# Spectral Analysis of resting-state fMRI Brain Networks

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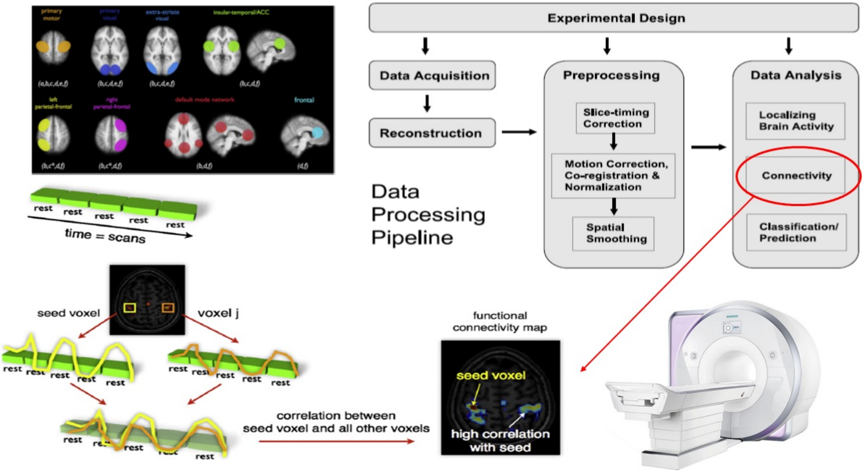
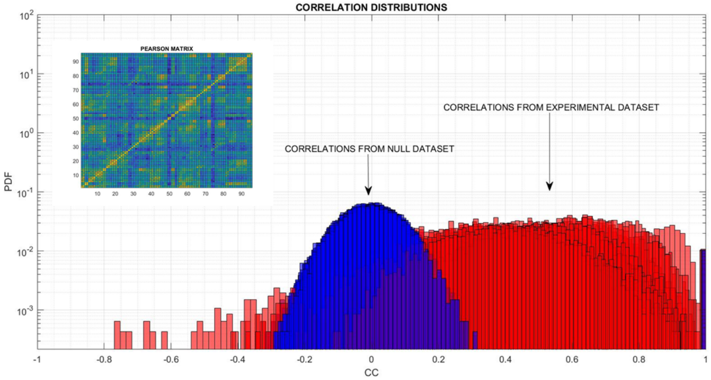
# The resting-state fMRI brain networks



# The resting-state fMRI brain networks

- Experimental Dataset: 15 Healthy subjects | 3T MRI scanner
- Question: are there some noise correlations?
  - Spectral analysis of Pearson correlation matrix



# The spectral analysis

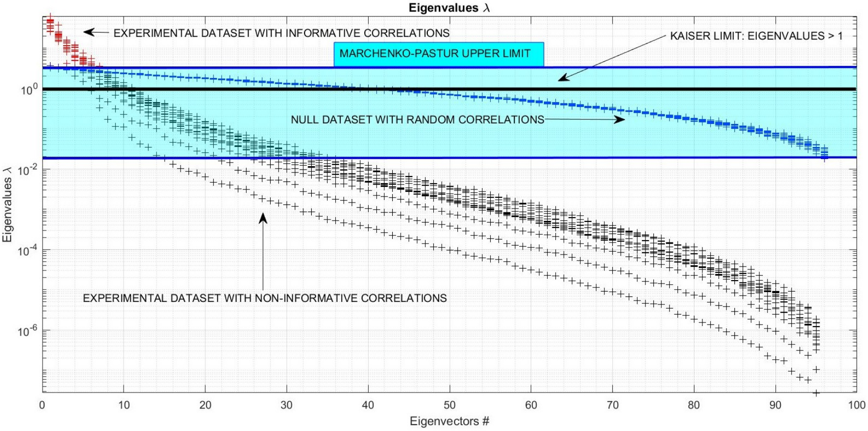
- **Principal Component Analysis (PCA)**: it is a method that find an orthogonal transformation that trasforms a multivariate system to new coordinated that are linearly uncorrelated (Pearson 1901, etc)
- **PCA** $\Rightarrow$ **Correlation Matrix** to study the collective brain activity that is identified as statistical analysis of the eigenvectos, i.e. the largest eigenvalues ...
- **Questions A**: how to select the largest eigenvalues? how to include eigenvalues associated to informative eigenvectors
- **Question B**: how exclude eigenvalues associate to non-informative eigenvectors? (randomness!)
  - Percentage of explained variance by eigenvalues ($\% > 70/80$)
  - Kaiser (eigenvalues $> 1$)
  - Random Matrix theory cut-off

# Random Matrix Theory cut-off

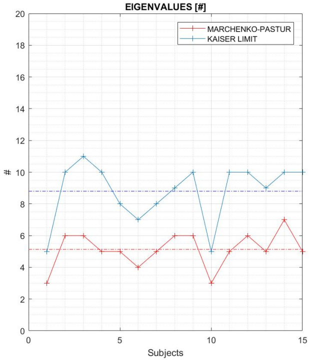
**Marchenko-Pastur Spectral Distribution**

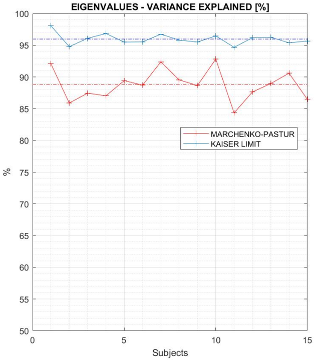
- i.e. the eigenvalues density of the empirical correlation matrix for uncorrelated i.i.d. Gaussian variables
- $\rho(\lambda) = \frac{1}{2\pi r\lambda}\sqrt{(\lambda_+ - \lambda)(\lambda - \lambda_-)}$
  - $r = N/T = 0,48$, i.e. N=96 ROIs and T=208 Time Points
  - $\lambda_\pm = (1 \pm \sqrt{r})^2$
- $\lambda_\pm$ **are the support of eigenvalues of Gaussian (uncorrelated) multivariate variables** $\Longrightarrow$ the formal range to include eigenvalues associated to random variables
  - $\lambda_- = 3.4571$
  - $\lambda_+ = 0.0198$
  - The eigenvalues greater then $\lambda_+$ are not random, therefore, they are associated to informative eigenvectors (and correlations)

# The selection of eigenvalues by formal methods



# The selection of eigenvalues by formal methods

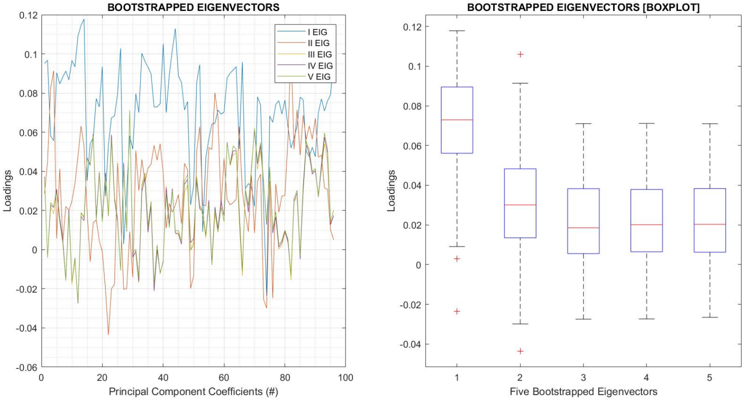


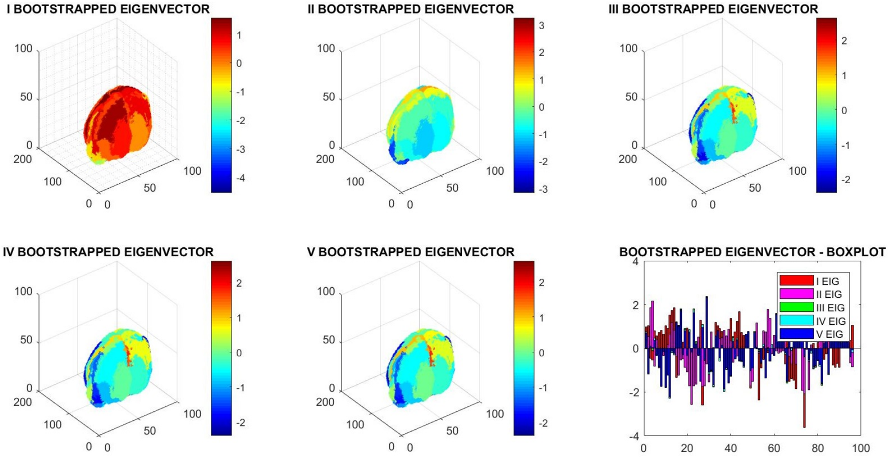

- According to Marchenko-Pastur limits, there are (in average) 5 informative eigenvectors in the dataset that explain approximately the 90 % of variance explained

# Computation of the five prototype eigenvectors

- There are 15 subjects ⇒ compute the bootstrapped-mean to have the **five prototype eigenvectors**



# Visualization of the five prototype eigenvectors



# Conclusion - Why use Marchenko-Pastur Eigenvalues Distribution

- In Neuroscience (and in Neuroimaging) it is important to find functional brain networks,
  - i.e. the standard model is that the human brain is intrinsically organized into anticorrelated functional networks (PNAS 2005 - seminal paper)
- know if correlations are informative (not random) is crucial for a correct explorative analysis of functional MRI images

# Conclusion - Why use Marchenko-Pastur Eigenvalues Distribution

- the Marchenko-Pastur Spectral Distribution is a null model based on Random Matrix Theory able to find random correlations
- in fMRI literature there are few papers that have used it (16) in the total fMRI works (767.000 - clustering, ICA, dual regression, etc)


- Thank you ;-)