Towards clinical applications in fMRI neurofeedback : learning how to change brain states

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The prevalence of mental disorders remains high at an estimated 18-36% worldwide, and even with a variety of treatment options available, a treatment gap still exists for many patient groups. A new treatment option currently under investigation is fMRI-based *neurofeedback* training, during which information reflecting *neural* processes in the brain related to the mental disorder is *fed back* to the participants in real time. Through *neurofeedback training,* patients are enabled to learn how to self-regulate, aiming at changing brain states to alleviate the associated symptoms. In the presented PhD thesis different aspects regarding the development *of neurofeedback trainings* within a clinical context were investigated. First, a review of previous approaches was performed. Second, a study on method improvement for *neurofeedback trainings* was conducted, evaluating the potential of using functional brain connectivity biomarkers as feedback information in future trainings. The results confirmed that functional brain connectivity measures provided unique information on relevant task aspects, and may therefore be a valuable tool for future clinical fMRI *neurofeedback* applications. Third, the representation of subjective anxiety in the brain as measured with fMRI was examined in order to improve the understanding of involved brain regions for developing a subsequent training for spider phobics. The results demonstrated that anxiety-provoking stimuli were processed hierarchically, and that the fMRI signal from brain regions at an intermediate processing level showed a linear relationship to the degree of subjective anxiety. The signal from these brain regions was therefore chosen as a brain indicator of anxiety level for the subsequent *neurofeedback training*. Fourth, a study on the potential of enhancing the efficacy of anxiety regulation through *neurofeedback training* was conducted with spider phobic participants for the first time. The results demonstrated that participants who received *neurofeedback* achieved a better down-regulation of anxiety during the training than participants who did not receive *neurofeedback*. It was therefore concluded that the provided *neurofeedback* enhanced the efficacy of anxiety regulation. Fifth, as a second clinical application, the effects of self-modulation of anterior cingulate cortex activation levels guided by fMRI *neurofeedback* were examined in a first exploratory study with adults diagnosed with attention-deficit/hyperactivity disorder. Preliminary results showed that *neurofeedback* participants improved on measures of attentional control, and working memory, a conclusion regarding the specific effects of presenting *neurofeedback* during the training could not be made based on the collected data. Overall, the presented research showed that fMRI *neurofeedback training* is a promising future option for treatments in patient groups with a treatment gap, confirming previous research with other patient groups. We concluded that further research into method optimization, and clinical applications of fMRI-based *neurofeedback trainings* is warranted.

This research was financed by BrainGain Smart Mix Program of The Netherlands Ministry of Economic Affairs and The Netherlands Ministry of Education, Culture and Science.