type of case is more the exception than the rule (for further exceptions, see Vignemont, 2012). Typically, the hands I see typing could be yours, and our hands can be easily confounded if we play a duet in piano, for example. Hence, most of the time I need to identify whose body I see and I can rationally doubt that the arms that are crossed are mine when I *see* them crossed. Vision then does not guarantee bodily IEM. Does multimodality then come at the cost of bodily IEM?

One can argue that the mere presence of a single perceptual ground that guarantees IEM (e.g., somatosensory perception) suffices for securing the IEM of multimodal experiences, regardless of the presence of other perceptual grounds. However, this is true only if the interaction between the grounds that results in the multimodal experiences does not involve self-identification. Consequently, in order to assess the IEM of multimodal experiences, one needs to understand the basic principles underlying perceptual multimodality, and more specifically to determine whether they require identifying the body we see with the body we feel. As argued earlier, multisensory binding is of interest if and only if sensory signals carry information about the same object or event. In their seminal article, Welch and Warren (1980) noted the challenge of accounting for the mechanisms that select the relevant signals to integrate (the parsing condition): multisensory binding depends on the cognitive assumption that the various signals carry information about the same object:

> an intersensory conflict can be registered as such only if the two sensory modalities are providing information about a sensory situation that the observer has strong reasons to believe (not necessarily consciously) signifies a single (unitary) distal object or event. This has been termed the "unity assumption" (e.g., Welch & Warren, 1980). (Welch, 1999, p. 373)

One way to interpret this assumption is that we must primarily *judge* that what we see is the hand that we feel for binding together visual and proprioceptive information. If so, visuo-proprioceptive integration is necessarily cognitively mediated. However, this view has two unwelcome consequences. First, it implies that our bodily experiences involve an identification component, and thus can lead to judgements that are sensitive to error through misidentification. The second unfortunate consequence is that it raises doubt about the validity of the Multimodality Thesis itself. As argued, the Multimodality Thesis is primarily concerned with perceptual multimodality. However, if multisensory binding required something like a cognitive unity assumption, then it could not occur at the perceptual level, at least if perceptual processes are cognitively impenetrable, as is often assumed.[17] Indeed, since Fodor (1983), it has been traditionally accepted that perceptual systems are informationally encapsulated modules, that is, they are insensitive to beliefs. For instance, many familiar visual illusions continue to look illusory even when the perceiver knows about the illusion. On this view, visuo-proprioceptive binding that depends on a cognitive assumption of unity must then occur at the cognitive level rather than at the perceptual level. Perceptual multimodality would be incompatible with the unity assumption.

However, the cognitive interpretation of the unity assumption seems hardly plausible in light of behavioural and neurophysiological data (the fact that low-level neural mechanisms are involved in multisensory binding). For instance, participants wearing prisms have no conscious access to the original proprioceptive information even if they are aware of the conflict or told that the hand they see belongs to another individual. Recent findings about the Rubber Hand Illusion further reveal that it requires limited visual analysis of the seen object. The similarity between the rubber and the biological hands can indeed be minimal (for review, see Vignemont, 2011). Visual dissimilarities, including difference in hand shape, skin complexion and

[17] However, some experimental results seem to indicate that what one believes about the typical colour of objects affects how one experiences the colour of objects (for instance, Delk and Fillenbaum, 1965). Based on this type of result, one may argue in favour of a kind of cognitive penetration of perceptual processes (see Macpherson, 2012). If so, perceptual multimodality may be compatible with the cognitive unity assumption.

handedness (left rubber hand and right biological hand) can reduce the illusion to some extent, but it does not prevent it (Hans et al., 2008; Longo et al., 2009; Petkova and Ehrsson, 2009). Interestingly, in a variant of the RHI set-up that uses a virtual whole body rather than a rubber hand, participants experience a full-body illusion for a virtual avatar of a different gender (Slater et al., 2010). All that is required to elicit the illusion is that: (i) the seen object looks like a hand, preferably of the same laterality, (ii) the rubber and the real hands are spatially congruent, and (iii) the stroking is synchronous. Based on these results, it seems unlikely that the participants must feel that their hand is F, see that the rubber hand is F, erroneously judge that their rubber hand is their own hand, and integrate what they feel with what they see. It may rather be the reverse. Participants do not judge that their hand is visually similar to the rubber hand and then experience the illusion; rather, they experience the illusion and only then do they feel as if the rubber hand were their hand (if they do not experience the illusion, like after asynchronous stroking, then they do not feel their hand to be similar to the rubber hand) (Longo et al., 2009). On this view, the self-attribution of the rubber hand is not a prerequisite of visuo-somatosensory binding; it is a consequence of it.

There needs to be selection and a registration at some level that the signals are about one's body, but it does not necessarily need to be at the cognitive level (Vignemont, forthcoming). In the same way that there is a perceptual mechanism that selects the relevant elements (e.g., shape and color) to bind together in unimodal experience (see Treisman, 1999 for example), there may be a perceptual mechanism that selects the relevant information to bind together in multimodal experiences, potentially partially constrained by the long-term body image (e.g., what is seen must look like a body part for the visual information to be selected, cf. Tsakiris, 2010). It may be based on the number of perceptual features that are congruent relative to the weighting assigned to these features (e.g., spatial location is more important and so has a higher weight than visual appearance) (Ernst, 2006). One can then dispense with self-identification. Hence, visuo-somatosensory binding, as found for instance in the Rubber Hand Illusion and prisms adaptation, does not necessarily threaten the special relationship to one's own body that characterizes bodily experiences.

To conclude, I have argued that the body senses cannot fully account for bodily experiences. Instead, vision is required to maximize the veridical perception of the body, which constitutes the function of bodily experiences. Consequently, bodily experiences in those who have never seen are of a different kind than those involved when one normally experiences one's body. Whether or not one is currently seeing one's body, vision plays an essential role in delineating the boundaries of the body, in locating our body parts in space, and in bridging the gap between what happens on the skin and what happens in the external world. In this weak sense, the bodily experiences of the sighted (or those who were once sighted) can be said to be constitutively multimodal. Yet, despite the pervasive role of vision, bodily experiences still involve a privileged relationship to one's own body, a relationship that one has with respect to no other body.[18]

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