University of Wisconsin
SCHOOL OF MEDICINE AND PUBLIC HEALTH

The Waisman Laboratory for Brain Imaging and Behavior

Hyper Network Analysis on Paired Images

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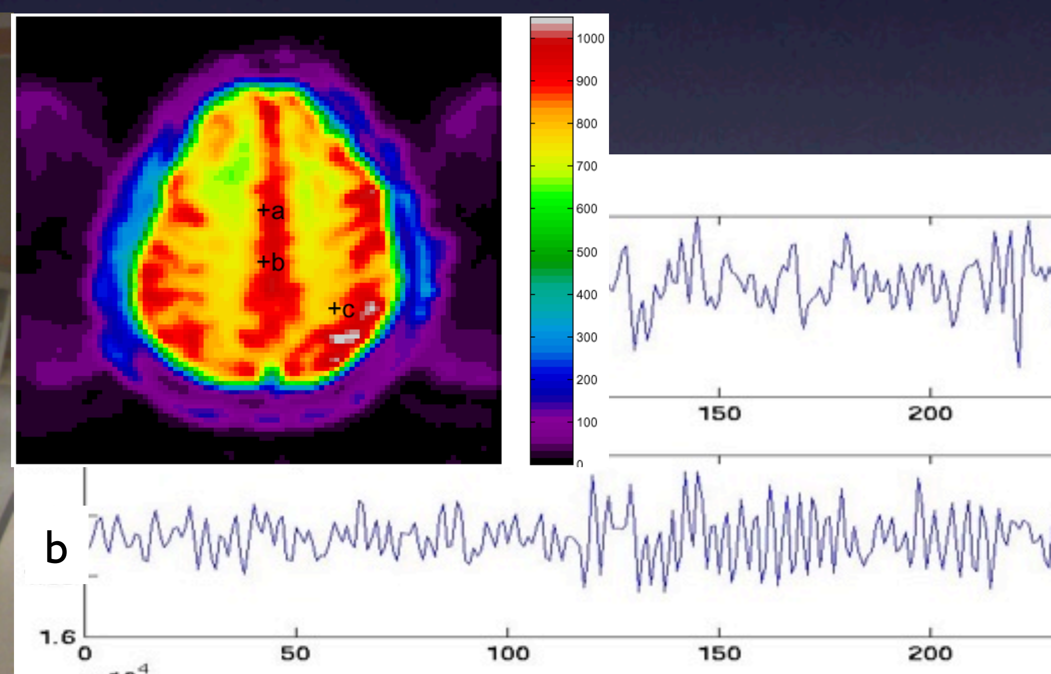
Twin functional-MRI study

11 monozygotic (MZ) twins

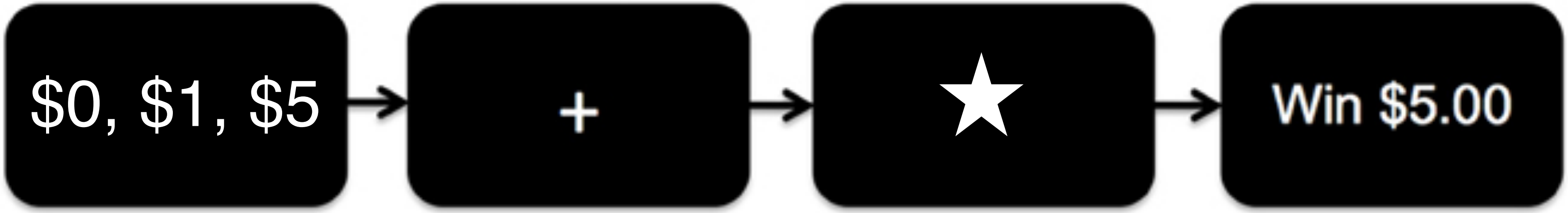
14 dizygotic (DZ) twins

- 9 same-sex DZ pairs (5 male, 4 female)
- 5 different-sex DZ pairs



Paired statistical contrast images

Monetary incentive delay task



3 runs of 40 trials

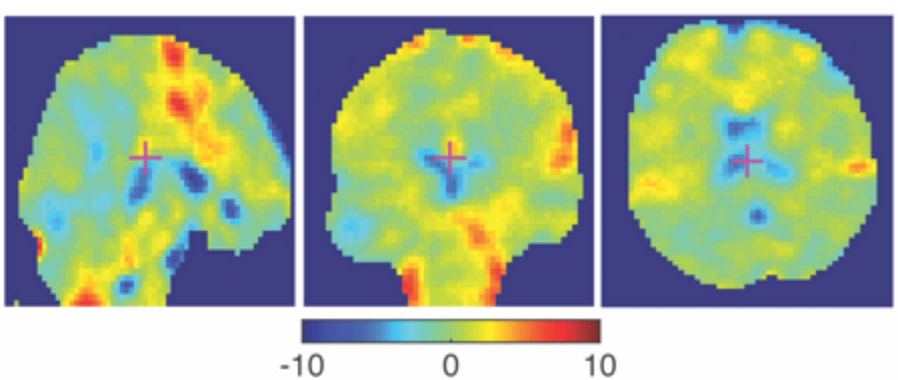
delay for $0 trials
delay for $1 trials
delay for $5 trials

