Consciousness and Cognition 53 (2017) 115–121

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Beyond differences between the body schema and the body image: insights from body hallucinations

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ARTICLE INFO

Keywords:
Alice in Wonderland syndrome
Body schema
Body image
Bayesian model
Hallucination
Schizophrenia

ABSTRACT

The distinction between the body schema and the body image has become the stock in trade of much recent work in cognitive neuroscience and philosophy. Yet little is known about the interactions between these two types of body representations. We need to account not only for their dissociations in rare cases, but also for their convergence most of the time. Indeed in our everyday life the body we perceive does not conflict with the body we act with. Are the body image and the body schema then somehow reshaping each other or are they relatively independent and do they only happen to be congruent? On the basis of the study of bodily hallucinations, we consider which model can best account for the body schema/body image interactions.

1. A dialogue between the body schema and the body image?

The distinction between the body schema and the body image has become the stock in trade of much recent work in neuropsychology, cognitive neuroscience and philosophy (e.g., de Vignemont, 2010; Dijkerman & de Haan, 2007; Di Vita, Boccia, Palermo, & Guariglia, 2016; Gallagher, 1986; Paillard, 1999). In brief, the body schema is involved in action, whereas the body image corresponds to how we perceive our body. This distinction is in line with the general functional hypothesis according to which perception and action require different transformations of the sensory signals, obey different rules, and are thus subserved by different cortical and subcortical pathways. This has been shown for visual and auditory signals (Milner & Goodale, 1995; Milner & Goodale, 2008; Romanski et al., 1999; Zatorre et al., 2002; Hall, 2003; Warren, Wise, & Warren, 2005; Dyson, Dunn, & Alain, 2010), but also for somatosensory ones (Dijkerman & de Haan, 2007). The so-called Perception-Action model, however, is controversial (Rossetti, 2003). In particular, the nature and the extent of the interactions between the two types of sensory processing are often left underspecified. Little has been said about the links between the body schema and the body image. To what extent do they communicate with each other? Are the body image and the body schema somehow reshaping each other or on the contrary, are they relatively independent? In most situations in our day-to-day life, the body we perceive does not conflict with the body we act with. In this case, are body representations converging precisely because they are co-constructed or are they built separately and do they only happen to be congruent? And if they are congruent, how can we know that actions are guided by the body schema only, and that the body image does not contribute to their guidance?

One of the difficulties that one has to face is that there is still little agreement on the definition of the notions themselves (de Vignemont, 2010). How should one draw the boundary between the body schema and the body image? In purely functional terms (action versus perception) (Paillard, 1999; Djikerman & de Haan, 2007)? Or could it depend also on their availability to the subject (unconscious versus conscious) (Head & Holmes, 1911)? A further dimension that might be relevant is their malleability: one can

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http://dx.doi.org/10.1016/j.concog.2017.06.006
Received 20 February 2017; Received in revised form 9 May 2017; Accepted 12 June 2017
Available online 26 June 2017

distinguish between short-term and long-term body representations (O'Shaughnessy, 1980).

A second difficulty is that there are very rare 'pure' cases in which only one type of representation is disturbed. Why are the body schema and the body image usually impaired together? Does the deficit of one affect the other? Or do their respective impairments have a common cause? Interestingly, when dissociations are found, they mainly concern short-term bodily information, either tactile or proprioceptive one. For instance, the patient KE failed to accurately localize tactile stimulations when asked to point to his own hand, but not to a pictorial representation of his hand, whereas the patient JO displayed the reverse pattern and failed to accurately localize tactile stimulations when asked to point to a pictorial representation of her hand, but not to her own hand (Anema et al., 2009; see also Paillard, 1999). In healthy participants similar dissociation has been found with the sensation of bodily position using the Rubber Hand Illusion (RHI). Participants saw a rubber hand in front of them while their own hand is hidden from sight. Both hands – the rubber one and the real one – are stroked on the same finger. After synchronous stroking only, participants mislocalize their hand in the direction of the location of the rubber hand (Botvinick & Cohen, 1998). Interestingly they still correctly localize their hand in motor responses, as shown by normal kinematics in reaching their hand and in using it (Kammers, Vignemont, Verhagen, & Dijkerman, 2009).

