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Facilitating skilled right hand motor function in older subjects by anodal polarization over the left primary motor cortex

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Abstract

Healthy ageing is accompanied by limitations in performance of activities of daily living and personal independence. Recent reports demonstrated improvements in motor function induced by noninvasive anodal direct current stimulation (tDCS) of the primary motor cortex (M1) in young healthy adults. Here we tested the hypothesis that a single session of anodal tDCS over left M1 could facilitate performance of right upper extremity tasks required for activities of daily living (Jebsen–Taylor hand function test, JTT) in older subjects relative to Sham in a double-blind cross-over study design. We found (a) significant improvement in JTT function with tDCS relative to Sham that outlasted the stimulation period by at least 30 min, (b) that the older the subjects the more prominent this improvement appeared and (c) that consistent with previous results in younger subjects, these effects were not accompanied by any overt undesired side effect. We conclude that anodal tDCS applied over M1 can facilitate performance of skilled hand functions required for activities of daily living in older subjects.

Keywords: Healthy ageing; Sensorimotor; Complex movements; Brain stimulation; Transcranial direct current stimulation; tDCS; Activities of daily living

1. Introduction

Functional independence in performance of activities of daily life requires skilled hand motor control. Healthy ageing is associated with slowing of movements (Bennett and Castiello, 1994), increased variability in grip and lift force production (Cole and Rotella, 2001; Cole et al., 1999), diminished accuracy of force release (Erim et al., 1999; Voelcker-Rehage and Alberts, 2005), and dexterity (Cole and Katifi, 1991), and reduced coordination in reach to grasp movements (Brown et al., 1996; Pratt et al., 1994; Sarlegna, 2006). Some of these deficits are evident for example during performance of choice-reaction times or in dual-task conditions (Ketcham et al., 2002). Ageing also leads to reorganization of neural networks engaged in performance of various sensorimotor tasks (Heuninckx et al., 2008; Talelli et al., 2008a) and to some extent to a decrease of neuronal activity in circuits involved in performance of cognitive tasks (for review Burke and Barnes, 2006; Chapman, 2005; Disterhoft and Oh, 2007; Ward et al., 2008). In the motor system, ageing is associated with changes in the excitability of the primary motor cortex (M1) (Oliviero et al., 2006; Yordanova et al., 2004), with reduced ability to encode an elementary motor memory within M1 with motor training (Sawaki et al., 2003), and possibly with reduced efficiency of

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training-based exercise programs relative to younger individuals. The significance of these deficits in relation to performance of activities of daily living has been explored only partially. What is known is that deficits in the motor domain appear to have more significant consequences on independent living than declines in visual or auditory functions (Anstey et al., 2005; Teasdale et al., 1991).

It has been reported that noninvasive transcranial stimulation of M1 results in improvements in motor performance (Carey et al., 2006; Fecteau et al., 2006; Kobayashi et al., 2004; Vines et al., 2006; Voss et al., 2007) and facilitates the response to motor training protocols (Butefisch et al., 2004) as well as motor learning (Nitsche et al., 2003a; Reis et al., 2008) in healthy younger adults. There is however a gap in knowledge on the ability of noninvasive stimulation of M1 to facilitate motor function in older subjects, in an age group characterized by declining motor function and higher susceptibility to brain lesions with subsequent invalidating motor impairment. Here, we tested the hypothesis that application of anodal tDCS over M1 would facilitate performance of a set of skilled hand motor functions required for activities of daily life (measured in the setting of the Jebsen–Taylor hand function test (JTT) (Jebsen et al., 1969)) relative to Sham stimulation in a double blind, Sham-controlled cross-over experimental design.

2. Methods

2.1. Subjects

Ten healthy subjects (age range 56–87 years, mean 69 ± 9.24 S.D.; five women) participated in the study. All of them were right-handed as assessed by the Edinburgh Handedness Inventory (Oldfield, 1971) with a score of 97.0 ± 3.4. None reported a history of neurological disease or musculoskeletal dysfunction. In all subjects, the Mini Mental Status was within normal limits (>29/30) (Folstein et al., 1975). Subjects were informed about the experimental procedures and gave their written informed consent according to the declaration of Helsinki. The study protocol was approved by the NINDS Institutional Review Board.

2.2. Experimental procedures

Subjects participated in three experimental sessions. In the first session, they familiarized with the Jebsen–Taylor task (JTT) (Jebsen et al., 1969), the experimental environment and with tDCS (Fregni et al., 2005; Hummel et al., 2005a). In this first session, they also practiced the JTT task until a plateau was reached and they could not improve further. The primary endpoint measure of the study was the time required to complete the JTT, a widely used well validated test for functional motor assessment that reflects activities of daily living (Jebsen et al., 1969), that has good validity and reliability, and for which normative data are available for different ages and genders (Hackel et al., 1992; Jebsen et al., 1969). Anodal tDCS or Sham were applied in a pseudo-randomized, counterbalanced order in separate sessions (2 and 3) separated by 5 days to the left (dominant) M1 of each subject in a double-blind, cross-over order. The site for positioning the electrode for application of anodal tDCS over M1 (hand knob, Yousry et al., 1997) was determined separately in each subject using a frameless stereotactic device (Brainsight®). In each of these two sessions, the JTT (primary outcome measure) was evaluated preceding (Baseline: JTT1-3) and following (Testing: JTT4-6) each intervention (tDCS or Sham). Four times in each session, subjects were asked to report their level of attention towards the task and perception of fatigue (before and after Baseline determination of the JTT and before and after each intervention, Fig. 1). The degree of discomfort with tDCS and Sham was evaluated one time at the end of the session using a separate visual-analogue scale (Fig. 1). Participating subjects and investigator performing motor testing and data analysis were blinded towards the type of intervention (tDCS or Sham).

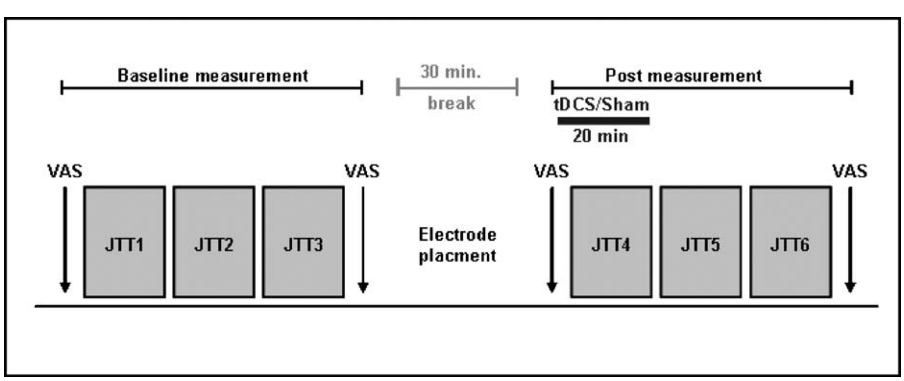

Fig. 1. Experimental design. Subjects participated in three sessions. In the first session, they familiarized themselves with the JTT and reached a stable level of performance. The second and third sessions started with questionnaires followed by baseline determinations of JTT (JTT1–3), cortical stimulation (tDCS) or Sham in a counterbalanced double-blind design and later by post-intervention JTT (JTT4–6), with JTT4 determined during stimulation and JTT5–6 after stimulation. Questionnaires (VAS) in which subjects characterized level of attention and fatigue during the experiment were given at four different times in each session.