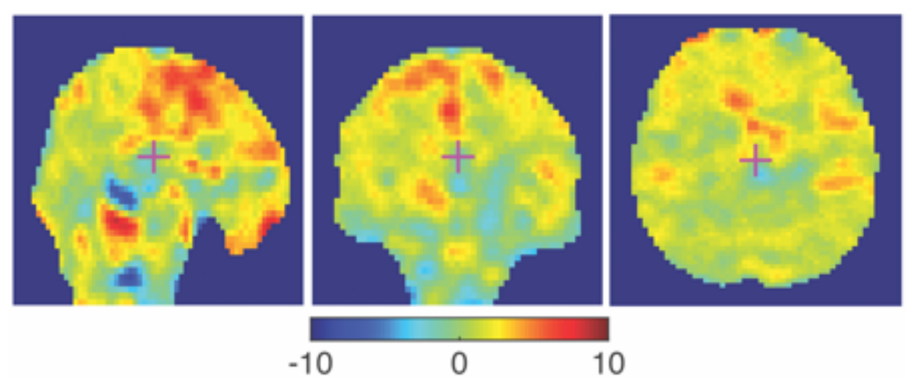
c

General Linear Model

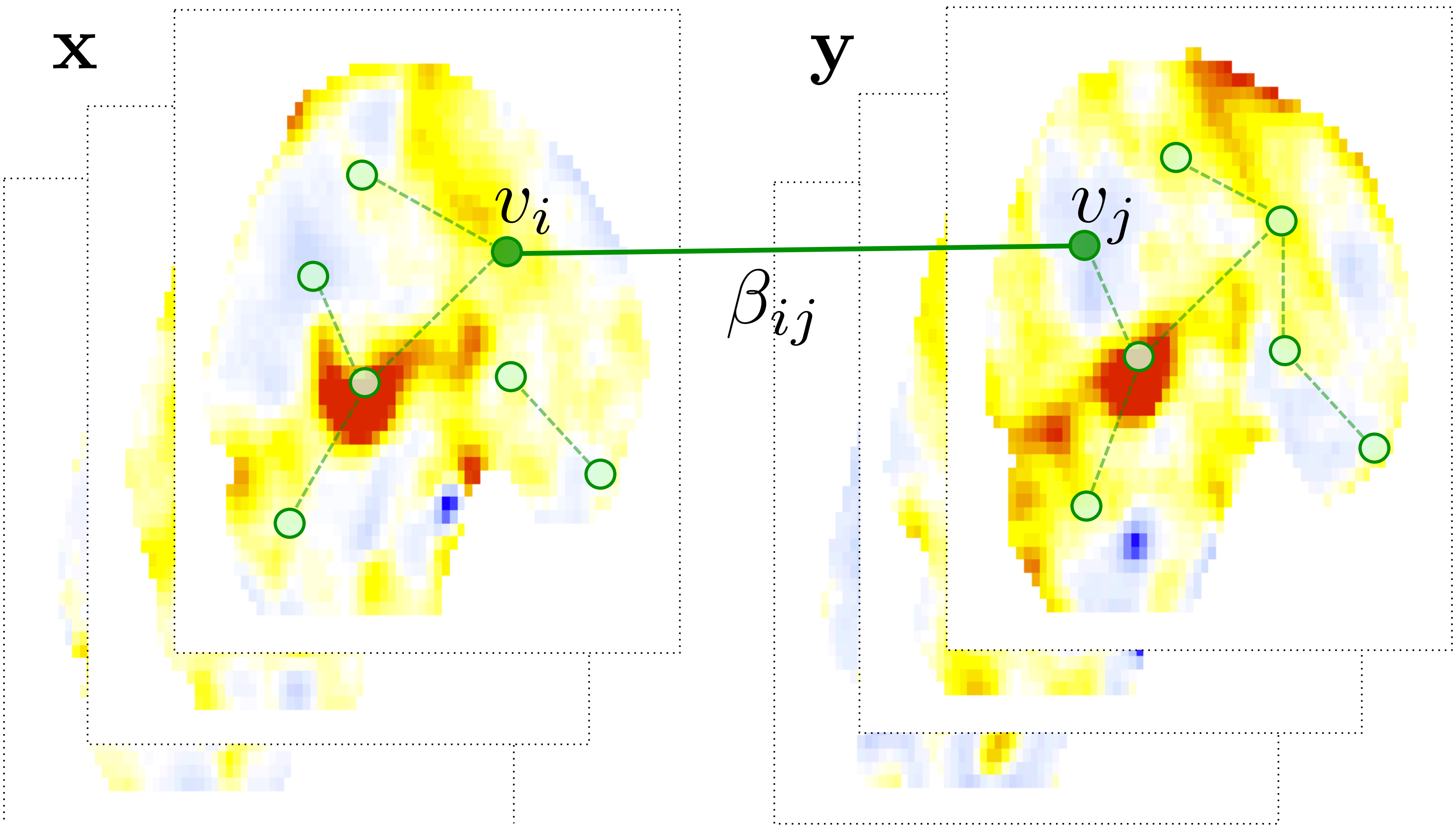
$$W(v_i) = Zb(v_i) + \varepsilon(v_i)$$

$$c^T b(v_i)$$ Contrast map



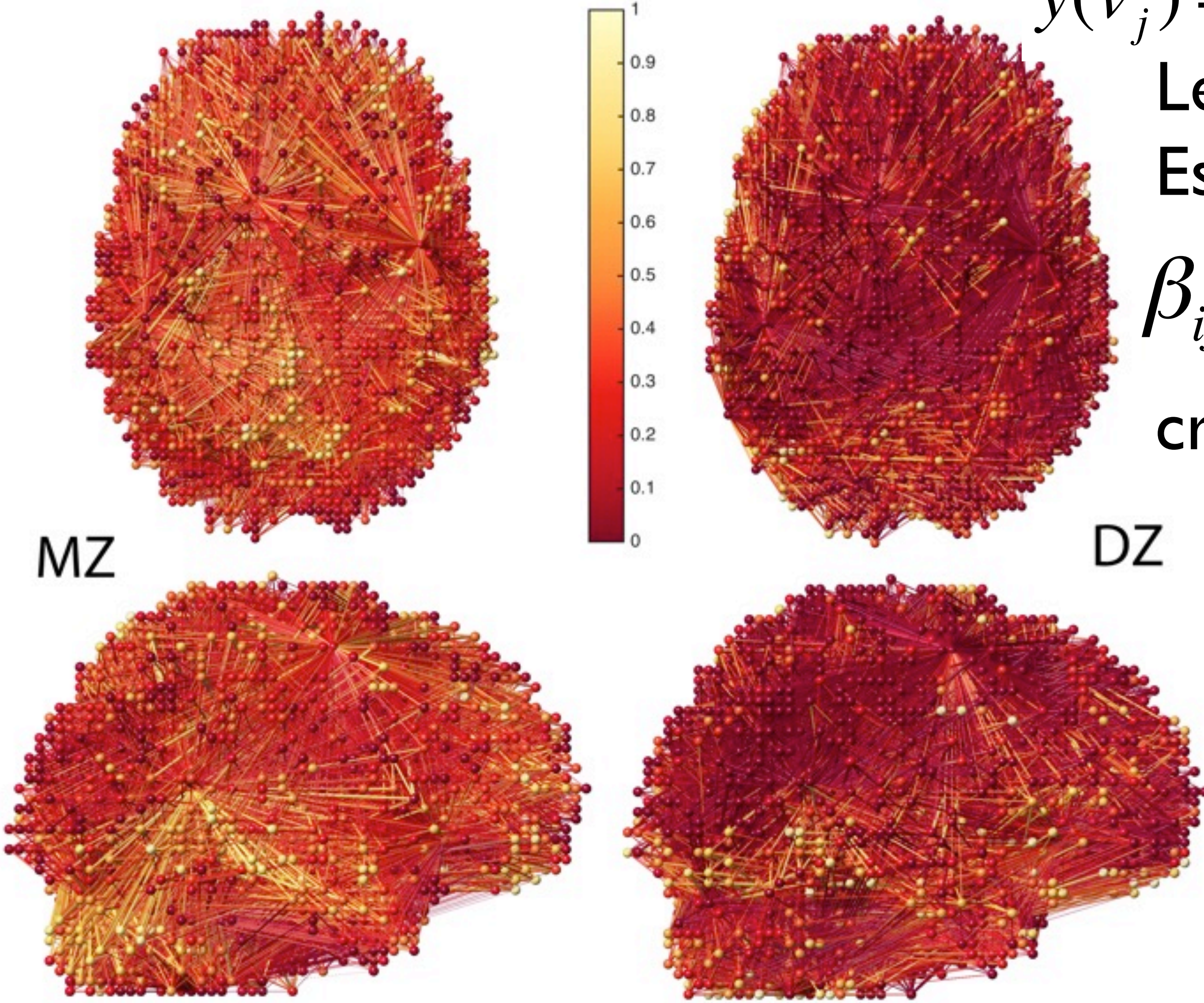


Hyper-network across paired images



$$y(v_j) = \sum_{i=1}^{p} \beta_{ij} x(v_i) + e(v_j) \dashrightarrow