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Sensory processes in phantom limb pain and embodied artificial limbs

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This dissertation presents two studies investigating the role of sensory processes in phantom limb pain (study 1) and during embodiment of an artificial hand (study 2).
In study 1, amputees with chronic phantom limb pain (N=23), amputees without phantom limb pain (N=14) and healthy controls (N=19) were tested using quantitative sensory testing (QST). The aims were to investigate whether perception and pain thresholds measured at the residual limb or at more remote body sites are associated with phantom limb pain. The main result was that heat pain thresholds correlated (negatively) with the intensity of phantom limb pain, although the thresholds did not differentiate between the groups. Moreover, significant associations were mainly found for remote body sites; at the residual limb, the thresholds mainly correlated with other variables, e.g., the level of amputation and prosthesis use. The results suggest that higher general heat pain sensitivity correlates with the intensity, but not the presence, of phantom limb pain.
In study 2, 31 healthy participants were tested using the so-called rubber hand illusion (RHI). In this paradigm, a seen artificial hand and the participant's hidden hand are simultaneously brush-stroked, inducing an illusion of touch felt on the artificial hand and of feelings of ownership of the artificial hand. Until now, the sensory processes underlying the illusion are not clear. It was assumed that the illusion results from vision overriding or recalibrating proprioception. However, the results show that vision and proprioception are combined in a "compromise" fashion. Additionally, the study indicated that until now poorly investigated dynamical components, such as learning effects, or perceptual instability, might also play a role in the RHI.
The results of study 1 indicate that altered pain sensitivity is a characteristic of chronic phantom limb pain. This finding improves our understanding and it might also have implications for diagnostic of phantom limb pain using QST. The results of study 2 might be useful to further optimize the conditions leading to embodiment of artificial hands or prostheses. In amputees, this type of embodiment has a high potential to alleviate phantom limb pain. Therefore, basic research using bodily illusions like the RHI can be helpful to improve treatment of phantom limb pain. Both research on phantom phenomena and on bodily illusions complement each other and contribute to understanding the mechanisms underlying body representations and their plasticity.