

Deriving a multi-subject functional-connectivity atlas to inform connectome estimation

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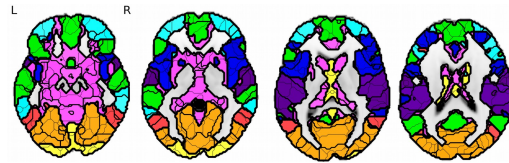
Goal

Given: resting state fMRI time-series
multiple subjects

Objective: estimate a functional **connectome** (connectivity atlas)
interpretability, stability → sparse connectivity
flexibility → simple update rules (new subjects)

Estimation

Resting state fMRI
n "samples"
p regions



Multi-subject joint estimation of connectivity
→ single control parameter
→ costly re-estimation

Individual estimation → unstable, high inter-subject variability

- Contribution**
- **decoupling** edge set from connectivity strength
 - aggregation into **connectome** (stabilized multi-subject estimate)
 - allows for **easy incremental model updates**

Model

Graph lasso

$$\hat{\Omega} = \arg \max_{\Omega} -\log \det \Omega + \text{trace } S \Omega + \lambda \|\Omega\|_1$$

Neg. max likelihood + penalty

max. likelihood (ML): model $\hat{\Omega}$ fitting empirical covariance S
penalty: **bias** (zeroes) in $\hat{\Omega}$ to reduce estimator **variance**

ML on graph: ML constrained to edge set E (e.g., using IPS)

$$\hat{\Omega} = \arg \max_{\Omega|E} -\log \det \Omega + \text{trace } S \Omega$$

Edge estimation

Data set: HCP Q1 resting state (2 sessions / subject)
1 training session (n=2400)
1 validation session (n=2400)
Regions: Harvard-Oxford atlas (p=96)

Method: 1) subject s → learn connectivity structure (edges)
2) accumulate marginal evidence → connectome

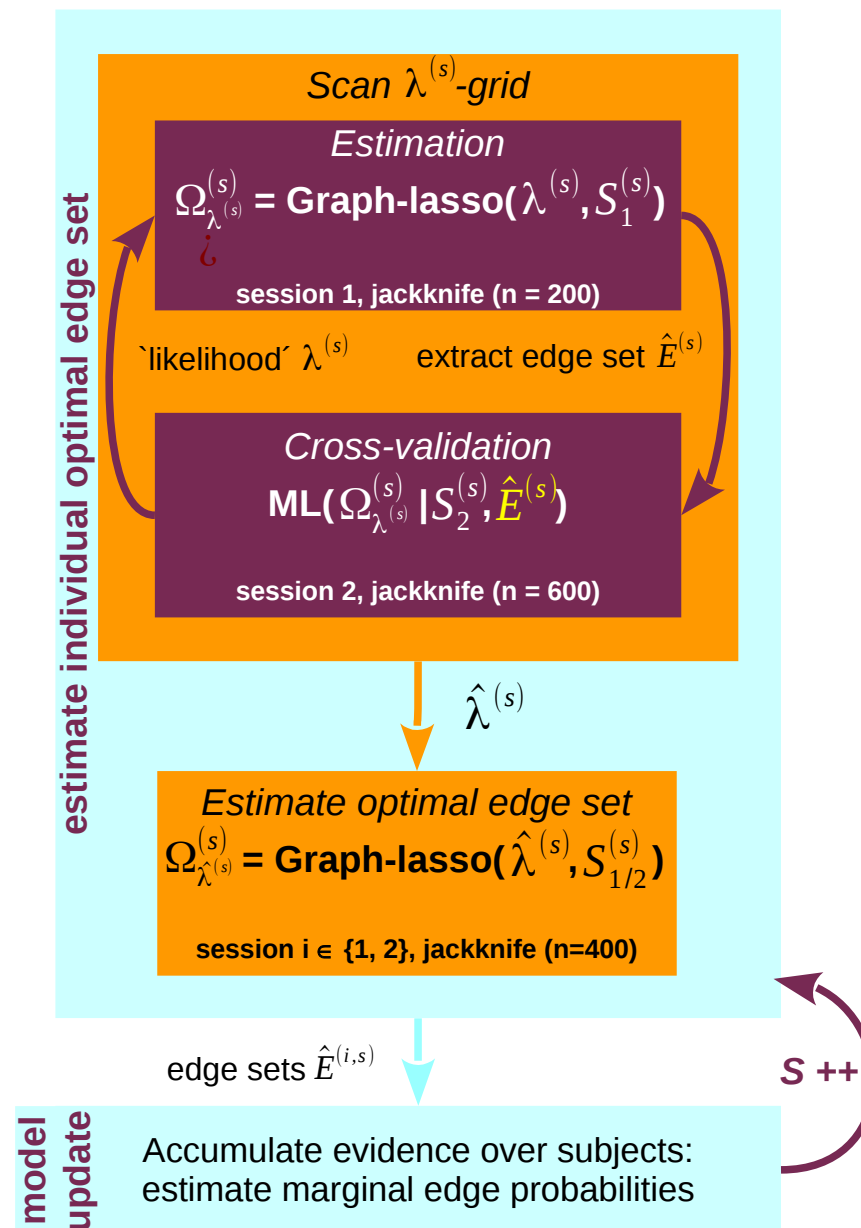


Fig.: accumulated **marginal edge probabilities** over all subjects of HCP Q1 (using spectral clustering for organization).

