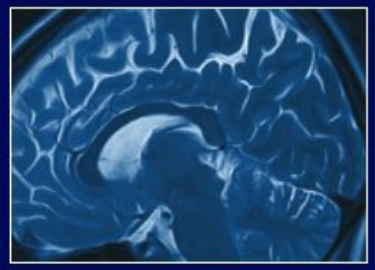

The Waisman Laboratory
for Brain Imaging and Behavior

University of Wisconsin
SCHOOL OF MEDICINE
AND PUBLIC HEALTH

Boosting Network Signals

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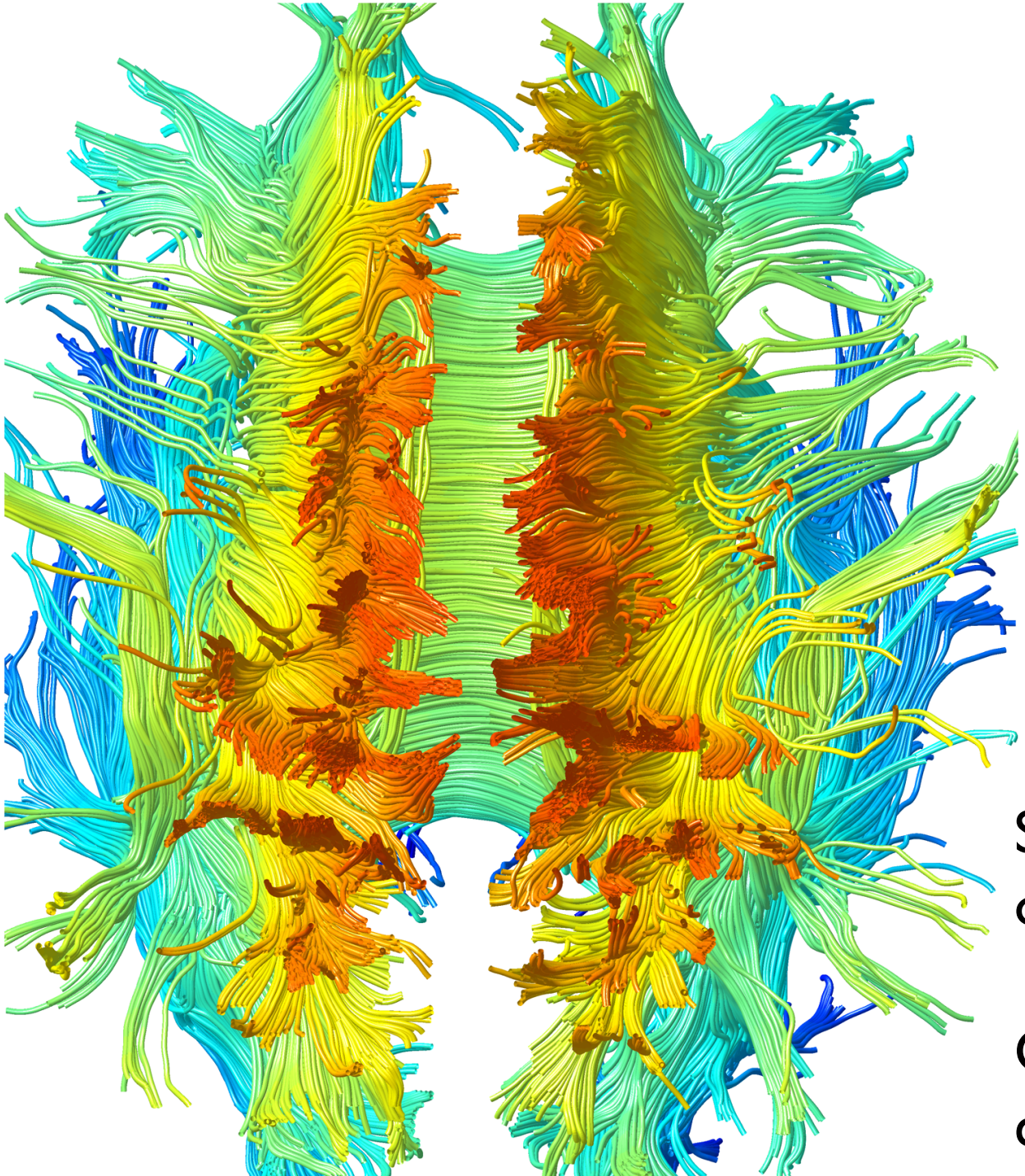
We will show two techniques for boosting brain network signals.

DTI study on maltreated children

- 3T DTI: 2 x 2 x 3 mm resolution
- 23 maltreated children who have been post-institutionalized in orphanages but later adopted in WI.
- Age-matched 31 normal control subjects.
- Age distribution

