High definition transcranial direct current stimulation (HD-tDCS) to probe the involvement of the primary somatosensory cortex in nociception

Cédric, Lenoir (1), Gan, Huang (1), Yves, Vandermeeren (1,2,3), Samar, Marie, Hatem (1,4), André, Mouraux (1)

(1) Institute of neuroscience, Cognition and System department, Université catholique de Louvain, Brussels, Belgium
(2) Neurology Department, Neuromodulation Unit (NeMU), CHU Dinant-Godinne, UCL, Namur, Belgium
(3) Louvain Bionics, UCL, Louvain-la-Neuve, Belgium
(4) Physical Medicine and Rehabilitation, Brugmann University Hospital, Brussels, Belgium

cedric.lenoir@uclouvain.be
gan.huang@uclouvain.be
yves.vandermeeren@uclouvain.be
samar.hatem@chu-brugmann.be
andre.mouraux@uclouvain.be

In order to assess the functional role of a given brain region, one commonly-used approach is to modulate its excitability using, for example, transcranial magnetic stimulation (TMS) or transcranial direct current stimulation (TDCS). In pain research, such "lesion-like" studies can be used to study the involvement and connectivity of the different brain areas responding to nociceptive input. Here, we used high-density transcranial direct current stimulation (HD-tDCS) combined with electroencephalography (EEG) to characterize the involvement of the primary somatosensory cortex (S1) in nociception. The role of S1 in vibrotaction is well established. In contrast, its involvement in nociception remains debated. In two separate groups, we compared, within-subjects, the after-effects of HD-tDCS (HD-tDCS experiment) and sham stimulation (sham experiment) of S1 on the perception and event-related potentials (ERPs) elicited by nociceptive and non-nociceptive somatosensory stimuli delivered to the ipsilateral and contralateral hand. HD-tDCS was delivered using a cathode electrode over C3 or C4, surrounded by four anode electrodes (HD-tDCS experiment: 20 min; 1 mA and sham experiment: 30 s; 1 mA). Nociceptive (laser heat pulses) and non-nociceptive (short-lasting mechanical vibration and transcutaneous electrical stimulation of the median nerve) were delivered to the ipsilateral and contralateral hand, immediately before and after HD-tDCS or sham stimulation. Cathodal HD-tDCS clearly decreased the responses to non-nociceptive somatosensory stimuli delivered to the contralateral hand, both early-latency ERPs from within S1 and late ERPs originating from outside S1. This lateralized effect of HD-tDCS on vibrotaction was not observed in the sham group. This supports the notion that S1 constitutes an obligatory relay for the cortical processing of tactile input originating from the contralateral hemibody. In contrast, HD-tDCS over S1 led to a symmetric reduction of the perception and ERPs elicited by nociceptive stimuli delivered to both the contralateral and ipsilateral hand. This symmetric effect of HD-tDCS on nociception was not observed in the sham experiment. Taken together, our results demonstrate a differential involvement of S1 in vibrotaction and nociception.