# **New Features and Tutorial**

# Graphar 2.02



| GraphVar - SampleWorkspace   |   |   |
|--|---|---|
| General Settings<br>Brain regions files<br>File with Variables<br>Colort Orbitate (Once Matricia   | Network Construction<br>Threshold<br>Significant  Relative  Absolute  SICE  None<br>Weights   | Network Calculations       Image: Community structure   |
| Select Subjects (Conn Matrix) Create Connectivity Matrix Subjects CorrMatrix(CorrMatrix, Sample, 01.mat CorrMatrix(CorrMatrix, Sample, 02.mat CorrMatrix(CorrMatrix, CorrMatrix, Sample, 03.mat CorrMatrix(CorrMatrix, CorrMatrix, Sample, 04.mat CorrMatrix(CorrMatrix, CorrMatrix, Sample, 05.mat CorrMatrix(CorrMatrix, CorrMatrix, Sample, 05.mat CorrMatrix(CorrMatrix, CorrMatrix, Sample, 05.mat CorrMatrix(CorrMatrix, CorrMatrix, Sample, 01.mat CorrMatrix(CorrMatrix, CorrMatrix, Sample, 01.mat CorrMatrix(CorrMatrix, CorrMatrix, Sample, 01.mat CorrMatrix(CorrMatrix, Sample, 01.mat CorrMatrix, CorrMatrix, Sample, 01.mat CorrMatrix(CorrMatrix, Sample, 01.mat CorrMatrix, CorrMatrix, Sample, 01.mat Start: 12 End (remaining characters): 4 Corr Matrix Array CorrMatrix 0 | <ul> <li>no change absolute weights negative weights to zero</li> <li>Network nodes / Brain areas</li> <li>Network thresholds</li> <li>Inferior temporal gyrus (Right)</li> <li>Cerebelum_Crus1_L</li> <li>Cerebelum_Crus2_L</li> <li>Cerebelum_Crus2_R</li> <li>Cerebelum_3_R</li> <li>Cerebelum_4_5_L</li> <li>Inferior temporal gyrus (Right)</li> <li>Cerebelum_3_R</li> <li>Cerebelum_4_5_L</li> <li>Generate</li> <li>randomized subject data<br/>(null model network)</li> </ul>   | Brain graph metrics       Select Dynamic         Binary: Assortativity o       Select Dynamic         Binary: Assortativity o       Select Dynamic         Binary: Assortativity o       connection: Number of fastest path - node i to node j         Binary: Assortativity o       connection: Duration of shortest path - node i to node j         Binary: Assortativity o       global: Temporal efficiency of dynamic network         Binary: Clustering coe       global: Temporal correlation coefficient of dynamic network         Binary: Clustering coe       local: Receive Centrality         Image: Normalize graph       local: Receive Centrality         Image: Use random netwo       Dynamic community flexibility: only with MULTISLICE affiliation vector         Dynamic community promiscuity: only with MULTISLICE affiliation vector       Summary: Variance over time   |
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# added dynamic network measures as in <u>Seizemore et al., 2017</u>

