FMRI study of sensorimotor interhemispheric connection combined with behavorial measures

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INTRODUCTION

The neural correlates of interhemispheric transmission (IT) are not completely understood. Consider the simple psycho-physical experiment of a unimanual reaction triggered by either an ipsilateral or contralateral sensory stimulation. Slower reaction time with the contralateral stimulation is considered a result of interhemispheric transmission [1,2]. Corpus callosum involvement in IT has been supported by evidence from patient studies [3]. However, whole brain based studies combining behavioral and physiological evidence are still lacking. The present study was conducted to gain more insight into the underlying neural basis.

METHODS

Image Acquisition

The fMRI experiments were performed on a 3T Siemens Trio scanner. An EPI-BOLD sequence was used to acquire 120 axial image volumes (30, 4mm thick slices) in each run, with an in-plane resolution of 3.44 mm×3.44 mm. Pulse sequence parameters were TR/TE/FA/FOV of 2000ms/35ms/90º/22 cm.

Experimental design

Tactile stimulation was applied using MRI-compatible piezo-electric buzzers (www.piezo.com) controlled through an analog output board (www.ni.com) using a MATLAB control script (www.mathworks.com). Stimuli were triggered from the scanner using a TTL line to achieve time-locking of events. Following informed consent, 9 right-handed volunteers participated in the present study. A buzzer was placed on each hand, and a button box (www.curdes.com) was used to collect response in Presentation (www.neurobs.com). Two conditions were used, each in a separate scan (24 trials, 10s ISI, l/r balanced); in the SAME condition, the subjects pressed a button with the hand contralateral to the vibrotactile sitmulus, and in the OPPOSITE condition, they responded with the hand ipsilateral to the stimulus.

fMRI Data analysis

Data preprocessing was performed in AFNI (http://afni.nimh.nih.gov/afni/) and included slice-timing correction, motion correction, spatial smoothing (using a 5mm FWHM), and Talairach transformation. Given the stimulus function, we first estimated the impulse response function (IRF) for each voxel. The IRF was then convolved with the stimulus time series to yield the estimated response. The final statistical parametric maps were generated by a multiple linear regression analysis evaluating the goodness of the fit. Activation was defined as voxel clusters with a significance threshold of $p<0.01$, and a contiguity threshold of at least 3 connecting voxels.

RESULTS AND DISCUSSION

The reaction time for the OPPOSITE condition was significantly longer ($p<10^{-5}$) than that in the SAME condition (Fig. 1). Similar to the so-called Poffenberger paradigm [1], our result showed a time cost related to interhemispheric transmission. Subject's hand motions was perfectly represented by the laterality of the primary motor area activation with a contralateral hemisphere control clearly identified. Under the OPPOSITE condition, in addition to a larger activation volume in the contralateral (relative to the response hand) motor area, the ipsilateral motor activation was also increased compared to the SAME condition. This result may suggest that an accurate hand motion in the OPPOSITE condition need not only a larger effort from the contralateral motor area but also an increased inhibitory influence of the ipsilateral motor cortex [4]. The enhanced OPPOSITE activation was not restricted to just the primary motor area, but recruited a more extended brain network including the supplementary motor area, parietal cortex, cingulate gyrus, and prefrontal cortex. (Fig. 2). This result supports the view that additional processing is also involved in the OPPOSITE task [5], in addition to the increased interhemispheric information transmission. The OPPOSITE cingulate activity shown might reflect the conflict between an automatic response by the stimulated hand and the task-required contralateral hand [6].

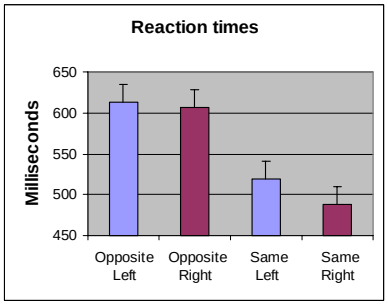

Figure 1. Comparison of the behavioral response time across experimental conditions. "Opposite left" refers to left hand response in the OPPOSITE condition, etc.

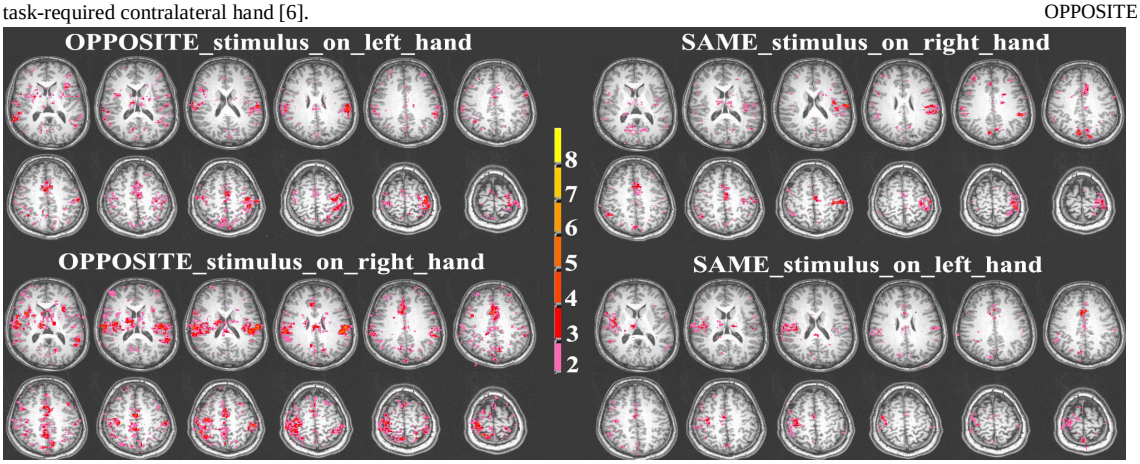

Figure 2. Comparison of the activation maps across experimental conditions. The color coding represents how many subjects (Maximum=9) activated ($p<0.01$, within at a cluster containing at least 3 connecting voxels) in the area.

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