Can Transcranial Electrical Stimulation Localize Brain Function?

Transcranial electrical stimulation (TES) uses constant (TDCS) or alternating currents (TACS) to modulate brain activity. Most TES studies apply low-intensity currents through scalp electrodes (≤ 2 mA) using bipolar electrode arrangements, producing weak electrical fields in the brain (< 1 V/m). Low-intensity TES has been employed in humans to induce changes in task performance during or after stimulation. In analogy to focal transcranial magnetic stimulation, TES-induced behavioral effects have often been taken as evidence for a causal involvement of the brain region underlying one of the two stimulation electrodes, often referred to as the active electrode. Here, we critically review the utility of bipolar low-intensity TES to localize human brain function. We summarize physiological substrates that constitute peripheral targets for TES and may mediate subliminal or overtly perceived peripheral stimulation during TES. We argue that peripheral co-stimulation may contribute to the behavioral effects of TES and should be controlled for by "sham" TES. We discuss biophysical properties of TES, which need to be considered, if one wishes to make realistic assumptions about which brain regions were preferentially targeted by TES. Using results from electric field calculations, we evaluate the validity of different strategies that have been used for selective spatial targeting. Finally, we comment on the challenge of adjusting the dose of TES considering dose-response relationships between the weak tissue currents and the physiological effects in targeted cortical areas. These considerations call for caution when attributing behavioral effects during or after low-intensity TES studies to a specific brain region and may facilitate the selection of best practices for future TES studies.

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