

Robust Correlation between volume based connectivity and functional connectivity in rat brain

Zhifeng Liang¹, Ziyu Cao², Liqin Yang², Fuchun Lin², Nanyin Zhang¹, and Hao Lei²

¹Department of Biomedical Engineering, The Pennsylvania State University, University Park, PA, United States, ²State Key Laboratory of Magnetic Resonance and Atomic and Molecular Physics, Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences, Wuhan, Hubei, China

Introduction: Different types of connectivity in the brain can be measured by various neuroimaging techniques, and it is intriguing to explore the relationship among those connectivity measures. Specifically, efforts have been made to elucidate the relationship between anatomical and functional connectivity (1). The current study compared the volume based connectivity and functional connectivity in rats from two independent datasets of relatively large sample sizes, and further validated the robust correlation between those two connectivity measures.

Method: For the volume-based connectivity matrix, 152 male Sprague-Dawley rats were imaged on a Bruker 7.0 T scanner under isoflurane anesthesia using a volume coil as the transmitter, and a 4-channel phase-array surface coil for signal reception. 52 coronal T₂-weighted images were acquired by a RARE sequence, with RARE factor 4, TR 5800 ms, TE_{eff} 40 ms, FOV 35 mm×35 mm, matrix size 512×384, slice thickness 0.58 mm and 8 averages. Images were first segmented into gray matter (GM), white matter (WM) and cerebrospinal fluid matter (CSF) probability maps with SPM8 using a set of 68×68×68μm GM/WM/CSF templates built in-house, and co-registered to a 256×256×31 base map with voxel size 12.5μm×12.5μm×100μm with DARTEL. The GM/WM maps were then masked with the binary masks of GM/WM (GM/WM probability > 0.4). The GM+WM volume maps were then smoothed and parcellated into 203 Region of Interests (ROI). The average value of all voxels within each ROI was calculated across all rats, and the correlation coefficients among ROIs series were calculated and Fisher's z transformed.

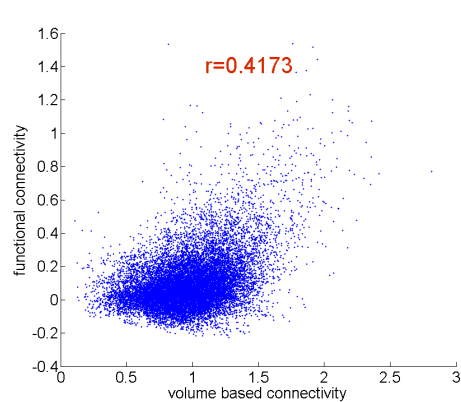


Fig. 1. Correlation between volume based connectivity and functional connectivity.

For the resting-state functional connectivity matrix, resting-state fMRI data of 42 male Long-Evans rats were acquired in previous studies (3-6) and re-analyzed for the purpose of this study. Briefly, rats were imaged in the awake condition with a 4.7 T Bruker scanner (gradient echo EPI, TR=1s, TE=30ms, flip angle=60°, matrix size=64*64, FOV=3.2*3.2cm, 18 1mm thick slices). Functional images were preprocessed with conventional procedures: registration to a segmented rat brain atlas with 194 ROIs, motion correction, spatial smoothing, regression of motion parameters and white matter/ventricle signals, band-pass filtering (0.002-0.1 Hz). Based on the parcellation scheme, a regionally averaged time course for each ROI was generated by averaging the time courses of all voxels within the ROI. Functional connectivity was evaluated by Pearson correlation and correlation coefficients were Fisher's z transformed using and averaged across all subjects.

To evaluate the relationship between volume based connectivity and functional connectivity, ROIs with sufficient coverage in both datasets are selected, resulting 179 total ROIs (15931 connections). Physical Distances among ROIs are calculated based on centroids of ROIs.

Results: Functional connectivity and volume based connectivity are strongly correlated with a correlation coefficient of 0.4173 (Fig. 1). Not surprisingly, both types of connectivity decrease with longer physical distances among ROIs and the relationship seems to be exponential decay (linear to log(distance), Fig. 2 and 3). It was possible that the correlation between those two connectivity measures was mediated by physical distance. Therefore, to eliminate the possible mediating effect,

correlation after regressing the log(distance) was calculated (Fig. 4), which was still robust.

Conclusion: The current study revealed significant correlation between volume based and functional connectivity in the rat brain. The result was particularly important given that the two datasets were independently acquired and methodology differences were vast.

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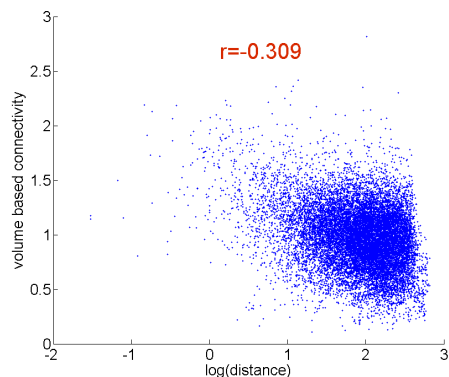


Fig. 2. Correlation between volume based connectivity and physical distance.

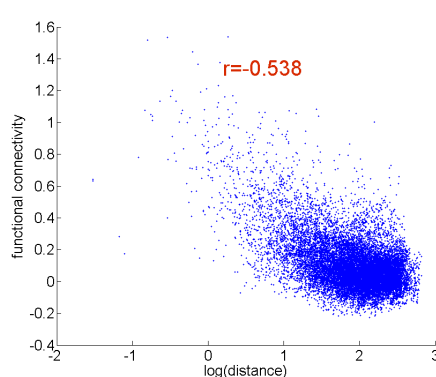


Fig. 3. Correlation between functional connectivity and physical distance.

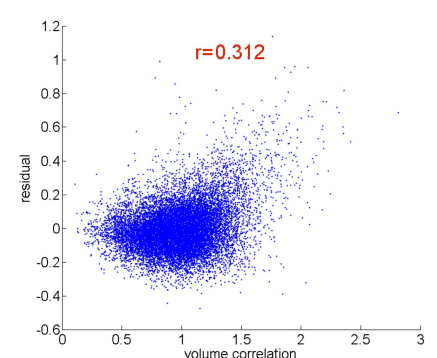


Fig. 4. Correlation between residual of functional connectivity after regressing physical distance and volume based connectivity.