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Title: Theta-modulated transcranial electrical stimulation for targeting Associative memory: A cross-modal integration of EEG and behavioral indicators

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Associative memory (AM) represents an ability to bind unrelated information into meaningful units and encode them as distinct memories. AM has been the function of interest in many non-invasive transcranial electrical stimulation (tES) studies aiming to maximize the potential for memory modulation by varying stimulation loci, frequency, and amplitude.

In the current study, we aimed to capture modulation potential of AM performance when tailoring the stimulation protocols to the individual brain rhythms. By matching the stimulation frequency to the frequency of each subject's AM task-induced electrophysiological (EEG) activity in theta spectrum (4-8 Hz), we developed two types of personalized oscillatory protocols: theta-modulated transcranial direct current stimulation (otDCS) and transcranial alternating current stimulation (tACS), which we administered alongside the constant tDCS and a sham condition in the single-blind cross-over experiment. To comparatively assess the effects of different tES protocols delivered over the posterior parietal cortex, we tested the recognition and recall ability of the 42 healthy young adults on paired-associate paradigms after each of four conditions. During AM assessment participant's EEG activity was recorded.

Group-level comparisons of each active tES condition against sham did not show differences in AM task performance either on recognition or cued-recall. However, data showed variability in performance depending on the task and the outcome measures precluding straightforward comparison between the conditions. To explore the potential sources of variability in effect expression, we propose a methodology for isolating different aspects of the function-relevant neurophysiological markers that could depict the modulatory tES effect, setting the groundwork for further analysis.

Apart from introducing a novel approach to probing AM with personalized tES, this well-powered, multi-protocol, multi-task, and multi-measure study produced a comprehensive dataset for the exploration of factors that could uncover patterns in responsiveness to tES, as well as the insight into the relationship between neurophysiological and behavioral indicators.