

GraphVar: A user-friendly toolbox for comprehensive graph analyses of functional brain connectivity.

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INTRODUCTION

- Graph theory provides a powerful formalism for comprehensive description of global and local topological network properties of functional brain connectivity (Bullmore and Sporns, 2009; Rubinov and Sporns, 2010).
- Recently developed software packages such as the Brain Connectivity Toolbox (Rubinov and Sporns 2010) have contributed to graph theory's increasing popularity for characterization of functional brain networks.
- However, most current software packages are command-line based and may require some programming experience. This precludes their use by many users without a computational background, including psychologists and physicians, whose research could otherwise benefit from graph-theoretical methods.

SETUP AND FEATURES GraphVar - SampleWorkspace General Settings Network Construction Network Calculations BrainRegions.csv Select Brain regions files (xls) Significant Absolute Calculate graph metrics File with Variables (xls) Variables.csv Network nodes / Brain areas Network thresholds Brain graph metrics Select Subjects (Corr Matrix) Binary: Betweenness centrality Create Correlation Matrix Binary: Clustering coefficient global Binary: Clustering coefficient local Subjects Binary: Characteristic path global rrMatrix sample 01.mat Binary: Characteristic Path local CorrMatrix_sample_02.mat Binary: Community structure Newman - affiliation CorrMatrix_sample_03.mat ddle frontal gyrus (Right) Binary: Community structure Louvain - affiliation \ CorrMatrix_sample_04.mat Binary: Community structure Newman - modularity CorrMatrix_sample_05.mat CorrMatrix_sample_06.mat CorrMatrix sample 07.mat Normalize graph metric with random networks Subjectname in Filename Generate Use random network to calc smallworldness randmio und CorrMatrix_sample_01.mat randomized subject data randmio_und_connected (null model network) Calculate variables and export ▼ Binary Weighted Start: 12 End (remaining characters): Raw Matrix (link wise). Corr Matrix Array rto z Raw matrix orrelation opartial correlation ogroup comparison Connectivity Thr. Partial correlation (control for nodes) Variables to correlate with ✓ Generate Create random time series random networks research_site research_site andom shuffle null_model_und_sigr eating_contest_chilli eating contest chilli beer_pong_score beer_pong_score Number of random series 1 fantasy_score fantasy_score **4** Ⅲ **→** Generate Correlation Matrix with 1 Iterations Test against random networks (graph metrics) Test against random networks (raw matrix) Open Previous Results Switch Workspace Load interim results Statistics with already calculated values Calculate & Statistics

- GraphVar is a GUI-based toolbox which runs MATLAB (MathWorks, Inc.) but not require any programming experience from the user.
- GraphVar functions Brain Connectivity and allows users to add Toolbox, functions which custom can subsequently be accessed via the GUI.
- GraphVar accepts correlation matrices also can generate correlation correlation partial matrices from input time series. The also input demographic, clinical and other subject specific data (in spreadsheet format) for statistical analyses.

Toolbox features:

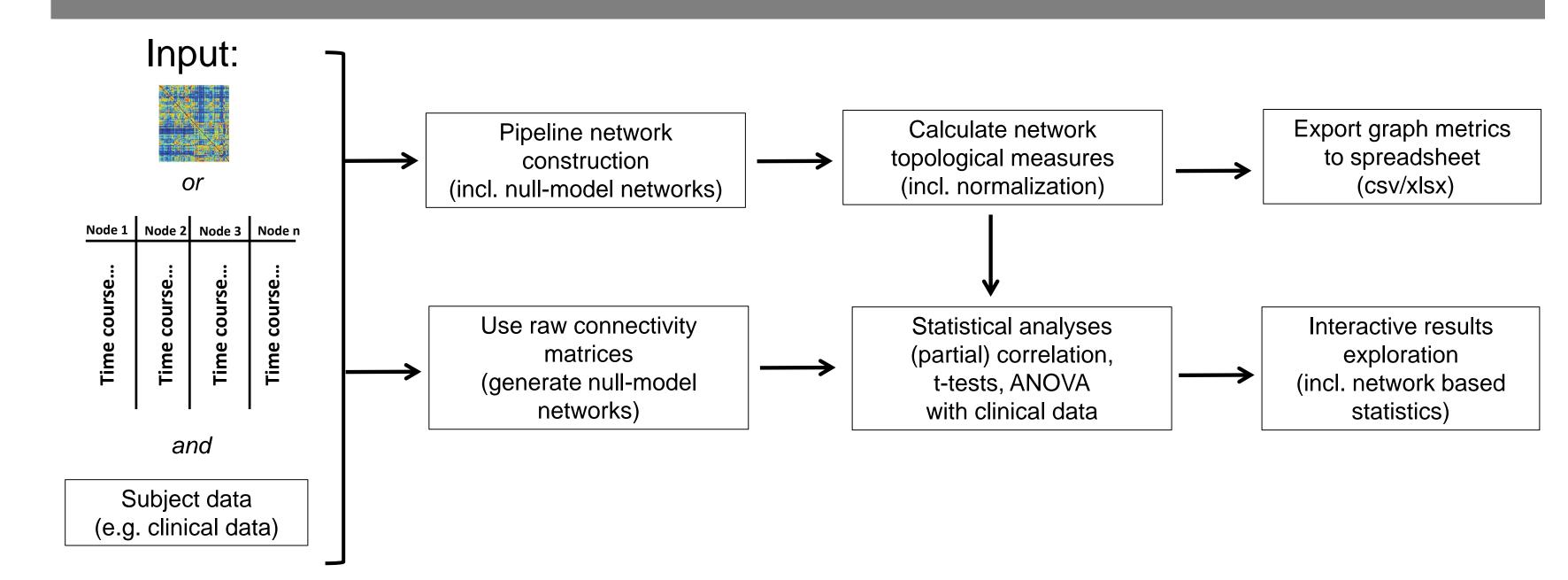
networks

- Generate correlation or partial correlation matrices from input time series
- Pipeline construction of graph networks
- Generate subject specific null-model
- Perform sub-network analyses
- Calculation, normalization, and export of binary and weighted network measures
- Statistical analyses:
 - Correlation and partial correlation analyses and group comparisons (t-test, ANOVA) on the network measures but also on the raw connectivity matrices (i.e., network based statistics including identification of graph components)
- Statistical testing in parametric and nonparametric fashion (i.e., testing against null-model networks, non-parametric permutation testing)

METHODS

- Here we developed "GraphVar", a user-friendly graphical-user-interface (GUI)-based toolbox for comprehensive graph-theoretical analyses of brain connectivity, including network construction and characterization, statistical analysis on network topological measures, and interactive exploration of results.
- By combining together features across multiple current toolboxes, such as the Brain Connectivity Toolbox, the Graph Analysis Toolbox, and the Network Based Statistic Toolbox (BCT, Rubinov and Sporns 2010; GAT, Hosseini et al., 2012; NBS, Zalesky et al., 2010), GraphVar represents a comprehensive collection of graph analysis routines for functional neuroimaging researchers.

WORKFLOW AND RESULTS EXPLORATION



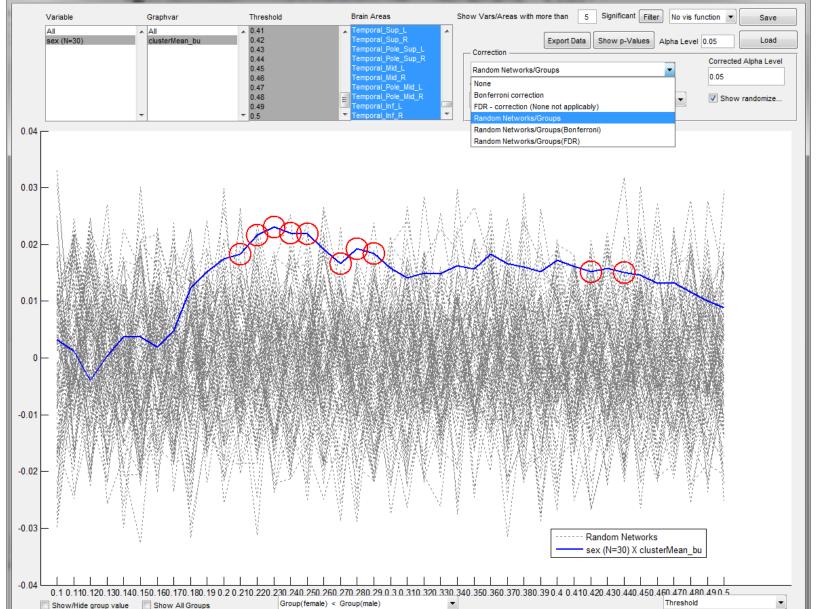


Figure 1: x-axis: the sholds/y-axis: correlation/ blue line: original networks/ grey lines: random networks

GraphVar offers an interactive viewer that allows intuitive exploration of statistical results as well correction methods including comparisons, correction and false discovery rate. Results can easily be exported (csv/xlsx), saved, and reloaded. The program entails a detailed manual that includes usage instructions and a

Figures results exploration:

functions.

