Does tDCS over the primary motor cortex improve consolidation of motor memories?

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Transcranial direct current stimulation (tDCS) (Nitsche et al., 2003a; Paulus, 2003) is a non-invasive, painless cortical stimulation technique (Nitsche and Paulus, 2000, 2001) that is well tolerated by healthy subjects and patients. Recent studies have demonstrated that non-invasive brain stimulation enhances memory formation and cortical plasticity for a variety of tasks including visuo-motor coordination (Antal et al., 2004a, b; Reis et al.,2009), implicit motor learning (Nitsche et al., 2003c) and probabilistic classification learning (Kincses et al., 2004) in healthy volunteers.
Here we tested whether anodal tDCS applied during a single training session of practicing ballistic thumb movements improved retention tested 30 min after training, at the next day or one week later as compared to a control group receiving sham tDCS. Moreover, we used transcranial magnetic stimulation (TMS) to test whether anodal tDCS as compared to sham tDCS would differentially influence motor cortex excitability, short interval intracortical inhibition (SICI) and intracortical facilitation (ICF) when measured during the first 30min after training.
We tested 13 healthy young volunteers (age 18 to 30, 6 females, 4 left handed) who practiced to flex their non-dominant thumb as fast as possible for 10 blocks, consisting of 20 movements each (1 movement every 3s). Between blocks there were 1min break to prevent fatigue, such that the overall duration of the training was 20min. In half of the subjects, anodal tDCS was applied to the contralateral primary motor cortex during training with the cathode placed on the shoulder. The other half received sham tDCS, which induced the same sensation without effectively stimulating the cortex. TMS was used to measure (1) cortical excitability, (2) SICI, and (3) ICF after the training (post). One TMS run consisted of 48 pulses (16 for each condition) and lasted approx. 7 min. After the training 4 more post runs were recorded (separated by 1 min breaks).

First analyses indicate that anodal tDCS had little effect on performance during training, however, there was a tendency that tDCS enhanced retention performance 1 day or 1 week later. TMS measurements executed during the first 30 min after training did not reveal differences between the tDCS interventions. However, there was high interindividual variability in the behavioral as well as the neural data and more subjects are needed to have sufficient statistical power.

Reference list

. Paulus W. Transcranial direct current stimulation (tDCS). Suppl Clin Neurophysiol 2003; 56: 249–54.

. Reis J, Schambra HM, Cohen LG, buch ER, Fritsch B, Zarahn E, Celnik PA, Krakauer JW. Noninvasive cortical stimulation enhances motor skill acquisition over multiple days through an effect on consolidation. PNAS February 3, 2009 vol. 106 no. 5 1590-1595

. Nitsche MA, Liebetanz D, Antal A, Lang N, Tergau F, Paulus W. Modulation of cortical excitability by weak direct current stimulation—technical, safety and functional aspects. Suppl Clin Neurophysiol 2003a; 56: 255–76.

. Nitsche MA, Paulus W. Excitability changes induced in the human motor cortex by weak transcranial direct current stimulation. J Physiol 2000; 527: 633–9.

. Nitsche MA, Paulus W. Sustained excitability elevations induced by transcranial DC motor cortex stimulation in humans. Neurology 2001; 57: 1899–901.

. Nitsche MA, Schauenburg A, Lang N, Liebetanz D, Exner C, Paulus W, et al. Facilitation of implicit motor learning by weak transcranial direct current stimulation of the primary motor cortex in the human. J Cogn Neurosci 2003c; 15: 619–26.

. Kincses TZ, Antal A, Nitsche MA, Bartfai O, Paulus W. Facilitation of probabilistic classification learning by transcranial direct current stimulation of the prefrontal cortex in the human. Neuropsychologia 2004; 42:113–7.

. Butefisch CM, Khurana V, Kopylev L, Cohen LG. Enhancing encoding of a motor memory in the primary motor cortex by cortical stimulation. J Neurophysiol 2004; 91: 2110–6.

. Antal A, Nitsche MA, Kincses TZ, Kruse W, Hoffmann KP, Paulus W. Facilitation of visuo-motor learning by transcranial direct current stimulation of the motor and extrastriate visual areas in humans. Eur J Neurosci 2004a; 19: 2888–92.

. Antal A, Nitsche MA, Kruse W, Kincses TZ, Hoffmann KP, Paulus W. Direct current stimulation over V5 enhances visuomotor coordination by improving motion perception in humans. J Cogn Neurosci 2004b; 16: 521–7.