  Maltreated : 11.26 ± 1.71 years
  Controls : 11.58 ± 1.61 years

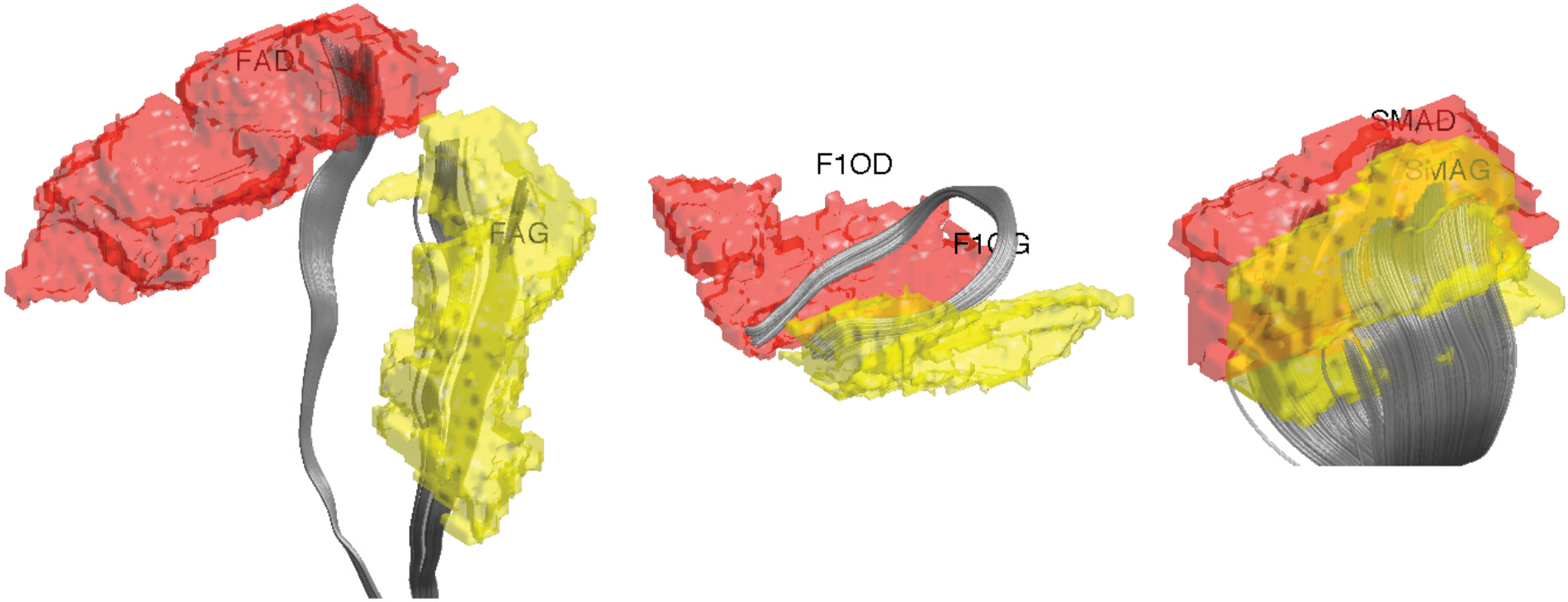


CAMINO-based tractography

Showing 3000 tracts out of 10000 tracts

Outlying tracts are culled.

AAL parcellation with 116 tracts

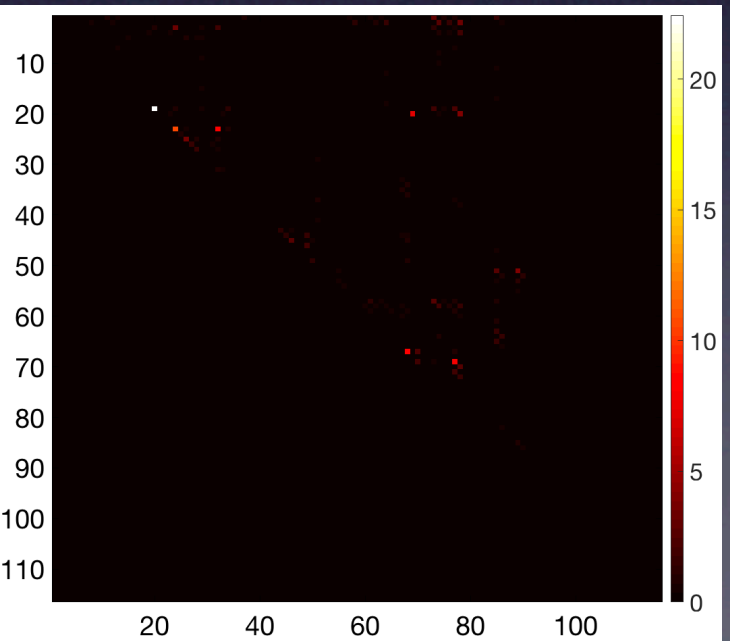


Tract count is used as the measure of connectivity.

Difficulty of detecting network signals

Node level analysis
pvalue 0.05/116 = 0.00043

Mean connectivity
Based on tract count



Network
116*115/2 = 6670 connections
pvalue = 0.05/6670= 0.00000075

In DTI, 1813 connections
pvalue 0.05/1813 = 0.0000275

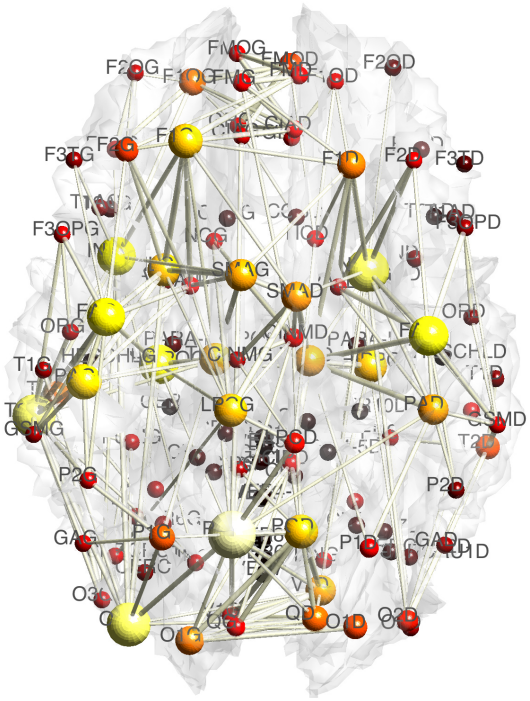
16 times more difficult!

