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# Mirrored hand movements: Cortical effects in chronic phantom limb pain patients and subjective responses by healthy controls

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The present thesis focuses on the effects of mirrored movements on phantom limb pain patients and healthy controls. In two studies, we investigated subjective responses to short-term mirror tasks and cortical responses two regular mirror training.

In order to assess reactions to conflicting multisensory feedback, 113 healthy right-handed participants performed hand and arm movements under conditions of congruent and incongruent sensory feedback. This was done by hiding one arm behind a mirror and thus presenting a mirror image in the same location where one's own arm would be expected. This resulted in sensory congruence when both arms or both hands were moved in unison, and in incongruence when movements were out of phase. Under circumstances of incongruent visual and proprioceptive information, some participants reported the feeling of supernumerary limbs, indicating an attempt to integrate the mirror image into the body representation. Painful sensations, as they had been proposed earlier as a possible reaction to incongruent feedback, have not been found. These results suggest that while our setup was able to present a challenge to the participants' body representation, this sensory conflict is not able to elicit pain and is unlikely to be an influential factor in the development of phantom limb pain.

The second study consisted of a daily four-week mirror training with 13 chronic phantom limb pain patients after unilateral upper limb amputation. We measured neuronal reactions to the mirror task before and after the training in 11 of these patients using functional magnetic resonance imaging. Additionally, their individual amount of cortical reorganization that had occurred as a result of the amputation was assessed. We found a moderate average alleviation of pain after the training, with a wide range between patients. Also, patients differed in their ability to relate the hand movement observed in the mirror to their phantom limb. Pain relief was positively correlated with a partial reversal of cortical reorganization and with a decrease of activity in the inferior parietal cortex during the mirror movement task. The individual ability to accept the mirrored hand as a representation of the phantom was found to be a predictor for treatment success. Differences in treatment benefit were negatively correlated with the presence and intensity of a telescopic distortion of the phantom limb. These results suggest that mirror therapy is only effective in patients that are able to include the mirror image into their body representation and that this integration can be disrupted by a distortion of the phantom. In patients who have this ability, however, mirror training is a simple treatment with measurable effects on both subjective pain levels and cortical reorganization.