y(v_j) = \beta_{ij} x(v_i) + e(v_j)$$

Dense connections



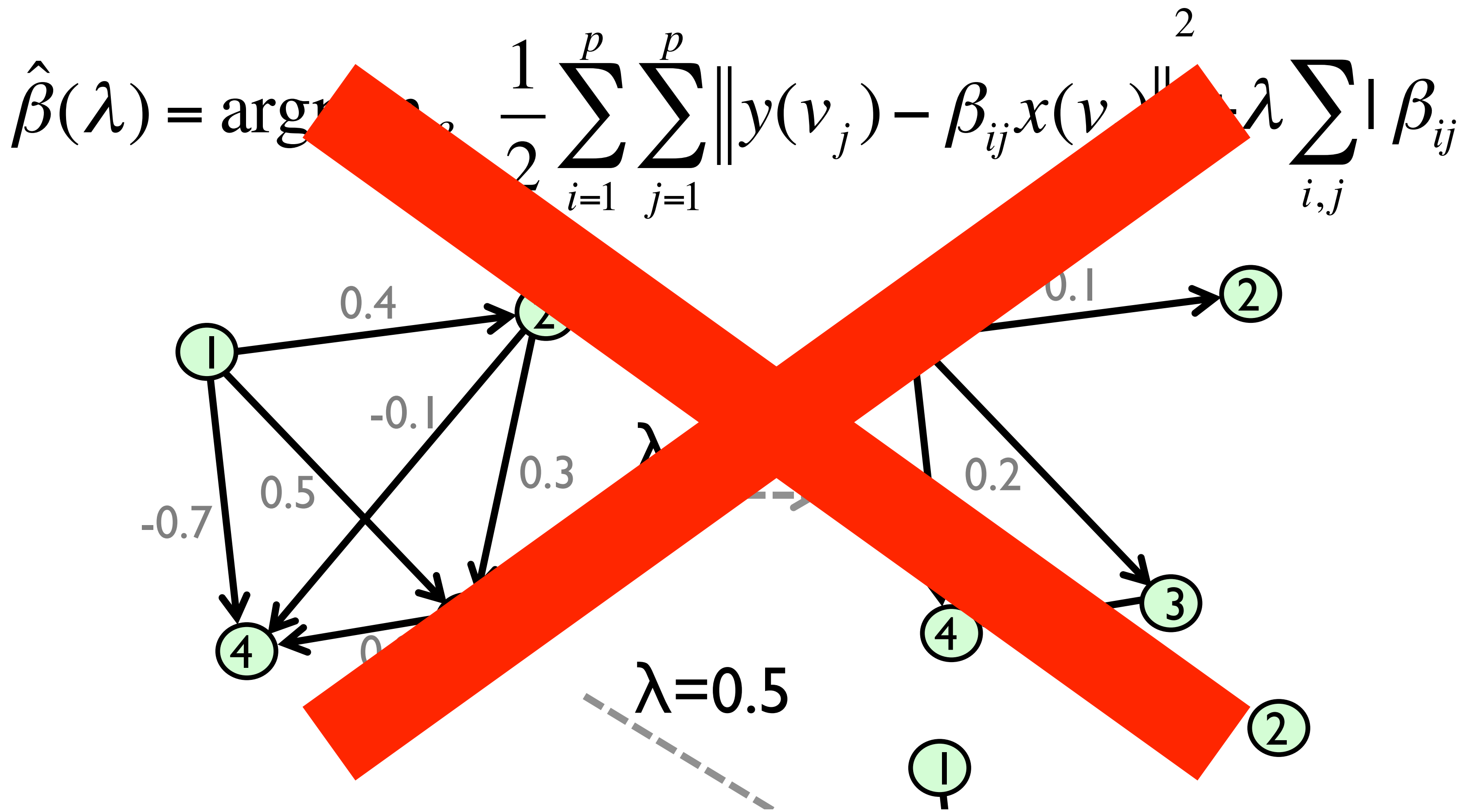
$$y(v_j) = \beta_{ij} x(v_i) + e(v_j)$$

Least squares
Estimation

$$\beta_{ij} = x'(v_i) y(v_j)$$

cross-correlation

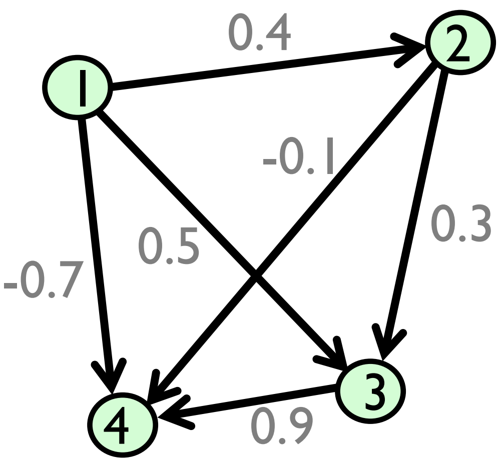
Sparse network model



NOT A GOOD APPROACH!

