

Undershoot-like signal associated with effort-induced mirror movements

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Introduction: Motor overflow is defined as the involuntary movements which accompany the production of voluntary movements(1). Effort-induced mirror movements(2) is one type of motor overflow which is unintended and unnecessary movements in homologous muscles. A possibility that transcallosal inhibition (TCI) contributes to mirror movements is high, so when related cortical regions are activated, the population of active non-glutamnergic neurons may be large. This may cause a different hemodynamic change from opposite cortical region. We have studied effort-induced mirror movements, using blood oxygenation level-dependent (BOLD) fMRI and vascular space occupancy (VASO)-dependent fMRI(3).

Materials and Methods: Twenty six healthy volunteers (13 men and 13 women) participated in this study. All were assessed as right-handed by self-declaration or Edinburgh inventory laterality quotient. Their mean age was 23.4 years old (standard deviation 3.56). Subjects performed sequential high-speed unimanual finger/thumb tapping of the dominant and the nondominant hand. They tapped as fast as possible for about four seconds. It took about four hundred seconds in one session which includes eight events. Each subject has done one or two session. Before and during scanning, electromyogram (EMG) recording were made from bilateral flexor pollicis brevis muscle by surface disposable carbon electrodes after skin preparation. All MRI experiments were performed using a 3T Allegra (Siemens) with a standard head coil. T1-weighted anatomical images were gathered with inversion recovery prepared MPRAGE with a matrix size of 256 x 256 over a field of view of 224 x 224 mm, and a slice thickness of 1 mm. We used single-shot gradient echo planar imaging (TR=1000 ms, TE=30 ms, FA=70 degrees, matrix size of 64 x 64, slice thickness of 7mm with a 1mm gap, and field of view of 224 mm) for BOLD fMRI, and non-selective inversion recovery prepared single-shot gradient echo planar imaging (TI=710 ms, TR=2000 ms, TE=10.9 ms, FA=90 degrees, matrix size of 64 x 64, slice thickness of 7mm, single slice, and field of view of 224 mm) for VASO GE-fMRI. Functional MRI data sets were preprocessed with FSL3.1, AFNI and in-house softwares. 3 or 6 degrees of freedom motion correction using mcflirt, gaussian spatial smoothing (FWHM=7mm), high pass filter (cut off point is 88 seconds) were applied to data sets.

Results: Mirror movements were seen in all subjects. Mirror movements were greater with left finger tapping than with right finger tapping (data not shown). BOLD and VASO fMRI signals are shown on fig 3 (average of all sessions). In the contralateral brain region (fig 3A), clear BOLD signal increase was seen, although the stimulus was very short (4 seconds), followed by an undershoot. The VASO signal showed a very similar time course to the BOLD signal, including the undershoot. This is somewhat inconsistent with previous report (3), but might be related to the fact that the stimulus is extremely short. In the ipsilateral brain region (fig 3B), the BOLD signal increase was much smaller, but a clear undershoot signal was seen with time course and the magnitude very similar to that of contralateral region. The VASO signal was again very similar to the BOLD signal. This might suggest a possibility of a separate mechanism behind the undershoot BOLD signal.

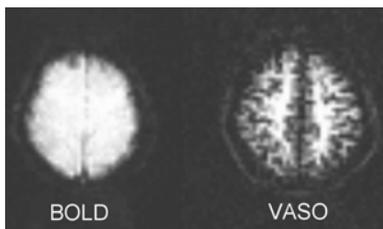


Figure 1: A BOLD image and a VASO image.

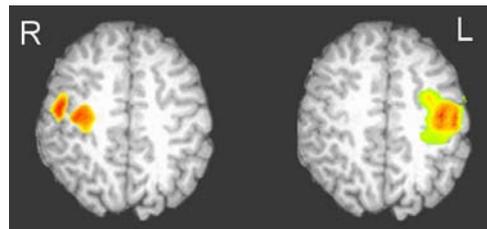


Figure 2: Regions of interest which were assigned to each subject based on z-statistic values (uncorrected voxel p threshold = 0.05) and anatomical characteristics (less than one gyrus from the central sulcus).

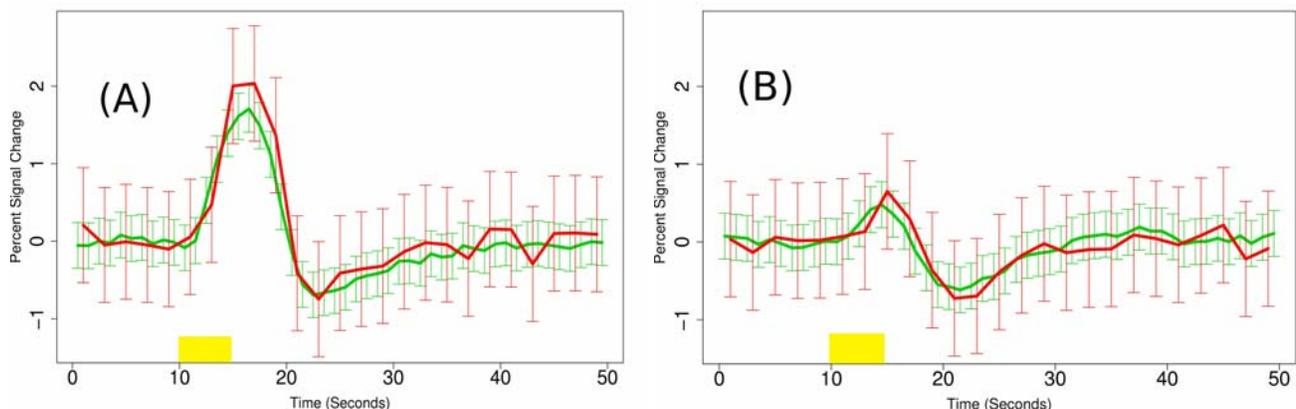


Figure 3: ROIs were set to Left primary motor and sensory area. Time courses of right (A; RtFT) and left (B; LtFT) finger tapping, BOLD and VASO signals are shown as green and red lines respectively. Percent signal changes of VASO were multiplied by minus one for comparison. In undershooting part, minimum values are -0.693, -0.748, -0.617, -0.726 for RtFT-BOLD, RtFT-VASO, LtFT-BOLD, LtFT-VASO, respectively. The yellow bar shows the period of finger tapping.

References: (1)Hoy KE, Fitzgerald PB, Bradshaw JL, Armatas CA, Georgiou-Karistianis N., Brain Res Brain Res Rev. 2004;46(3):315-27. (2)Aranyi Z, Rosler KM., Exp Brain Res. 2002;145(1):76-82. (3)Lu H, Golay X, Pekar JJ, Van Zijl PC., Magn Reson Med. 2003;50(2):263-74.