



Indiana University  
**Network Science Institute**

# Topological summaries for the analysis of neuroimaging datasets

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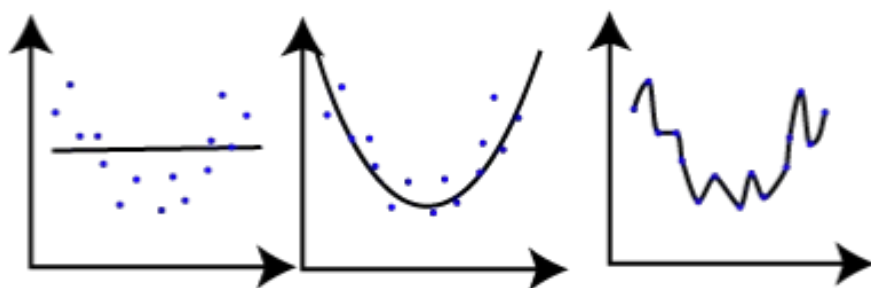


# What is shape?

Shape for data translation

You might have performed shape analysis before, and did not know.

All these examples become too complicated to handle in **high-dimension**



Healthy

Severe AD

<http://www.nlm.nih.gov/medlineplus/magazine/index.html>



TAKENS EMBEDDING

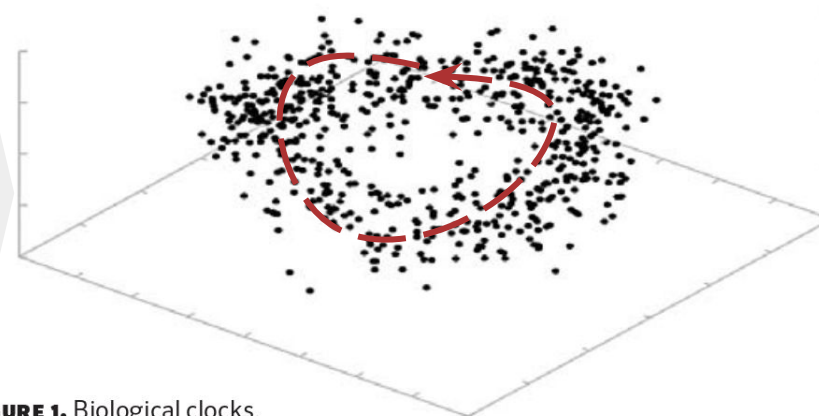


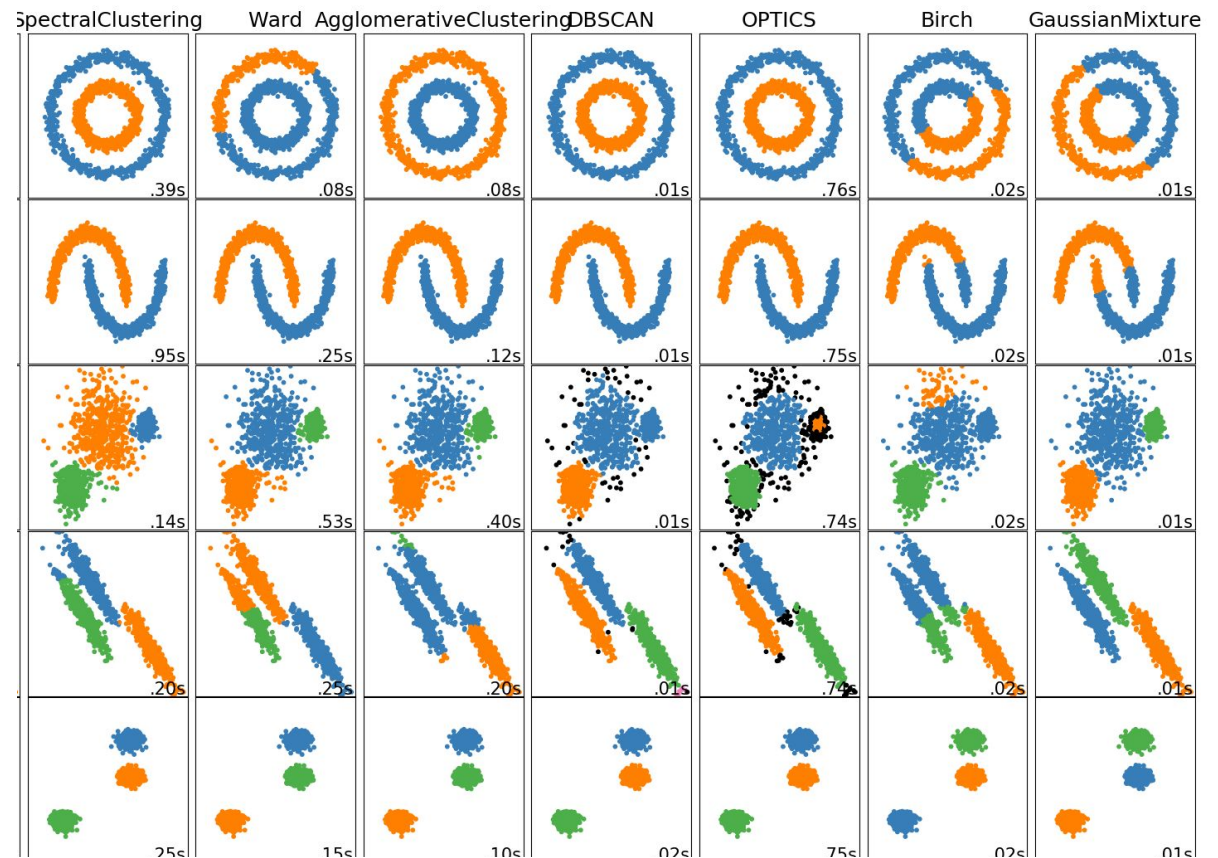
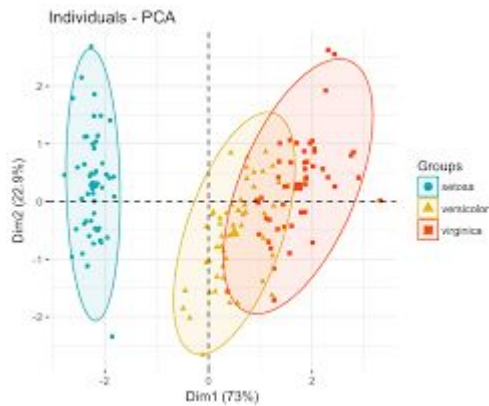
FIGURE 1. Biological clocks.



# What is shape?

What to do in high-dimension?

We project and we cluster

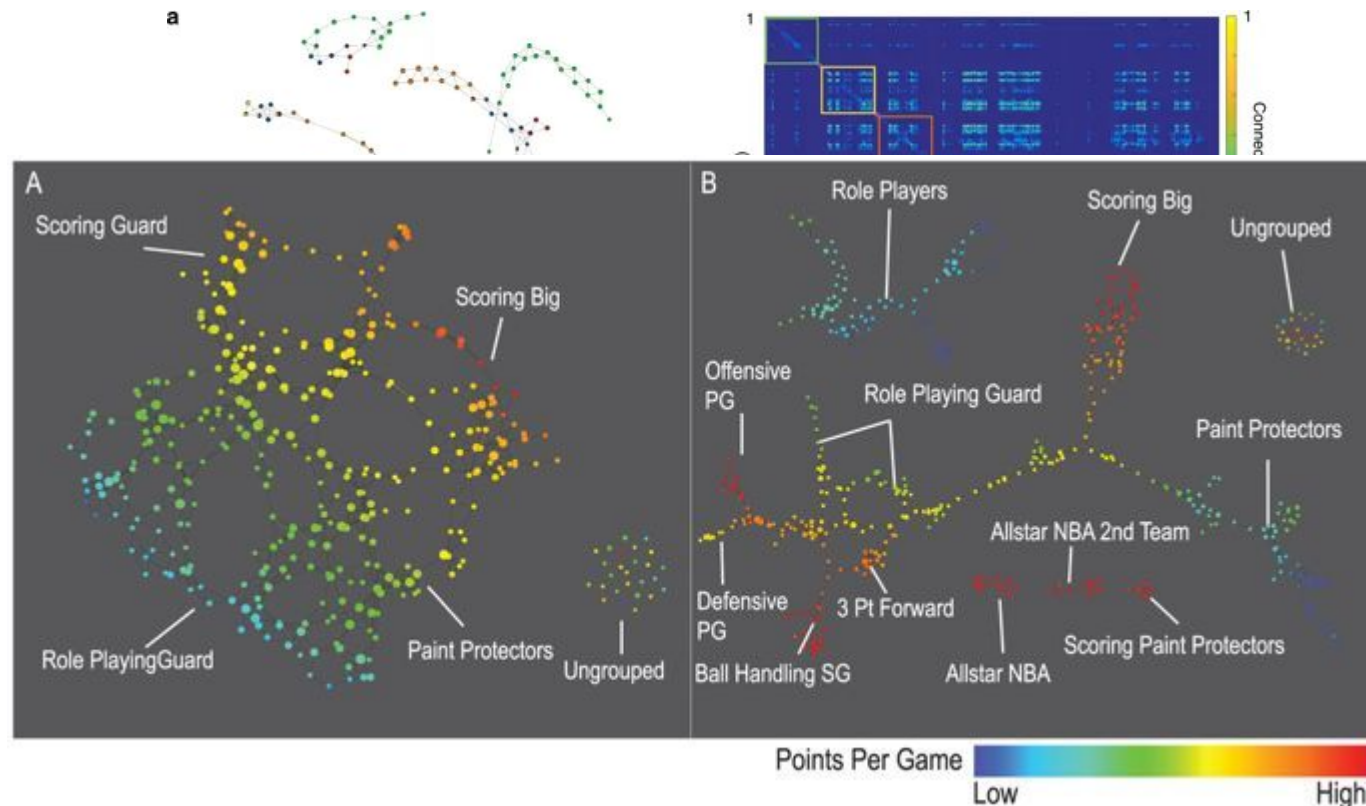


Sklearn comparison of clustering techniques

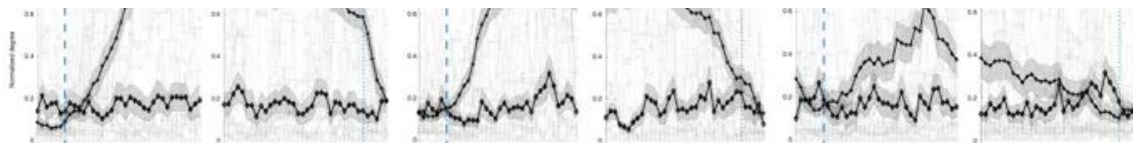


# What is shape?

Low dimensional skeleton representing the shape of a dataset

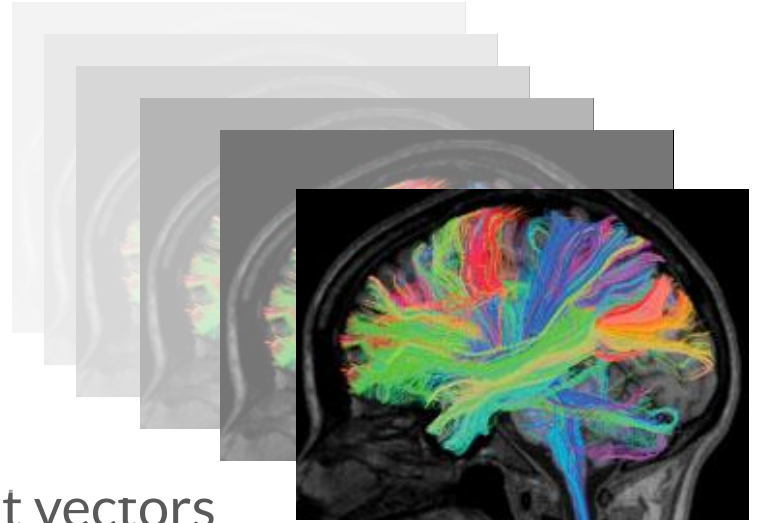


P. Y. Lum, et al., Extracting insights from the shape of complex data using topology, *Sci. Rep.*, 3 (2013)



Saggar, Manish, et al. "Towards a new approach to reveal dynamical organization of the brain using topological data analysis." *Nature communications* 9.1 (2018): 1399.

## Our idea

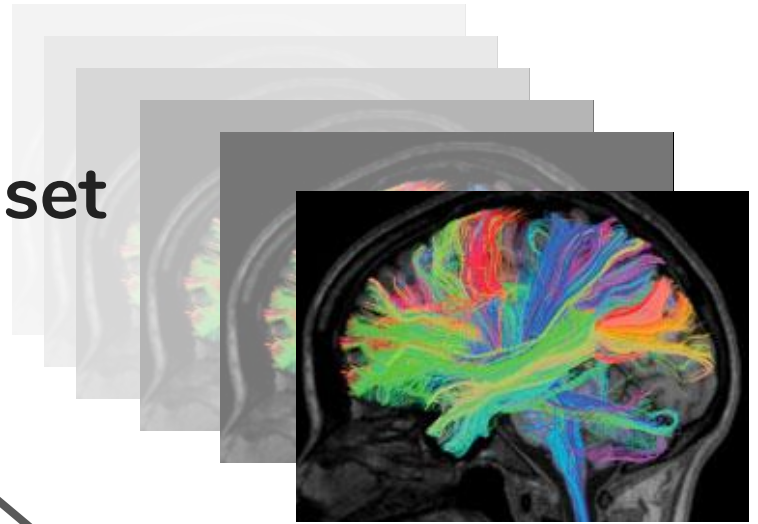


- Use neuroimages/brain networks as input vectors
- Describe the entire dataset with a single graph encoding similarity pattern in its shape
- Study the effect of a variable on the way the shape is arranged

**It is an exploratory analysis that tries to go beyond similarity matrices**



# The Nathan Kline Institute data set



7 y.o.

The enhanced Nathan Kline Institute-Rockland Sample (NKI-RS) is an ongoing, institutionally centered endeavor aimed at creating a large-scale ( $N > 1000$ ) community sample of **participants across the human lifespan**.

85 y.o.

Our data was generated from 620 human subjects (63% female) Both T1-weighted (T1w) and diffusion (dMRI) images were collected, with which ~~we~~ generated streamline **tractography** in the MNI space.

~~Josh~~

~~Josh~~ We constructed streamline count adjacency matrices by counting the **number of streamlines** that terminated in each region of interest (ROI) of the **Yeo network parcellation**.

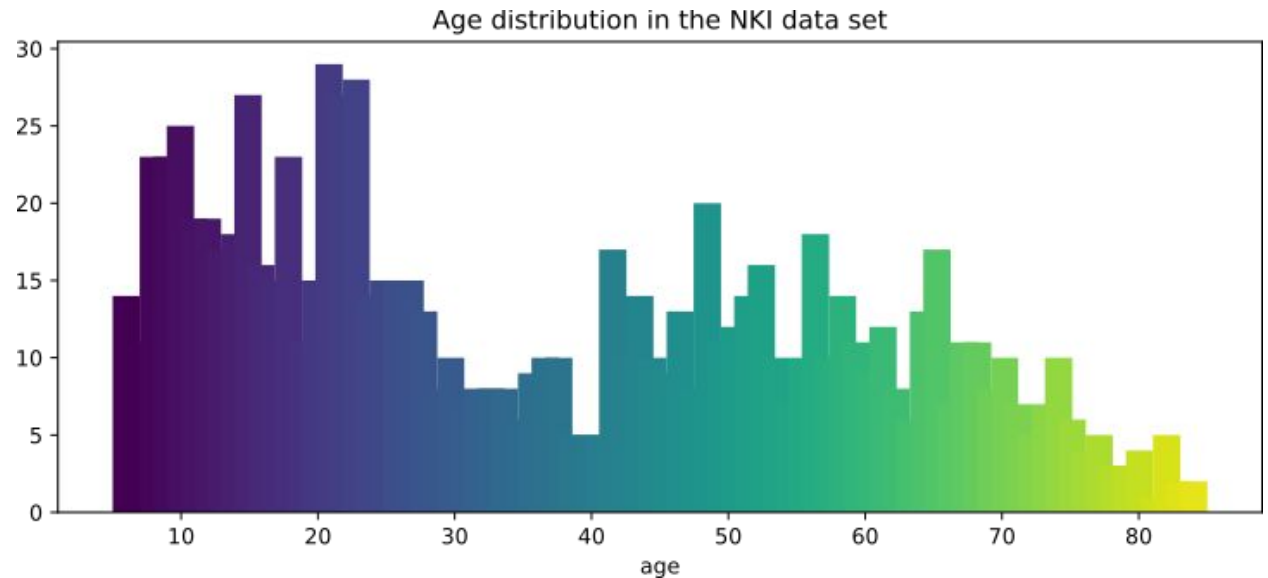


Josh

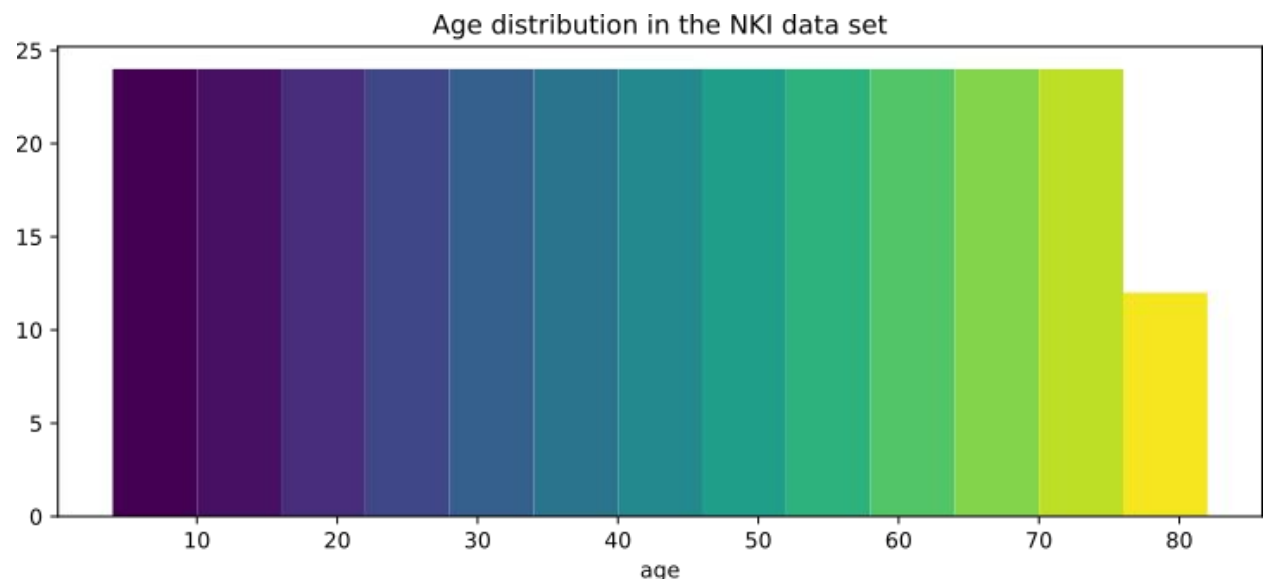


# Leveling the playing field

The distribution of age across the data set is not uniform



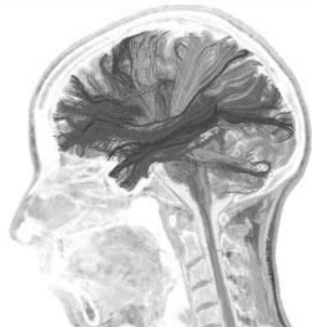
We divide the data set in age groups and uniformly sample 300 subjects





# Building the shape graph

Nathan Kline Institute dataset



Subsample of 300 participants dMRI  
uniform across age  
Age range: 7-85 y.o.



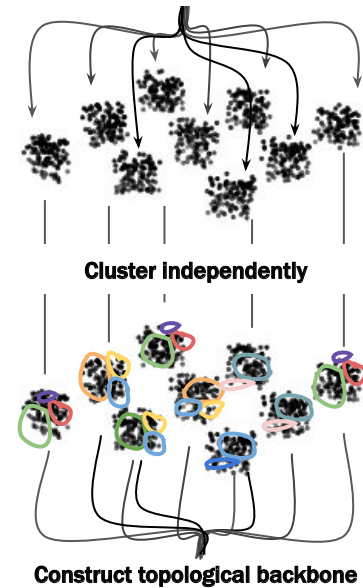
Normalize streamline counts  
Vectorialize upper-triangle

300 x 6786



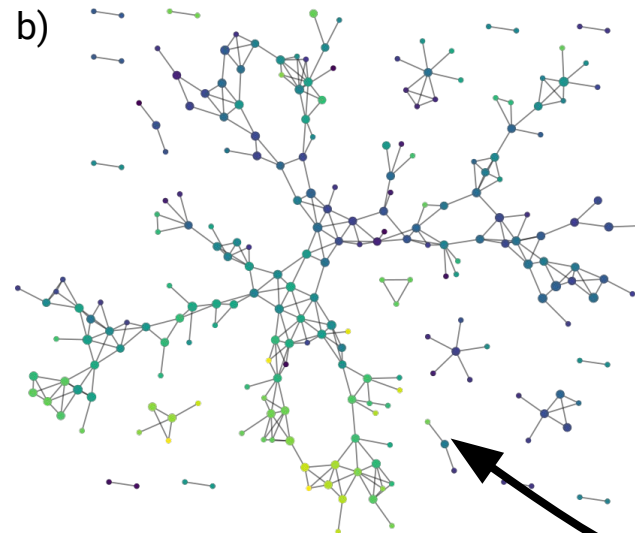
Use PCA to slice the dataset

a)

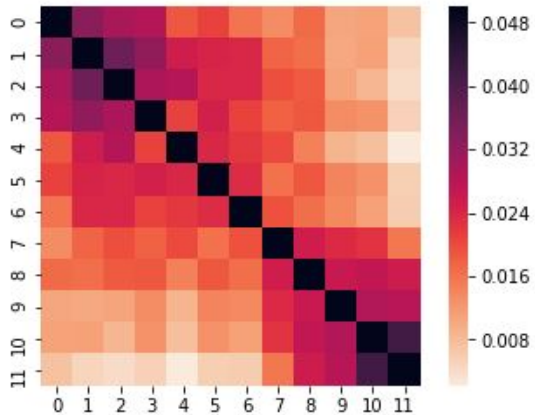


Mapper Algorithm

b)



Density matrix



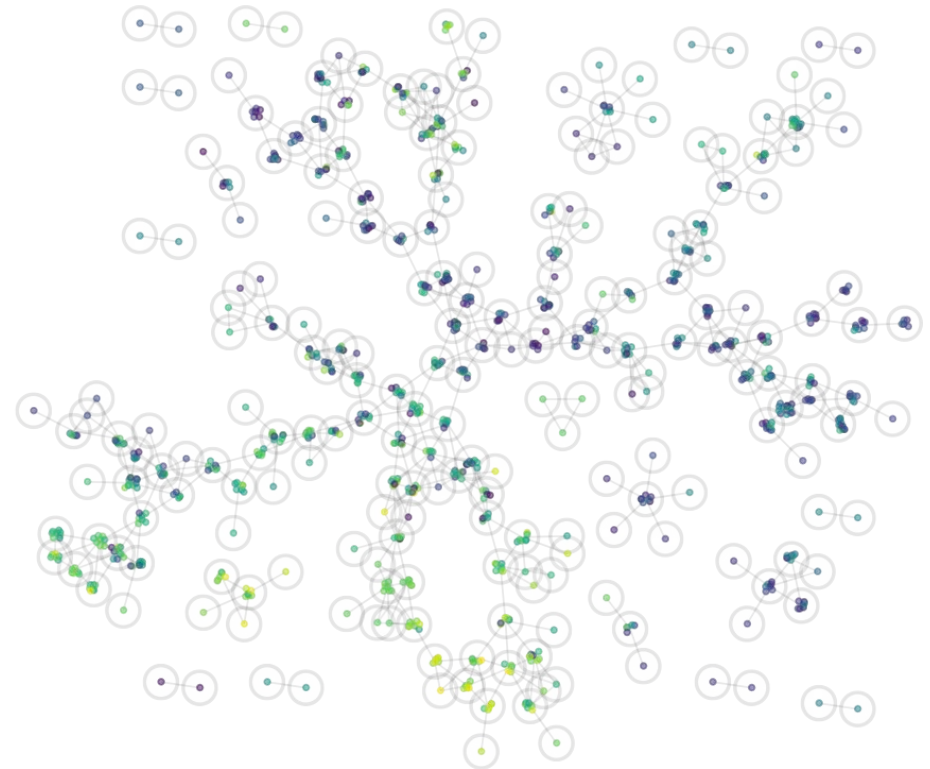
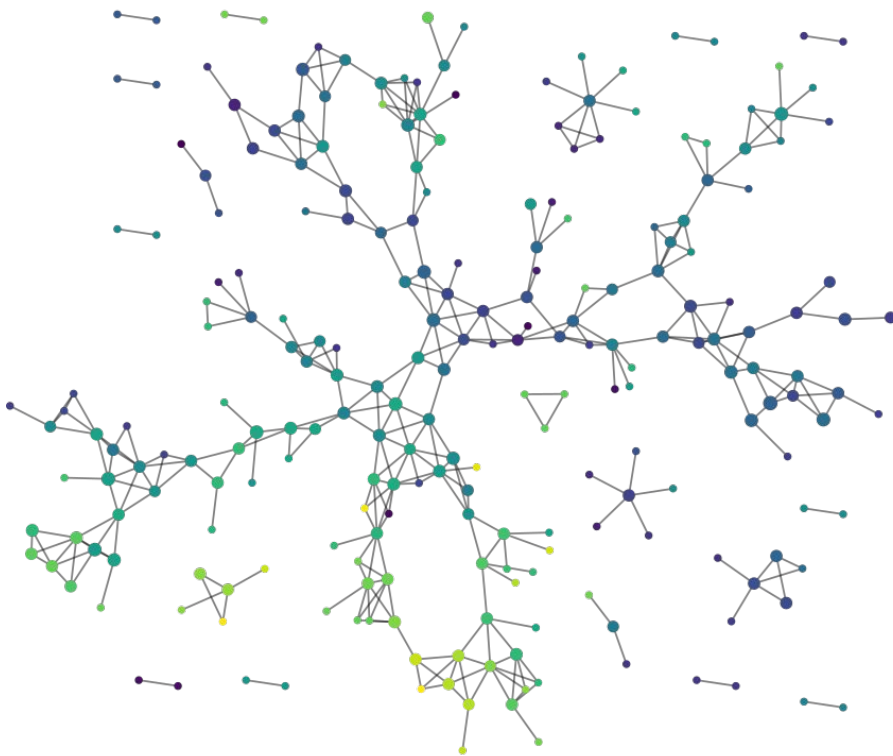


# Results



What is a shape graph hiding?

Shape graph and underlying clusters



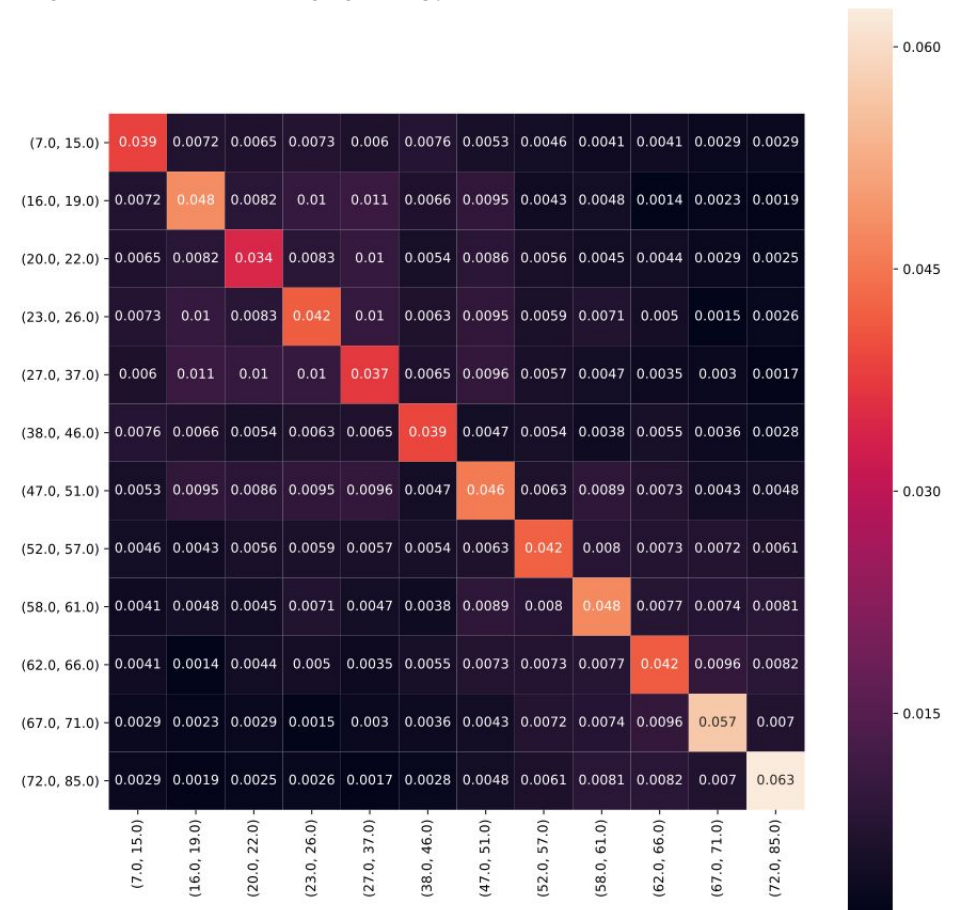
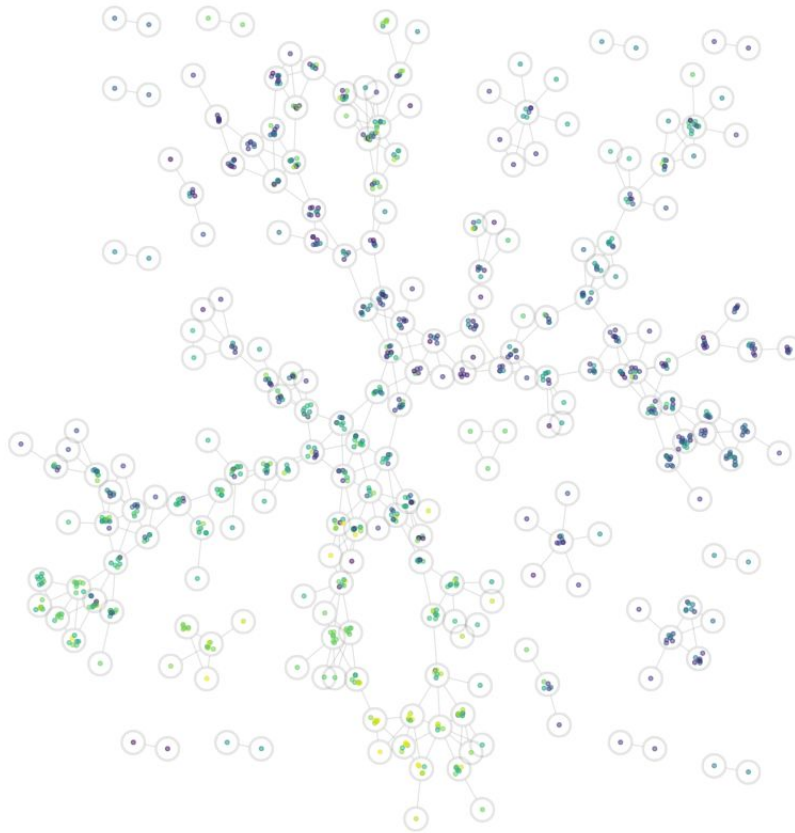
# Results



## Building the density matrix

To describe the distribution of age groups along the shape graph, we use a density matrix.

We **count** the number of time subjects in the same/different age group are clustered in the same node and we **normalize** each matrix entry by the possible number of co-occurrences.



# Results

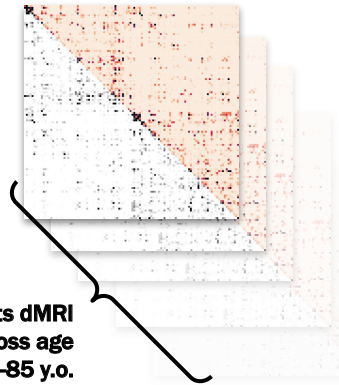


Is it worth going through the local clustering phase?

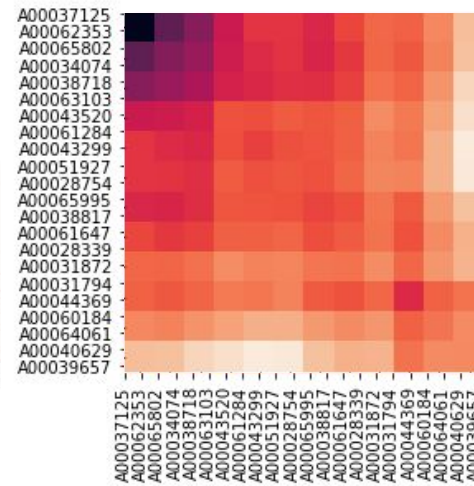
Nathan Kline Institute dataset



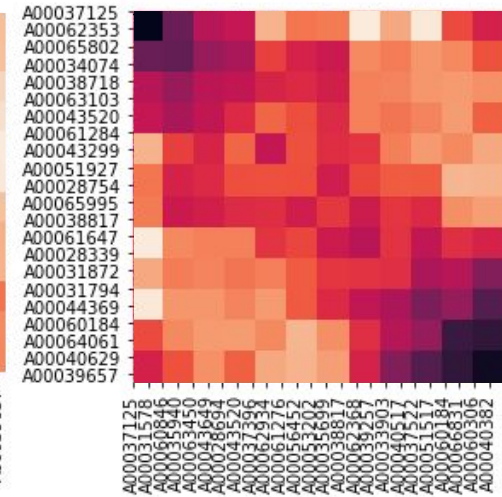
Subsample of 300 participants dMRI  
uniform across age  
Age range: 7-85 y.o.



Distance matrix



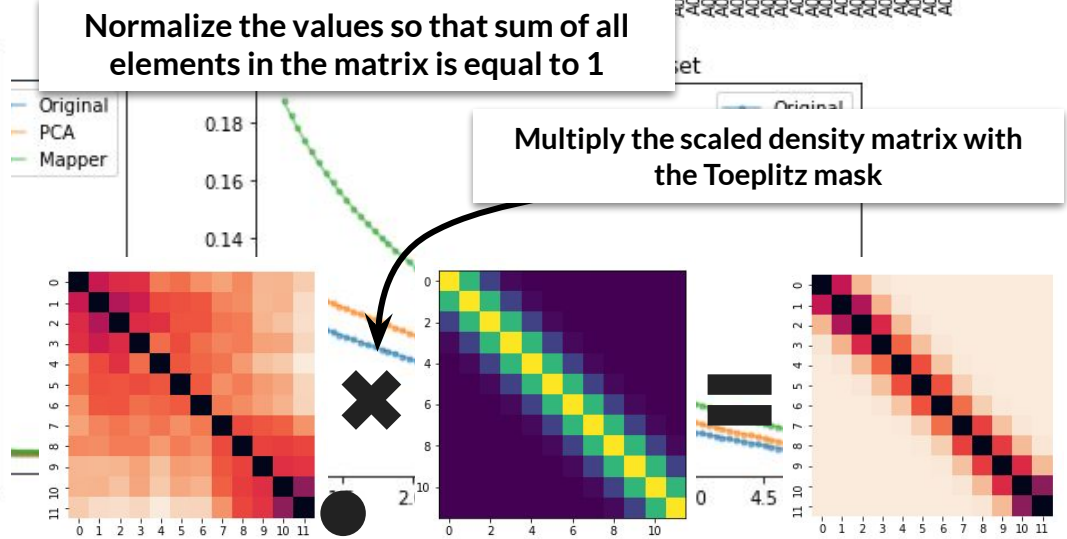
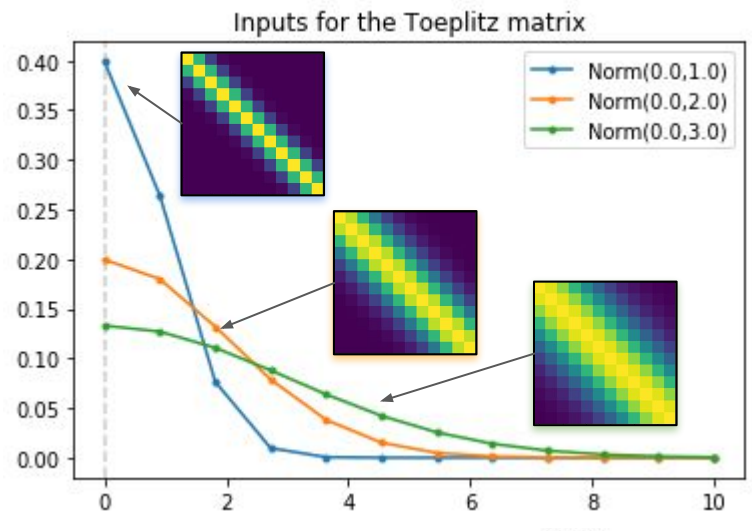
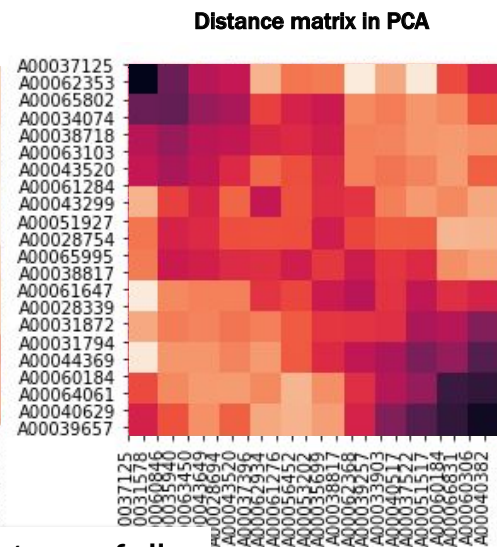
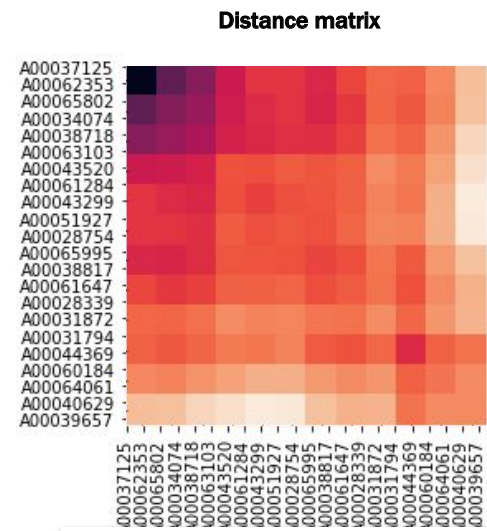
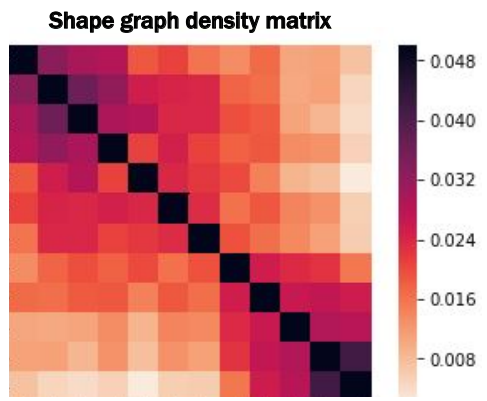
Distance matrix in PCA





# Results

Is it worth going through the local clustering phase?

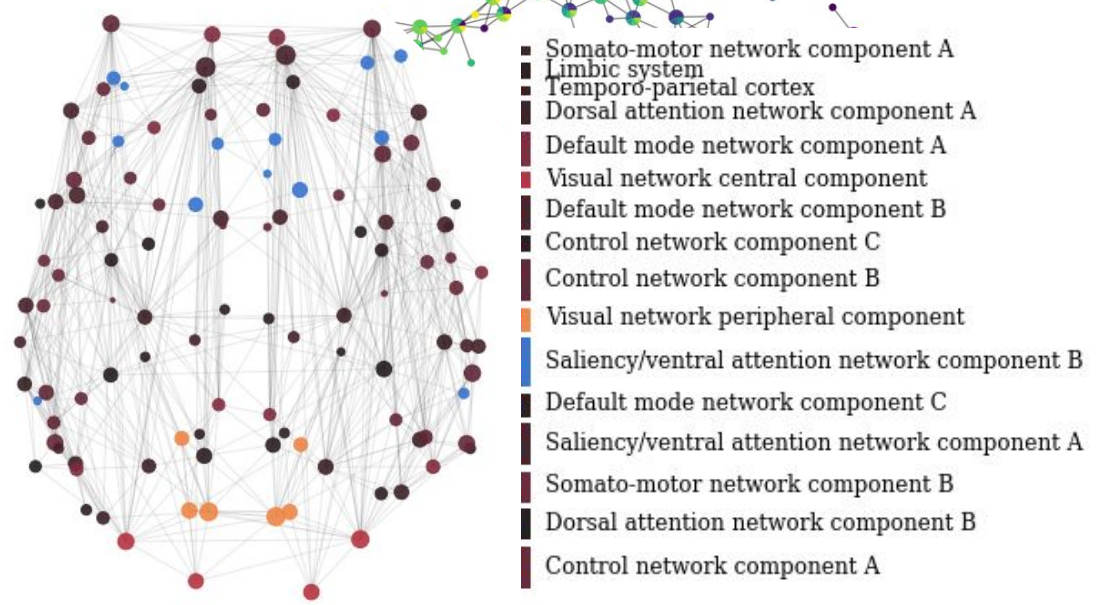
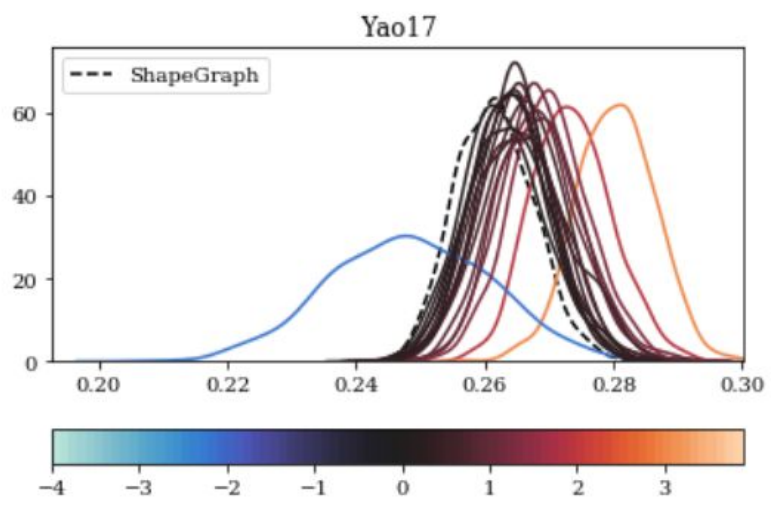
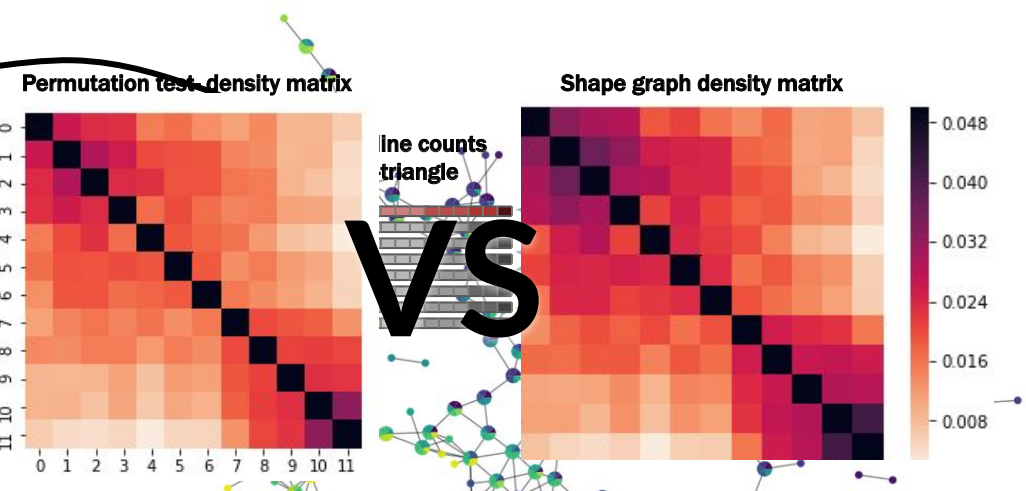
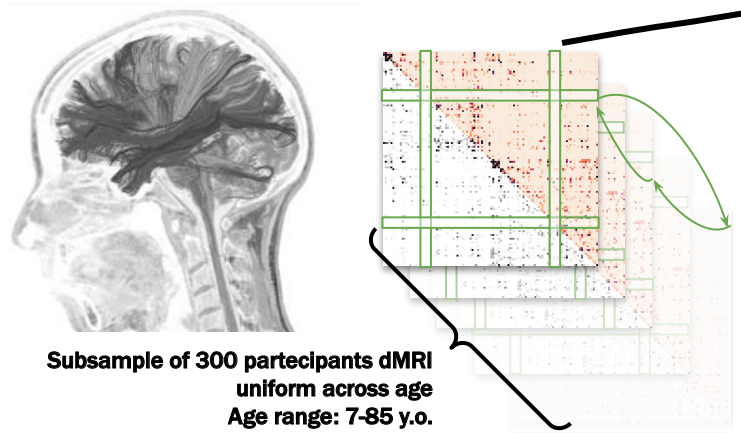






# Effect of functional networks on the shape

Nathan Kline Institute dataset







# Summary

**Exploratory analysis** to describe the entire dataset with a single graph encoding similarity pattern in its shape

Use this construction to study the effect of a variable on the way the shape is arranged

We found a strong effect of weight reshuffling for Saliency/Ventral Attention network and Visual Network related ROIs.

# Thank you for the attention

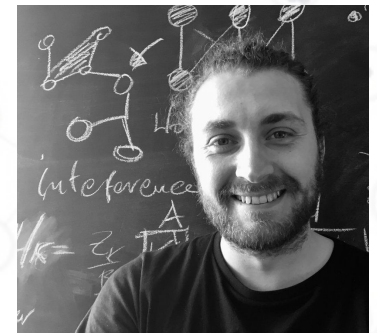
## My collaborators:



Prof. Olaf Sporns



Josh(u) Faskowitz



Giovanni Petri

## My supporters:

