Electrode Configuration Shapes Motion Perception in Noninvasive Brain Stimulation

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Abstract

Transcranial Electrical Stimulation (tES) enables modulation of cortical activity, offering insights into how stimulation affects visual performance. Our research explored the impact of tES over the human motion-sensitive area hMT+ on motion coherence thresholds using *random dot kinematograms* - visual stimuli composed of moving dots, where a subset moves coherently in one direction, allowing assessment of motion perception sensitivity.

In the first study, we applied high-frequency transcranial random noise stimulation (hf-tRNS), a non-invasive brain stimulation technique that delivers alternating current with randomly varying frequencies (typically 100–640 Hz), thought to enhance cortical excitability. Using a cephalic montage - active electrode over hMT+ and return over the vertex - this configuration significantly improved motion direction discrimination, reflected in reduced coherence thresholds in the visual field contralateral to stimulation.

A follow-up study examined whether this enhancement persists when current distribution changes. Using the same visual task, we compared the cephalic montage to an extracephalic setup, placing the return electrode on the arm. The perceptual benefit disappeared with increased electrode distance. Electric field simulations revealed that the extracephalic montage generated a weaker and spatially displaced field over hMT+, likely accounting for the absence of behavioural effects.

Together, these findings demonstrate that the perceptual benefits of hf-tRNS critically depend on electrode configuration, influencing both the precision of region-of-interest targeting and current flow geometry. This work highlights the importance of optimized stimulation design for reliable neuromodulation of visual perception and provides practical guidance for future cognitive and clinical applications of brain stimulation.

Index Terms

High-Frequency Transcranial Random Noise Stimulation (hf-tRNS), Cephalic Stimulation, Extracephalic Stimulation, e-Field Simulation