Electrical Stimulation Reduces Smokers’ Craving by Modulating the Coupling between DLPFC and Parahippocampal Gyrus

Li-Zhuang Yang1, Bin Shi2, Wei Zhang1, Feng Gu1, Ying Wang1, Ying Liu1, Xiaochu Zhang1,3,4,5*

1Key Laboratory of Brain Function and Disease, Chinese Academy of Sciences, School of Life Sciences, University of Science & Technology of China, Hefei, Anhui 230027, China
2Provincial Hospital Affiliated to Anhui Medical University, Hefei, Anhui 230001, China
3School of Humanities & Social Science, University of Science & Technology of China, Hefei, Anhui 230026, China
4Center of Medical Physics and Technology, Hefei Institutes of Physical Science, CAS, Hefei, Anhui 230031, China
5Centers for Biomedical Engineering, University of Science & Technology of China, Hefei, Anhui 230027, China
*Email: zxcustc@ustc.edu.cn

Abstract: Applying transcranial direct current stimulation (tDCS) over dorsal lateral prefrontal cortex (DLPFC) can reduce cue-elicited craving in smokers. However, the underlying neural mechanism is not clear. We hypothesized that 1) tDCS over DLPFC can enhance the coupling between DLPFC and brain regions related with smoking cue reactivity; 2) the alteration in functional connectivity can even be manifested in the intrinsic properties of the brain. Nineteen male smokers attended the present study. Participants received the LaRc (anode: left DLPFC, cathode: right DLPFC, 1mA of 30 minutes) or sham stimulation in each session. A total of 3 fMRI scans were acquired within each session, including the go/no-go task, the resting state fMRI, and the smoking-cue attention bias task (AB). The smoking cue-elicited craving was reduced in the LaRc condition compared with the sham condition. The whole brain analysis on task-based fMRI revealed significant tDCS effect in the go/no-go and AB task. In the go/no-go task, stimulating DLPFC reduce activations in cognitive control systems such as DLPFC and the inferior parietal lobe (IPL). The main effect of tDCS was also revealed in the right superior temporal gyrus in the AB task. Three brain regions showed specific reactivity to smoking-cue, including superior frontal gyrus (SFG), and bilateral Parahippocampal gyrus (PHG). Psychophysical interaction analysis (PPI) analysis revealed that the functional
coupling between bilateral PHG and DLPFC were modulated by tDCS. Besides, the resting state functional connectivity analysis (rs-fc) revealed that those alterations in functional coupling could also manifested in the resting state brain network. The present study supports the viewpoint that the local function of DLPFC can be enhanced by tDCS. Moreover, we show that tDCS over DLPFC modulates the functional coupling between DLPFC and bilateral PHG, suggesting that electrical stimulation may help smokers regulate involuntary memory retrieval of smoking memories.

**Key words:** tDCS, smoking, craving, DLPFC, fMRI