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Active and passive-touch during interpersonal multisensory stimulation change self–other boundaries

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ABSTRACT

In the "enfacement" illusion seeing an unfamiliar face being touched at the same time as one's own face evokes changes in self-face recognition. We investigated the contribution of proprioceptive and motor signals derived from self-generated actions in the sensory-driven malleability of self–other boundaries during the "enfacement" illusion. Changes in self-face recognition during active- and passive-touch interpersonal visuo-tactile stimulation were quantified by means of psychophysical and psychometric tasks. Active- and passive-touch evoked comparable changes in the categorical boundaries of self–other distinction, changing the extent to which the other is assimilated into the mental self-representation. Actively touching or simply feeling touch on one's own face with concurrent observed touch on someone else's face seems to elicit comparable changes in self-recognition, suggesting that afferent input might be sufficient for updating one's body-image, although some components of the experience of self-identification seem to be more affected by passive- than by active-touch.

1. Introduction

One's own face is often the most distinctive feature of one's body, constituting a sign of self-identity which marks the distinction between self and other (Zahavi & Roepstorff, 2011). Seeing one's own face, either reflected in a mirror or in any multimedia format (e.g., photographs or movies), seems to automatically trigger awareness of oneself (Gallup, 1970; Rochat & Zahavi, 2011). The experience of observing oneself reflected in the mirror involves the integration of motor, proprioceptive, tactile and visual cues, as every touch on one's face is mirrored by a compatible visual event. Recent research, capitalizing on the known primary role of multisensory integration for triggering the experience of owning a body (for a review see Tsakiris, 2010), has shown that multisensory stimulation can induce changes in the recognition of one's face (Paladino, Mazzurega, Pavani, & Schubert, 2010; Sforza, Bufalari, Haggard, & Aglioti, 2010; Tajadura-Jiménez, Grehl, & Tsakiris, 2012; Tajadura-Jiménez, Longo, Coleman, & Tsakiris, 2012; Tajadura-Jiménez & Tsakiris, 2013; Tsakiris, 2008). During the "enfacement" illusion paradigm, one sees another person's face being touched while experiencing touch, delivered by the experimenter, at the same time and at the specularly congruent location. This "mirror-like" experience results in changes in self-face recognition, as shown by introspective, behavioral and physiological measures. In particular, the other person's face becomes partly assimilated in the way one mentally represents one's face (Tajadura-Jiménez, Grehl, et al., 2012). It has been shown that the enfacement illusion affects performance in a self-recognition task, but not the recognition of the other face, suggesting that what is being affected by the illusion is the representation of one's own face.

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While these studies have shown how the integration of visual and tactile cues affects self-recognition, they have not addressed the fact that when people look in the mirror and feel touch, the touch is usually generated by themselves, for instance by their own hand. Proprioceptive and motor signals derived from self-generated actions (i.e., active-touch) may then provide additional cues that aid self-recognition. The exact contribution of self-generated movement to self-face recognition remains unknown.

Currently, the only evidence for the role of the integration between visual and proprioceptive cues in self-identification and self–other distinction comes from research on body-parts other than face. Important differences between self-generated and externally-generated sensory events have been found in the updating of the body-schema (Dijkerman & de Haan, 2007). Moreover, recognition of one's own hand passively moving is more accurate during active- vs. passive-movement conditions (Tsakiris, Haggard, Franck, Mainy, & Sirigu, 2005). Furthermore, research on bodily illusions not involving the face has provided evidence for the role that proprioceptive and motor signals, in combination with other sensory signals, play in updating body-representations (Kalckert & Ehrsson, 2012; Newport, Pearce, & Preston, 2010; Sánchez-Vives, Spanlang, Frisoli, Bergamasco, & Slater, 2010; Tsakiris, Prabhu, & Haggard, 2006). In particular, it has been shown that the feeling that an artificial hand is part of one's body (the so called "rubber hand" illusion – RHI), can be elicited by synchronous visuo-tactile stimulation between a fake hand and one's own unseen hand during passive-touch (Botvinick & Cohen, 1998), active-touch (Aimola Davies, White, Thew, Aimola, & Davies, 2010), and by synchronous seen and felt movement of a hand and one's own unseen hand (Kalckert & Ehrsson, 2012; Newport et al., 2010; Sánchez-Vives et al., 2010; Tsakiris et al., 2006). Although some studies have provided weak evidence supporting differences in RHI for active- as compared to passive-movement during conditions of synchronous seen and felt movement (see Dummer, Picot-Annand, Neal, & Moore, 2009; Kalckert & Ehrsson, 2012), others have found no differences (Walsh, Moseley, Taylor, & Gandevia, 2011). Other studies have investigated the role of the integration between tactile and proprioceptive cues, rather than the integration between visual and proprioceptive cues, in the sense of body-ownership. Dieguez, Mercier, Newby, and Blanke (2009) addressed the contribution of self-generated touch to the "numbness illusion", a tactile illusion in which the participant's stroking of two index fingers (his/her own finger and the experimenter's finger), performed with the free hand opened as in a grip, results in a disruption of tactile sensation and body-ownership over one's own finger. They compared conditions of active- and passive-movement when the touch to the fingers was delivered by the participant's hand, as opposed to external touch delivered by the experimenter's hand, and found no difference between the active- and passive-movement conditions, but ownership over the touched index finger was disrupted when the touch was delivered by the experimenter's hand. They concluded that as long as tactile input is maintained (i.e., the participant receives tactile input to both the touching and the touched hand), body-ownership over the index finger is preserved, independently of how movement is generated. Furthermore, Aimola Davies and White (2011) found that ownership over an unseen hand and the illusion of self-touch can be elicited when the participant's right hand is guided to touch the right side of her face, while a similar touch, generated by another person's hand, is felt in synchrony on the left side of the face.

When considering the contribution of self-generated movement to self-face recognition, three alternative hypotheses may be formulated. Based on findings from research on the RHI (Dummer et al., 2009; Kalckert & Ehrsson, 2012), proprioceptive and motor cues from self-generated actions may contribute to self-recognition and therefore active-touch, as opposed to passive-touch, would perhaps result in larger changes in self-face recognition. Alternatively, based on findings showing better recognition of one's hand passively moving during active- vs. passive-movement conditions (Tsakiris et al., 2005), active-touch during an enfacement paradigm may result in a less malleable self-face representation or less acceptance of the other person's face. Finally, based on findings from other bodily illusions not involving visual cues, which showed that similar feelings of body-ownership over a finger being touched arise during both active- and passive-touch conditions as long as tactile input to the participant is maintained (Dieguez et al., 2009), one might expect similar changes in self-face recognition during active- and passive-touch conditions since in both types of conditions participants always receive the same tactile input.

We here sought to investigate the contribution of active-touch to the magnitude of multisensory-induced changes in self-face representations during mirror-like experiences. We quantified the interaction between self- and other-representations during active- and passive-touch interpersonal multisensory stimulation (IMS) by means of psychophysical and psychometric tasks.

2. Materials and methods

2.1. Participants

30 Female paid-volunteers (M_{age} = 21.74 years, SD = 5.28) participated in this experiment, after giving their informed consent. The study was approved by the Departmental Ethics Committees, Royal Holloway, University of London.

Our sample of only female participants was opportunistic as the population of the undergraduate students in UK social science departments is largely female. However, it should be noted that in a previous study in which we investigated the effect of gender on the enfacement illusion (Tajadura-Jiménez, Longo, et al., 2012), we did not find any significant effect of gender on the strength of the enfacement illusion.