Tightly connected – high energy consumption? Investigation of the Default Mode Network via trimodal simultaneous MR-PET-EEG imaging

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Background: The human brain uses 80% of its energy for intrinsic activity, i.e. ongoing neural activity that occurs in isolation from any particular stimulus1,2. Is a high degree of connectivity as assessed via the parameter Regional Homogeneity (ReHo) coupled with a high degree of glucose consumption rate within the default mode network (DMN) as assessed via FDG-PET? Is this associated with a specific EEG frequency?

Methods: Data Acquisition: fMRI, FDG-PET and EEG data were recorded simultaneously from 11 healthy male volunteers (mean age = 28.6±3.4 years) in a 3T hybrid MR-PET system (Siemens, Germany). Resting state fMRI data: T2*-weighted EPI sequence (TR2.2 s/TE30 ms/FOV200mm/6 minutes/eyes closed). PET data: App. 200 MBq FDG, injection in scanner, list mode, iteratively reconstructed (single frame, 253 slices, voxel 1.25 mm3 isotropic, all standard corrections). EEG data were acquired via a 32-channel MR compatible system (Brain Products, Germany).

Data Processing: ReHo (voxel cluster size 27) was calculated using the C-PAC software3 package for fMRI data after pre-processing (normalisation MNI 3mm, slice timing, motion, nuisance signal correction, temporal filtering 0.01 to 0.1 Hz). ReHo values and normalised PET data were linearly standardised to Z values. EEG raw data were corrected for artefacts (gradient, ocular, cardioballistic) (Brain Vision Analyser 2.0, EEGLab4). eLORETA5 was applied for source estimation at different EEG frequency bands (α, β, δ and θ). Voxel wise correlations among each modality were computed using the Biologic Parametric Mapping toolbox6.

Results: ReHo and glucose consumption rate in the DMN correlated with the Pearson’s coefficient 0.53. No specific EEG frequency band showed a significantly higher correlation with ReHo and glucose consumption rate.

Conclusions: The high connectivity of the DMN hubs is coupled with a high glucose consumption rate. This mechanism leaves the DMN very vulnerable to disease. There is no specific EEG frequency linked to this coupling. Further investigations in patients with neuropsychiatric disorders in different disease stages are necessary to explore the potential of simultaneous imaging as a biomarker for disease staging (early diagnosis before clinical symptoms occur), treatment response and monitoring.


Figure 1: a) ReHo map averaged across all subjects; b) Normalised PET image averaged across all subjects