

Title: Illusory Loss of Sense of Agency induced by Closed-Loop TMS-EMG

Abstract: The present study aimed to investigate the factors that contribute to disrupting the sense of agency (SoA) using closed-loop transcranial magnetic stimulation and electromyography (TMS-EMG) trials, where intentional action was required to trigger the TMS. Three experiments were conducted to explore the role of involuntary movement and multisensory feedback in the induction of the SoA illusion. Experiment 1 (rHead condition) demonstrated that SoA over action initiation could be disrupted by applying TMS to the motor cortex, eliciting movement closely timed to occur after initiation of voluntary action. This resulted in an illusion wherein participants believed they did not initiate a voluntary action. Participants reported significantly higher illusion scores in this condition compared to the TMS sham. Experiment 2 (sHead condition) assessed the role of visual, auditory, and tactile cues in disrupting SoA. A sham TMS coil was used to deliver a diffuse, non-focal pulse to the brain while maintaining the same experimental setup as Experiment 1. Results indicated that the combination of these sensory feedback cues alone was insufficient to replicate the illusion observed in Experiment 1. Experiment 3 (rHand condition) investigated whether triggering involuntary movement from the brain's motor cortex was necessary for inducing the SoA illusion or if triggering movement from the forearm would suffice. The TMS coil was relocated to the forearm to elicit involuntary arm muscle movement. Findings revealed that the illusion effect was comparable to that observed in Experiment 1. In conclusion, this study establishes that TMS-facilitated movement coupled with multisensory feedback is crucial in inducing the illusion of loss of SoA in closed-loop TMS-EMG trials. Further research is needed to understand the underlying neural mechanisms and potential applications in other settings.