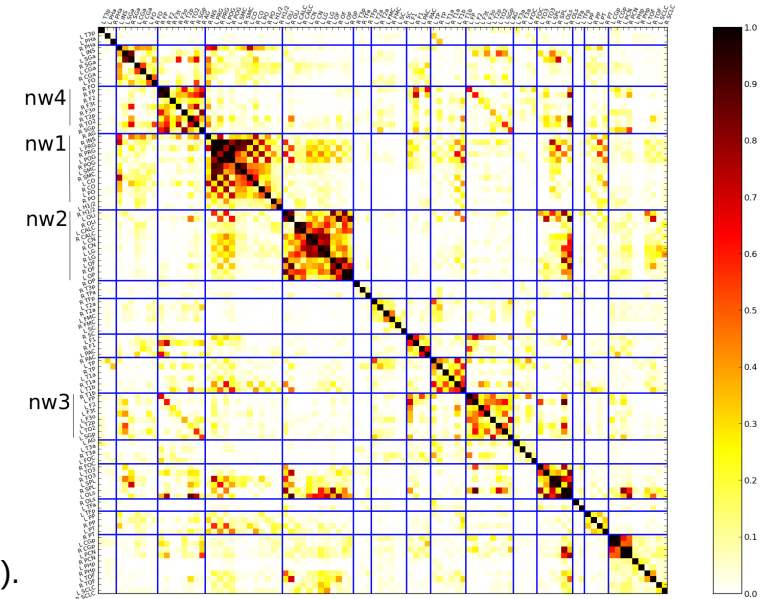
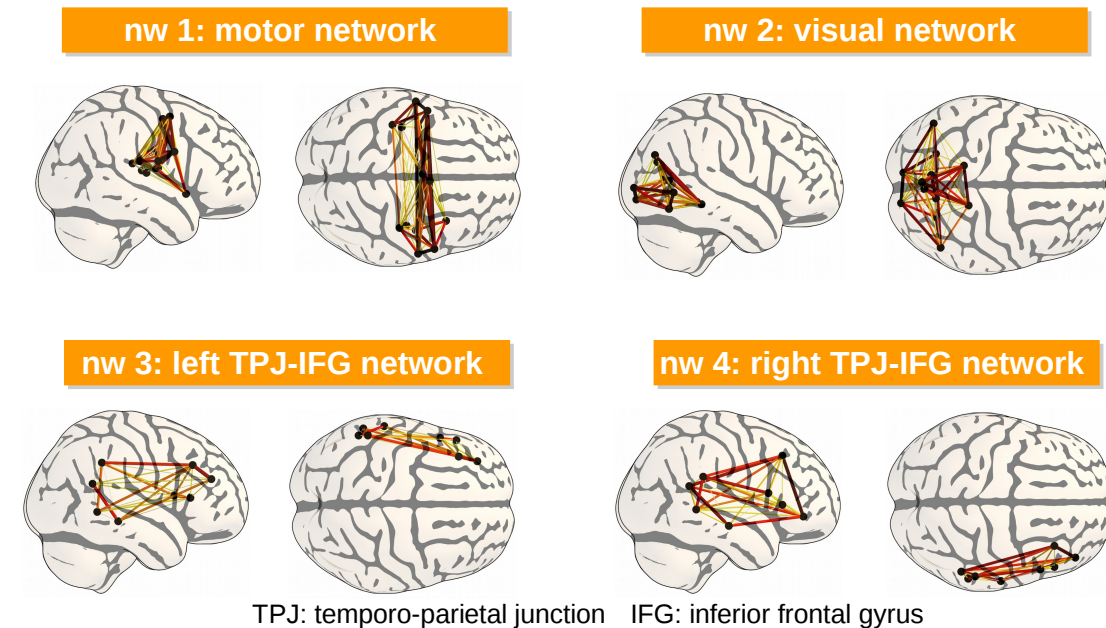


Fig. below: most prominent **networks** (clusters).



Conclusions

- Framework reminiscent to **stability selection**
- **Unbiased ML** validation metric → allows for sparser solutions
- Network properties: laterality, symmetry, ...

Damoiseaux, J.S., Rubinov, S.A.R.B., Barkhof, F., Scheltens, P., Stam, C.J., Smith, S.M., Beckmann, C.F.: Consistent resting-state networks across healthy subjects. Proceedings of the National Academy of Sciences 103(37) (2006) 13848–13853.
Meinshausen, N., Bühlmann, P.: Stability selection. Journal of the Royal Statistical Society: Series B (Statistical Methodology) 72(4) (2010) 417–473.