- Fig 1: example non-parametric correlation testing with random networks and global clustering coefficient across densities
 - Fig 2: example correlation testing with local clustering coefficient in 10 brain regions across densities Fig 3: example results of a group comparison on the raw correlation matrices

description of all the implemented

Bonferroni

Fig 4: "network inspector" which may be used to identify graph components

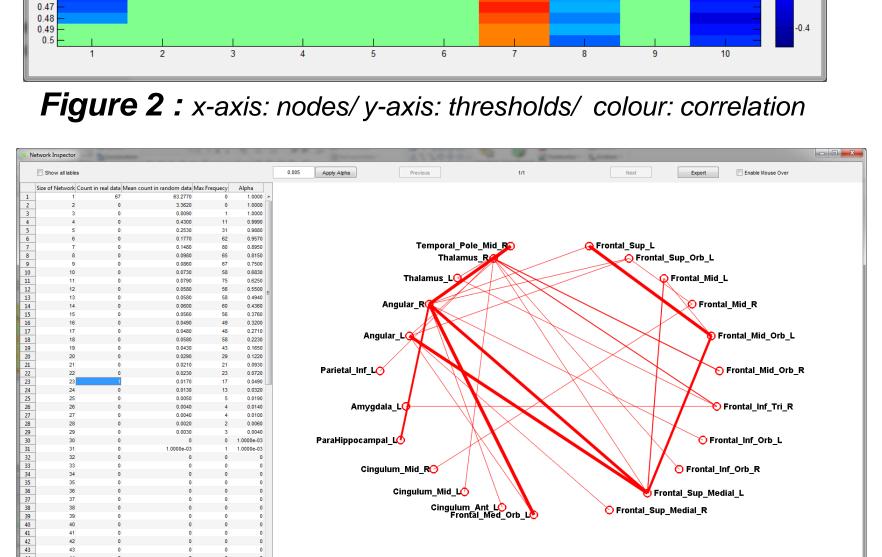


Figure 4: left: probability table/ right: graph component

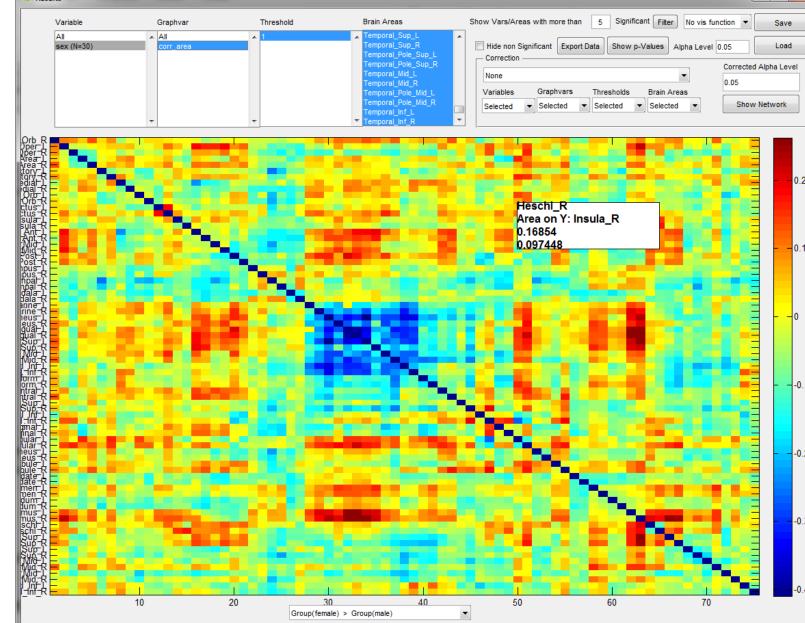


Figure 3: x-axis: nodes/y-axis: nodes/ colour: group difference

CONCLUSIONS

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- GraphVar is a new comprehensive and user-friendly toolbox for easy pipeline network construction, graph analysis, statistical analysis on network topological measures, network based statistics, and interactive results exploration.
- The availability of such comprehensive network analysis tools may increase the accessibility of graphtheoretical connectivity to neuroimaging researchers.

REFERENCES

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