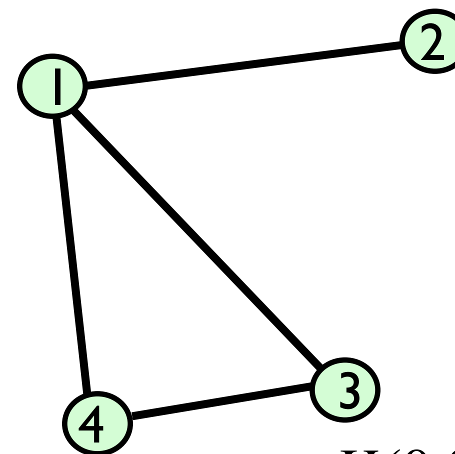
Sparse network + persistent homology

$$\hat{\beta} = \operatorname{argmin}_{\beta} \ \frac{1}{2} \sum_{i=1}^{p} \sum_{j=1}^{p} \left\| x(v_i) - \beta_{ij} y(v_j) \right\|^2 + \lambda \sum_{i,j} |\beta_{ij}|$$



Soft thresholding

$$edge = \begin{cases} 1 \text{ if } |x'(v_i) y(v_j)| > \lambda \\ 0 \text{ otherwise} \end{cases}$$



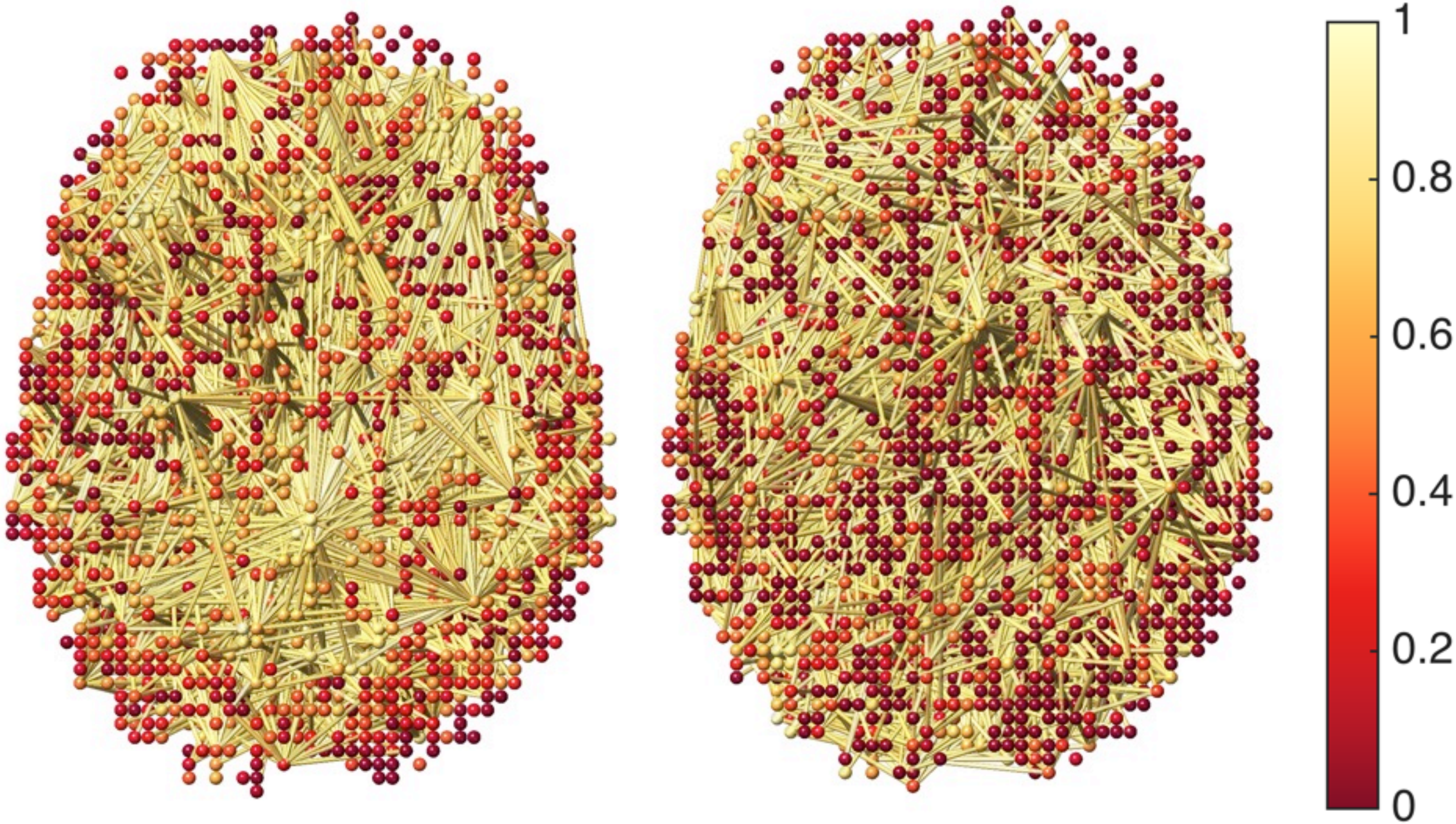
$H(0.3)$

