CORTEX 104 (2018) 163–179

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

Social perception of others shapes one's own multisensory peripersonal space

Elisa Pellencin [a], *Maria Paola Paladino* [a,**], *Bruno Herbelin* [b] *and Andrea Serino* [b,c,d,*]

[a] *Department of Cognitive Science and Psychology, University of Trento, Trento, Italy*
[b] *Center for Neuroprosthetics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland*
[c] *MySpace Lab, Department of Clinical Neurosciences, University Hospital Lausanne (Centre Hospitalier Universitaire Vaudois, CHUV), Lausanne, Switzerland*
[d] *MindMaze, SA, Lausanne, Switzerland*

ARTICLE INFO

Article history:
Received 13 November 2016
Reviewed 16 January 2017
Revised 24 March 2017
Accepted 15 August 2017
Published online 6 September 2017

Keywords:
Peripersonal space
Social perception
Morality
Body representation
Interpersonal distance

ABSTRACT

The perception of our self is not restricted to our physical boundaries, but it extends beyond the body to incorporate the space where individual–environment interactions occur, i.e., the peripersonal space (PPS). PPS is generally conceived as a low-level multisensory-motor interface mediating hand–object interactions. Recent studies, however, showed that PPS representation is affected by higher-level cognitive factors. Here we asked whether the multisensory representation of PPS is influenced by high-level mechanisms implied in social interactions, such as the social perception of others. To this aim, in Experiment 1, we developed and validated a new multisensory interaction task in mixed reality (i.e., the Social PPS task). This task allows measuring the boundaries of PPS between one self and another person in a fully controlled, yet highly ecological, set-up. In the Experiment 2, we used this task to measure how participants' PPS varied when facing another person. The social perception of this person was manipulated via a classic social psychology procedure, so that, in two conditions, she was perceived either as a moral or an immoral character. We found that PPS representation is sensitive to the social perception of the other, being more extended when participants were facing a moral than when facing an immoral person. This effect was specific for social context, as no change in PPS was found if participants were facing an object, instead of the person. Interestingly, the social manipulation affected also attitude, identification, willingness to interact with the other, so as interpersonal distance. Together these findings show that social perception of others affects both the psychological representation of the others in relation to oneself and the multisensory representations of the space between oneself and the other, offering new insights about the role of social cognition in body representation.

* *Corresponding author*. Department of Clinical Neurosciences, University Hospital Lausanne (CHUV), Rue du Bugnon 46, CH-1011 Lausanne, Switzerland.
** *Corresponding author*. Department of Psychology and Cognitive Science, University of Trento, Corso Bettini 31, 38068 Rovereto, Italy.
E-mail addresses: mariapaola.paladino@unitn.it (M.P. Paladino), andrea.serino@unil.ch (A. Serino).
http://dx.doi.org/10.1016/j.cortex.2017.08.033
0010-9452/

1. Introduction

The neural representation of our body does not end with its physical boundaries. Studies have shown that the multisensory representation of our body includes also the area surrounding it – the peri-personal space (hereafter, PPS) – where physical interactions between the body and the environment normally occur. Neurophysiological studies on monkeys (Duhamel, Colby, & Goldberg, 1998; Graziano, Yap, & Gross, 1994; Graziano & Cooke, 2006; Rizzolatti, Scandolara, Matelli, & Gentilucci, 1981) described special populations of multisensory neurons responding to somatosensory stimuli on the body and visual and/or auditory stimuli related to external objects, specifically occurring close to (and not far from) the body. In keeping with this, further neuropsychological (di Pellegrino, Làdavas, & Farnè, 1997; di Pellegrino & Ladavas, 2014; Ladavas, 2002), neuroimaging (e.g., Blanke, Slater, & Serino, 2015; Bremmer, Duhamel, Ben Hamed, & Graf, 2002; Cléry, Guipponi, Wardak, & Hamed, 2015) and psychophysical (see Maravita, Spence, & Driver, 2003; Maravita, Spence, Kennet, & Driver, 2002) studies on humans have shown that processing of tactile bodily stimuli is more strongly affected by external stimuli presented near the body, as compared to when the same stimuli occur farther apart, suggesting that multisensory bodily cues are specially integrated within a spatial region close to the body, defining the extent of PPS.

