Exploring latent networks in resting-state fMRI using voxel-to-voxel causal modeling feature selection

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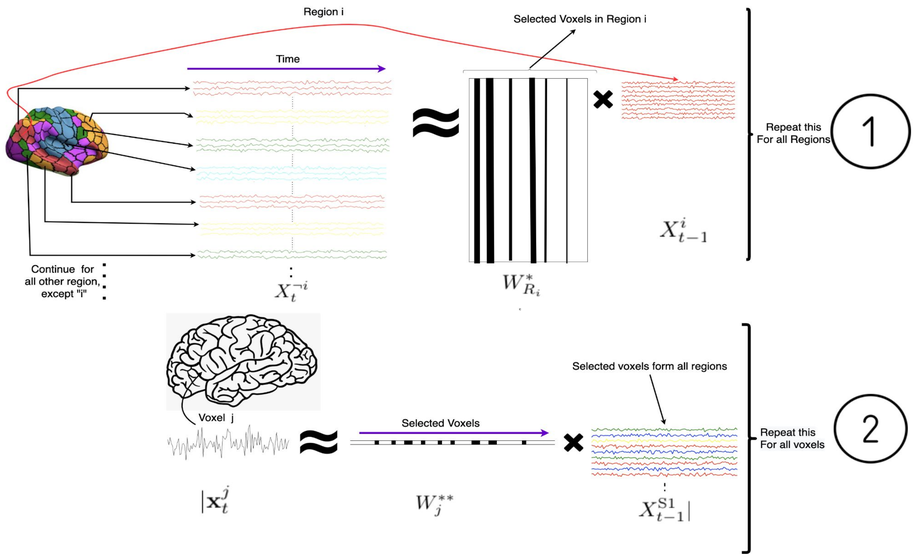
Goal

- Model the rs-fMRI for all cortical grey-matter voxels using a subset of predictive voxels.
- Find latent networks within the selected voxels.

Methodology (Stage 1 and 2)

Fig. I: Divide and conquer sparse linear modeling approach



- (Stage 1) Find voxels within each region.
  - For each of 1000 regions, use a $\ell_{2,1}$-norm penalized linear causal model to predict the activity at the next time step of all other regions.

$$W_{R_i}^* = \underset{W \in \mathbb{R}^{(V-V_i)\times V_i}}{\arg\min} \|X_t^{\neg i} - W X_{t-1}^i\|_F^2 + \lambda_{2,1}\|W\|_{2,1},$$

    - Take the union over predictive voxel subsets for each region.
  - (Stage 2) For each voxel, find a non-redundant set of voxels from stage 1 by applying an ℓ_1-norm penalized linear model (LASSO).

$$\mathbf{w}_j^{**} = \underset{\mathbf{w}\in\mathbb{R}^{V_{S1}}}{\arg\min} \|\mathbf{x}_t^j - (X_{t-1}^{S1})^\top \mathbf{w}\|_2^2 + \lambda_j\|\mathbf{w}\|_1,$$

Methodology (Stage 3)

- (Stage 3) Apply ICA on stage 2 voxels and project each source back using predictive coefficients.
  - Align to common space (MNI152) and blur to deal with cortical misalignment.

Results

- (Fig. II) Method finds unique ICs that have high similarity across multiple subjects but low similarity with ICs obtained from group-based ICA.
- (Fig. III) Our analysis is able to find common latent networks across subjects that group-based ICA is not able to find.

Fig. II: Hierarchical clustering of subject ICs by inter-subject similarity and similarity to group ICs (column labeled 24)

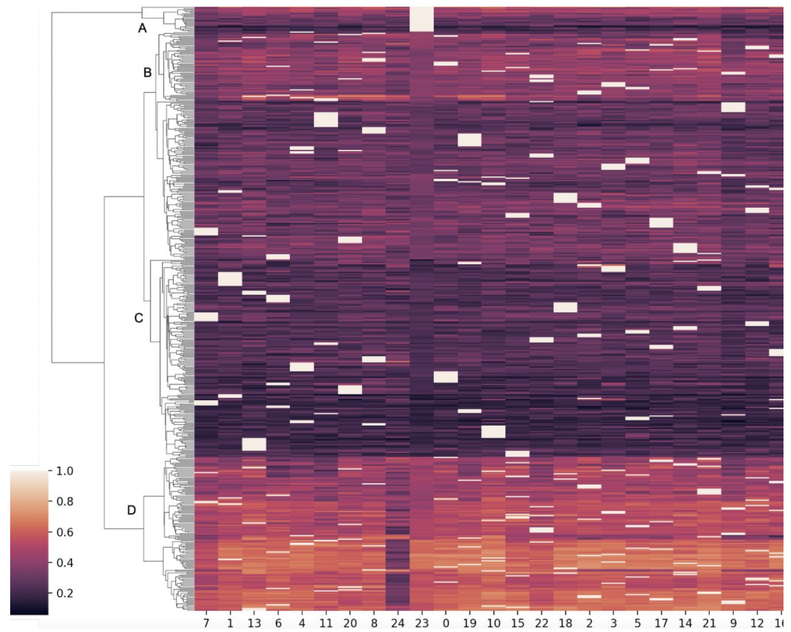
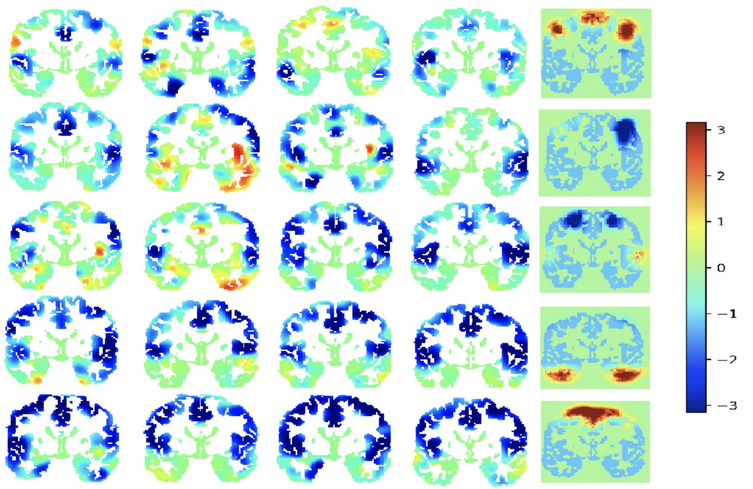


Fig. III: Slices of ICs from cluster D (last column are group ICs)



Future Work

We are now testing whether these unique IC patterns are meaningful in distinguishing healthy versus non-healthy subjects.