Node level analysis

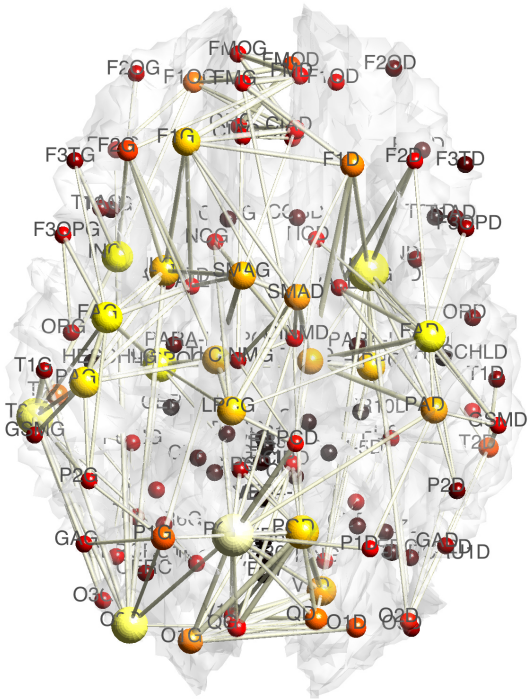
116 comparisons
→ 1 comparison

Average node degrees

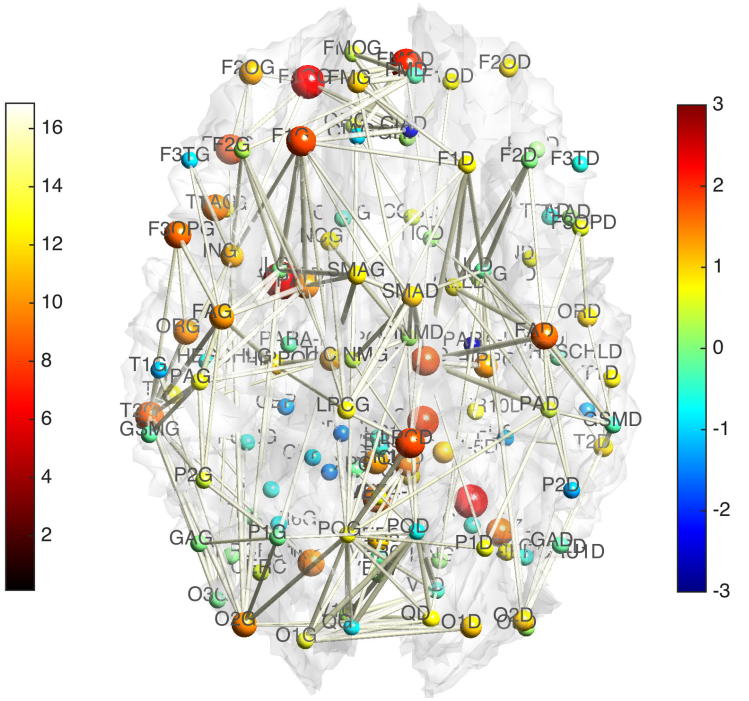
Controls - Maltreated



A. Controls



B. Maltreated



C. T-stat.

t-stat 2.95 (pvalue = 0.0048)
t-stat -2.08 (pavlue = 0.0423)

