



**Karolinska
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Department of Neuroscience

MOVING A RUBBER HAND – THE SENSE OF OWNERSHIP AND AGENCY IN BODILY SELF- RECOGNITION

AKADEMISK AVHANDLING

som för avläggande av medicine doktorsexamen vid Karolinska
Institutet offentligen försvaras i Hillarpsalen, Retzius väg 8

Fredagen den 11 April, 2014, kl 09.00

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Most of us take for granted that our body is our body. One typically experiences one's body as something belonging just to oneself, as something that can only be "me". However, this has poses a fundamental problem in philosophy and psychology: how do we know that the body is our own? It has been suggested that two distinct experiences of our own body help us recognize it as such: the sense of ownership, that is the experience that a limb is part of one's body, and the sense of agency, that is the experience of being able to voluntarily control limb movement. In the present thesis we introduce a new version of the classical rubber hand illusion that is based on finger movements instead of stroking and systematically investigate how ownership and agency contributes to bodily self-recognition.

To induce "the moving rubber hand illusion" participants control the movements of the index finger of a right wooden model hand in full view by moving their own right index finger, which is hidden from view. The illusion is quantified subjectively with visual analogue rating scales and behaviourally as changes in manually indicated sensed hand position ("proprioceptive drift"). In 9 separate experiments involving a total of 352 healthy volunteers we first characterized the basic constrains of the illusion. Secondly, we examined the relationship of ownership and agency. And finally, investigate a possible relationship between the illusion and individual differences in delusion proneness (using Peter's Delusion Inventory).

Our results show that synchronized movements of the model's index finger and the participant's index can trigger a strong illusory feeling of ownership of the model hand and robust experience of agency. The moving rubber hand illusion is similarly strong as the classical version, and follows similar temporal, spatial and anatomical rules. Asynchronous seen and felt finger movements, a too great distance between the real and model hands (≥ 27 cm), or the model placed in an anatomically implausible position abolishes the ownership-illusion.

We also found that ownership and agency can be dissociated. Unlike ownership, agency can be experienced for the model hand when it is when placed in an anatomically implausible position. And ownership can be experienced irrespective of the hand moving actively or passively, so with or without agency. Furthermore only ownership, but not agency ratings correlate with the proprioceptive drift. Finally, we observed that delusion prone-individuals tend to give generally higher overall ratings on agency, when they experience the hand moved passively.

Collectively, these observations advance our understanding of how ownership and agency contribute to bodily self-recognition. Ownership and agency constitute different processes: Integration of spatio-temporally congruent signals from moving limbs determine the sense of ownership and a match of movement intentions and feedback determines the sense of agency. These results offer new ways to study bodily self-recognition both at the behavioural and neural level.