ABSTRACT

Sequence learning is one of the most important functions of the motor system since almost every advanced motor skill consists of many component movements that need to be executed in sequential order. For successful performance both, the correct serial order of movements and adequate timing are of importance. Learning a new sequence does not necessarily require conscious awareness: it can occur implicitly. This thesis investigates both the behavioral (Study I) and neural (Study II, Study III) basis of timing control and implicit sequence learning. Additionally, we study if brief periods of motor sequence learning can induce short-term plasticity in the functional connectivity between brain regions (Study IV).

In Study I, we use the process dissociation procedure to show that distinct implicit and explicit systems exist for temporal sequence learning: Whereas implicit learning is gradual and gives rise to knowledge that is inaccessible to conscious control, the explicit system is fast and results in representations that can be consciously accessed. In Study II, we used fMRI to investigate the influence of the training and pacing modality on the neural control of rhythmic sequence performance. We showed that the dorsal auditory pathway was activated during the performance of both visual and auditory rhythms, suggesting that over-learned rhythms, even those that were both trained and paced in visual modality, are transformed into auditory-motor representations. In Study III, we used PET to investigate if individual differences in implicit and explicit sequence learning are related to dopamine receptor densities in the functional subregions of the striatum. We found that densities in the limbic striatum were specifically

related to implicit but not explicit learning, supporting the idea that implicit and explicit sequence learning depend on partly distinct neural circuitry. In Study IV, we used TMS to investigate if motor sequence training can induce training-dependent transient changes in the functional connection between posterior parietal cortex (PPC) and primary motor cortex (M1). We could show that brief periods of motor sequence training did induce plasticity-like effects in the PPC-M1 connection, suggesting that motor training has a very powerful modulatory effect on brain connectivity.

In sum, our results offer both behavioral and anatomical support for the fact that implicit and explicit learning seem to rely on at least partially different neural circuits. They also show that that the influence of stimulus modality on the neural activity and functional connectivity is rather small, at least when the sequences are over-learned. Finally, they suggest that already short periods of motor sequence training can induce short-term plasticity-like effects in the connectivity of different motor regions.