Functional Magnetic Resonance Imaging Revealed Cortical and Subcortical Neural Activations During Expectancy and Anticipation Processing in a Time Estimation Task

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Introduction

Expectancy and anticipation are important factors for human subjects to achieve better performance and appropriate behavioral responses. In electroencephalogram (EEG) studies employing a time estimation task, an event-related potential (ERP) referred to as the stimulus-preceding negativity (SPN) was observed prior to feedback stimuli about timing performance [(1), (2)]. In contrast, the SPN was not observed when no information-valence (i.e. false) feedback stimuli were conveyed. Thus, the SPN was considered representation of neural activity relating to expectancy and anticipation. The previous studies showed the SPN gradually emerged toward to the feedback stimulus, however, its origins remained unveiled due to limitation of spatial resolution. We performed fMRI in order to identify the SPN sources and functional anatomy of expectancy and anticipation processing in the brain.

Materials and Methods

In the present study twenty healthy volunteers performed the time estimation task. Participants had to press a button when he/she judged three seconds had elapsed after the offset of cue stimulus. A visual feedback was presented informing whether their timing performance was undershoot, overshoot, or within the adjusted correct range (typically +/- 300ms), with '-', '+', or '|' signs, respectively. Counter-balanced two experimental conditions were applied; (a) TFB: true feedback condition, and (b) FFB: false feedback condition, where the correct signs were displayed in TFB, while randomly selected signs were displayed in FFB. The participants were told which condition was applied prior to a session. Two blocks containing the fifteen trials were given with one-minute rest periods before and after each block.

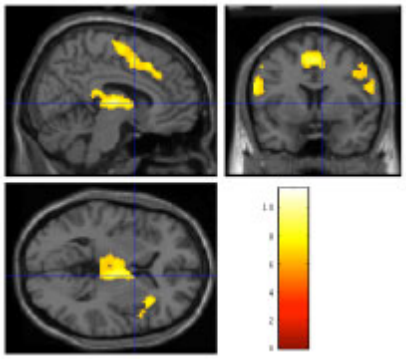

Fig.1. Activation maps in the true feedback condition on three orthogonal sections. In the axial plane, increased activities were found in the bilateral thalamus and the right insula/operculum.

The experiment was conducted on a 1.5T GE scanner (GE Medical Systems, USA) with gradient-echo EPI (TR 3s, TE 50ms, 30 slices, FOV 24cm, Thickness 4mm) after two training sessions outside the magnet. Motion correction, spatial normalization, spatial smoothing, and statistical analysis were all carried out on SPM99.

Results and Discussion

Increased activations with TFB condition were found in the supplementary motor area (SMA), the pre-motor area (BA 4, BA 6), the thalamus, the right insula/operculum, the right frontal lobe (BA 9, BA 10), and the right parietal lobe (BA 40) ($p<0.05$, corrected). Fig.1 shows three orthogonal sections containing the thalamus. In contrast, increased activations with FFB condition were only found in the SMA and the left hemisphere (BA 6, BA22).

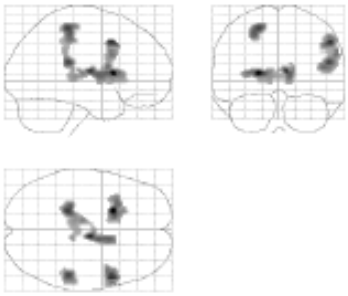

Fig.2. Direct comparison result of true-false condition. Increased activity with true feedback was found in subcortical areas including the caudate, the putamen and the thalamus.

The result of direct comparison of TFB vs. FFB was shown in Fig.2 ($P<0.001$, uncorrected). Statistically significant activations were found in the left putamen, the right caudate, the right thalamus, the right operculum as well as the left post central and the right pre-motor cortices.

These results suggested the subcortical regions were involved in the SPN occurrence, i.e., neural activation in these areas plays dominant role for expectancy and anticipation processing.

References

(1) Brunia C. H. M., Damen E. J. P. Electroencephal. Clin. Neurophysiol, 69, 234, (1988).

(2) Kotani Y., Hiraku S., Suda K., Aihara Y. Psychophysiology, 38, 873, (2001).