Consciousness and Cognition 21 (2012) 1355–1364

Contents lists available at SciVerse ScienceDirect

Consciousness and Cognition

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

I feel who I see: Visual body identity affects visual–tactile integration in peripersonal space

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ARTICLE INFO

Article history:
Received 13 January 2012
Available online 23 July 2012

Keywords:
Crossmodal integration
Visual tactile integration
Self-consciousness
Bodily representation
Social cognition
Self-representation
Crossmodal congruency

ABSTRACT

Recent studies have shown the importance of integrating multisensory information in the body representation for constituting self-consciousness. However, one idea that has received only scant attention is that our body representation is also constituted by knowledge of bodily visual characteristics (i.e. 'what I look like'). Here in two experiments we used a full body crossmodal congruency task in which visual distractors were presented on a photograph of the participant, another person, who was either familiar or unfamiliar, or an object. Results revealed that during the 'self-condition' CCEs were enhanced compared to the 'other condition'. The CCE was similar for unfamiliar and familiar others. CCEs for the object condition were significantly smaller. The results show that presentation of an irrelevant image of a body affects multimodal processing and that the effect is enhanced when that image is of the self. The results hold intriguing implications for body representation in social situations.

1. Introduction

How the brain represents and integrates bodily information from different sensory modalities while taking into account previous knowledge to give rise to our bodily consciousness is not well understood. The integration of bodily signals such as touch and proprioception with external information from vision has been studied extensively during the past few years (Holmes, Sanabria, Calvert, & Spence, 2007; Macaluso, Frith, & Driver, 2002; Shore, Barnes, & Spence, 2006; Spence et al., 2004). These investigations were spurred by studies using single cell recordings in animals which revealed neurons that have receptive fields that respond to both visual and tactile stimuli (Graziano, Yap, & Gross, 1994; Mountcastle, Lynch, Georgopoulos, Sakata, & Acuna, 1975) as well as data from right brain-damaged patients with abnormalities in visuo–tactile integration (di Pellegrino, Làdavas, & Farné, 1997; Làdavas, Pellegrino, Farnè, & Zeloni, 1998). Subsequent studies suggested that similar multimodal representations of personal and peripersonal space can also be studied in healthy participants (Lloyd, Shore, Spence, & Calvert, 2002; Macaluso, Frith, & Driver, 2000; Spence, Pavani, Maravita, & Holmes, 2004). One well established paradigm to quantitatively test such multimodal representations in humans is the crossmodal congruency task (Maravita, Spence, & Driver, 2003; Spence, Pavani, & Driver, 1998; Spence, Pavani, Maravita, & Holmes, 2004). In the crossmodal congruency task participants are required to report the location of a tactile stimulation (up or down) while an irrelevant visual distractor is flashed at either the same spatial elevation (congruent condition) or the different elevation

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http://dx.doi.org/10.1016/j.concog.2012.06.012

(incongruent condition). The basic finding – termed the crossmodal congruency effect (CCE) – is of slower reaction times (RTs) and/or more errors when the visual and tactile stimuli are incongruent. Furthermore, a larger CCE is observed when the visual distractor occurs on the same spatial side as the vibrotactile stimulation (e.g. distractor at lower left side, vibration at upper left side) (Spence, Pavani, & Driver, 2004).

The CCE can be used as a measure of the crossmodal mapping of peripersonal space and to study the extension of personal space such as during the incorporation of external objects (tools or fake hands) into the body representation (Spence, Pavani, Maravita, et al., 2004). For example, a CCE (that is generally found between vibrations and light in close proximity to the participant's hands) has been shown when the visual distractors were located on rubber hands, but only when these were placed in a plausible position in relation to the participant's own hands (Pavani, Spence, & Driver, 2000; Zopf, Savage, & Williams, 2010). Similarly, CCEs have been found for distractors placed at the end of elongated tools, but only after participants had practiced using the tool (Holmes, Calvert, & Spence, 2007; Maravita, Spence, Kennett, & Driver, 2002). This finding has been interpreted as reflecting an extension of peripersonal space to incorporate the tool, comparable to the finding of an increase in the receptive field size of visual–tactile neurons following tool use in monkeys (but see Holmes, Sanabria, et al. 2007; Iriki, Tanaka, & Iwamura, 1996). In addition, these CCE effects are not limited to the hands and handheld tools. For example, CCEs were also modulated by visual distractors displayed on the trunk of a body that was viewed via a video camera from a distance of 2 m and from behind. These CCEs were further modulated by visuo–tactile stroking, decreased for non-bodily control objects and enhanced when viewing and self-identifying with the seen human body (Aspell, Lenggenhager, & Blanke, 2009; Palluel, Aspell, & Blanke, 2011). Thus, events occurring in our extra-personal and peripersonal space may affect the way in which we experience our body. The body representation seems to be highly malleable (Holmes & Spence, 2004), and under certain conditions it can be extended to include objects (Armel & Ramachandran, 2003; Maravita et al., 2002), body parts (Botvinick & Cohen, 1998) or even full bodies (Aspell et al., 2009; Lenggenhager, Mouthon, & Blanke, 2009). Yet despite this flexibility, under normal conditions we rarely confuse our bodies with other objects or the bodies of others suggesting that the malleability of the body representation is constrained by additional mechanisms.