Solution

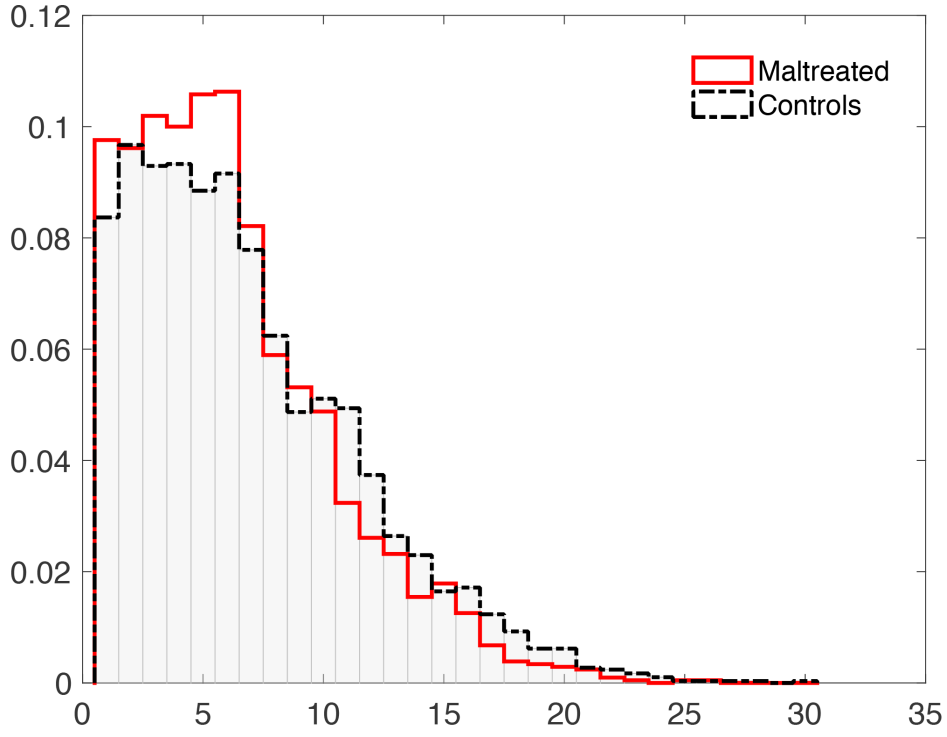
Must reduce the number of comparisons

How? Graph theory features

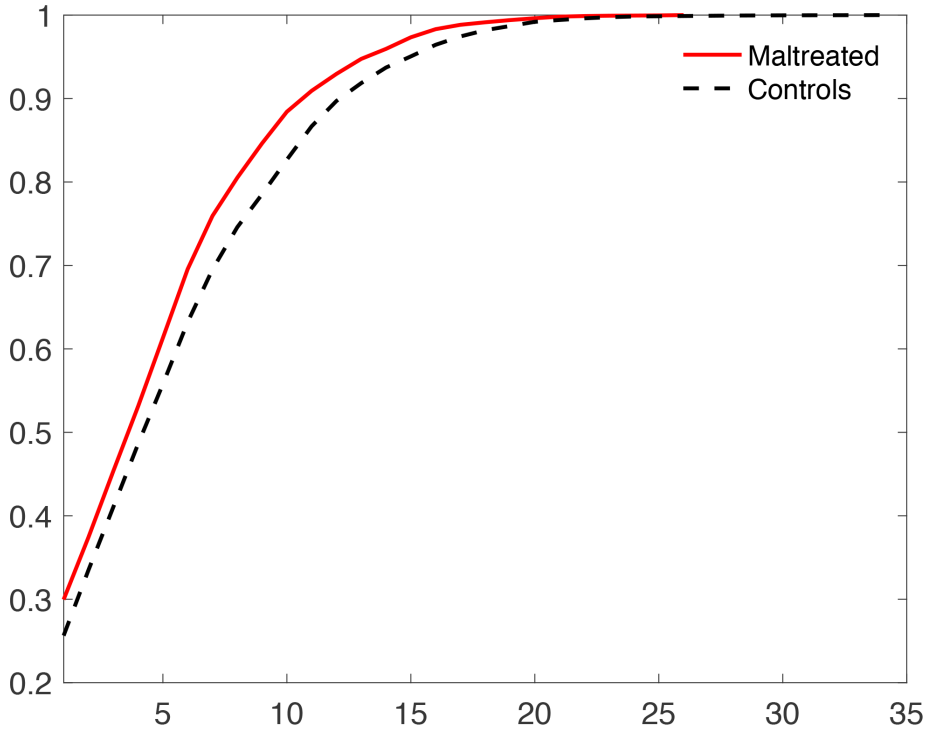
Node degree: number of connections at node

1813 parameters to 116 parameters

Parametric model on degree distribution



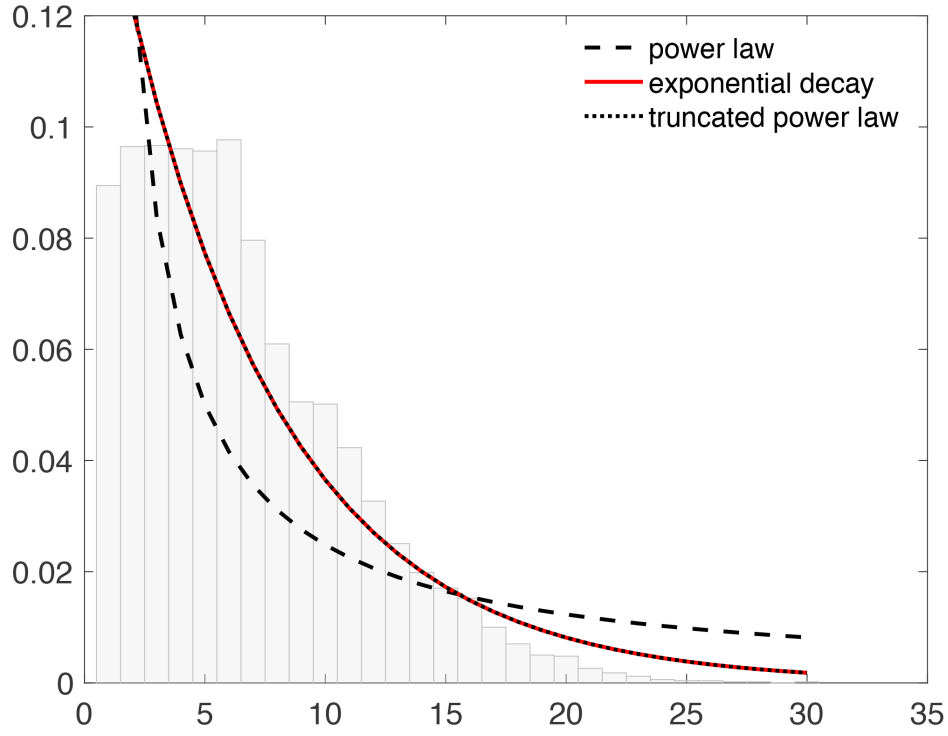
A. Degree distributions



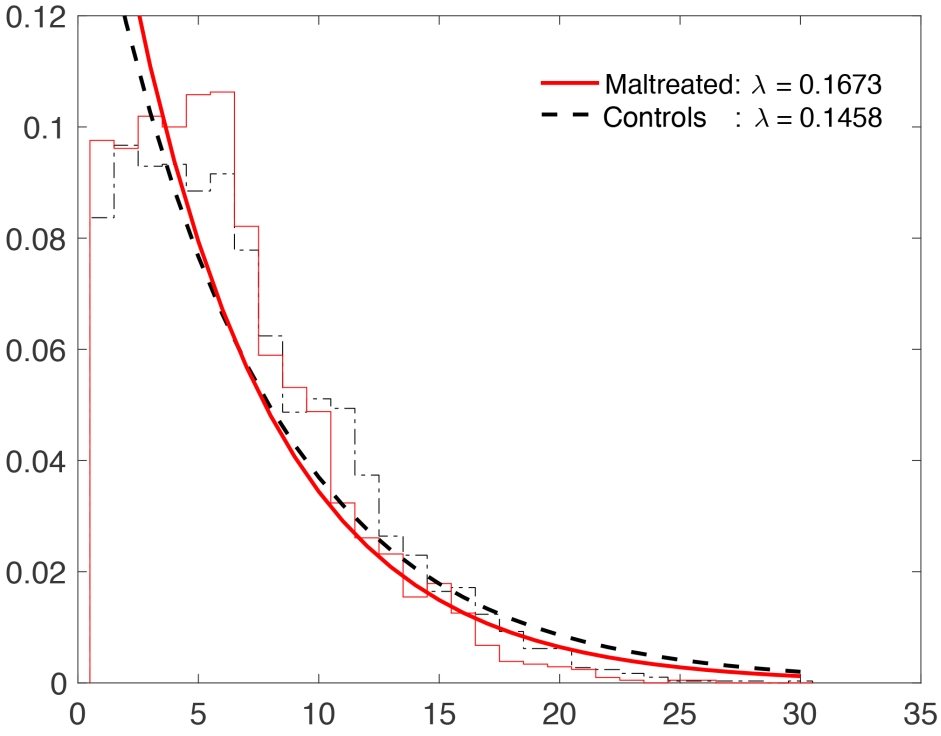
B. Cumulatitive distributions

Brain network is not scale-free
Follows exponential decay

$$P(k) \sim e^{-\lambda k}$$



C. Parametric models



D. Exponential decay

Result based on 4 decimal accuracy

Gong et al. (2009) and Zalesky et al. (2010) reported the truncated power law:

$$P(k) \sim k^{-\gamma} e^{-\lambda k}$$

The statistical logic in the paper is incorrect.

Hub nodes

Label	Parcellation Name	Combined	Controls	Maltreated
PQG	Precuneus-L	16.11	16.87	15.09
NLD	Putamen-R	14.96	15.26	14.57
O2G	Occipital-Mid-L	14.44	15.52	13.00
T2G	Temporal-Mid-L	14.30	15.16	13.13
HIPPOG	Hippocampus-L	13.15	13.94	12.09
FAD	Precentral-R	12.85	14.00	11.30
ING	Insula-L	12.56	13.61	11.13
FAG	Precentral-L	12.43	13.45	11.04
PQD	Precuneus-R	12.00	12.03	11.96
PAG	Postcentral-L	11.89	12.52	11.04
NLG	Putamen-L	11.39	11.68	11.00
F1G	Frontal-Sup-L	11.22	12.13	10.00
HIPPOD	Hippocampus-R	11.15	11.90	10.13

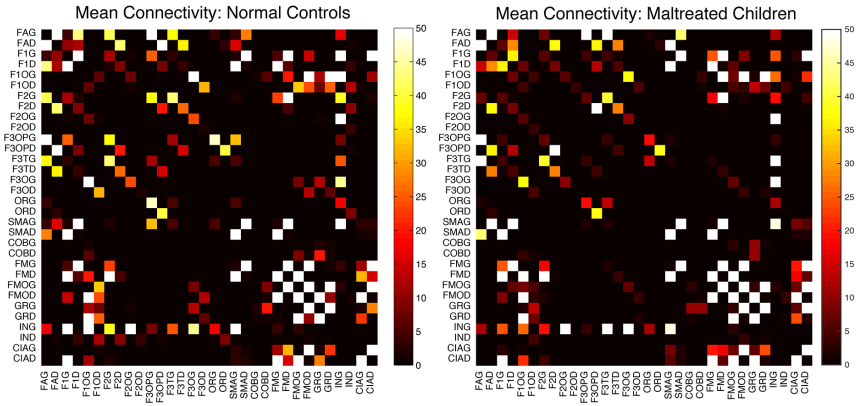
Probability of this happening? $2^{-13} = 0.00012$

Edge level analysis

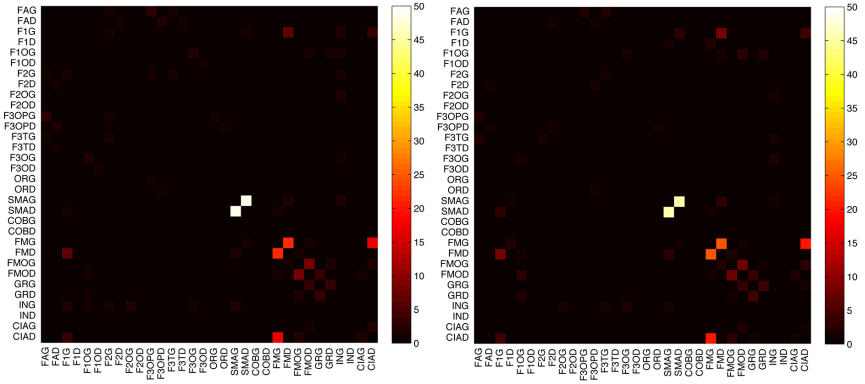
1813 comparisons x
3 connectivity maps

→ 1813 comparisons

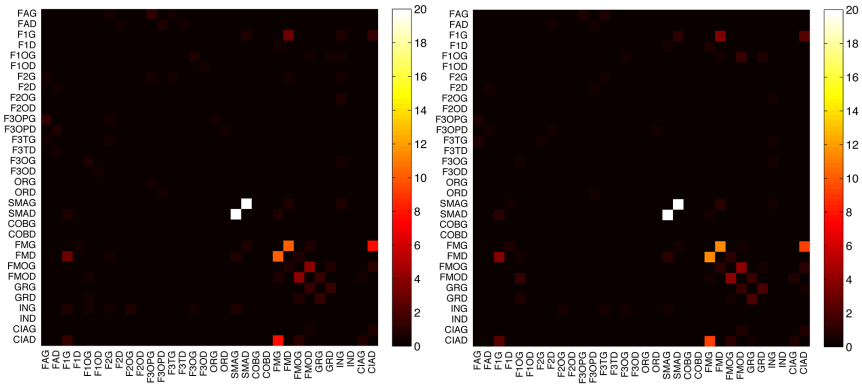
Three different connectivity measures



Tract count



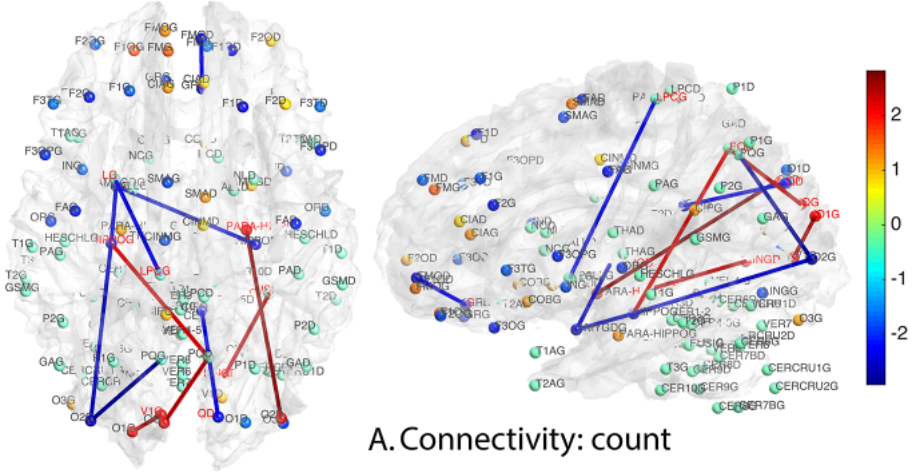
length-based model



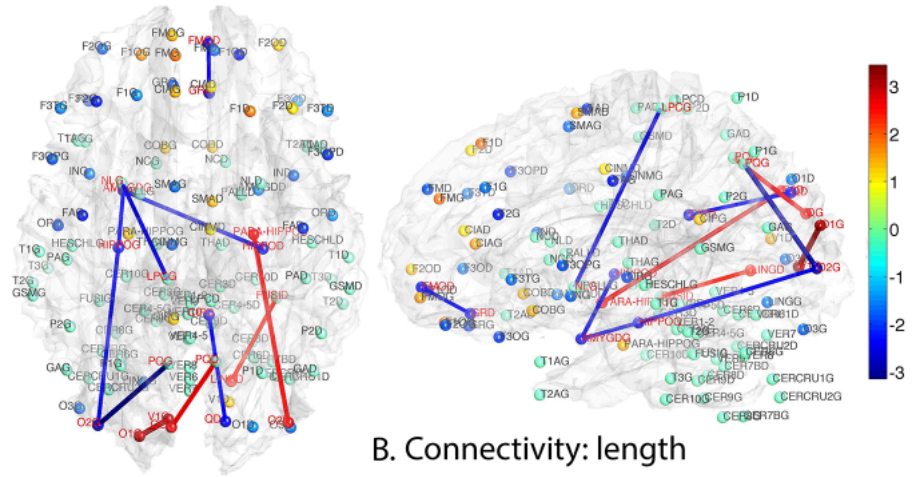
length-based Model + FA

Controls

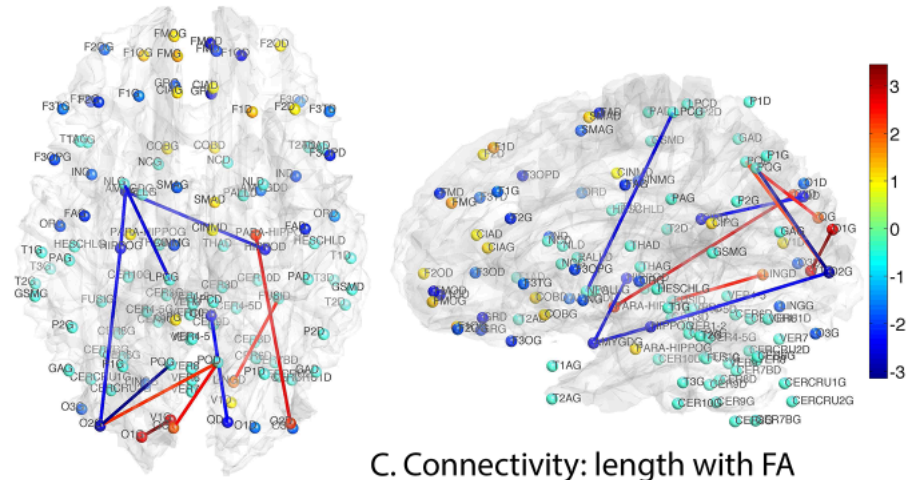