| several Settings<br>Fire with Variables<br>Variables cost<br>Subjects<br>Subjects<br>Correlative, sample_01 mat<br>Correlative, sample_03 mat<br>Correlativ  | GraphVar - SampleWorkspace                  |   |   |            |
|--|---|---|---|------------|
| Brain regions files       Brain Regions case       Select         File with Variables       Variables.csv       Select         Subjects       Create Connectively Matrix       Image: Connectively Matrix       Image: Connectively Matrix         Subjects       Conflating: sample_01 mat       Image: Connectively Matrix       Image: Connectively Matrix         Conflating: sample_01 mat       Temporal pole superor temporal of the superor temporal pole superor temporal pol   | General Settings                            | Network Construction  |   | ?          |
| Fie with Variables       Variables       Variables       Variables       Select         Select Subjects       Connuntry structure       Connuntry structure         Created connectively Matrix       Image: absolute weights       negative weights to zero         Network nodes / Brain areas       Network thresholds         ConfMatrix_sample_02 and       Image: absolute weights       Image: absolute weights </td <td>Brain regions files BrainRegions.csv Select</td> <td>Threshold</td> <td>Network Calculations</td> <td></td>  | Brain regions files BrainRegions.csv Select | Threshold   | Network Calculations  |            |
| Salect Subjects       Connative       in consist       in consis   | File with Variables Variables.csv Select    | Significant  Relative Absolute SICE   | None     Calculate graph metrics     Community struct         | ture       |
| Create Connectivity Matrix         Subjects         Subjects         CorrMatrix_sample_02 mat         CorrMatrix_sample_03 mat         CorrMatrix_sample_04 uperor temporal gryss (Upit)         Temporal pole         Mode temporal gryss (Upit)         Temporal pole         Subjects         CorrMatrix_sample_01.mat         Subjects         CorrMatrix_sample_01.mat         Start:       12 End (remaining characters); 4<br>CorrMatrix Array         CorrMatrix_sample_01.mat         Start:       12 End (remaining characters); 4<br>CorrMatrix Array         CorrMatrix Array       CorrMatrix         Raw Matrix (link wise)       CheckFras         Connectivity Thr.       r to z         Start       10 Encertal         Raw Matrix (link wise)       Connectivity Thr.         CorrMatrix_sample_01.mat       Salex         Salex       random networks         03 So       random networks         03 So       random network   | Select Subjects (Conn Matrix)               | <ul> <li>no change</li> <li>absolute weights</li> <li>negative w</li> </ul> | eights to zero  |            |
| Subjects       At subjects         CorrMatrix_sample_01 mat<br>CorrMatrix_sample_02 mat<br>CorrMatrix_sample_03 mat<br>CorrMatrix_sample_04 mat<br>CorrMatrix_sample_05 mat<br>CorrMatrix_sample_07 mat       Image: CorrMatrix<br>Temporal poil: (Reput)<br>Temporal poil:  | Create Connectivity Matrix                  | Network nodes / Brain areas Network three                                   | sholds  |            |
| CorrMatrix_sample_02_mat       Image: CorrMatrix_sample_02_mat         CorrMatrix_sample_04_mat       Image: CorrMatrix_sample_06_mat         CorrMatrix_sample_06_mat       Image: CorrMatrix_sample_06_mat         Subjectname in Filename       Image: CorrMatrix_sample_07_mat         CorrMatrix_sample_07_mat       Image: CorrMatrix_sample_07_mat         Stubjectname in Filename       Image: CorrMatrix_sample_07_mat         CorrMatrix_sample_07_mat       Image: CorrMatrix_sample_07_mat         Stat:       12         CorrMatrix_sample_07_mat       Image: CorrMatrix_sample_07_   | Subjects                                    | Superior temporal ovrus (Right)   | All subjects  |            |
| CorrMatrix_sample_0.3 nat       Temporal pole superor temporal         CorrMatrix_sample_0.5 nat       Temporal pole superor temporal         CorrMatrix_sample_0.5 nat       Temporal pole superor temporal         CorrMatrix_sample_0.7 nat       Temporal pole superor temporal         Subjectname in Flename       1.0         CorrMatrix_sample_0.7 nat       Temporal pole motile temporal         Start:       12       End (remaining characters):         Attack       Generate         randomized subject data       0.17         (null model network)       CheckFirag         Save interim results       Parallel Workers:         Or       Rew Matrix (link wise)         Generate       Generate         (null model network)       CheckFirag         Visualize modules with BrainNet viewer         Parallel Workers:       0         Or       Rew Matrix (link wise)         Generate       Generate         04       05         05       Gost         06       Generate         07       Generate         08       Generate         09       Generate         04       05         05       01         06       Gener   | CorrMatrix_sample_01.mat                    | Temporal pole: superior temporal  |   |            |
| CorrMatrix_sample_04 mat<br>CorrMatrix_sample_06 mat<br>CorrMatrix_sample_06 mat<br>CorrMatrix_sample_07 mat       Mddd temporal gyrus (Left)<br>Temporal pole mddl temporal   | CorrMatrix_sample_02.mat                    | Temporal pole: superior temporal 0.12                                       | E Two groups  |            |
| Constants_sample_0.5 mail<br>CorrMatrix_sample_0.5 mail<br>CorrMatrix_sample_0.7 mail<br>Subjectname in Flename<br>CorrMatrix_sample_0.1 mat<br>Start: 12 End (remaining characters): 4<br>Corr Matrix Array CorrMatrix<br>Save interim results Paralel Workers: 0<br>Rew Matrix (link wise)<br>Concectivity Thr. r to z<br>0<br>Concectivity Thr. r to z<br>0<br>Concect | CorrMatrix_sample_03.mat                    | Middle temporal gyrus (Left) 0.13   |   |            |
| CorrMatrix_sample_0.6 mat       Impound pose. middle temporal by the state of the  | CorrMatrix sample 05.mat                    | Temporal pole: middle temporal gr   | Resolution (gamma): 1.0                                       |            |
