ELSEVIER

Clinical Neurophysiology 116 (2005) 1072–1076

www.elsevier.com/locate/clinph

Short-lasting impairment of temperature perception by high frequency rTMS of the sensorimotor cortex

A. Oliviero[a,b,*], M. Rubio Esteban[a], F. Sebastian de la Cruz[a], L. Fernádez Cabredo[a], V. Di Lazzaro[b]

[a]*FENNSI Group and Unidad Neurología Funcional, Hospital Nacional de Parapléjicos, SESCAM, Toledo, Spain*
[b]*Istituto di Neurologia, Università Cattolica, Rome, Italy*

Accepted 11 December 2004

Abstract

Objective: Repetitive transcranial magnetic stimulation (rTMS) has become a useful tool for investigating and even modulating human brain function. RTMS of the human motor cortex can produce changes in excitability that outlast the period of stimulation. To investigate the persistent effect of high-frequency rTMS of sensorimotor cortex (SM1) on somatosensory function.

Methods: We evaluated the thermal thresholds (cold and warm sensation) in 14 normal subjects before and after a short train of 5 Hz rTMS over the SM1 or occipital cortex (OC).

Results: Threshold for cold perception was increased immediately after rTMS of the left SM1 and no effects at all were noticed after OC stimulation. There was a slight, not significant, increase of warm threshold immediately after the rTMS of the left SM1 and no effects at all were noticed after OC stimulation.

Conclusions: High frequency rTMS over primary sensorimotor cortex seems to modulate sensory function related to thermal (cold) perception.

Significance: The method may be useful for both the study of normal human physiology of temperature perception and for rTMS based manipulation of brain plasticity in patients with sensory disturbances.

Keywords: Repetitive transcranial magnetic stimulation; Quantitative sensory testing; Temperature; Motor cortex

1. Introduction

Repetitive transcranial magnetic stimulation (rTMS) has become a useful tool for investigating and even modulating human brain function (Cohen et al., 1998; Pascual-Leone et al., 1998). RTMS of the human motor cortex can produce changes in cortical excitability that outlast the period of stimulation (Siebner and Rothwell, 2003). High frequency transcranial magnetic stimulation (stimulus rates of more than 1 Hz) may promote a short term increase in cortical excitability, a reduction of intracortical inhibition, modulate activity of corticocortical connections and produce a net change in synaptic cortical activity (Bestmann et al., 2003; Di Lazzaro et al., 2002; Maeda et al., 2000; Oliviero et al., 2003; Pascual-Leone et al., 1998; Peinemann et al., 2000; Siebner et al., 2000). RTMS has been reported to have different effects on pain perception depending on the nature of pain (Tamura et al., 2004a,b). So far there have been few reports of sensory effects of rTMS. Tactile threshold was increased for a short duration after low-frequency rTMS over the sensory-motor cortex (Satow et al., 2003).

We hypothesised that rTMS over the sensorimotorcortex can have an effect also on the perception threshold of warm and cold sensation. In the present study, we evaluated the persistent effect of high-frequency rTMS of sensorimotor cortex (SM1) on the detection of temperature variation

* Corresponding author. Address: Hospital Nacional de Paraplejicos, Unidad de Neurologia Funcional, Finca La Peraleda s/n, 45071, Toledo, Spain. Tel.: +34 925247700x263; fax: +34 704600810.
E-mail address: antonioo@sescam.jccm.es (A. Oliviero).

1388-2457/$30.00
doi:10.1016/j.clinph.2004.12.003

(cold and warm sensation). Temperature perception threshold (cold and warm thresholds) were measured by stimulating right thenar eminence. The question we addressed was whether there are any behaviour consequences of the high-frequency rTMS on the temperature perception. We tested the temperature perception threshold using quantitative sensory testing (QST) (see Shy et al., 2003 for a review). Thermal stimuli characteristically consist of a controlled ramp of ascending (warm) or descending (cold) thermal energy delivered through a thermode. The thermode consists of a thermoelectric unit with a series of thermal couples in parallel that incorporates the Peltier effect. These instruments deliver precisely quantified sensory stimuli and allow accurate thresholds of sensory (temperature) perception to be established.