Maltreated



A. Connectivity: count



B. Connectivity: length



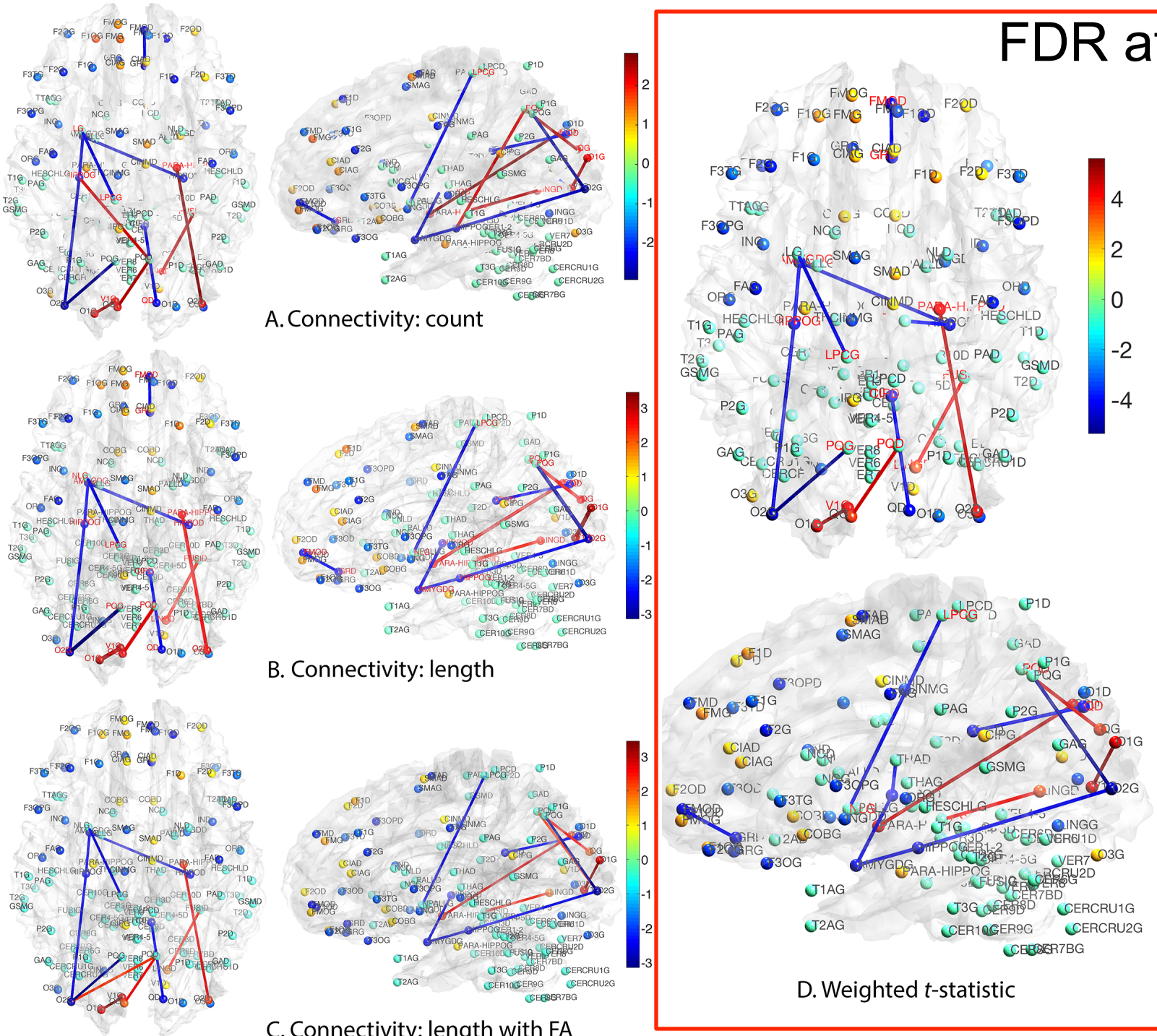
C. Connectivity: length with FA

Three similar t-statistics maps without statistical significance

None of edges are significant at FDR 0.05 level

Meta-analytic aggregation
Weighted t-statistics

$$T = \frac{w_1 t^1 + \cdots + w_n t^n}{\sqrt{w_1^2 + \cdots + w_n^2}} \sim N(0,1)$$