$$H(\lambda_1) \supset H(\lambda_2) \supset H(\lambda_3) \supset \cdots$$

for $\lambda_1 \leq \lambda_2 \leq \lambda_3 \leq \cdots$

Chung et al. 2015 IEEE Trans. on Medical Imaging 34:1928-1939

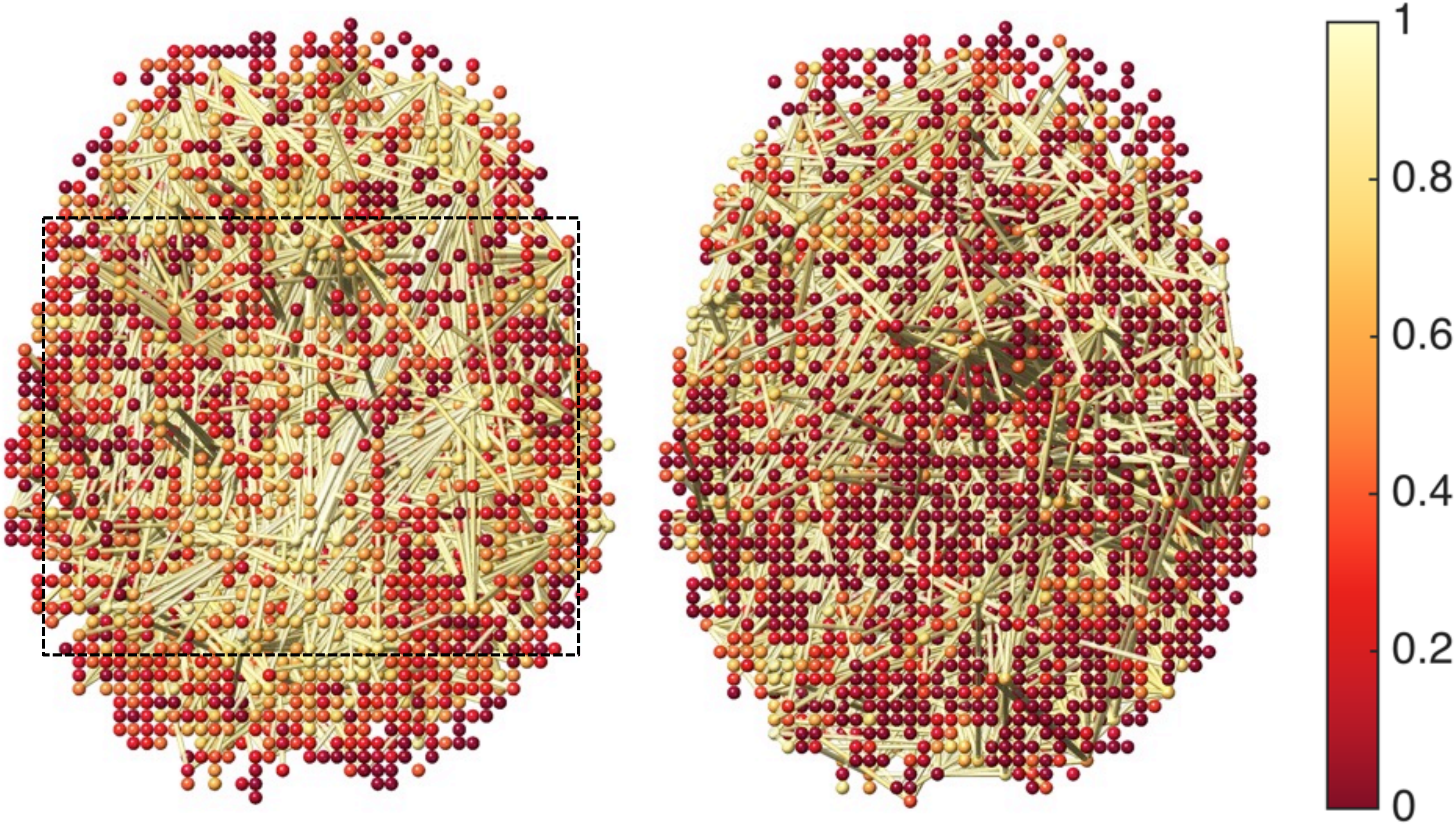
Networks at sparse parameter 0.7



MZ-twins

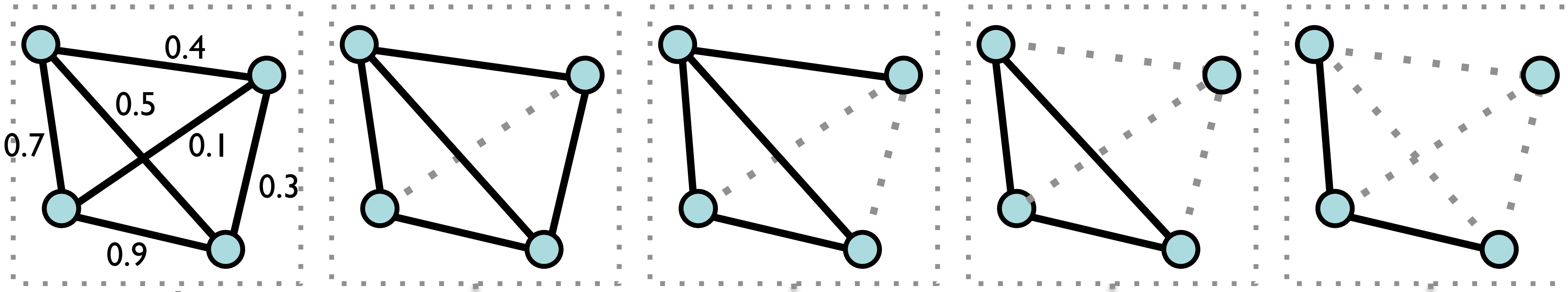
DZ-twins

Networks at sparse parameter 0.8

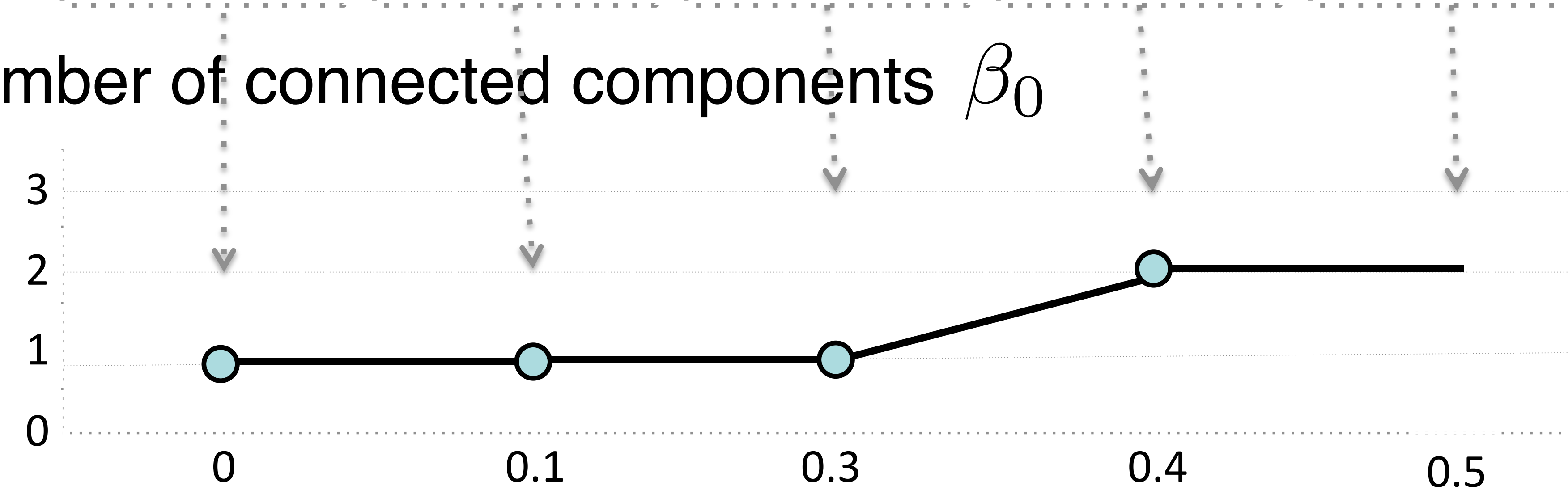


MZ-twins DZ-twins

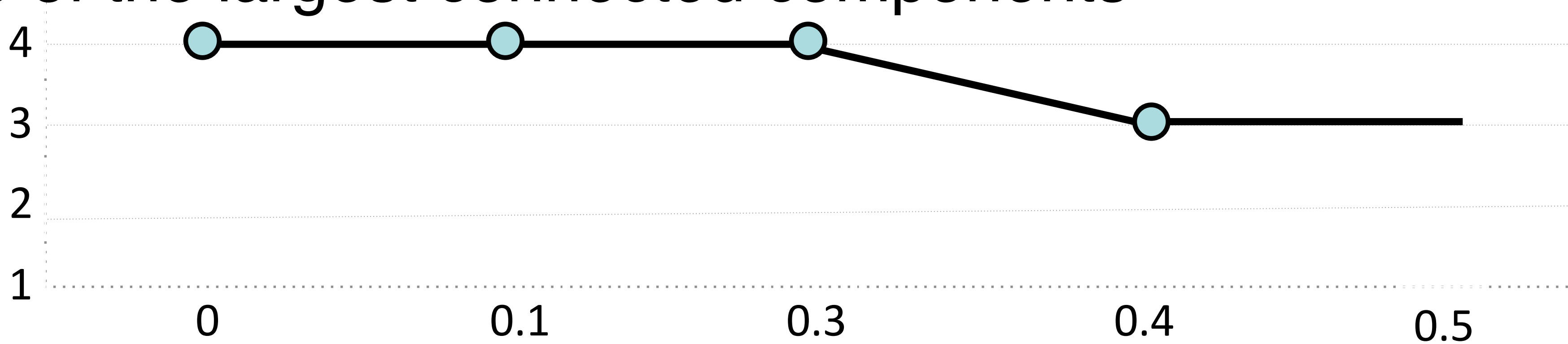
