Fingerprints of Resting BOLD-based fMRI

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Background

The consistent and characteristic tripod pattern of resting rhythm has been detected by utilizing BOLD-based fMRI at both 1.5T and 3T field strength (Yeh et al, 2004). The tripod resting rhythm involved bilateral occipital, precuneus, posterior cingulate, inferior parietal lobule and medial prefrontal cortices (Yeh et al, 2002). For the same subjects, repetitive measurements of resting tripod components were obtained by intervention of movie viewing between two sessions of the resting fMRI studies. With spatiotemporal results of resting fMRI using independent component analyses, resting tripod components of different subjects were characterized by individual specificity and longitudinal reproducibility using correlation analyses and evaluation of Bhattacharyya distance. Therefore, resting tripod component may represent the "cerebro-prints (the fingerprints of brain)".

Materials and Methods

(1) Resting fMRI

Ten right-handed subjects (male : female = 5 : 5, age: 26 +/- 2 years old) were instructed to "empty their mind" and "prohibit imagery tasks" during the studies. After 5-minute sensory deprivation by auditory protection and dimmed room light, imaging studies of resting state were obtained with eye fixation on a dimmed red cross which was viewed through a mirror projection. Subjects were free to blink during eye fixation for the resting fMRI study of about seven minutes with the head fixation using a vacuum pillow. For verifying the state of consciousness, subjects responded to the end of each imaging session by pushing bottom using right hand. Images were acquired using a 3T Medspec S300 system (Bruker GmbH, Ettlingen, Germany) equipped with an actively shielded gradient coil, a quadrature transceiver of head. Single-shot echo planar images (64x64 matrix, slice thickness/ gap = 5/1 mm, 20 slices) covering whole brain were acquired with a flip angle = 90 degree, echo time (TE) = 50 ms, repetition time (TR) = 2000 ms, dummy scan (DS) = 5 for reaching stable magnetization and repetition number (NR) = 200.

(2) Longitudinal fMRI with movie intervention

For the longitudinal study and intervention of viewing movie, a session of fMRI study of eighteen minutes was constructed as 6-min (NR=200) resting with eye fixation, 6-min (NR=200) movie viewing with perception of Chinese caption for reporting the details of movie after experiment and another 6-min (NR=200) resting with fixation. Subjects were requested to push bottom using right hand at the end of the study when gradient noise was gone.

(3) Data Analyses

Off-line analysis using modified AFNI (Analysis of Functional NeuroImages, NIMH, Bethesda, USA) ensured the head motion with head translation < 1 mm and head rotation < 0.5 degree. Studies of head motion exceeding the motion criteria mentioned above were rejected from data analysis, because no preprocessing of motion correction was applied for independent component analyses (ICA). Identification of resting tripod component was performed by informax ICA (Computational Neurobiology Laboratory, The Salk Institute for Biological Studies, La Jolla, USA) and spatial correlates of normalized coordinate system for the characteristic tripod resting component, Maximal correlation analyses with temporal shifting and Bhattacharyya distance (BD) using the tripod template identified in resting fMRI were applied as similarity indices for two tripod components derived from longitudinal fMRI studies for homologous (within the same subject, N=20) and heterogeneous (cross subjects, N=180) analyses. Segments (50~200 time points) of tripod template were searched for the informatics of cerebro-prints.

Results

Co-existence of task-relevant (viewing movie with visual involvement) and task-irrelevant (tripod component) activities was demonstrated in one subject for spatiotemporal correlates (**Figure 1**). Maximal correlation analyses and Bhattacharyya distance of tripod components derived from longitudinal fMRI studies using segments (50-200 time points) of tripod component identified in resting fMRI was summarized as **Figure 2.** Differentiation between homologous and heterogeneous groups was statistically significant ($p < 0.04$) when tripod segment <= 155 time points, interval <= 310 seconds). Normalized Bhattacharyya distance (0~1) showed increment with shortening template segment from 200 to 50 and saturation at template segment ~ 60.

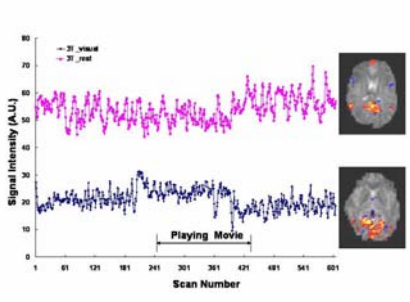

Figure 1 : Co-existence of visual (3T visual) and resting tripod (3T rest) activities was verified in the longitudinal study with paradigm design of resting-movie viewing-resting.

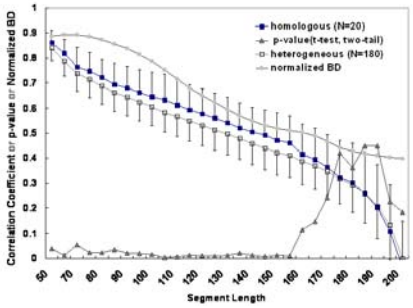

Figure 2 : Similarity indices (correlation analyses and normalized Bhattacharyya distance) showed coherent change with data segments (50~200 data points) of tripod component template. Homologous groups (within the same subject, N=20) showed higher maximal correlation coefficient(s) as compared to heterogeneous groups (cross subjects, N=180) when data segment is less than 155.

Conclusions

To our knowledge, this is the first study to address the cerebro-prints by BOLD-based fMRI study in the world. The characteristic tripod component persisted in either awake resting or task performance such as viewing movies. By criteria of (1) individual specificity, (2) independence and (3) longitudinal reproducibility, resting tripod components fulfilled the requirement as the cerebro-prints. This opens a brand-new field for personal identification using brain MR signals. But dissection of the resting activities and long-term longitudinal study will be required for further evaluation.

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References

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