

The rubber hand illusion: Sensitivity and reference frame for body ownership

Marcello Costantini ^{a,*}, Patrick Haggard ^b

^a *Department of Clinical Sciences and Bio-imaging, University of Chieti, Via Dei Vestini 33, 66013 Chieti, Italy*

^b *Institute of Cognitive Neuroscience and Department of Psychology, University College London, London, UK*

Received 22 February 2006

Available online 20 February 2007

Abstract

When subjects view stimulation of a rubber hand while feeling congruent stimulation of their own hand, they may come to feel that the rubber hand is part of their own body. This illusion of body ownership is termed ‘Rubber Hand Illusion’ (RHI). We investigated sensitivity of RHI to spatial mismatches between visual and somatic experience. We compared the effects of spatial mismatch between the stimulation of the two hands, and equivalent mismatches between the postures of the two hands. We created the mismatch either by adjusting stimulation or posture of the subject’s hand, or, in a separate group of subjects, by adjusting stimulation or posture of the rubber hand. The matching processes underlying body ownership were asymmetrical. The illusion survived small changes in the subject’s hand posture, but disappeared when the same posture transformations were applied to the rubber hand. Mismatch between the stimulation delivered to the subject’s hand and the rubber hand abolished the illusion. The combination of these two situations is of particular interest. When the subject’s hand posture was slightly different from the rubber hand posture, the RHI remained as long as stimulation of the two hands was congruent in a hand-centred spatial reference frame, even though the altered posture of the subject’s hand meant that stimulation was incongruent in external space. Conversely, the RHI was reduced when the stimulation was incongruent in hand-centred space but congruent in external space. We conclude that the visual–tactile correlation that causes the RHI is computed within a hand-centred frame of reference, which is updated with changes in body posture. Current sensory evidence about what is ‘me’ is interpreted with respect to a prior mental body representation.

© 2007 Elsevier Inc. All rights reserved.

Keywords: Body image; Body schema; Rubber hand illusion; Body ownership; Proprioception

1. Introduction

1.1. Body ownership and body representations

The sense of one’s own body is a fundamental aspect of self-consciousness. In everyday life, we see, feel and move our body, and have no doubt that it is our own. The term ‘body ownership’ has been given to this

* Corresponding author. Fax: +39 0871 3556930.

E-mail address: marcello.costantini@unich.it (M. Costantini).

experience (Gallagher, 2000). The sense of body ownership presumably depends on afferent sensations arising within the body itself (Tsakiris, Hesse, Boy, Haggard, & Fink, 2006), but also on the coherence of current sensory input with pre-existing cognitive representations of the body (Tsakiris & Haggard, 2005).

Psychological and neurological studies classically distinguish at least two internal representations of the body, often called *body schema* and *body image* (for overviews of the distinction, see Bermudez, 2005; Cole & Paillard, 1995; Eilan, Marcel, & Bermúdez, 1995; Gallagher, 1986; Gallagher, 1995; Paillard, 1999). According to Head's (1920) classical description, the *body schema* is a model or representation of one's own body that provides a standard against which postures and body movements are judged. This model is considered to be the result of past sensory experiences (primarily proprioceptive, but also tactile, and vestibular). This gives rise to an unconscious representation of body configuration which allows us to move fluently through space, to know where our body parts are, and to localise tactile stimuli on the body surface. In particular, the body schema is described as intimately related to voluntary action: it is updated during action, and also supports coordinated actions by providing a proprioceptive representation of the initial conditions for movement (Ghez, Gordon, & Ghilardi, 1995; Sainburg, Poizner, & Ghez, 1993).

Body image, on the other hand is defined as a conscious idea or mental representation of one's own body (Adame, Radell, Johnson, & Cole, 1991; Schilder, 1935). It comprises body-specific perceptions, mental representations, beliefs, attitudes and emotions (Cash & Brown, 1987; Gardner & Moncrieff, 1988; Powers, Schulman, Gleghorn, & Prange, 1987). The appearance of one's own body 'from the outside', is thought to be an important component of body image. Therefore, we focus here on the visual perceptual component of body image.

In normal circumstances, body schema and body image together form a coherent basis for self-consciousness. In abnormal circumstances, such as brain lesions or deafferentation, they may be dissociated (Gallagher & Cole, 1995; Paillard, 1999; Rossetti, Rode, & Boisson, 1995).

1.2. Manipulating body ownership with the rubber hand illusion

Body image and body schema are putative internal representations, defined by their epistemic rather than phenomenal properties. The link between these representations and the phenomenal sense of ownership has not been explored. For example, does our experience of our own body arise primarily 'from the inside' through body schema, or 'from the outside' through body image? Illusions which manipulate sense of ownership are a powerful experimental tool to investigate this question. In the rubber hand illusion (RHI; Botvinick & Cohen, 1998), watching a rubber hand being stroked synchronously with one's own unseen hand causes the rubber hand to "feel like it's my hand". A sense of ownership arises due to the matching visual and tactile stimulation. Because the subject takes the viewed rubber hand as their own hand, one consequence of the illusion is that the viewed location of the rubber hand adapts the proprioceptively perceived location of the subject's own hand. The processes of this adaptation are presumably the same as those in standard visual-proprioceptive conflicts such as prismatic adaptation (Welch, 1978). Therefore, the RHI can be measured indirectly but quantitatively as a drift of the perceived position of the subject's own hand toward the rubber hand, offering one of the few experimental measures of body ownership (Botvinick & Cohen, 1998; Tsakiris & Haggard, 2005).

Several studies suggest that the RHI depends not only on matching the pattern of stimulation, but also on the match between the rubber hand and pre-existing body representations. Ehrsson et al. (Ehrsson, Spence, & Passingham, 2004), and Tsakiris and Haggard (Tsakiris & Haggard, 2005) both showed that orienting the rubber hand at 180° and 90°, respectively, to the subject's own hand abolishes the illusion. This suggests that the rubber hand must match the subject's proprioceptive body schema for a sense of ownership to arise.

Tsakiris and Haggard (2005) showed that when subjects viewed a piece of wood, or a right rubber hand, while being stroked on their left hand, the illusion was reduced. That is, the RHI requires that the to-be-incorporated object be visually similar to the actual body part that is stimulated. This suggests that the rubber hand must also match the subject's visual body image.

1.3. Two levels of multisensory matching

Ownership may therefore involve multiple levels of multisensory matching. First, the incorporation of the rubber hand into the body depends on visual stimulation of the rubber hand matching the tactile stimulation

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات