

Throwing balls to control your brain – an fMRI neurofeedback study of SMA modulation in healthy controls and patients with MDD

Sophie Kühne¹, Tengfei Feng^{1,2}, Camellia N. Ibrahim¹, Halim I. Baqapuri³, Felix Stöhr¹, Jana Zweerings¹, Klaus Mathiak¹

1 Department of Psychiatry, Psychotherapy and Psychosomatics, Faculty of Medicine, RWTH Aachen, Aachen, Germany

2 School of Biomedical Engineering, Faculty of Medicine, Dalian University of Technology, Dalian 116620, China

3 Department of Neurology, Section Epileptology, Faculty of Medicine, RWTH Aachen, Aachen, Germany

Introduction

Depression approximately affects 5.7% of the global population, significantly impairing their quality of life. Previous research indicates that the supplementary motor area (SMA) is not only involved in motor functions but also associated with apathy and reduced motivation which are common symptoms of depression. Real-time functional magnetic resonance neurofeedback (rt-fMRI nf) is a technique that provides participants with feedback on their brain activity, enabling them to develop strategies for actively modulating it. This study examined if individuals with major depressive disorder (MDD) and healthy individuals can regulate their brain activity in the SMA during a rt-fMRI nf study.

Methods

The rt-fMRI nf study was conducted on two separate days. Participants had to either up- or downregulate SMA activity in a bidirectional, double-blind and randomized design. Neurofeedback was delivered through an immersive ball-tossing game set in a virtual environment featuring two other players in a meadow surrounded by trees. Successful regulation resulted in a higher probability of receiving the ball. Additionally, questionnaires assessing depressive symptoms and subjective neurofeedback experience were administered.

Results

In a preliminary analysis, ROI activation during regulation exhibited a significant effect of the blinded regulation direction. There was a significant difference in the down regulation condition between MDD and healthy controls after FWE-correction in clusters bigger than 20 voxels in: SMA ($p = .03$), frontal eye fields (FEF) ($p < .001$), Left dorsal posterior cingulate cortex (PCC) ($p < .001$), Left medial temporal gyrus ($p < .001$), Right superior temporal gyrus ($p = .002$), Left agranular retrolimbic cortex ($p < .001$). No significant group difference emerged during upregulation.

Conclusions

Implicit reward using a ball-tossing game can train voluntary SMA regulation. Reduced left-hemispheric involvement during SMA regulation in patients with MDD compared to HC.