Functional connectivity and temporal patterns of brain networks involved in alternative finger tapping

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Introduction

In the last decades, a few studies approached to extract coherent slow frequency blood oxygenation level dependent (BOLD) signals from task based fMRI data using independent component analysis (ICA) method [1,2]. These studies showed that the independent component (IC), which extracted from task based fMRI data, is very similar with the task-evoked brain network. However, previous researchers did not attempt to identify other ICs possibly reflecting brain networks, which were implicitly associated with the task. Therefore, in this study, we aimed to identify not only IC reflecting motor network but also ICs reflecting neural network implicitly involved with alternative finger tapping task using ICA. Furthermore, we also investigated the relation between the temporal patterns of identified ICs and the hemodynamic response of finger tapping task to evaluate the possible difference in the temporal patterns of identified ICs between welders with chronic manganese exposure and healthy controls.

Subjects and methods

Forty-two males aged more than 40 years, who were fulltime current welders with more than 5 years welding experience in factories were recruited to the present study. Twenty-six age- and gender-matched, non-welding production workers from the same workplaces, who were not exposed to other hazardous material such as paint, were recruited as control group in the present study. All subjects were right handed according to the Edinburgh handedness scale. After detailed explanation of the study design and potential risks, all subjects gave written informed consent. The subjects were required to place their thumbs on tip of other finger as quickly and precisely as they could in serial order (fore finger, second finger, third finger, little finger, third finger, second finger, fore finger). They were instructed to rehearse the finger tapping task before measurement to ensure that they comprehended the task instructions. The task consisted of three cycles of 30-s unilateral finger tapping and a subsequent 30-s rest. BOLD functional images were acquired using a 3.0T GE HD scanner (EPI, TR=3000ms, TE=40ms, matrix=64x64, Thickness=4.0mm, FOV=220mm, no gap). Anatomical images were acquired using 3D-FSPGR sequence (TR=7.8ms, TE=3ms, matrix=256x256, no gap). Image processing and statistical analyses were carried out using SPM5. In fMRI data within-group analysis, contrast images from the analysis of individual subjects were analyzed by one-sample *t*-test. The SPM{t}s were thresholded at $P<0.00001$, false discovery rate (FDR) corrected for multiple comparisons across the whole brain. To make direct comparisons of brain activations between control and welder group during finger tapping movement, contrast images for the main effects were assessed using a two-sample *t*-test. SPM{t}s were thresholded at $P<0.0005$, FDR corrected for multiple comparisons across the whole brain. Group ICA was performed using GIFT (http://www.icatb.sourceforge.net) with smoothed data from preprocessed data of task. Three cortical networks which reflect motor, working memory and default mode network were selected among thirty ICs and extracted mean time course data from selected three ICs. Z score spatial maps of ICs were converted to t score maps through the random effect analysis within group. SPM[t]s of three ICs were thresholded at $P < 0.001$ with 32 voxel level, FDR corrected for multiple comparisons across the whole brain. We used Pearson correlation analyses to determine the correlations among HDR model and component of interest were performed using extracted temporal modeled data from the general linear model for finger tapping task and averaged temporal data from individual connectivity maps for independent components. SPSS V.15 software was used for all statistical analyses.

Results and Discussion

In the present study, ICA effectively identified ICs which reflect motor, working memory (WM), default mode network (DMN) from data of finger tapping task. Three ICs which was identified from active motor task showed similar spatial connectivity patterns with that of ICA found in resting-state fMRI data. The correlation analyses among the temporal patterns of ICs and hemodynamic response of finger tapping task revealed the similarity and the interesting difference between welder and control group. For IC which reflects motor network, the temporal pattern showed strong correlation with hemodynamic response of finger tapping task in both welders and controls. For IC which reflects DMN, strong anti-correlations with hemodynamic response were found in both welders and controls. However, for IC which reflects WM, the significant correlation with hemodynamic response was found only in welder group. Therefore, our results demonstrated that ICA could identify not only IC reflecting motor network but also ICs reflecting neural network implicitly involved with alternative finger tapping task. In addition, the strong correlation of IC reflecting WM with hemodynamic response of alternative finger tapping task suggest that welders required more WM resource for successful complex motor task due to WM deficit [3].

References

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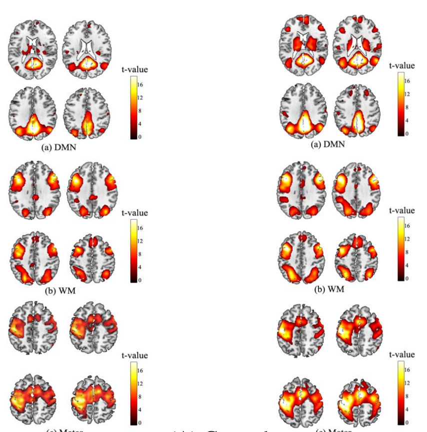

(A) Control (B) Welder

Fig 1. IC maps which reflect DMN, WM, and motor in control (A) and welder group (B). ($P < 0.001$ with 32 voxel level, FDR corrected.)

Table 1. Pearson's correlation between ICs and temporal data of block designed model

	Correlation coefficients with temporal data of block designed model	
	Control	Welder
DMN	-.596**	-.803**
WM	.009	.388**
Motor	.859**	.867**

** : *P < .01*