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Body ownership: When feeling and knowing diverge

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ABSTRACT

Individuals with the peculiar disturbance of '*overcompleteness*' experience an intense desire to amputate one of their healthy limbs, describing a sense of disownership for it (Body Integrity Identity Disorder – BIID). This condition is similar to somatoparaphrenia, the acquired delusion that one's own limb belongs to someone else. In ten individuals with BIID, we measured skin conductance response to noxious stimuli, delivered to the accepted and non-accepted limb, touching the body part or simulating the contact (stimuli approach the body without contacting it), hypothesizing that these individuals have responses like somatoparaphrenic patients, who previously showed reduced pain anticipation, when the threat was directed to the disowned limb. We found reduced anticipatory response to stimuli approaching, but not contacting, the unwanted limb. Conversely, stimuli contacting the non-accepted body-part, induced stronger SCR than those contacting the healthy parts, suggesting that feeling of ownership is critically related to a proper processing of incoming threats.

1. Introduction

Body representation is our body mapped in the brain (Head & Holmes, 1911). There are several distinct body representations, some of them responsible for processing primary sensory inputs, some others for controlling motor outputs (Zeharia, Hertz, Flash, & Amedi, 2012). Beyond this first level of processing, various supplementary representations of a higher cognitive order have been proposed, supposedly involved in complex behaviors (de Vignemont, 2011). The sense of ownership corresponds to the awareness of one's body as belonging to one's self, and the feeling that a given body part belongs to one's own body (de Vignemont, 2011). This sense of ownership is seemingly derived from a specific type of body representation. Ownership over body parts constitutes one of the prerequisites for the kind of embodied self-consciousness ordinary humans tacitly take for granted.

Individuals with Body Integrity Identity Disorder – BIID – report a highly disturbed sense of ownership for one or more of their limbs (Sedda, 2011). Paradoxically, they experience themselves as "incomplete", as long as they continuously feel the presence of the limb they do not accept as a part of their bodily self. Consequently, these people develop an intense desire to get rid of the particular limb, either physically ("desire for amputation", First, 2005) or functionally ("desire for paraplegia",

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Giummarra, Bradshaw, Hilti, Nicholls, & Brugger, 2012). This peculiar condition was originally ascribed to paraphilias and labelled as apotemnophilia (“love for amputation” Money, Jobaris, & Furth, 1977). In 2005, the first survey on a large group of individuals desiring amputation ($n = 42$) lead to a change in nomenclature from apotemnophilia, which implied a sexual connotation, to the term BIID and the concept of body identity. The new focus on “identity” rather than sexuality was clearly inspired by work on gender dysphoria, then labelled “gender identity disorder”, GID. Still more recently, the nosologically more neutral label “xenomelia” (McGeoch et al., 2011) was proposed, emphasizing the feelings of alienation, or disownership mentioned by individuals with BIID. This semantic path highlights the shift from considering only the psychiatric components of the condition to the inclusion of neurological correlates more related to the cerebral representation of the body. In this paper, we will adopt the more descriptive label “amputation-desire” to avoid biasing the reader toward one particular etiological direction. A dysfunctional activity of the right parietal lobe has been proposed as a neural correlate for the amputation-desire (McGeoch et al., 2011). The authors examined three individuals with xenomelia and found a reduced responsivity of the right superior parietal lobule (SPL) for tactile stimulation of the affected limb, as compared to its healthy counterpart or the limb of control participants. Interestingly, another locus of altered brain activity was the insula, an area traditionally associated with higher-order body representations (Berlucchi & Aglioti, 2010). In accordance with these functional correlates of amputation-desire, Hilti et al. (2013) recently demonstrated structural differences in the right SPL, the right primary and secondary somatosensory cortices, and the anterior insula when comparing individuals with amputation-desire with control subjects (Hilti et al., 2013). Another recent study, adopting a functional paradigm, found an involvement of the premotor cortex in individuals desiring amputation (Van Dijk et al., 2013).