| CorrMatrix_sample_07.mat       Interior temporal pryous (Left)       0.17         Subjectname in Fiename       Interior temporal pryous (Left)       0.17         CorrMatrix_sample_01.mat       Interior temporal pryous (Left)       0.17         Start:       12       End (remaining characters):       4         CorrMatrix Array       CorrMatrix       Parallel Workers:       0         Save interim results       Parallel Workers:       0         Raw Matrix (link wise)       CheckFrag       CheckFrag         Raw Matrix (link wise)       GLM Machine Learning         Valualize modules with BrainNet viewer       9         Ø5       Generate       9         Ø4       Gonerate       9         Ø4       Gonerate       9         Ø5       Generate       9         Ø4       Gonerate       9         Ø5       Generate       9         Ø5       Global and networks       9         Ø25       Global and networks       9         Ø25       Global and networks       9         Ø25       0       9       9         Ø25       0       9       9         Ø25       0       9       9  | CorrMatrix_sample_06.mat                    | Temporal pole: middle temporal gr   |   |            |
| Subjectname in Flename       0.18         CorrMatrix_sample_01.mat       0.18         Start:       12       End (remaining characters):       4         Corr Matrix_Array       CorrMatrix       •         Save interim results       Parallel Workers:       •         Raw Matrix (ink wise)       •       •         Raw Matrix (ink wise)       •       •         Other the subject data (null model network)       •       •         Connectivity Thr.       •       •         Corr Age in the intervent weights       •       •         Objectname       •       •         Corr Age intervent weights       •       •         Raw matrix       •       •       •         Objectname       •       •       •         Outpet       •       •       •         Connectivity Thr.       •       •       •         Objectname       •       • <td>CorrMatrix_sample_07.mat</td> <td>Inferior temporal gyrus (Left) 0.17</td> <td>Pre-calculated groups</td> <td></td>  | CorrMatrix_sample_07.mat                    | Inferior temporal gyrus (Left) 0.17   | Pre-calculated groups   |            |
| CorrMatrix_sample_01.mat         Start:       12       End (remaining characters):       4         Corr Matrix Array       CorrMatrix         Save interim results       Parallel Workers:       0         Raw Matrix (link wise)       CheckFrag         Correctivity Thr.       r to z         Correctivity Thr.       r to z         Correctivity Thr.       Generate         random networks       005         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       015         015       016         016       Nuisance covariates         007       009         008       008         009       008         009       009         009       009         009   | Subjectname in Filename                     | la forior tomporal aurus (Diabt) 0.18                                       | ·   |            |
| Start:       12       End (remaining characters):       4         Corr Matrix Array       CorrMatrix       CorrMatrix       CorrMatrix       Parallel Workers:       0         Save interim results       Parallel Workers:       0       Parallel Workers:       0         Raw Matrix (link wise)       CheckErag       CheckErag       CheckErag         Raw Matrix (link wise)       Connectivity Thr.       r to z         045       Generate       0       0         035       Correlation       Correlation       Between covariates         009       003       Correlation       Between factors         009       009       Correlation       Within covariates       Correlation         Weights       In on change       absolute weights       Select Within D       No Interactions         In on change       absolute weights to zero       Craph metrics       r and NW       permutation         Raw matrix       In on change       absolute weights       To zero       Carph metrics       r and NW       permutation         In on change       absolute weights       To zero       To zero       To zero       To zero  | CorrMatrix_sample_01.mat                    |   | Classification consistency and diversity                      |            |
| Corr Matrix       randomized subject data<br>(null model network)       Image: CorrMatrix         Save interim results       Parallel Workers: 0         Raw Matrix (ink wise)       CheckFrag         Image: Correctivity Thr.       r to z         Image: Correctivity Thr.       Image: Correctivity Thr.         Image: Correctivity Thr.  | Start: 12 End (remaining characters): 4     | Generate  | Partition distance (MIn, VIn) for two group                   | ps         |
| Construct       (null model network)       CheckFrag         Save interim results       Parallel Workers: 0         Raw Matrix (link wise)       Raw matrix         Connectivity Thr.       r to z         045       Generate  | Corr Matrix Array                           | randomized subject data   | Visualize modules with BrainNet viewer                        |            |
| Save interim results       Parallel Workers:       0         Raw Matrix (link wise)       Raw matrix         Connectivity Thr.       r to z         Officiency       Generate         Image: Connectivity Thr.       r to z         Officiency       Between covariates         Image: Connectivity Thr.       Image: Connectivity Thr.  | corr matrix Array                           | (null model network)  | Chaol/Error   |            |
| Raw Matrix (link wise)       GLM Machine Learning         Raw matrix       Connectivity Thr.       r to z         0       0       0         045       0       0         035       0       0         035       0       0         035       0       0         035       0       0         036       0       0         007       absolute weights       Within ID         No Interactions       *         Select Within ID       No Interactions         •       •         • <td< th=""><th>Save interim results Parallel Workers: 0</th><th></th><th>Спескггад</th><th></th></td<>   | Save interim results Parallel Workers: 0    |   | Спескггад   |            |
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| 045       random networks         035       035         025       02         015       01         008       007         007       absolute weights         Image: Image  |   | 05 Generate   | research site   | -          |
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| e negative weights to zero     e parametric rand NW permutation     #Rep   |   | no change absolute weights  | Graph metrics   |            |
| Raw matrix     Permutation     1   |   | negative weights to zero  | #F  | Rep        |
|  |   |   | Raw matrix<br>parametric rand NW permutation                  | 1          |
| Switch Workenace Onen Previous Results < Load interim results > Statistics with already calculated values Calculate & Statistics   | Switch Workenson                            |   | atistics with already calculated values Calculate & Statistic | cs         |

