Conflict between posture and motor imagery: insights from a deafferented subject

Mercier C[1], Aballea A[1], Vargas CD[1, 2], Paillard J[3], Sirigu A[1]

1) Institut des Sciences cognitives CNRS, 67 Blvd Pinel, 69675, Bron, France
2) IBCCF°, UFRJ, Ilha do Fundão 21 949 900, Rio de Janeiro, Brasil
3) Laboratoire de Neurobiologie des mouvements CNRS, Marseille, France.
Contact information: mercier@isc.cnrs.fr

INTRODUCTION

Several studies have shown that there is corticospinal facilitation during motor imagery in an effector-specific manner [1,2]. It has recently been shown that the corticospinal facilitation induced by motor imagery is posture dependent, that is, strong when the hand is kept in a position compatible with the imagined movement, but significantly weaker when the posture is incompatible with the imagined movement [3]. To determine whether the conflict between the posture and the motor imagery process arises from online proprioceptive information, we examined TMS-induced motor evoked potentials during motor imagery in a deafferented subject. In addition, the role of visual information about posture was explored.

METHODS

Subject description: G.L. is a 56 years old right-handed woman. After an episode of sensory neuropathy occurring 25 years ago, she suffered a permanent, specific loss of the large peripheral myelinated sensory fibers. Her clinical condition is characterized by the complete loss of light and crude touch, vibration perception, kinesthesia and position sense in all four limbs, as well as in the trunk, neck and face below the nose. Previous investigations revealed no abnormalities of the motor pathways.

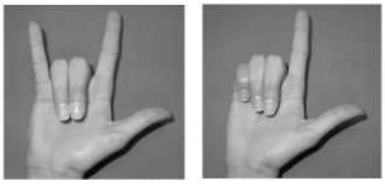

Figure 1. The motor imagery task (joining the tips of the thumb and the little finger) was performed by the deafferented subject while keeping either a posture compatible or incompatible with the task to imagine. This task was performed either with the eyes closed or while looking at the hand. Two blocks of eight trials were performed in each experimental condition, that is every combination of the following factors: task (rest or imagery), posture (compatible or incompatible) and vision (eyes closed or opened).

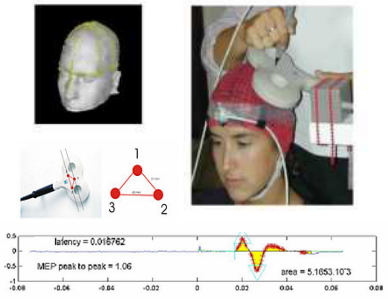

Figure 2. TMS pulses were applied at the hotspot for Opponens pollicis (OP) in the primary motor cortex (M1) with a Magstim 200® stimulator via a 70mm figure-of-eight coil at 120% of the motor threshold. An estimate of TMS pulse localization onto the magnetic resonance image (MRI) of the subject's brain was obtained on-line by means of co-registration: each TMS site was localized using a 3D tracking system (Polhemus) and co-registered on the subject's MRI [4]. Motor evoked potentials (MEP) were recorded by means of Ag-AgCl surface electrodes. EMG sweeps were band pass filtered (20-1000 Hz), digitized and recorded for successive off-line measurement of MEPs peak-to-peak amplitude and pre-pulse area.

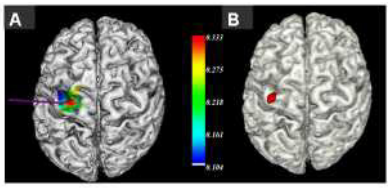

Figure 3. A. The map of OP representation is presented on subject's MRI, with the hotspot in red and the center of gravity in purple (the scale is in mV). **B.** The red dots on the brain show the superposition of the stimulation points for all experimental blocks. The use of image-guided TMS allowed a precise replacement of the coil throughout the experiment.

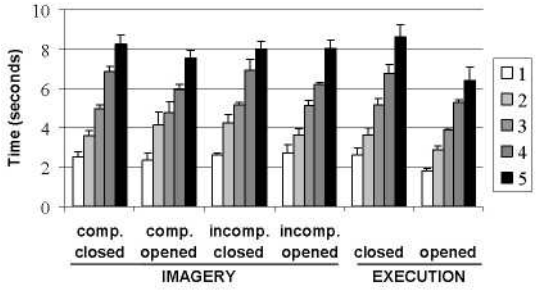

Figure 4. Mean time (and standard deviation) required to perform the movement from one to five times and for each condition.

G.L. always reported seeing her hand in action instead of experiencing a kinesthetic feeling during motor imagery. Nevertheless, she asserted that she was really "performing" the movement, and no just "looking" at it passively.

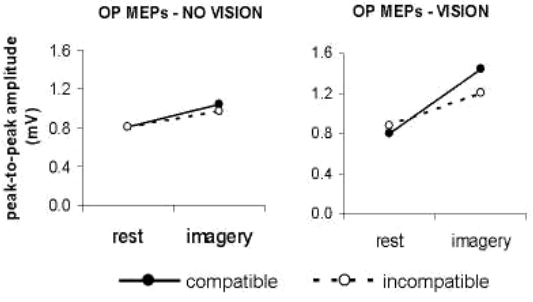

Figure 5. Mean peak-to-peak amplitude of MEPs in the *Opponens pollicis* (OP) for all the experimental conditions. With eyes closed there was a significant effect of the task, indicating that motor imagery produced a facilitation compared to rest ($p<0.01$), but no effect of posture or interaction between the two factors. However when G.L. was looking at her hand a significant interaction between posture and task was found ($p<0.05$), indicating more imagery-induced facilitation in the compatible posture.

DISCUSSION

- Results obtained with the eyes closed show that information arising from the motor commands alone is not sufficient to generate a conflict between the actual hand posture and the motor imagery process. This result supports the hypothesis that proprioception may be responsible for triggering the interference effect observed in normal subjects.
- Results obtained with the eyes opened demonstrate that visual feedback may generate a conflict between actual posture and central motor processes thus interfering with M1 cortico-spinal excitability.
- The finding that the posture interference effect was obtained in normal subjects with intact proprioceptive feedback but no vision of the hand [3] and in a patient with visual feedback but no proprioceptive information supports the idea that limb position in the brain is organized around multisensory representations.

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