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# Cortical representation of illusory body perception in healthy persons and amputees: implications for the understanding and treatment of phantom limb pain

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A disturbed body perception is characteristic for various neurological and mental disorders and becomes particularly evident in phantom phenomena after limb amputation. Body illusions, such as mirror visual feedback (MVF) illusions, have been shown to be efficient in treating chronic pain and to be further related to a reversal of cortical reorganization. The present thesis aimed at identifying the neural circuitry of illusory body perception in healthy subjects and unilateral upper-limb amputees using functional magnetic resonance imaging. Study 1 investigated the perceived mirror illusion capacity and the neural correlates of a novel MVF-device (the mirror glasses) in comparison to the well-established mirror box in healthy persons. Study 2 investigated the neural circuitry of stimulus-evoked non-painful phantom phenomena in unilateral upper-limb amputees.

During mirror illusions, movements of the affected limb are visually recreated by movements of the contralateral limb. The visual recreation of the affected limb seems to be linked to a recruitment of the primary sensorimotor representation of the affected limb. In contrast to the mirror box, the mirror glasses limit the user's view to the visual reflection of the moving hand as opposed to seeing both hands moving in synchrony. It has been proposed that seeing the actually moving limb in addition to the mirror reflection might have a distracting effect. Study 1 evaluated the utility of mirror glasses based on a comparison to the mirror box and tested the hypothesis that increased interhemispheric communication between motor hand representations might drive the activation in the non-mirrored limb representation. Mirror illusion capacity and brain circuitry were measured in a within-subject design during both MVF-conditions with 20 healthy subjects in counterbalanced order. The self-reported mirror illusion capacity and brain activation patterns did not significantly differ between both mirror tasks. The representation of the non-mirrored hand was recruited in both mirror tasks. A significant increase in interhemispheric connectivity between the hand areas, however, was only found in the mirror glasses condition, suggesting divergent mechanisms for the recruitment of the non-mirrored hand representation between both mirror tasks.

Most amputees still perceive their amputated limb (phantom limb awareness). Phantom phenomena comprise a variety of non-painful and painful sensations allocated to the amputated limb. Some amputees experience non-painful phantom phenomena when the residual limb or other parts of the body are stimulated (evoked phantom sensations). The neural correlates of non-painful phantom phenomena remain unknown. Study 2 aimed to identify the neural circuitry of evoked nonpainful phantom sensations. Twelve upper-limb amputees who reliably perceived non-painful phantom sensations upon stimulation of distal body parts and 12 yoked controls (matched for sex and age) were investigated. Amputees were stimulated at a body site eliciting phantom sensation with a stimulus related on- and offset and a control site without illusory perception. Controls were stimulated at matched body sites. A conjunction analysis showed specificity of the left ventral premotor and inferior frontal cortices (BA44/45) for the perception of referred sensations. Generalized psychophysiological interaction analyses revealed a widespread network showing significant positive intra-parietal and fronto-parietal connectivity. Our study indicates a high convergence between the neural correlates of nonpainful phantom sensations and (other) body illusions.

Both studies of the present thesis offer new insights into the understanding the neuronal basis of illusory body perception. Such illusory body perceptions are frequent in chronic pain and targeting these distortions of body perception has been shown to be fruitful for relieving pain and disability.