Dynamic Property of Network Centrality Revealed with Resting-state fMRI of Healthy Human Brain

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Introduction:

Circadian rhythm is a fundamental physiological property of human brain which may be reflected by functional connectivity[1].In this study, we mapped the network centrality based on the data of resting-state functional MRI to provide an insight into the patterns and complexity of the diurnal functional alterations of human brain.

Materials and Methods:

MRI data were obtained using a 3T scanner (Trio system, Siemens), with a 12-channel head coil for 16 healthy subjects (6 males, 10 females, 23-31 years, mean age 24.8 ± 2.0 years). For each subject the MR examinations were acquired in the morning (8:30a.m. ± 0.5h) and repeated in the evening (7:30p.m. ± 0.5h) during a 24-hour interval. Resting state fMRI data were acquired using an echo-planar imaging sequence with typical parameters of TR/TE 3000/30 ms, flip angle 90°; field of view (FOV)210 mm, matrix 128×128, slice thickness 3mm, bandwidth 1395 Hz/ pixel, 60 volumes. Subjects were instructed to relax their minds with eyes closed and remain motionless as much as possible during the scanning. In addition, continuous high resolution T1-weighted images were acquired using MPRAGE sequence (TR/TE/TI=1900/2.53/900 ms; flip angle=9°; FOV=250 mm; in-plane resolution 1.0 mm × 1.0 mm × 1.0 mm).Data preprocessing was conducted using the Data Processing Assistant for Resting-State fMRI (DPARSF, http://www.restfmri.net)based on Statistical Parametric Mapping (SPM8, http://www.fil.ion.ucl.ac.uk/spm) and Resting-State fMRI Data Analysis Toolkit (http://www.restfmri.net). Preprocessing procedures included: 1) removal of the first 10 volumes; 2) slice dependent time shifts; 3) motion correction; 4) normalization to the MNI space and resampled to 3×3×3 mm^3; 5) spatial smoothing (4 mm full-width half-maximum Gaussian filter); 6) band-pass temporal filtering (0.01–0.08 Hz); 7) removing linear trends; 8)regression of nuisance variables(six-parameter rigid body motion, global mean, white matter, and CSF signals). Voxel-wise weighted degree centrality(DC) was calculated and standardized to z-scores as previously reported[2].Diurnal changes in DC between the two scans were examined using paired t-test (AlphaSim corrected, $p<0.05$, cluster size > 85 voxels).

Results:

Compared to the evening dataset, DC measured in the morning was significantly increased in bilateral precentralgyrus, postcentralgyrus, calcarine sulcus, cuneus, lingual gyrus, and decreased in the bilateral olfactory, inferior frontal gyrus and orbitofrontal area (Figure).

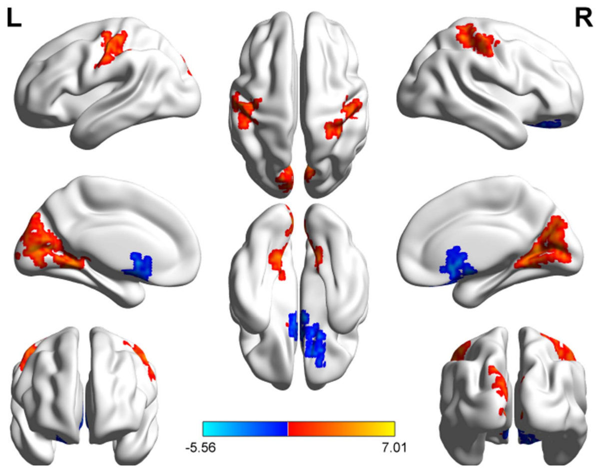

Figure. Diurnal changes of DC. The final statistical maps are visualized by 8 views (The first row from left to right are lateral view of left hemisphere, top side, lateral view of right hemisphere. The second row from left to right is medial view of left hemisphere, bottom side, medial view of right hemisphere. The third row are frontal and back side). Color bar indicates t value (Red-yellow, AM >PM, blue-green, AM<PM).

Discussion:

Degree centrality assesses the centrality or functional importance of a network. The diurnally varied DC implies that the property of cerebral functional network is not stationary but fluctuates with biorhythms. The aforementioned brain areas may reflect adaptive regulation of connectivity or metabolism that is more subject to human behaviors associated with visual, sensory, motor and cognitive functions in appropriate environmental settings.

Conclusion:

Functional connectivity of human brain manifests dynamic property. The pattern of diurnal network centrality provides an informative reference for characterizing the functional substrate in neuropsychological and psychiatric disorders that circadian rhythm matters.

References

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