# Dynamic Temporal Topological Structure of Default Mode Network

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**Introduction:**The default mode network (DMN) is an intrinsic brain system that participates in internal modes of cognition [1-2]. Functional connectivity within the default network dynamic changes is associated with internal mental state during rest or task state. Characterization of the dynamic resting sate network properties have been received great interest for the study of DMN neural mechanisms [3-5]. However, what remains unclear is the key issue of how the DMN organization dynamic configuration across resting state or task state. To better understand temporal dynamic topology structure of DMN, we used weighted complex network and clustering method to investigate default mode network during different brain mental state. Our results show that the node degree, clustering coefficient, local efficiency and global efficiency dynamic evolving during time and brain state. In addition, DMN temporal clustering structure shows dynamic change across different mental state. These results would suggest the important role of the dynamic temporal-topological structure of DMN link to underling brain adaptive processing information function.

**Methods:**15 subjects participated in this study. For the pre-resting state scanning, subjects were instructed to keep their eyes closed and to not think of anything in particular. The scanning lasted for 10 min. After resting state task, the subjects were imaged followed by two runs visual attention task in which subjects were instructed to respond as quickly as possible to a lateralized visual target with an ipsilateral or a contralateral button press. After subjects was performed the visual attention task, subjects was performed another 10 min post-resting state scanning. A 4.0 T Bruker Medspec scanner equipped with an eight-channel multi receive system was used. Structural images (3D MPRAGE, 1x1x1 $mm^3$, GRAPPA IPAT = 2, [7]) and BOLD EPI data, corrected for distortion with the PSF method [6]. (TR/TE = 2500/33ms, flip angle=$73^0$, 3x3x3 $mm^3$) were acquired. fMRI data Analysis:fMRI analysis was performed in AFNI and FSL software. Pre-processing consisted of motion correction, temporal band-pass filtering (0.009 Hz<f<0.08Hz), spatial normalization to standard space and spatial smoothing (Gaussian, FWHM 6mm). Several sources of nuisance covariates (six head motion parameters, signal from the white matter, the CSF and global signal) were eliminated using linear regression. The pre-resting state fMRI data was analyzed with FSL MELODIC ICA to define key areas of the DMN.To evaluate complex network topology within DMN, the major brain regions of interesting within DMN, each of the ROIs was defined as a spherical region with a radius of 8mm at the center of the obtained coordinates for each ROI. ROIs mean time series were estimated by averaging the times series of all voxels in these region. The dynamic pearson's correlation coefficients were computed between each pair of brain regions for each subject based on 1min sliding window and sliding in step of one TR and then dynamic correlation matrix for each subject and each sliding window was obtained. Then we characterized the dynamic temporal-topological structure of DMN for each sliding window by using weighted complex network analysis method based on BCT Matlab toolbox (http://www.brain-connectivity-toolbox.net) and R software clue 3.0 packages.