One of the most intriguing aspects of PPS representation is its plasticity. Plastic properties of PPS have been largely investigated in the context of the sensory-motor processes involved in individual–objects interactions. For example, it has been shown that the PPS representation dynamically projects towards the end goal of an action, such as reaching (Brozzoli, Cardinali, Pavani, & Farnè, 2010) or walking (Noel, Grivaz et al., 2015). PPS plastically extends after using tools to act in the far space (Maravita & Iriki, 2004) and it conversely contracts if actions are impeded, such as after a period of immobilization (Bassolino, Finisguerra, Canzoneri, Serino, & Pozzo, 2015) or in amputee patients (without prostheses; Canzoneri, Marzolla, Amoresano, Verni, & Serino, 2013). Other studies both in monkeys (Cooke, Taylor, Moore, & Graziano, 2003) and humans (Avenanti, Annela, & Serino, 2012; Makin, Holmes, Brozzoli, Rossetti, & Farne, 2009; Serino, Annella, & Avenanti, 2009) have also demonstrated that brain regions hosting multisensory PPS neurons directly project to the motor system, allowing faster and appropriate reactions to external objects. Together, these findings suggest that PPS representation should be considered a multisensory-motor representation of the body in space whose ultimately goal is mediating interactions between the individual and the environment (Brozzoli, Ehrsson, & Farnè, 2014; Cléry et al., 2015; Graziano & Cooke, 2006; Serino, 2016).

While the sensory-motor nature of PPS representation has been largely studied, much less is known about the role of higher-level cognitive and social mechanisms in this process. In particular, in the view of PPS as an interface for individual–environment interactions, the role of social modulators of PPS representation is particularly intriguing, considering that other people are probably the most relevant external stimulus we interact with. Indeed, it has been recently shown that areas representing the PPS are also activated by stimuli in the space close to another person (Brozzoli, Gentile, Bergouignan, & Ehrsson, 2013). However, relatively few studies have examined whether the social context affects PPS representation. For instance, Heed, Habets, Sebanz, and Knoblich (2010) showed that the integration of tactile stimuli on one's own hand and visual stimuli close to the hand varies depending on whether the participant is alone or facing a person, suggesting that the physical presence of another person in the space impacts on PPS. In addition, Teneggi, Canzoneri, di Pellegrino, and Serino (2013) showed that not only the presence, but also the nature of the interaction with another person affects PPS. By using an audio-tactile interaction to measure the extent of PPS, these authors first found that participants' PPS boundary shrunk towards their own body when they shared the space with another unknown person, as compared to when facing an inanimate body, i.e., a mannequin. However, when the PPS representation was measured before and after participants were treated fairly (*vs* unfairly) by the other person in an economic game (i.e., receiving equal *vs* unequal payoff), they found that the PPS boundary depended of the relationship with the other person. An extension of the participants' PPS towards the body of the fair (but not of the unfair) other was found. Similar changes in PPS were shown by Maister, Cardini, Zamariola, Serino, and Tsakiris (2015) by using another form of social manipulation. PPS was tested after participants received synchronous (*vs* asynchronous, as a control condition) multisensory stimulations on their own and on another person face. This manipulation, which is used to induce the so-called enfacement effect (Sforza, Bufalari, Haggard, & Aglioti, 2010; Tsakiris, 2008), has been shown to induce also a feeling of trust and closeness towards the other person (Mazzurega, Pavani, Paladino, & Schubert, 2011; Paladino, Mazzurega, Pavani, & Schubert, 2010). Maister et al. (2015) showed that these effects are also associated to a remapping of the space where the other person was placed as one's own PPS after the synchronous (and not the asynchronous) stimulation. Taken together, these studies demonstrate that people' PPS representation is sensitive to the social contexts; however, they do not point to the higher-level cognitive and social mechanisms responsible for it.

If we conceive PPS as an interface for individual–environment interactions, one could hypothesize that social perception – that is the ability to quickly form an impression of other people – is a key process to link the social environment with the one's own bodily representation. This account is intriguing as, on the one hand, it may shed some light on the interplay between social, cognitive and bodily processing and, on the other hand, it may provide some insights about the functions of PPS regulation in social interactions. We know from research in social cognition that action is the ultimate function of social perception; that is, we quickly form an impression of other persons, as this would guide our behaviour towards them (Fiske & Taylor, 2013). Following this line of reasoning, previous studies suggest that one's own PPS extends towards a person, when she/he is perceived as a fair and trustworthy (Teneggi et al., 2013) or a close partner (Maister et al., 2015). However, the manipulations used in these studies (and reviewed above) did not directly vary, nor assessed, the social perception of the partner. Teneggi et al.