The Embodied Self

Dimensions, Coherence and Disorders

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7 Cognitive and Bodily Selves

7.1 How Do They Interact Following Brain Lesion?
Yves Rossetti, Nicholas P. Holmes, Gilles Rode and Alessandro Farné

Dualism has long distinguished between the mental and the body experiences. Probing the structure and organisation of the self traditionally calls for a distinction between these two sides of the self coin. It is far beyond the scope of this chapter to address these philosophical issues, and our starting point will be the simple distinction between reflective processes involved in the elaboration of body image, self awareness and self-recognition (i.e. “the self”) and the sensorimotor dialogues involved in action control, reactions and automatisms (i.e. “the body’ schema”). This oversimplification

Figure 7-1 Distinguishing between two levels of body representation. Schematic depiction of the relationship between central cognitive processes linked to self-formation and sensorimotor dialogues operating at the body interface. The level of alteration linked to central and peripheral deafferentation and to unilateral neglect are shown (derived from Rossetti et al. 2005).
does not take into account the complex interactions taking place between these two levels of description, but our initial aim will be to distinguish between them, before addressing the question of their interactions. Cognitive and sensorimotor processes have frequently been distinguished (review in Rossetti & Revonsuo 2000), and it may be proposed that a similar dissociation can be put forward, a priori, between a central representation of self and a bodily representation corresponding to body schema (see Figure 7-1).

**Body Schema and Body Image**

Human pathology often reveals dissociated deficits for cognitive and sensorimotor representations. Jacques Paillard, among the firsts of many others (review in Rossetti 1998; Rossetti & Revonsuo 2000), provided a theoretical framework to distinguish between these two processes and reviewed empirical evidence for the distinction (e.g. Paillard 1985; 1987). From his initial sensorimotor area of research practice, which led him to emphasise the role of the moving body in the construction of spatial representations (Paillard 1971), he in turn exported the theoretical distinction into several other fields. His most important contribution to the exploration of the self has been his version of the distinction between body schema and body image (Paillard 1980; 1982). His first account of the distinction was to translate the “what” and “where” dissociation emphasised in the visual system onto body representations (Paillard 1980), binding the classical psychological distinctions with modern neurophysiological data.

As argued by several authors (e.g., Head & Holmes 1911; Paillard 1999; 2005) several aspects of body representation should be distinguished. Obviously one is able to make use of the skin information fed to the primary cortex to construct a “superficial schema”. Then a “postural schema” is used to register all changes of posture. This latter representation is now more often referred to as “Body schema” (Schindler 1935). This level is considered to correspond to a low-level sensorimotor processing of body information prior to its conscious processing. The proper body image (“l’image du corps”; Lhermitte 1942) refers to the actual conscious representation of information related to the body, not only of somatosensory but also of visual and motor origin. Beyond the physiological descriptions, further experiences of the body can be described. As proposed by F. Dolto for example, there are also unconscious levels of body image (“l’image inconsciente du corps”). These images refer to symbolic representations of one’s own body that are not directly linked to the low-level sensory inputs. As argued by Dolto, this unconscious body image is purely unconscious whereas the body schema is partly unconscious but also preconscious. She also delineates a “conscious body schema” which can be taken as an equivalent of the (conscious) body image defined by Lhermitte. Although they have not been investigated systematically by neuropsychological approaches, these unconscious representations inevitably play an important role in the organisation of the patient’s reactions to a deficit. The dominant account of these distinctions in the field of cognitive neuroscience is the distinction between body schema and body image (Paillard 1980; 1999; 2005).
Neurological Arguments for the Distinction

The key empirical argument used to argue for a double dissociation between body schema and body image comes from the comparison of central and peripheral deafferentation. As early as 1983, Jacques Paillard and colleagues published a contribution on a centrally deafferented patient AT (Paillard et al. 1983). Following the discovery of blindsight, they similarly showed that this patient could not feel any tactile stimulus applied to her hand, but could nevertheless point with significant accuracy toward the stimulus. Paillard et al. interpreted their result as a dissociation between “what” (impaired) and “where” (preserved) processing in the somatosensory domain. This tactile equivalent to blindsight was further explored in a patient with a thalamic lesion leading to a complete somatosensory loss on the right side (Rossetti et al. 1995). As the previous case, this patient, JA, could not detect if a touch was applied to his arm,

