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Review

Bodily ownership and self-location: Components of bodily self-consciousness

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ABSTRACT

Recent research on bodily self-consciousness has assumed that it consists of three distinct components: the experience of owning a body (body ownership); the experience of being a body with a given location within the environment (self-location); and the experience of taking a first-person, body-centered, perspective on that environment (perspective). Here we review recent neuroimaging studies suggesting that at least two of these components—body ownership and self-location—are implemented in rather distinct neural substrates, located, respectively, in the premotor cortex and in the temporo-parietal junction. We examine these results and consider them in relation to clinical evidence from patients with altered body perception and work on a variety of multisensory, body-related illusions, such as the rubber hand illusion, the full body illusion, the body swap illusion and the enfacement illusion. We conclude by providing a preliminary synthesis of the data on bodily self-consciousness and its neural correlates.

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1. Introduction

Self-consciousness is not a simple phenomenon; a full explanation of self-consciousness must explain many things. But often progress can be made in understanding a complex phenomenon by understanding something rather simple at its heart, and progressing from there. Recent work on the psychology and neuroscience of self-consciousness can be seen as exemplifying this research strategy. Instead of focusing on 'higher' forms of self-consciousness involved in, for example, mastery of the 'I' concept (Bermúdez, 1998; Peacocke, 2008), mirror self-recognition (Gallup, 1975; Morin, 2006) and understanding of one's own identity over time (Gallagher, 2000; Morin, 2006), a number of researchers have instead focused on more basic, *bodily* forms of self-consciousness. In particular, they have explored the ways in which multisensory bodily illusions can modulate the experience of oneself as a bodily subject.

This research is characterised by a number of basic assumptions. The first is that the behavioural effects of manipulating proprioceptive, interoceptive and exteroceptive signals can serve as implicit measures of phenomena described in explicit reports of subjective experience. The second is that global aspects of bodily self-consciousness (pertaining to the experience of the body as a whole) can be studied by manipulating these sensory signals, despite the fact that their immediate processing is physiologically and computationally constrained to individual body parts (Ehrsson, 2007; Guterstam & Ehrsson, 2012; Lenggenhager, Tadi, Metzinger, & Blanke, 2007; see also Altschuler & Ramachandran, 2007; Mizumoto & Ishikawa, 2005; Petkova & Ehrsson, 2008; Slater, Perez-Marcos, Ehrsson, & Sanchez-Vives, 2009).

Our aim in the following discussion is to provide some degree of validation for a third assumption driving this research, namely that bodily self-consciousness comprises at least three distinct components: the experience of owning a body (*body ownership*); the experience of being a body with a given location within our environment (*self-location*); and the experience of taking a first-person, body-centered, perspective on that environment (*perspective*) (Blanke & Metzinger, 2009; de Vignemont, 2011; Vogeley & Fink, 2003). Bodily self-consciousness might in principle include other components, for example sense of agency for bodily actions (see, Jeannerod, 2006), but these exceed the scope of the present analysis. In its strongest form, this assumption states that each of the aforementioned three components is distinct from one another. Although we will not fully evaluate the stronger claim here, we think that there is good reason for thinking that *perspective* is not wholly distinct from *self-location*, and thus that the strongest claim is false. Our discussion will focus on a weaker form of the assumption: that there are at least two components of bodily self-consciousness that are distinct from one another, namely *body ownership* and *self-location*.

Our evaluation of this assumption will initially focus on two studies: one by Ionta et al. (2011) and the other by Petkova et al. (2011). These studies exemplify the first two assumptions noted above: each of these studies had the explicit aim of combining multisensory stimulation, concurrently delivered to the participant's body and to a virtual body, with fMRI to study the neural mechanisms underlying global forms of bodily self-consciousness. And in both studies, the manipulation of these forms of bodily self-consciousness was thought to be demonstrated by both explicit reports and measurement of behavioural effects: a shift in the perceived self-location towards the location of the virtual body in Ionta et al.'s (2011) study, and by an increase in autonomic response to a threat towards the virtual body in Petkova et al.'s (2011) study. But more interesting for our purposes is the fact that whilst similar multisensory stimulation was used, the results of these two studies differed both with respect to the phenomenological effects inferred from participants' reports and behavioural measures, and the neural correlates of these effects. In particular, distinct changes in bodily self-consciousness were related to neural activity in either the temporo-parietal junction (TPJ) in Ionta et al. (2011), or in the ventral premotor cortex (vPMc) in Petkova et al. (2011).

Taken together, these two neuroimaging studies seem to provide a case for validating the assumption that there are at least two components of bodily self-consciousness, i.e., self-location and body ownership, that are distinct from one another. We outline this case by first comparing the experimental conditions used, the phenomenological effects of the visuo-tactile conflicts in both studies, and the different patterns of neural activation reported. It seems that, experimentally, it is possible to manipulate body ownership without altering self-location, but not the converse. We delineate the case for a double dissociation by drawing on clinical evidence also. We then move on to a more detailed comparison of the brain structures involved. In doing so, we provide a tentative synthesis, merging the functional and anatomical data from these two studies with previous models thought to account for ownership of isolated body parts (Ehrsson, 2012; Makin, Holmes, & Zohary, 2007; Tsakiris, 2010) and self-location (Blanke & Arzy, 2005; Blanke & Metzinger, 2009).