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The regulation of large-scale brain networks via functional magnetic resonance imaging: Neurofeedback as treatment approach

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Real-time functional magnetic resonance imaging neurofeedback (rt-fMRI NF) is a non-invasive approach to voluntarily control brain activity. Whereas the first decades since its development have been focussed on Region-of-Interest (ROI)-based rt-fMRI NF that feeds back activity of a single brain region as a target brain process, new approaches are constantly developed. One of these promising new approaches is functional connectivity (FC)-based rt-fMRI NF which is characterized by its focus on network-based brain connectivity. This approach has the advantage to be applicable in a plurality of mental disorders, since brain structures with central functions are known to be disturbed in a variety of mental disorders. Secondly, most mental disorders are characterized by distortions in whole brain networks as opposed to specific areas. Therefore, a strong advantage of the approach would be its application in a transdiagnostic way. Due to their involvement in a variety of mental disorders i.e. schizophrenia, frontostriatal networks are a suitable target network for the application of such approaches. The present dissertation attempted to investigate the feasibility of rt-fMRI NF FC targeting large-scale frontostriatal networks.

In a first pre-registered, randomized, double-blind and yoke-controlled proof-of-concept study conducted in a single training session, it was found that application of a large-scale frontostriatal target network including dorsolateral prefrontal cortex (DLPFC), anterior cingulate cortex (ACC) and striatum can be strongly biased by respiratory artefacts. Following up on this, a way to remove the influence of these respiratory artefacts in the offline analyses was found. Global Signal Regression (GSR) and a model-based physiological nuisance regression approach were able to eliminate these detrimental associations and clean the data sufficiently. It was concluded that GSR might be adequate for online data correction for respiratory artefacts.

In the subsequent second study, the methodology was elaborated on the basis of the findings from the first study. This included an extension of the training duration from one to three training sessions for demonstration of learning effects and, most importantly, application of GSR to the offline and specifically also the online data. Furthermore, the network was reduced to DLPFC and striatum only to increase adjustability. While the pre-registered significant effect of the NF training could not be proven, we found evidence for a medium effect size in the last NF run on the third training day.

In summary, the present dissertation aimed at enhancing the understanding of rt-fMRI NF FC and address its feasibility. It is concluded that extensive NF training is a promising method for generating circuit-specific treatment approaches for mental disorders that could translate to symptom improvements. However, careful correction of data and preceding power analyses to allow for reasonable sample sizes are required in future rt-fMRI NF FC studies.