![Figure 7-2 Numbsense. Pointing performance of patient JA in response to tactile stimuli (stars) delivered on the forearm. Black dots show the correct responses, which are well above the chance level in the direct pointing condition and just around chance level in the pointing on an arm drawing condition. Incorrect responses are indicated by an arrow.](image)
even in a forced-choice manner. And he remained able to point to the location of the stimulus with a well above chance performance. However, the patient could not show where he had been touched on a full-scale drawing of his own arm, demonstrating that the residual pointing ability could only be expressed when pointing where directed at the stimulus (see Figure 7-2). Therefore it was concluded that the residual ability found in this patient did not pertain to “where” processing but rather to “how” processing. The common feature of the two patients was that they remained fully unaware of somatosensory stimuli but could express some residual processing via the sensorimotor representation provided by their body schema.

Paillard contrasted this finding with another patient, GL, who presented with a peripheral loss of somatosensory processing. In this patient, tactile and proprioceptive capacities were lost for long, and she has been extensively studied in to research on proprioceptive deafferentation. However she exhibited a residual thermal stimulus processing, which could be used to investigate her ability to locate stimuli applied to her body surface. Paillard first tested her capacity to locate thermal stimuli by pointing to her own body, a task in which she performed randomly. Paillard then tested her ability to verbalize and to show on a picture of the body where she had been touched. On these tasks she proved to be very accurate in localising the stimulated site (Paillard 2005). Paillard concluded that GL was able to locate the stimulus on her body, using a conscious body image, without being able to use the same information to drive stimulus oriented movements, i.e. she wasn’t able to incorporate this thermal stimulus in her body schema.

Taken together, these two neurological conditions suggested that there may be a double dissociation between the body schema and the body image (Paillard 2005). However a number of points deserve discussion before this hypothesis can be validated. First, should the inability of GL to point at a cutaneous stimulus be attributed to a sensory or to a motor deficit? A proprioceptive deafferentation makes it difficult to locate the hand in space and hence to guide hand movement in the absence of visual feedback. The apparent failure to locate the stimulus on her body may be explained by a relatively low level motor control deficit rather than by a central representation problem. It would be crucial to know whether GL could show where the location of the stimulus was on her body once she could open her eyes.

Second, one may expect the higher level of body representation to be less quickly prone to deterioration in the presence of a sensory deficit. The sensorimotor levels should be directly and immediately affected by sensory loss, but the higher level should exhibit more inertia. As a matter of fact, JA had a recent stroke causing his deficit while GL presented her deficit for over 10 years.

Third, it seems necessary to further define or assess whether localising a stimulus on a body map is representative of the body image. This point is reminiscent of Gordon Holmes’ classification including a superficial schemata next to the body schema. As pointed out by Paillard himself, it is interesting that this superficial representation was defined as a schema, just like the body schema, and not like an image. Can we simply consider that pointing directly to a superficial stimulus activates the body schema whereas pointing to a body map activates the body image? In patients with higher-level body representation problems such as auto-topoagnosia, the deficit exhibited by the patients does not seem to correspond to a simple body schema deficit, and accordingly their simple actions are not altered (Felician et al. 2003).
Fourth, and more theoretically, several types of interaction have been described between the so called dissociated levels (e.g., Rossetti 1998; Rossetti & Pisella 2002).