# added community functionalities as in Fornito et al., 2012

# What is this new feature?

It can be used to obtain a group based consensus of the graph decomposition



Community functionalities as in Fornito et al., 2012

# Tutorial



added community functionalities as in e.g. <u>Fornito et al., 2012</u>

### Consensus Community structure - general procedure (text adapted from Dwyer et al. 2014):



#### 1. Individual level modular decomposition:

We run multiple iterations (1000) of the Louvain/Newman modularity algorithm (which is an optimization algorithm and thus produces slightly different outcomes per iteration) to obtain a set of possible clusters in the graph. To identify the final clustering solution, we use a consensus-based approach in which we generate a co-classification matrix (in which each [i, j] element contained 1 if two nodes were classified in the same module and 0 otherwise) and subsequently run a second decomposition of this co-classification matrix (c.f. Lancichinetti and Fortunato, 2012). In this manner, nodes frequently co-classified in the same module across multiple iterations of the algorithm will be assigned to the same module in the final solution.

#### 2. Group-level modular decomposition:

To obtain a group based consensus of the graph decomposition, we pass the final consensus decompositions for each individual to a second level to derive a group-level representation of network modularity based on a similar logic to the consensus approach used at the single-subject level. Specifically, the individuals final consensus decompositions are summed across individuals to generate a sample-level consistency matrix. A high weight in elements of this matrix indicates that two nodes were frequently classified in the same module across individuals. As such, a subsequent modular decomposition of this group-level consistency matrix ensures that nodes frequently co-classified together are likely to be assigned to the same module in the final solution.

By aggregating results across single-participant decompositions, this consensus-based approach allows to derive a group-level representation of community structure while also characterizing interindividual variability in network organization using classification consistency and diversity metrics. Such analyses are not possible when decomposition is performed on a group-averaged correlation matrix. Consensus-based approaches have also been shown to yield more stable individual module solutions, given the known degeneracy of most graph theoretic module detection algorithms (Good et al., 2010; Lancichinetti and Fortunato, 2012).

# All subjects :

(Variable sheet with Subject IDs recquired)

|   |  | GraphVar - SampleWorkspace   |
|---|--|--|
| Group community structure All subjects Two groups Resolution (gamma): 1.0 |  | General Settings Brain regions files BrainRegions.csv Select File with Variables Variables.csv Select Select Subjects (Conn Matrix) Create Connectivity Matrix Subjects CorrMatrix/CorrMatrix_CorrMatrix_sample_01.mat CorrMatrix/CorrMatrix_CorrMatrix_sample_03.mat CorrMatrix/CorrMatrix_CorrMatrix_sample_04.mat CorrMatrix/CorrMatrix_CorrMa |
| Pre-calculated groups   | Performs a group consensus clustering<br>across all subjects that are loaded | CorrMatrix/CorrMatrix_CorrMatrix_sample_05.mat   |
| Classification consistency and diversity                                  | in the current workspace   | CorrMatrix_CorrMatrix_sample_01.mat  |
| Partition distance (MIn, VIn) for two groups                              |  | Start: 12 End (remaining characters): 4  |
| Visualize modules with BrainNet viewer                                    |  | Corr Matrix Array CorrMatrix   |

# **Two groups:**

(Variable sheet with Subject IDs recquired)



#### **TESTING BETWEEN-GROUP DIFFERENCES IN MODULAR ORGANIZATION:**

To evaluate the significance of between-goup differences in modular organization we use a permutation approach. By permuting labels across groups and re-calculating the difference between groups in the respective modularity metric (see next slide) we obtain a distribution of this group difference under the null-hypothesis. By placing the real group difference "delta" in the random distribution of deltas we can determine the significance from its percentile position in the distribution.



If you have perfomed previous modularity analyses on different sets of subjects with the "All subjects" function, you can compare the results by loading the respective "GroupCommunity" folder (similar to "Two groups" function)

# Measures of modular organization I:

| Group community structure                    |  |  |  |  |
|--|--|--|--|--|
| or oup community structure                   |  |  |  |  |
|  |  |  |  |  |
| All subjects                                 |  |  |  |  |
|  |  |  |  |  |
| -  |  |  |  |  |
| I wo groups                                  |  |  |  |  |
|  |  |  |  |  |
| Resolution (gamma): 1.0                      |  |  |  |  |
|  |  |  |  |  |
| Pre-calculated around                        |  |  |  |  |
| Pre-calculated groups                        |  |  |  |  |
|  |  |  |  |  |
| Classification consistency and diversity     |  |  |  |  |
| Partition distance (MIn, VIn) for two groups |  |  |  |  |
| Visualize modules with BrainNet viewer       |  |  |  |  |
|  |  |  |  |  |

#### **OPTIMAL MODULAR DECOMPOSITION – Q** (text adapted from Fischi-Gomez et al., 2016):

In the Louvain modularity algorithm, Q is obtained by iteratively repeating 2 steps until convergence to a modularity maximum (Q).

First, each node is placed in a separate module, and all possible node moves between modules are evaluated in terms of modularity gain (step 1). When no individual move can further improve the Q value, nodes belonging to the same community are agglomerated (step 2) in order to form new 'super-nodes'. Step one (moves evaluation) is repeated on the new 'super-nodes' network. The two steps are repeated until convergence.





# Measures of modular organization II:



#### **CLASSIFICATION CONSISTENCY AND DIVERSITY** (text adapted from Fornito et al., 2012):

To understand the functional roles played by each module and their constituent nodes, one can examine the **consistency and diversity** with which different regions are coclassified into the same module across participants.

*Classification consistency* is estimated by computing the within-module strength, *z*, of each node in the group-level consistency matrix. *Classification diversity* is computed using the diversity coefficient *h*.

Applied in this context, *z* quantifies the degree to which each region is classified in the same module across participants relative to other nodes in the same module. Brain regions with high *z* values represent core components of their module and thus act as local connectivity hubs. The diversity coefficient, *h*, quantifies the variability of each region's modular assignment across participants. Regions with high *h* have a relatively equal probability of being classified into different modules across participants, because their connectivity is dispersed between modules from individual to individual. These regions, therefore, represent transitional nodes that facilitate functional integration between modules.

### Measures of modular organization III:

| Group community structure                    |
|--|
| All subjects                                 |
| Two groups                                   |
| Resolution (gamma): 1.0                      |
| Pre-calculated groups                        |
| Classification consistency and diversity     |
| Partition distance (Mln, Vln) for two groups |
| Visualize modules with BrainNet viewer       |

#### PARTITION DISTANCE (text adapted from Fischi-Gomez et al., 2016):

Quantifies the distance between pairs of community partitions with information theoretic measures: mutual information and variational information (Meila, 2007).

