Detection of ipsilateral and contralateral activation components in unilateral fingers-tapping using spinal BOLD fMRI

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Introduction

Ipsilateral activation component has been reported by researchers in brain fMRI studies using unilateral finger motion[1]. However, the neurophysiology and the nature (inhibitory or excitatory) of the ipsilateral activation are still unknown. It has been suggested that there is direct firing in the ipsilateral, uncrossed descending projection[2] or interhemispheric interaction[3] for facilitatory and inhibitory effects on the contralateral cortex. During simple movements with the dominant hand, the activation in the motor cortex is generally in the contralateral hemisphere but sparse in the ipsilateral primary motor cortex[4,5]. On the other hand, BOLD fMRI has been shown to be feasible in the spinal cord in both 1.5T and 3T[6,7]. It was found that the activation areas detected by spinal fMRI correlated well with the knowledge of the neural anatomy. In this study, we would like to investigate the ipsilateral and contralateral activation components in the cervical spinal cord by unilateral fingers-tapping. Accordingly to the best of our knowledge, we are the first group to investigate the ipsilateral and contralateral activation inside the cervical spinal cord by spinal fMRI.

Methods

Cervical spinal fMRI studies were carried out on 4 healthy right-handed volunteers (mean age=20 & s.d.=1) in a 3T Philips Achieva System with a CTL spine coil covering C2/C3-C6/C7 (One of the subjects underwent the experiment twice for reproducibility test). Each subject participated in two series of fMRI studies sequentially. In the first series, the subjects were asked to have left hand fingers-tapping to have sensorimotor stimulation and in the second series, right hand fingers-tapping was performed. Spinal BOLD fMRI was conducted. The pulse sequence FFE-EPI was employed with parameters: TR=2.5s, TE=15ms, flip angle=45degree, voxel resolution=1*1.33*5mm^3, NEX=3 and dynamic resolution=7.5s. The exercise paradigm used in these two studies were the same which was a block design of alternative rest and stimulation with different number of scans (3 rest, 4 stimulations), a total of 63 scans in each series (Fig 1). SPM99[8] was used for rigid body registration and reslicing the data volumes. Statistical analysis was also done by the same software. Masked statistical maps were generated (P<0.01).

Task	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
No. of scan	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4

Fig 1: exercise paradigm where R stands for rest and T stands for fingers-tapping

Results

All subjects included had positive activation inside the spinal cord in left/right fingers-tapping. It is observed that more activation was found at the spinal level C5-C6/C7 (Table 1) which corresponded to the dermatomes and myotomes of the thumb, index and middle fingers. Bilateral activation was observed in all subjects both in left/right hand fingers-tapping. Figure 2 shows the activation maps of one of the subjects.

Spinal level	C6/C7	C6	C5/C6	C5	C4/C5	C4	C3/C4	C3	C2/C3
Percentage (%)	80	70	90	100	20	50	30	60	40

Table 1: percentage of series with activation at each spinal level in left/right hand finger-tapping.

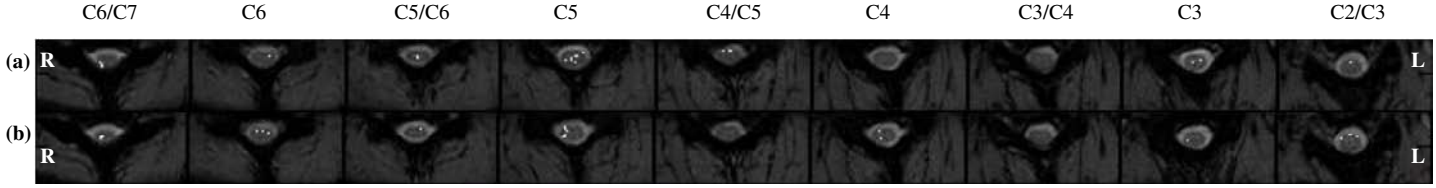

Fig 2: activation maps (P<0.01) of one of the subjects overlaid on the EPI images in **(a)** left hand fingers-tapping. **(b)** right hand fingers-tapping. White areas indicate the activation regions. Bilateral activation exists in both cases.

Discussion and Conclusions

Activation could be found in the grey horns of the cervical spinal cords during left/right fingers-tapping. Contralateral component was also found inside the spinal cord in every case. Our spinal fMRI was sensitive to detect bilateral firing in fingers-tapping using dominant or non-dominant hands and our data support the idea of direct firing in the ipsilateral, uncrossed descending projection[2] or interhemispheric interaction[3] on the contralateral cerebral cortex.

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