One’s sense of ownership is critically related to pain anticipation and the processing of incipient threat (Ehrsson, Wiech, Weiskopf, Dolan, & Passingham, 2007), which is relevant for adaptive purposes, as the recognition and avoidance of danger. It has been show that experiencing a sense of ownership toward an alien hand is related to the emotional reaction when that hand is threatened both in healthy participants under bodily illusions (Armel & Ramachandran, 2003; Ehrsson et al., 2007), and in patients experiencing pathological embodiment for alien hands (Garbarini, Fornia, et al., 2014). Early research in anosognosia, the non-recognition of one’s own illness, revealed a basic disturbance in the “circuits for danger recognition” suggesting that being aware of one’s own body is a critical function for adaptive behavior (Vocat & Vuilleumier, 2010). “Personification anosognosia” (Critchley, 1955) is a particular form of anosognosia, relevant in the context of the sense of ownership, where a patient with hemiplegia, unaware of the paralysis, claims that the affected limb belongs to another person. This disorder, not uncommon in the initial phases of a right hemisphere stroke, is now better known as “somatoparaphrenia” (Gerstmann, 1942; Invernizzi et al., 2012; Romano, Gandola, Bottini, & Maravita, 2014; Vallar & Ronchi, 2009).

Recently, it has been shown that Skin Conductance Responses (SCR) to sensory threats approaching the body are reduced in somatoparaphrenic patients, supporting the idea that a detachment of the affected body part from the patient’s body representation also modulates pain anticipation (Romano, Gandola et al., 2014). While a preliminary exploration of pain perception in two individuals with amputation-desire showed increased SCRs for noxious stimuli contacting the unwanted limb (Brang, McGeoch, & Ramachandran, 2008), no data on pain anticipation are available yet. A conceptual similarity between somatoparaphrenia and the disturbance of ‘overcompleteness’ has been previously proposed based on the disownership sensations associated with both conditions (Berti, 2013; Brang et al., 2008; Lenggenhager, Hilti, Palla, Macauda, & Brugger, 2014). However, there is also a fundamental theoretical difference between the two disorders. De Vignemont recently proposed that the ownership experience could be divided in the feeling of ownership and the judgment of ownership. The hypothesis is that our judgments of ownership, which we have on our biological body parts under normal conditions, are based on a primitive non-conceptual feeling of ownership (de Vignemont, 2011). We propose that a critical difference is that individuals with amputation-desire lack the *feeling* of ownership but not the *cognitive appreciation* that these are their own limbs.[1] On the other side, in somatoparaphrenia, patients are delusional and lack both the ownership feeling and the ownership judgment. Amputation-desire is also reminiscent of another peculiar disturbance of body awareness, namely misoplegia. This latter condition is defined as a morbid dislike or hatred toward paralyzed limbs in patients with hemiplegia (Critchley, 1955, 1974) that typically presents with somatoparaphrenia, even if double dissociations are on record (Loetscher, Regard, & Brugger, 2006). Despite amputation-desire and misoplegia share aggressive desires toward one’s own limb, an important difference should be acknowledged. First, only a few cases of misoplegia are well documented in the literature (Loetscher et al., 2006). Thus, there is a profound need for more experimental data to precisely determine behavioral manifestations and neural underpinnings of misoplegia. However it is possible to observe that individuals with amputation-desire typically present with very precise characteristics of the body part to amputee, including a sharp line from where they do not experience the limb as a part of their body desiring its removal. Less is known for individuals with misoplegia, where aggressive behavior toward the impaired limb seem to be more generalized ranging from verbal aggression to physical actions generally targeting the impaired limb as a whole. Moreover, these behaviors seem to be related to a general impairment of emotional processing such as anosodiaphoria, impulsive behavior, and other emotional disturbance (Loetscher et al., 2006).

Thus amputation-desire shares some features with acquired impairments of body awareness, but is at the same time unique in that it reflects a lack of feeling of ownership accompanied by a normal judgment of ownership.

[1] In the original 2011 paper de Vignemont proposed that the desire for amputation was a matter of judgment of disownership with preserved feeling of disownership, the opposite of our view expressed here. However, she herself recently revised this distinction, entertaining an interpretation of the disorder in terms of an absent ownership feeling with preserved ownership judgments (de Vignemont, 2014 [e-pub ahead-of-print]).