These two measures, based on the concept of entropy, quantify similarities and differences between graphs partitions. The *mutual information (MI)* quantifies how much information is shared by the two (different) partitions Ci and Cj of a given network G. Roughly speaking, MI tells how much we learn about Ci if we know Cj, and viceversa. Nevertheless the most commonly used measure of similarity in graph is the normalized mutual information (MIn), introduced by (Danon et al., 2005). This measure equals 1 if the two partitions are identical, whereas it has an expected value of 0 is the two partitions are independent.

The variation of information (VI) expresses the quantity of information intrinsic to the two partitions, corrected by the information shared by the two partitions. VI is upbounded by the logarithm of the number of nodes (log n) and can be therefore normalized by this value, giving a rescaled value of VI to the range [0,1].





# **Output visualization:**





| • | male Modules in Community for Thr. 0.5 |              |                          |                           |  |  |  |
|---|--|--------------|--------------------------|---------------------------|--|--|--|
| Γ |  | 1            | 2                        | 3                         |  |  |  |
| Γ | 1                                      | Summary      | red                      | yellow                    |  |  |  |
| Γ | 2                                      | sizes: 46 44 | Precentral gyrus (Left)  | Superior frontal gyrus    |  |  |  |
| Γ | 3                                      | Q: 0.48789   | Precentral gyrus (Right) | Superior frontal gyrus    |  |  |  |
| Γ | 4                                      |              | Inferior frontal gyrus,  | Superior frontal gyrus    |  |  |  |
| Γ | 5                                      |              | Rolandic operculum (L    | Superior frontal gyrus    |  |  |  |
| [ | 6                                      |              | Rolandic operculum (R    | Middle frontal gyrus (L   |  |  |  |
|   | 7                                      |              | Supplementary motor      | Middle frontal gyrus (    |  |  |  |
| Γ | 8                                      |              | Supplementary motor      | Middle frontal gyrus or   |  |  |  |
| Γ | 9                                      |              | Insula (Left)            | Middle frontal gyrus or   |  |  |  |
|   | 10                                     |              | Insula (Right)           | Inferior frontal gyrus,   |  |  |  |
| Γ | 11                                     |              | Median cingulate and     | Inferior frontal gyrus, t |  |  |  |
| Γ | 12                                     |              | Median cingulate and     | Inferior frontal gyrus, t |  |  |  |
| Γ | 13                                     |              | Amygdala (Left)          | Inferior frontal gyrus,   |  |  |  |
|   | 14                                     |              | Amygdala (Right)         | Inferior frontal gyrus,   |  |  |  |
|   | 15                                     |              | Calcarine fissure and    | Olfactory cortex (Left)   |  |  |  |
| Γ | 16                                     |              | Calcarine fissure and    | Olfactory cortex (Right)  |  |  |  |
| Γ | 17                                     |              | Cuneus (Left)            | Superior frontal gyrus    |  |  |  |
|   | 18                                     |              | Cuneus (Right)           | Superior frontal gyrus    |  |  |  |
|   | 19                                     |              | Lingual gyrus (Left)     | Superior frontal gyrus    |  |  |  |
|   | 20                                     |              | Lingual gyrus (Right)    | Superior frontal gyrus    |  |  |  |
|   | 21                                     |              | Superior occipital gyru  | Gyrus rectus (Left)       |  |  |  |