An important aspect of maintaining a coherent body representation is our ability to distinguish between what belongs to our own body proper and what does not (i.e. we take off our hat before combing our hair and we typically do not hesitate to poke in a fire with a stick, although we would not do such a thing with our finger) (Boinski, 1988). Several studies have shown that our proficiency in distinguishing ourselves from others relies on the use of visual information, by means of a comparison between online visual information and pre-existing knowledge of our body's visual appearance, which we will refer to here as 'visual body identity'. This 'visual body identity' includes the stored knowledge of our external appearance that allows one to identify oneself in a photograph. The visual body identity can be considered a perceptual element of the more general concept of the 'body image' which has been defined as the perceptual, conceptual and emotional representations of the body which are not related to action (de Vignemont, 2010). Many studies have focused on the behavioral and neural mechanisms underlying the visual recognition of one's own face (Devue & Bredart, 2011; Dieguez, Scherer, & Blanke, 2011; Kircher et al., 2000; Platek et al., 2006; Uddin, Kaplan, Molnar-Szakacs, Zaidel, & Iacoboni, 2005) and body (Frassinetti, Ferri, Maini, Benassi, & Gallese, 2011; Frassinetti et al., 2009; Myers & Sowden, 2008; Sugiura et al., 2006). For example, one study investigated the neural correlates of recognition of the self, a familiar other and a stranger from facial and body movies and pictures. The results indicated that self-recognition was faster than recognition of a stranger, for both faces and bodies, regardless of stimulus type (Sugiura et al., 2006). Several other studies have shown an advantage for processing and recognition of the own body (Devue et al., 2007) and body parts (Frassinetti et al., 2009; Salomon, Malach, & Lamy, 2009). Taken together these findings show that our own visual body image (face, body or body parts) enjoys privileged processing which is governed by specific brain mechanisms. This self-representation may serve to constrain changes in body representation allowing us to differentiate our body from the environment.

Thus, on the one hand, studies of multisensory integration provide evidence for the flexibility of our body representation, while on the other hand, other studies show a privileged processing of visual information related to one's own body, suggesting the involvement of long-term visual knowledge in the body representation. Relatively little is known about how such body knowledge interacts with the integration of multisensory information related to one's body. For instance, when we are combing our hair in front of a mirror we need to integrate visual information about our body with multisensory information about the relative positions of our body parts. Such a seemingly simple task could easily go wrong, for instance when we are standing in front of a laughing mirror, causing us to be mistaken about the actual position of our body parts and thereby underlining the importance of long-term visual knowledge for a coherent body representation.

In the present study, we tested if crossmodal integration (the CCE) was modulated when an image of a body was viewed and whether this was further modulated by the identity of the body (i.e. whether the body belongs to me or not). Participants performed a full body crossmodal congruency task in which the visual distractors were superimposed on a picture of themselves or another person displayed on a large computer screen. We tested if images of the own body induced larger CCEs than images of another person or of an object. In the first experimental condition participants observed their own picture or that of an unfamiliar other. In the second experimental condition a second group of participants observed their own picture or that of a familiar person. In this way we controlled for the possible confound that eventual differences in the CCE are partly driven by familiarity (i.e. own body image is more familiar than the image of a stranger's body) (Dieguez et al., 2011) rather than by the identity of the body alone. In an additional experiment we tested whether CCEs would be larger for bodies then for a body sized object. Based on previous studies showing that the degree of identification with an external