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Effects of transcranial direct current stimulation of the primary sensory cortex on somatosensory perception

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Background
Transcranial direct current stimulation (tDCS) is able to modify cortical excitability and activity in humans.

Objective
The aim of the present study was to analyze the effects of tDCS of the primary sensory cortex (SI) on thermal and mechanical perception, assessed by quantitative sensory testing (QST).

Methods
The comprehensive QST protocol encompassing thermal and mechanical detection and pain thresholds as devised by the German Research Network on Neuropathic Pain (DFNS) was applied to skin areas innervated by the radial and median nerve of 12 healthy subjects, who were examined before and after each tDCS stimulation type. Anodal, cathodal, and sham tDCS was applied at a 1 mA current intensity with the active electrode placed over the left primary sensory cortex (SI) and the reference electrode above the right orbit for 15 minutes.

Results
After cathodal tDCS cold detection threshold (CDT) significantly increased in the contralateral ($P < .01$) and ipsilateral hand ($P < .05$) as compared to baseline condition and sham stimulation, after cathodal stimulation significantly increased warm detection threshold (WDT) was observed in the contralateral hand when compared with the baseline condition ($P < .05$) but not with sham stimulation. Thermal pain as well as mechanical detection and pain thresholds remained unaltered.

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Conclusions
Cathodal tDCS of the primary sensory cortex significantly reduced the sensitivity to Aδ-fiber-mediated cold sensation, C-fiber-mediated warm sensation was reduced only compared with baseline, whereas Aß-fiber-mediated somatosensory inputs were less affected. Our results correspond with our previous observations of primary motor cortex tDCS effects on QST parameters.

Keywords quantitative sensory testing; QST; transcranial direct current stimulation; somatosensory cortex

Transcranial direct current stimulation applied to the human cortex has been shown to modify cortical excitability. Anodal stimulation is known to increase cortical excitability, whereas cathodal stimulation decreases it. The length of tDCS after-effects depends on the duration of stimulation.[1-3] Promising results of pilot studies showing evidence for its efficiency and the convenience of a portable equipment lead to an enhanced use of tDCS.[4]

Matsunaga et al.[5] demonstrated that 1 mA anodal tDCS over the motor cortex results in long-lasting facilitation of somatosensory evoked potential (SEP) amplitudes evoked by stimulation of the contralateral, but not ipsilateral median nerve. Cathodal stimulation had no effect on SEPs from either arm. For the somatosensory cortex a sustained reduction of the N20 source component of the SEP was shown after anodal tDCS. Based on those results, tDCS was proposed to primarily have local effects, because the N20 source amplitude is known to be generated in the depth of area 3b of the primary sensory cortex.[6,7]

These findings correspond with the study of Rogalewski et al.[8]: They were the first to show that tDCS of the somatosensory cortex modulates the excitability of the somatosensory system. Cathodal stimulation applied to this area induced a prolonged decrease of tactile discrimination, while anodal and sham stimulation had no effect.

A recent study of our group assessed the effects of tDCS of the primary motor cortex on thermal and mechanical perception by quantitative sensory testing (QST). An increase of cold detection threshold (CDT) and mechanical detection threshold (MDT) after cathodal stimulation at the contralateral hand as compared with the baseline condition was observed.[9] Further investigation showed that tDCS has an antinociceptive effect when applied to the somatosensory cortex: it diminishes experimentally induced acute pain perception.[10] In addition, tDCS ameliorates pain perception in patients with central pain[11,12]

The aim of the current study conducted was to assess the effect of tDCS over the sensory cortex (SI) on QST parameters. The applied QST protocol of the German Research Network on Neuropathic Pain (DFNS) is a battery of reliable and valid tests[13] for nearly all aspects of somatosensation.[9,14-16]

Bachmann et al.[9] showed that tDCS of the motor cortex is able to modulate distinct aspects of somatosensation. It is tempting to speculate that a direct stimulation of the somatosensory cortex has even a greater effect on those parameters, because SI receives the bulk of thalamocortical projection from the sensory input fields.

Materials and methods

Subjects

Twelve healthy subjects (five female, seven male, mean age 30.0 years; range: 22-42 years of age) were included in the experiment, each showed normal nerve conduction velocities and normal somatosensory evoked potentials of both median nerves. There were no abnormalities in the neurologic examination and global laboratory chemistry parameters. Any relevant previous or concomitant psychiatric or neurologic diseases or any condition associated with acute or chronic pain or somatosensory abnormalities were excluded. All subjects were able to understand the instructions of the QST protocol. In addition, none of the subjects received regular or acute medication, except for those females taking oral contraception. All subjects gave their written informed consent. The study was performed in accordance with the declaration of Helsinki and approved by the ethics committee of the Georg August University, Goettingen, Germany.

QST

A standardized QST battery, developed by the German Research Network on Neuropathic Pain (DFNS) and consisting of seven tests measuring 13 parameters of somatosensation, was performed on skin areas innervated by the radial and median nerve of both hands:[14,15]

- Thermal detection threshold for cold and warm perception and paradoxical heat sensations,
- thermal pain thresholds for cold and hot stimuli,
- mechanical detection thresholds (MDTs) for touch and vibration,
- mechanical pain sensitivity including thresholds for pinprick and blunt pressure, a stimulus-response-function for pinprick sensitivity and dynamic mechanical allodynia, and pain summation to repetitive pinprick stimuli.[14]