# Diurnal variations of regional homogeneity in healthy human brain evaluated using Resting-State fMRI

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**Introduction:**

Spontaneous low-frequency (<0.08Hz) fluctuations of blood oxygenation level-dependent (BOLD) signal assessed by regional homogeneity (ReHo) method [1] may vary circadianly as a fundamental physiological property of brain [2]. In this study, we investigated the diurnal changes of synchrony of neuronal activity represented by ReHo of healthy adult human brain using resting state fMRI.

**Materials and Methods:**

Fifteen healthy subjects were recruited (6 males, 9 females, 23-31 years, mean age 24.8 ± 2.1 years). MRI data were obtained using a 3T scanner (Trio system, Siemens), with a 12-channel head coil. For each subject the MR examinations were performed 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 images were acquired axially using an echo-planar imaging sequence with typical parameters of TR/TE 3000/30 ms, flip angle 90°; field of view 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 data acquisition. In addition, 3D MPRAGE was performed to obtain continuous high resolution T1-weighted images (TR/TE/TI=1900/2.53/900 ms; flip angle=9°; field of view=250 mm; in-plane resolution 1.0 mm × 1.0 mm × 1.0 mm). Image analysis was conducted using Statistical Parametric Mapping software (SPM8, http://www.fil.ion.ucl.ac.uk/spm/). The first 10 volumes of the resting fMRI data for each time series were discarded for the instability of the initial MRI signal and subjects' adaptation. The remained 50 volumes were spatially normalized to the standard T1 template and resampled to 3×3×3 $mm^3$ after slice timing and head motion correction. Resting State fMRI Data Analysis Toolkit (Version 1.6, http://www.restfmri.net) implemented in Matlab was then employed to remove the linear trend of time courses and for temporally band-pass filtering (0.01–0.08 Hz) to reduce low-frequency drift and high frequency respiratory and cardiac physiological noise. Kendall's coefficient of concordance (KCC) between the given voxel and its nearest 26 neighbors was defined as ReHo and divided by the global mean for each subject. To explore the ReHo differences within and between the morning and evening sessions, one sample t-test and paired t-test was applied for inner- and inter-group comparison, respectively. P<0.05 was considered to be significant corrected by AlphaSim program with cluster size > 85 voxels. Statistical maps were superimposed on the anatomical template (Ch2.nii) to facilitate visual inspection.

**Results and Discussion:**

Higher ReHo was observed in regions including posterior cingulate cortex (PCC), precuneus, medial prefrontal cortex (MPFC) and bilateral inferior parietal lobe (IPL), which outlined the default mode network with greater activity during resting state. Compared to the evening dataset, the ReHo measured in the morning was significant increased in bilateral occipital lobes, precentral and postcentral gyrus, and decreased in the medial frontal gyrus and PCC as shown in the figure. These significant diurnal alterations of the resting-state neural activity in healthy adult human brain may reflect the internal network dynamics of human brain coordinating behaviors associated with visual, motor and cognitive functions at appropriate environmental and social settings.

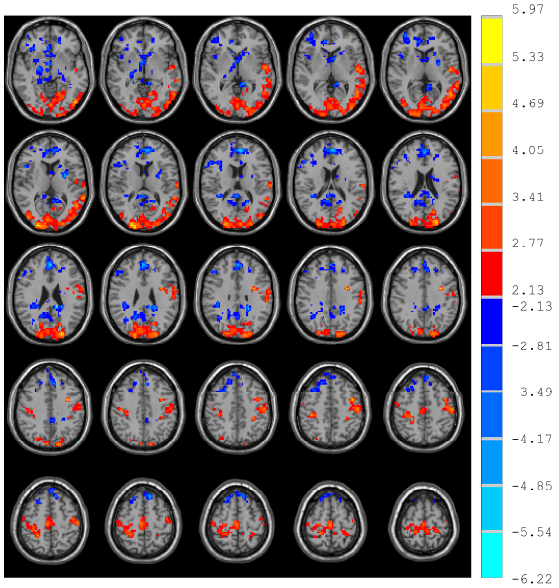


Figure. Axial view of the t-statistical map highlights the significant morning-evening (AM-PM) alterations in ReHo. Color bar indicates t value (Red-yellow, AM >PM, blue-green, AM<PM).

**Conclusion:**

The pattern of neuronal activity measured as regional homogeneity of BOLD signal in healthy adult brain manifests significant diurnal variations in brain regions involving visual, motor-sensory, emotional and cognitive performances, which may provide informative reference for characterizing the functional substrate of neurological, psychological and psychiatric disorders associated with circadian rhythm abnormalities.

**References**

[1] Zang YF, et al. NeuroImage 2004; 22:394–400.

[2] Smale L, et al. Biological Rhythm Research 2008; 39: 305-318.