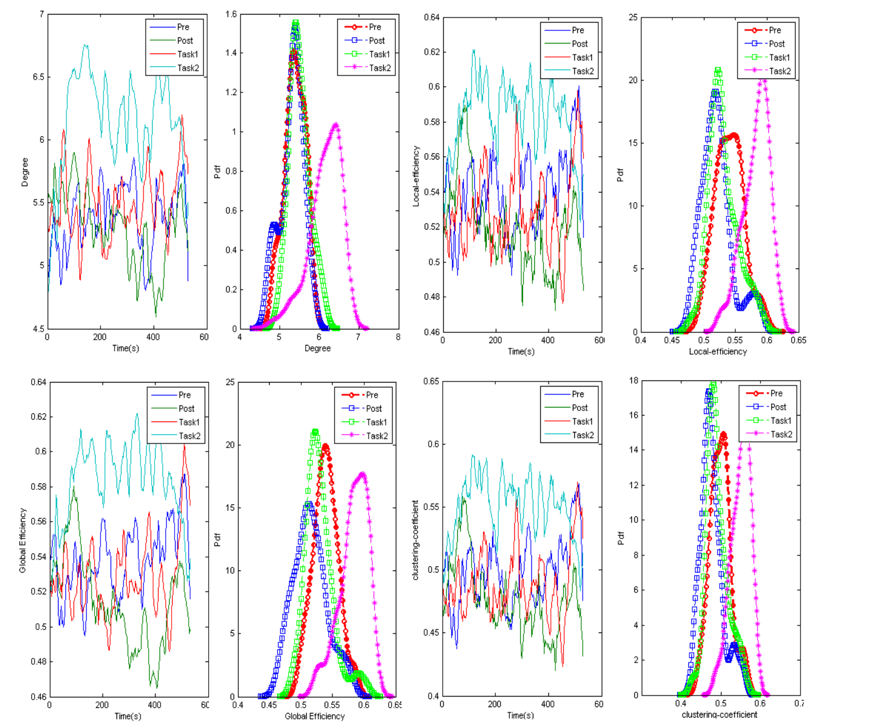


Fig. 1 The time-evolving complex network properties for pre-task resting state (pre), task-run1 state (Task1),task-run2 state (Task2) and post-task resting state (Post).Top row is PCC degree (left) and local efficiency (right), bottom row is global efficiency (left) and clustering coefficient (right).

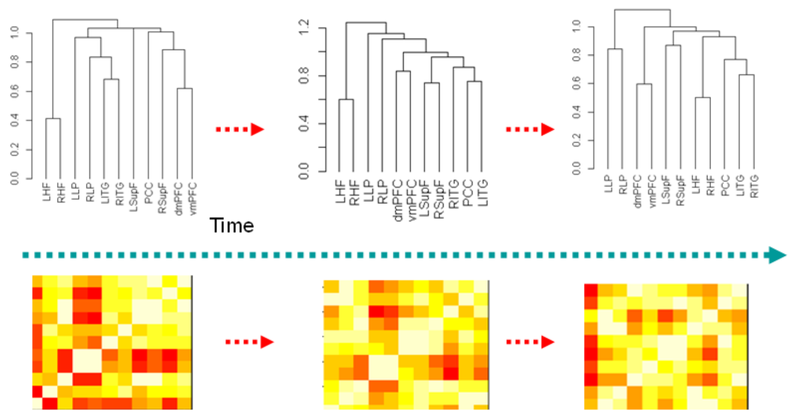


Fig. 2 The time-evolving the dynamical clusters within DMN during pre-task resting state. PCC, Posterior cingulate cortex; vmPFC and dmPFC, ventral and dorsal medial prefrontal cortex; RITG/ RITG, right/left inferolateral temporal gyrus; RLP/LLP, right/left lateral posterior cortex; RHF/LHF, right/left hippocampal; RSupF/LSupF, right/left superior frontal cortex.

**Results and Discussion:**The time-evolving complex network properties (PCC degree, clustering coefficient, local Efficiency and global efficiency) of the weighted default mode network and the corresponding distribution function, as illustrated in Fig. 1. In order to test the statistical significance of changes in a complex network measure across during brain state (pre- resting state, task-run1 state,task-run2 state and post-resting state), nonparametric statistical tests are used. The changes in each different brain state network are statistically tested using the Wilcoxon signed rank test. There are significant changes in the brain network topological metric across different brain state ($p<0.05$). Fig.2 shows the time-evolving the dynamical hierarchical clusters within DMN during pre-resting state. The DMN shows dynamic clustering reorganization across different time points. In addition, the topological structure of DMN including DMN hub node PCC degree, clustering coefficient, local efficiency and global efficiency vary at the different time points. The observed dynamic topological structure of DMN could represent brain microstate temporal signature for supporting internal and on-going different brain state cognitive processes. Especially, the topological properties distribution function for pre task resting state, task state and post task resting sate show significant different. DMN temporal topological structure dynamic reconfigure during different brain state for supporting brain adaptive processing information function. Moreover, these results may also indicate brain dynamic reconfiguration for establishing or reinforcing the most recently acquired novel information.

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