Dissociations of these types have been used to show that there must be at least two distinct types of body representations, which seems relatively accepted nowadays. However, what may be true at the short-term level may not be true at the long-term level of the enduring properties of the body (i.e. bodily configuration and metrics). Instead, it has been suggested that there is a unique type of long-term representation used for both action and bodily experiences (O'Shaughnessy, 1980; Brewer, 1995; Bermúdez, 2005; Alsmith, 2009). This hypothesis has the advantage to be relatively parsimonious:

> "This first category of body-relative information performs two tasks. First, it is responsible for the felt location of sensations. Sensations are referred to specific body-parts in virtue of a body of information about the structure of the body. Second, *the same body of information* informs the motor system about the body-parts that are available to be employed in action." (Bermúdez, 2005, p. 305, our underline).

Here we shall focus exclusively on long-term body representations. We will ask the following two questions: (i) is there a unique multifunctional representation of bodily metrics and configuration or does the distinction body schema/body image also apply for enduring bodily properties? (ii) if there are two functionally defined long-term body representations, how do they interact? We shall discuss three theoretical options (see Fig. 1):

a. The Fusion model: There is a unique representation of the enduring properties of the body that both spatially frames bodily experiences and guide bodily movements (O'Shaughnessy, 1980; Brewer, 1995; de Bermúdez, 2005; Alsmith, 2009);
b. The Independence model: There are two distinct functionally defined representations of the enduring properties of the body, a long-term body schema for action and a long-term body image for perception, and they work independently of each other;
c. The Co-construction model: There are two distinct functionally defined representations of the enduring properties of the body, a long-term body schema for action and a long-term body image for perception, and they can interact and reshape each other.

We shall consider each model in light of the existing literature but as mentioned earlier almost no studies have directly addressed the question of the body schema/body image in the specific context of long-term body representations (Carruthers, 2008). Here we

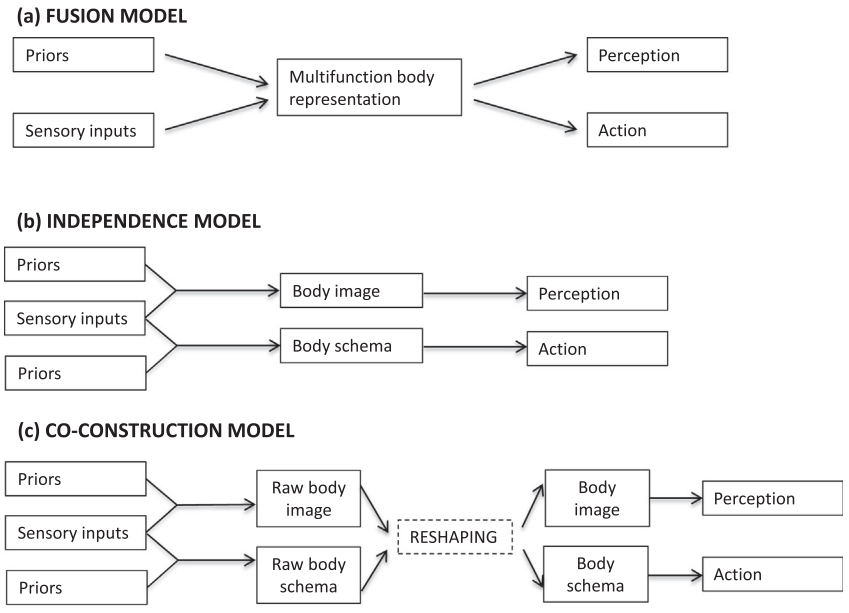

Fig. 1. Models of interactions between body representations.