FDR at 0.05
A. Connectivity: count
B. Connectivity: length
C. Connectivity: length with FA
D. Weighted t-statistic

Significant nodes at FDR at 0.05

max. t-stat. = 5.59
(p-value =1.11 x 10^{-8})

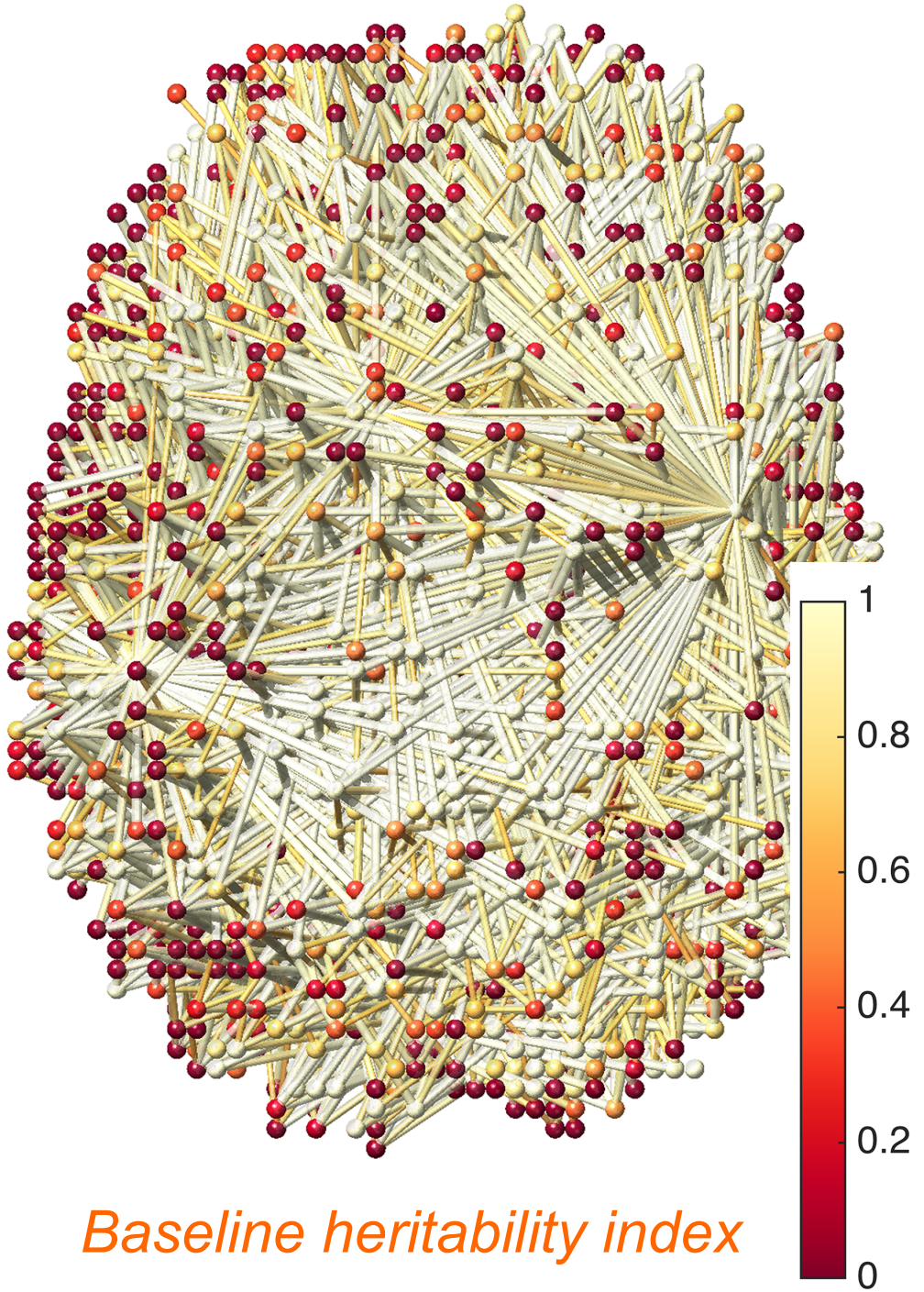
min. t-stat. = -5.34
(p-value= 4.55 x 10^{-8})

Label	Parcellation Name
FMOD	Frontal-Med-Orb-R
GRD	Rectus-R
CIPD	Cingulum-Post-R
HIPPOG	Hippocampus-L
HIPPOD	Hippocampus-R
PARA-HIPPOD	ParaHippocampal-R
AMYGDG	Amygdala-L
V1G	Calcarine-L
QG	Cuneus-L
QD	Cuneus-R
LINGD	Lingual-R
O1G	Occipital-Sup-L
O2G	Occipital-Mid-L
O2D	Occipital-Mid-R
FUSID	Fusiform-R
PQG	Precuneus-L
PQD	Precuneus-R
LPCG	Paracentral-Lobule-L
NLG	Putamen-L
THAD	Thalamus-R

Postdoctoral positions

Multimodal (MRI/DTI/fMRI) twin brain network study

200 twin pairs



Baseline heritability index