2. Methods

2.1. Subjects

Fourteen healthy volunteers were studied (9 women, mean age 30.7±7.5 (SD) years, range 23–40 years). All subjects gave informed consent prior to participation and the study was approved by the local ethics committee.

2.2. Experimental design

Subjects were seated in a comfortable chair with their arms resting horizontally at their sides and the whole body at rest. Sensory testing was evaluated prior to, immediately after and 25 min after rTMS (times pre, post 0 and post 25, respectively). See Fig. 1 for a schematic description of the experimental protocols.

2.3. Transcranial magnetic stimulation

Transcranial magnetic stimulation (TMS) was performed with a Medtronic Magpro X100 and a figure of 8 shaped-coil with an outer winding diameter of 70 mm (Medtronic). The magnetic stimulus had a biphasic waveform with a pulse width of about 300 μs. During the first phase of the stimulus, the current in the centre of the coil flowed towards the handle. The coil was placed tangentially on the scalp inducing a posterior-anterior current in the brain.

We determined the optimal position for activation of the right FDI by moving the coil in 0.5 cm steps around the presumed motor hand area of the left motor cortex. The site where stimuli of slightly suprathreshold intensity consistently produced the largest MEPs with the steepest negative slope in the target muscle was marked as the 'hot spot' with a marker. Active motor threshold (AMT) was defined as the lowest stimulus intensity at which 5 out of 10 consecutive stimuli elicited MEPs of 200 μV amplitude in FDI during voluntary contraction. AMT was determined at baseline immediately before rTMS.

RTMS was applied to the left sensorimotor hand area using a frequency of 5 Hz, with the subject at rest. The coil was held in an identical way as described in the threshold measurements. The intensity of the rTMS was set at the AMT of the left motor cortex hand area (as defined above) for each individual subject. Fifty stimuli were given. Stimulation variables were well below the published safety recommendations (Wassermann, 1998). As control condition we used the same intensity, frequency and number of stimuli delivered over the occipital cortex (stimulation over Oz).

2.4. Warm and cold threshold determination

QST was conducted by using a Medoc TSA II. This device uses computer controlled Peltier elements to heat or

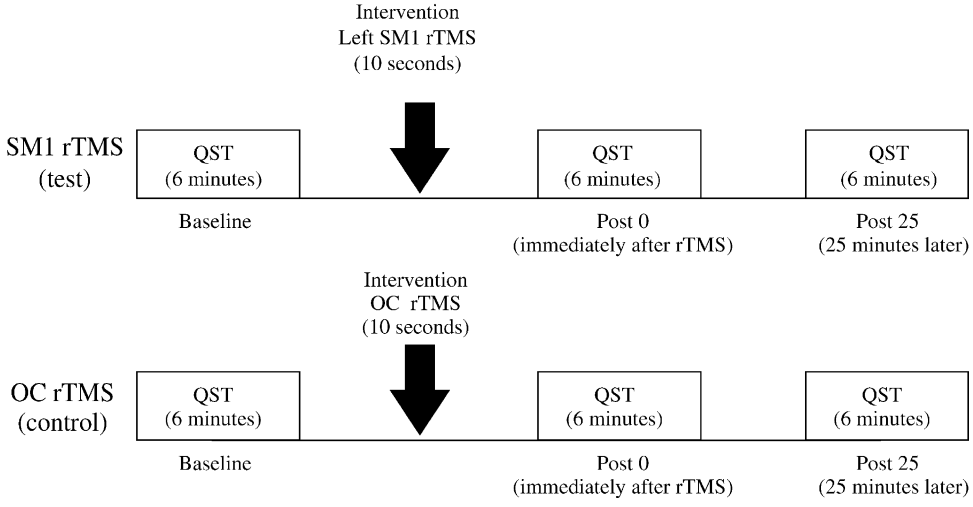

Fig. 1. Experimental set-up.