Proton Density-weighted Spinal fMRI Comparison between Sensorimotor Task and Acupoint Stimulation

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Introduction

A second contrast mechanism has been found to co-exist with BOLD in fMRI. The increase of the water proton density during neuronal activation contributes to the second contrast which is termed Signal Enhancement by Extravascular Protons (SEEP)[1]. Proton density-weighted fMRI studies have been carried out in both the brain and the spinal cord to verify the stimulation-induced proton density change[2-5]. Activation correlating well with the neuronal anatomy was detected verifying the proton density change[2-5]. In this study, we would like to compare the activation driven by hand-gripping task and electro-acupuncture stimulation.

Methods

fMRI studies were carried out on 28 healthy volunteers (mean age=25.96 & s.d.=5.25) with a 0.2T Profile MRI System (General Electric Medical System, Milwaukee, WI) with a 9-inch GP coil in Dong Guan QiaoTou Hospital, Guangzhou, China. Each subject participated two fMRI studies sequentially. In the first study, the subjects were asked to grip their hands to have sensorimotor stimulation and in the second study, electro-acupuncture stimulation was provided by acupoints of LI4 and LI11 on the right hand which are the treatment points for sensorimotor deficit. Proton density-weighted imaging was used. The pulse sequence FSE was employed with parameters: TR=1s, TE=24ms, ETL=6, FOV=160mm, slice thickness=10mm, matrix size=128*128, and NEX=2. 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 28 scans in each study. A rigid-body registration package, AIR[6] was used to register and reslice the data volumes. Exclusion threshold values on the motion parameters (4.2mm in translations and 0.04 radian in rotations) were set prior to fMRI analysis to minimize bulk motion artifacts. The total number of subjects satisfying this criterion was 14 (6 males and 8 females) in sensorimotor task and 11 (5 males and 6 females) in acupuncture stimulation. SPM99[7] was used for statistical analysis. Masked statistical maps were generated (P<0.006) which were overlaid on the original axial images.

Results

After analyzing all the activation maps, 11 out of 14 subjects included (78.57%) had positive activation in sensorimotor task and 8 out of 11 (72.72%) had activation in electro-acupuncture stimulation. The activation is likely to be localized at spinal levels between C6 and C7 in both cases (11/14 in sensorimotor and 7/11 in acupuncture stimulation). Figure 1 shows the activation maps of sensorimotor task and electro-acupuncture stimulation overlaid on the original axial images. Figure 2 shows the average signal change of activation in the spinal cords in sensorimotor and electro-acupuncture respectively (about 4% in both cases).

Discussion and Conclusions

Discrete activation can be found in the anterior, posterior and lateral grey horns of the spinal cords, and the amount of activation induced by sensorimotor task is in general greater than that induced by electro-acupuncture stimulation (Fig. 1). More neurons are involved during hand gripping than during acupuncture stimulation. The average percentage signal changes in both cases are comparable (Fig. 2). This is different from BOLD-fMRI studies in the brain in which acupuncture stimulation produced lower percentage signal change than sensorimotor task (unpublished data). Our results indicate that proton density-weighted fMRI in low field MRI system can be used for sensorimotor and acupuncture pathway research.
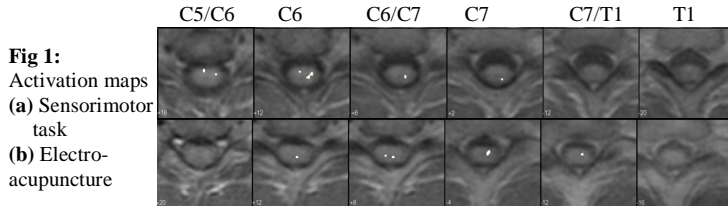

Fig 1: Activation maps **(a)** Sensorimotor task **(b)** Electro-acupuncture

C5/C6   C6   C6/C7   C7   C7/T1   T1

Acknowledgment

References

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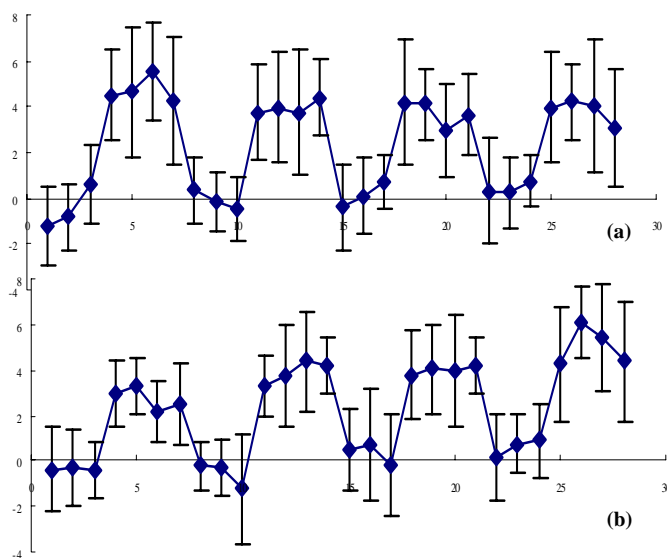
Fig 2: Average percentage signal change with s.d. of all activation inside the spinal cords **(a)** in motor task over 11 subjects. **(b)** in electro-acupuncture stimulation over 8 subjects. Y-axis is the percentage signal change and X-axis is the scan number.