Persistent Homology



Number of connected components β_0

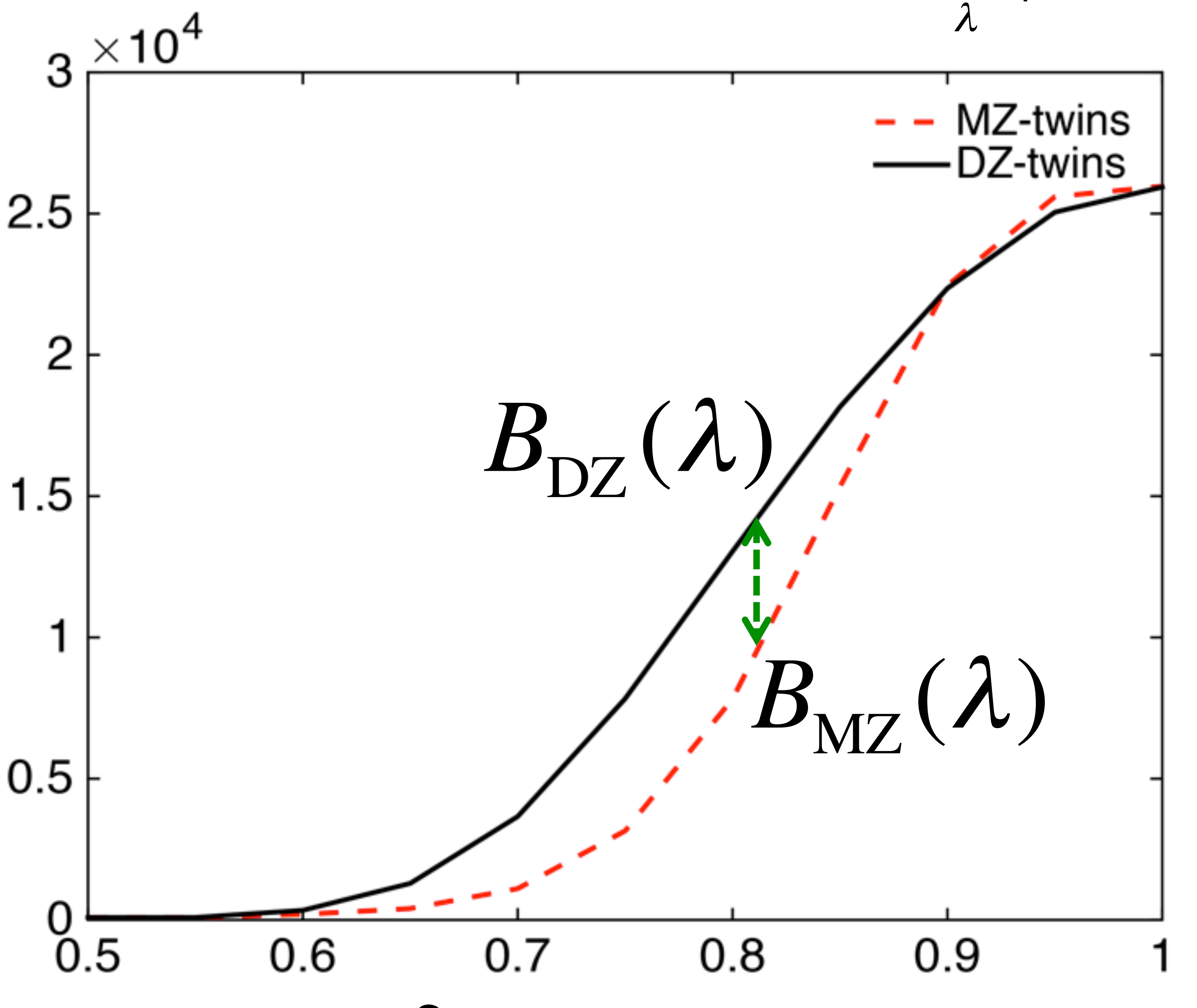


Size of the largest connected components



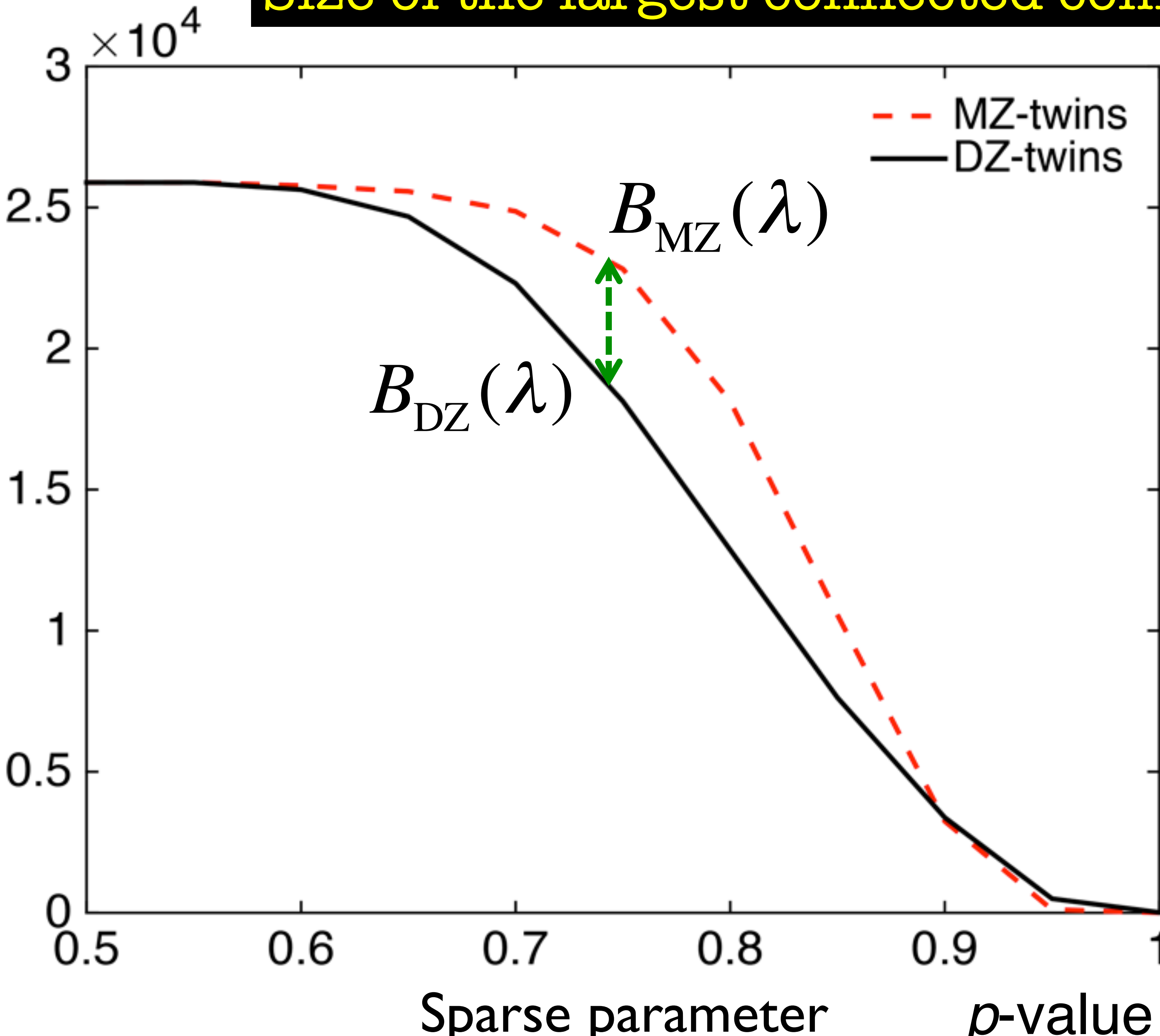
Distance between networks

$$\sup_{\lambda} \left| B_{\mathrm{MZ}}(\lambda) - B_{DZ}(\lambda) \right|$$



p-value < 0.0002

Size of the largest connected components

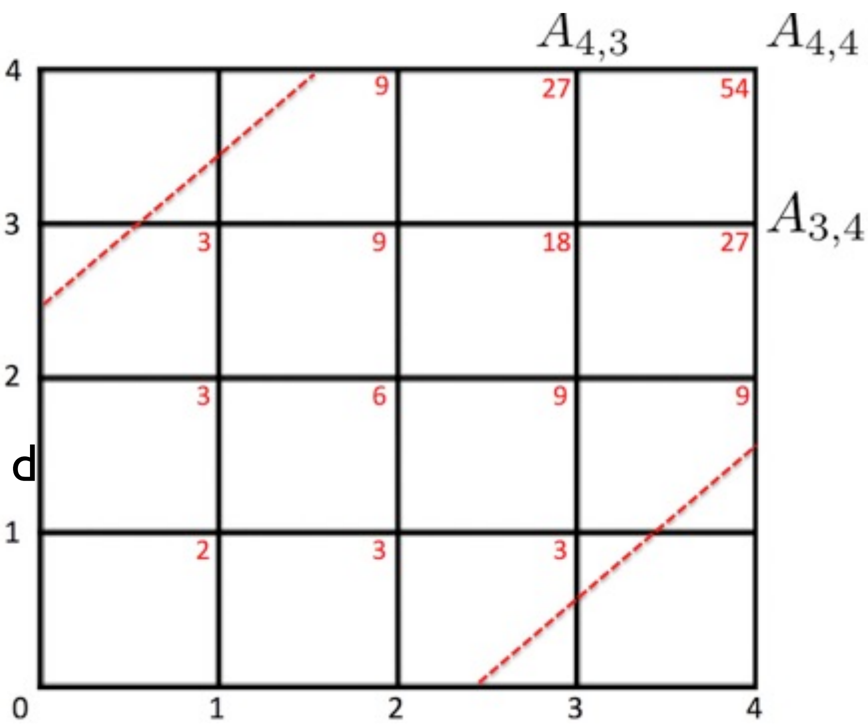


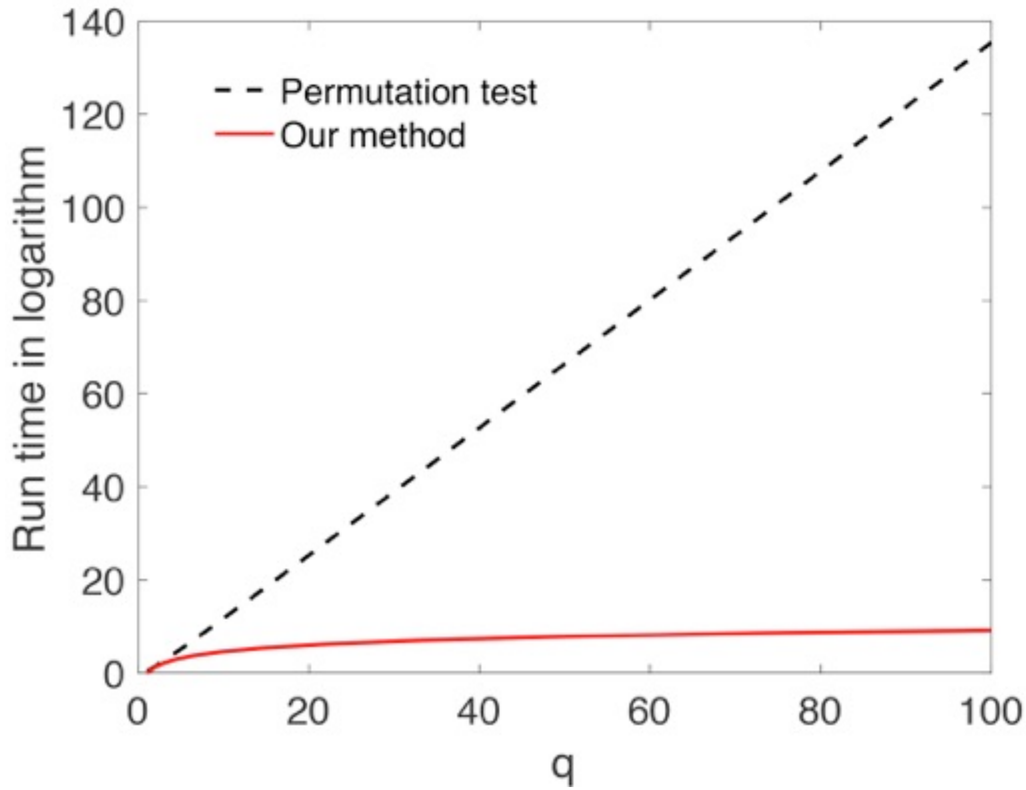
