T2* Modulation of Functional Connectivity using a Multi-echo Strategy

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Introduction: Resting-state fMRI has been thought to stem from perturbations of magnetic susceptibility sensitive to hemoglobin concentration accompanying with synchronies of neuronal events (1). This suggests that functional connectivity should be modulated by the weighting of transverse relaxation times (T_2^*) (2,3), however, the spatial and frequency characteristics of the modulation is not well known. In the current study, a multi-echo gradient-echo sequence was used to examine spatial and spectral features of functional connectivity across multiple TEs at 3T.

Methods: Ten healthy subjects were recruited for fMRI experiments on a Siemens Allegra 3T scanner. 35 axial slices (220 × 220 mm^2 field of view, 64 × 64 in-plane matrix size, and 4 mm slice thickness without gap) were prescribed to cover the whole brain. A four-echo EPI sequence was used with partial k-space acquisition, repetition time of 3 s, 200 measurements and TEs of 7.7, 22, 37, 52 ms. Functional data underwent motion correction, linear detrend, low-pass-filtering (<0.1 Hz), normalization and smooth (FWHM 6 mm). Cardiac and respiratory estimations were performed using PESTICA (4). Right spherical seeds (6 mm in diameter) were prescribed for default-mode networks on posterior cingulate cortex [12, -48, 32]. Seed-based correlation analysis was employed considering nuisance covariates such as motion parameters, respiratory/cardiac noise, and the curves retrieved from white matter and CSF.

Results: *1) Spatial variability*: The connected regions at 7.7 ms (Short TE) and 37 ms (Normal TE) are shown in Fig.1. Short TE shows broad local but few remote connections compared to Normal TE. Using the two masks generated from the connectivity maps of Short TE and Normal TE, respectively, correlation coefficients (CC) at different TEs were analyzed and results are shown in Fig. 2. TE dependence of CC of Normal TE has a quasi-convex curve; however, the CC of Short TE drops down with increasing TE, indicating a different TE modulation. *2) Spectral specificity*: The power spectra (Fig.3) were normalized to the DC power (0 Hz) and then averaged across subjects. With Normal TE, the spectrum of the shortest echo is flat in all frequency range for all brain networks but other spectra are notably elevated with increasing TE. In contrast, with the Short TE, differences in power spectra between TEs are negligible in the default-mode network.

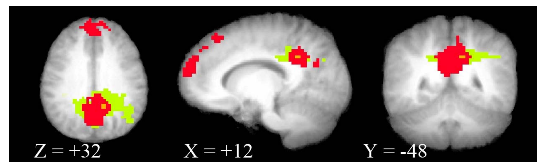

Fig. 1 Masks generated from functional connectivity of Short TE (7.7 ms, green) and Normal TE (37 ms, red).

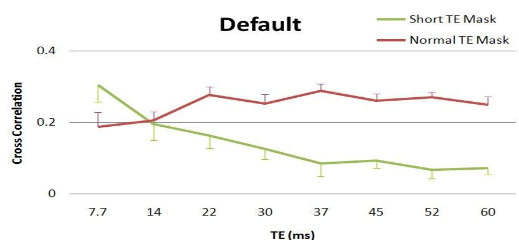

Fig. 2 Correlation coefficients across TE from masks.

Discussion & Conclusions: The current work examined the spatial and spectral specificities of functional connectivity using a multi-echo strategy at 3T. Broad local connections but less remote connections were observed at ultra-short TEs compared to longer TEs. The power spectrum was almost flat at ultra-short TEs, but the power in the frequency range of 0.01-0.05 Hz increases with TE. The spatial variability between TEs may stem from the inflow effect or distinct intra-/extra-vascular weightings across TEs. The flat spectrum at the shortest TE suggests that non-neuronal sources might dominate in the dataset. In contrast, the distant spatial connections in specific brain circuits and the elevated spectral power in the low frequency at longer TEs imply the contribution of synchronized neuronal activities.

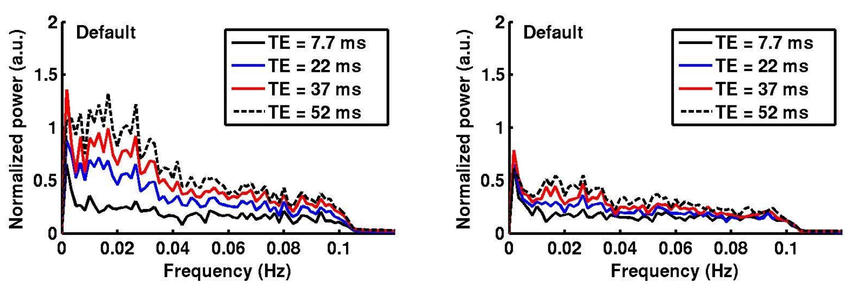

Fig. 3 Spectral comparisons from masks.

REFERENCES

1. Hyde et al., MRM, 2001.2. Peltier et al., NI, 2002. 3 Yan et al. MRM, 2009. 4. Beall et al., NI, 2007.