Perspectives of brain stimulation for memory

Individual differences in electric fields induced by transcranial electrical stimulation
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Computational modeling allows accurate head reconstruction and simulation of current distributions induced by transcranial electrical stimulation (tES). These simulations unveil differences in electric fields between individuals as well as associations with several individually varying factors such as head and brain anatomy, but also with empirically assessed neurophysiological and behavioral tES effects. I will introduce the opportunities modeling approaches provide in explaining interindividual variability in tES effects on the human brain, showing recent data linking the estimated fields in each participant to the magnitude of individually induced tES effects. I will further demonstrate how the examination of individual field differences can be used for the ultimate aim to develop individualized interventions.

Causal role of cross-frequency coupling in cognitive control
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Cognitive control is the capacity to guide motor and perceptual systems towards abstract goals. High-frequency neural oscillations related to motor activity (beta; 13-30 Hz) and visual processing (gamma; >30 Hz) are known to be modulated by cognitive control signals via cross-frequency coupling with low frequency network oscillations in prefrontal cortex (delta, 2-3 Hz; and theta, 4-8 Hz). Thus, we delivered cross-frequency transcranial alternating current stimulation (CF-tACS) during performance of a task that manipulated cognitive control demands along two dimensions: abstraction of rules (action-planning) that increased delta-beta coupling and number of rules (held in memory) that increased theta-gamma coupling. We found that CF-tACS increased the targeted phase-amplitude coupling and modulated task performance of the associated cognitive control component

Personalized frequency-modulated oscillatory tDCS for memory enhancement
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One of the main prerequisites for translating brain stimulation form basic research to clinical applications is reducing the individual differences in response to tDCS. This is especially notable when it comes to cognitive functions like memory. One step in that direction is to abandon the one-size-fits-all approach and move towards personalization of different aspects of the stimulation protocol. Here I will focus on personalization of the tDCS by matching the frequency of oscillations in the stimulation protocol to the peak theta-band (4-8Hz) frequency recorded in the pre-stimulation EEG. The effects of this new stimulation protocol on the associative memory performance in healthy volunteers will be presented and discussed.

Modulation of episodic memory in aging
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What is new and exciting in Alzheimer's disease (AD) research is the idea of prevention trials, such as helping healthy people reduce their risk of developing AD (primary prevention), or delaying the progression of amnestic mild cognitive impairment (aMCI) to AD (secondary prevention). Since pharmacological interventions have failed to show efficacy in clinical trials with aMCI, non-invasive brain stimulation interventions, have received increasing attention. In this talk I will present an overview about memory formation, consolidation and modification through reconsolidation. Next, I will show the causal role of lateral PFC in episodic memory reconsolidation. I will conclude presenting some transcranial direct current stimulation (tDCS) studies showing memory enhancement in physiological and pathological aging.