p-value < 0.0001

Exact permutation test

$$P\left(\sup_{1\le j\le q}\left|\beta_0^1(\lambda_j)-\beta_0^2(\lambda_j)\right|>d\right)=1-\frac{A_{q,q}}{\binom{2q}{q}}$$

$$A_{u,v}=A_{u-1,v}+A_{u,v-1}\quad |u-v|<d$$





Chung et al. 2017 Information Processing in Medical Imaging (IPMI)

ACE model for twins

MZ-twins share 100% of genes
DZ-twins share 50% of genes

$$\rho_{\mathrm{MZ}} = A + C$$

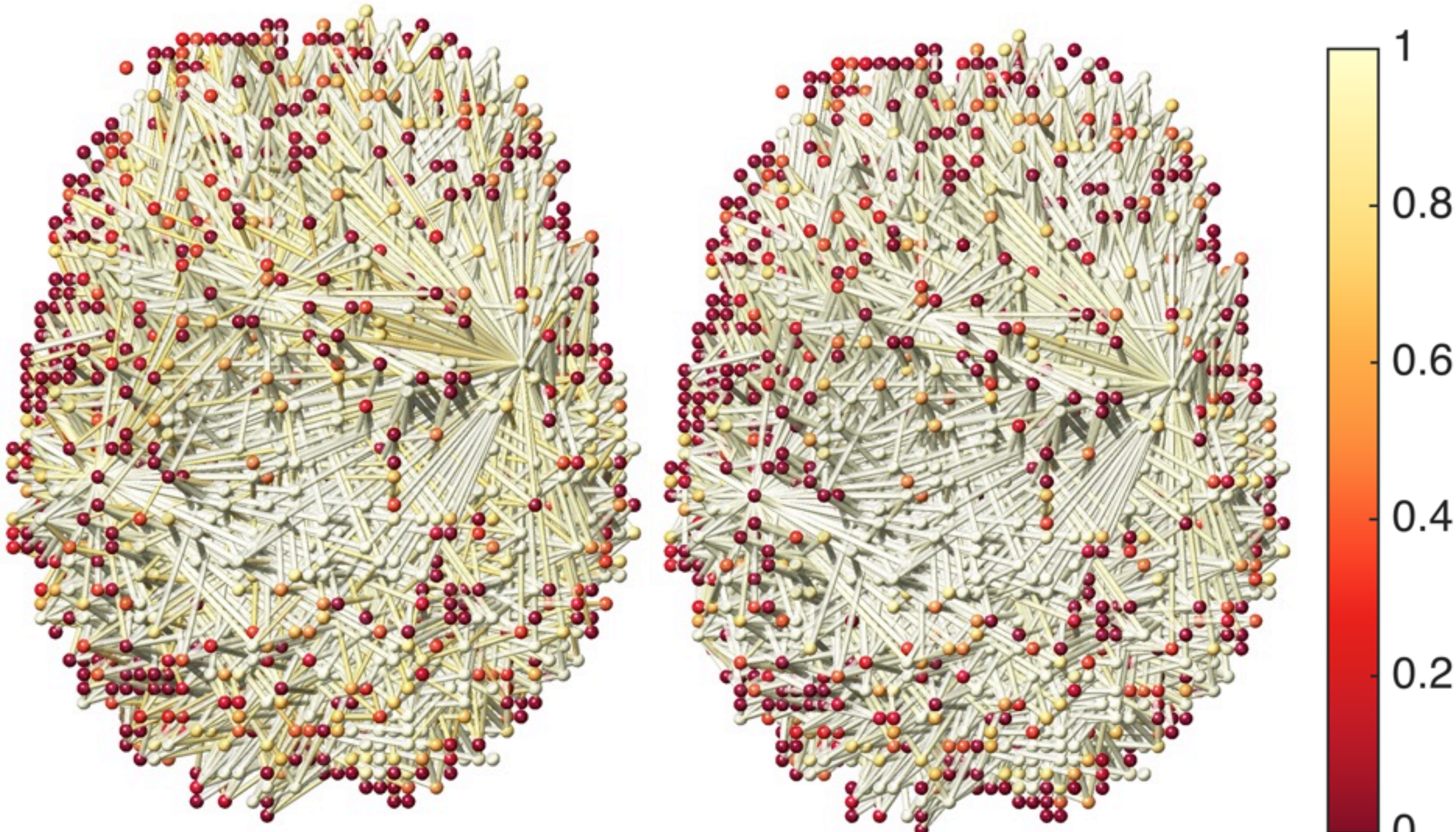
Additive genetics   Common environment

$$\rho_{\mathrm{DZ}} = A/2 + C$$

Falconer's formula for heritability index (HI)

$$\mathrm{HI} = A = 2(\rho_{\mathrm{MZ}} - \rho_{\mathrm{DZ}})$$

Heritability Index (both nodes and edges)



Sparse parameter 0.7 Sparse parameter 0.9

p-value < 0.0002

Thank you

MATLAB codes
google
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Looking for postdoc. Send inquiry to
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