Nuisance Regression of High-frequency FMRI Data: De-noising Can Be Noisy

J.E. Chen1,2, H. Jahanian1, G.H. Glover1,2

1Radiology and 2Electrical Engineering Department, Stanford University, CA, USA

Background: A growing number of studies using fast sampling have demonstrated the persistence of resting state functional connectivity (RSFC) beyond the typical 0.1 Hz. However, these studies commonly included whole-band linear nuisance regression (WB-LNR) in the preprocessing pipeline to remove noisy variances in the dataset prior to temporal filtering. Since the fitting parameters in the LNR model are likely driven by the dominating low-frequency (LF) fluctuations in both the signals and regressors, high-frequency (HF) components of the original dataset may not be effectively de-noised. Instead, artificial RSFC may be introduced via WB-LNR. Here, we demonstrated via both simulation and real data that LNR can introduce network structures in HF bands, which accounts largely for the observations of HF-RSFC.

Methods: Ten-minute RS scans from 10 healthy subjects were collected at 3T using a blipped CAIPI sequence, (TR = 350 ms, voxel size 3.14×3.14×4 mm³). Basic preprocessing steps included slice timing correction, removal of scanner drifts and cyclic physiological fluctuations using RETROICOR ('real' dataset). A 'dummy' dataset was created by eliminating any possible HF correlations via randomly shuffling the phases of frequency components above 0.2 Hz of each voxel. Then for both the 'dummy' and 'real' dataset, LNR was performed using common regressors estimated from the 'real' dataset. RSFC were compared before and after LNR using seed-based approaches.

Results: (1) ‘Dummy’ dataset: (Fig. 1, up) prominent network structures were artificially introduced by LNR, even if only a small fraction of regressors were included (e.g., ‘white matter+CSF’). (2) ‘Real’ dataset (Fig. 1, bottom): FC artifactually introduced by LNR accounted largely for the observed HF-RSFC in real dataset. (3) Contrast to noise ratios (CNRs) of the RSFC dropped significantly > 0.2 Hz (not shown).

Conclusions: We have demonstrated that (1) WB-LNR can introduce artificial HF-RSFC, and that (2) CNRs of RSNs drop significantly above 0.2 Hz.