**Self Schema and Self Image**

The above questions emphasise the need for clarification before clear conclusions can be drawn about a clear separation of body schema and body image. As a matter of fact, correlates of self perception can be searched for either at the level of body schema or at the level of body image. At the methodological level, it should be stressed that, since the body schema is involved in sensorimotor interactions, it is important to distinguish between its sensory and motor aspects. Interestingly, most of the empirical studies performed to explore the sense of ownership or agency have relied on action paradigms, both in healthy participants and in neurological or psychiatric patients. Most of these studies concluded that there was a bias in favour of self recognition of other’s movements or body parts (e.g. Daprati et al. 1997; van der Bos & Jeannerod 2002; Farrer et al. 2003). One crucial methodological question about these approaches is about whether they tested for sensory-motor or inter-sensory difference detection capacities, i.e. a self schema, or for a proper self representation, i.e. a self image? This question calls for using different paradigms, relying on a different question, in order to eliminate this possible bias. A compelling conclusion of these sensorimotor studies is nevertheless that there is a bias for “self” response in all categories of subjects. However it is known for long that patients with Anton-Babinski syndrome show the opposite trend: they typically deny ownership of their own upper or lower left limb. We have therefore investigated the sense of hand ownership with a simple, but original paradigm (see also Frassinetti et al. 2008).

In the absence of brain damage, recognising your own body, and particularly your own hands, is a trivially simple thing that seems to require very little effort. We are typically always aware of both where our hands are in space, and of the fact that the hands we see and feel in front of us are ours. the ability to recognise and perceive our own body can be lost or impaired following brain damage, resulting in, for example, somatoparaphrenia (e.g., Rode et al. 1992). The fact that this ability (i.e., self-recognition) can be impaired by brain damage suggests that it depends on the operation of a particular brain area which is specialised for self-recognition, and is damaged in those patients with somatoparaphrenia. Alternatively, self-recognition may depend on other brain areas that are not damaged in these patients, but the loss of sensory and motor information related to the hand (e.g., visual, tactile, proprioceptive, efference copy), forces the self-recognition system into a conservative state of “denial” – the brain reasons that “if I don’t have sufficient sensory information to feel ownership over a particular body part, then it can’t be mine”.

We tested this idea in healthy participants. We photographed the left and right hands of participants in both a palm-down and a palm-up posture, then presented the images to them on screen, intermixed with similar photographs of other participants’ hands (matched for sex, hand-size, and gross surface features such as skin tone and hairiness). We manipulated the duration that the hand stimuli were displayed
on screen, and backward-masked them with an image of scrambled hand-parts (see Figure 7-3). The rationale was to examine how well healthy participants can recognise their own hands (i.e. responding “mine” or “not mine”) when the available information about the visible hands is decreased to the point that the stimulus is barely visible. When the visual stimuli were on-screen for 67 ms or longer, healthy participants could recognise their own hands better than chance, and displayed no systematic biases in their responding (i.e. they were just as good at saying an image of their own hand was theirs, as saying that an image of another person’s hand was not theirs). By contrast, when the visual stimuli were presented for 33 ms, participants performed significantly above chance levels, but their responses became more conservative – they began to “disown” the hand images, and typically responded “not mine”. With only 17 ms of stimulus presentation, performance was at chance levels, and participants’ strategy became even more conservative. Participants responded about 70% of the time “not mine”, even when they were repeatedly informed that half of the stimuli were photographs of their own hands, and half of other people’s hands (see Figure 7-4).

How does this relate to somatoparaphrenia and related disorders? It seems that healthy participants are very likely to “disown” static images of their hands when they do not have sufficient sensory information to make a confident ownership decision: They become more conservative in making explicit ownership judgements. These healthy subjects seem to have an intact mechanism for recognising their own hands, since they performed above chance performance with just 33 ms of visual information, but they systematically erred towards denial of ownership when the available sensory information was impoverished. The implications for studying self-recognition in neglect, anosognosia, or somatoparaphrenia are that we need to rule out the possibil-
How Do They Interact Following Brain Lesion?

The apparent hierarchy between body image and body schema

When cognitive and sensorimotor levels of processing are distinguished, most emphasis is put on the top-down controls exerted by the higher cognitive level on the more primitive sensorimotor processes (review in Rossetti 1998; Rossetti & Revonsuo 2000). In short, all types of hierarchical control seem to be applied to the sensorimotor level: it can be configured, activated or inhibited by the cognitive supervisor (Rossetti 1998; see Figure 7-5).

In the case of body schema and body image, a similar description can be proposed (Rossetti et al. 2005). If one considers the case of numbsense described above, three types of control can be observed. First, as is the case in blindsight, the patients cannot make a spontaneous use of the stimulus. They have to be precisely instructed about...