| fem | ale Modules in Com | munity for Thr. 0.5       |                           |                           | Σ |
|-----|--------------------|---------------------------|---------------------------|---------------------------|---|
|     | 1                  | 2                         | 3                         | 4                         | - |
| 1   | Summary            | red                       | yellow                    | green                     | ŀ |
| 2   | sizes: 31 30 29    | Superior frontal gyrus    | Precentral gyrus (Left)   | Hippocampus (Left)        | ſ |
| 3   | Q: 0.61841         | Superior frontal gyrus    | Precentral gyrus (Right)  | Hippocampus (Right)       | 1 |
| 4   | 1                  | Superior frontal gyrus    | Middle frontal gyrus (    | Parahippocampal gyru.     |   |
| 5   |                    | Superior frontal gyrus    | Inferior frontal gyrus,   | Parahippocampal gyru.     |   |
| 6   | 1                  | Middle frontal gyrus (L   | Inferior frontal gyrus,   | Amygdala (Left)           |   |
| 7   |                    | Middle frontal gyrus or   | Inferior frontal gyrus, t | Amygdala (Right)          | 1 |
| 8   | 1                  | Middle frontal gyrus or   | Rolandic operculum (L     | Calcarine fissure and     |   |
| 9   |                    | Inferior frontal gyrus, t | Rolandic operculum (R     | Calcarine fissure and     |   |
| 10  | 1                  | Inferior frontal gyrus,   | Supplementary motor       | Lingual gyrus (Left)      | 1 |
| 11  |                    | Inferior frontal gyrus,   | Supplementary motor       | Lingual gyrus (Right)     | 1 |
| 12  | 1                  | Olfactory cortex (Left)   | Insula (Left)             | Superior occipital gyru.  |   |
| 13  |                    | Olfactory cortex (Right)  | Insula (Right)            | Superior occipital gyru.  |   |
| 14  | 1                  | Superior frontal gyrus    | Median cingulate and      | Middle occipital gyrus    |   |
| 15  |                    | Superior frontal gyrus    | Median cingulate and      | Middle occipital gyrus    |   |
| 16  | 1                  | Superior frontal gyrus    | Cuneus (Right)            | Inferior occipital gyrus. | l |
| 17  |                    | Superior frontal gyrus    | Postcentral gyrus (Left)  | Inferior occipital gyrus. |   |
| 18  | 1                  | Gyrus rectus (Left)       | Postcentral gyrus (Rig    | Fusiform gyrus (Left)     |   |
| 19  |                    | Gyrus rectus (Right)      | Superior parietal gyru    | Fusiform gyrus (Right)    |   |
| 20  | 1                  | Anterior cingulate and    | Superior parietal gyru    | Caudate nucleus (Left)    |   |
| 21  |                    | Anterior cingulate and    | Inferior parietal, but su | Caudate nucleus (Right    | ŧ |
| 22  | 1                  | Posterior cingulate gyr   | Inferior parietal, but su | Lenticular nucleus, pu.   |   |
| 23  |                    | Posterior cingulate gyr   | Supramarginal gyrus (     | Lenticular nucleus, pu.   |   |
|     | •                  |                           |                           | •                         |   |

# Saved output in folder "Group Community":



Figures created by BrainNetViewer and zh-Plots are also saved in this folder

## Saved output in folder "GraphVars":

Difference in h between groups Difference in Q between groups Difference in Z between groups MIn – between groups VIn – between groups Subject-level consistency matrices (one per subject) Permutation distribution of difference in h (sorted) Permutation distribution of difference in Q (sorted) Permutation distribution of difference in Z (sorted) Permutation distribution MIn (sorted) Permutation distribution VIn (sorted) Permutation generated Affiliation vectors of rand groups Permutation generated h per region per permutation Permutation generated Q per permutation Permutation generated Z per permutation

Subject-level consensus affiliation vector (one per subj) Overlap of nodes in modules: Group 1 -> Group 2 Overlap of nodes in modules: Group 2 -> Group 1 P-value for h (one per region) P-value for MIn P-value for Q P-value for VIn P-value for Z (one per region)

actual\_delta\_h actual delta Q actual delta Z actual MIn actual VIn agreement\_matrix\_1\_2 distr\_delta\_h\_group\_perm distr\_delta\_Q\_group\_perm distr\_delta\_Z\_group\_perm distr\_MIn\_group\_perm distr\_VIn\_group\_perm group\_1\_perm\_C group\_1\_perm\_h group\_1\_perm\_Q group\_1\_perm\_Z group\_2\_perm\_C group\_2\_perm\_h group\_2\_perm\_Q group\_2\_perm\_Z modularity\_louvain\_cOut\_und\_1\_2 Modularity\_overlap\_percent\_1\_2 Modularity\_overlap\_percent\_2\_1 愉 P\_h P MIn ៉ P\_Q 🛍 P\_VIn 1 P Z

# **Miscellaneous:**

#### Binarized Affiliation vectors (one per module)

#### Moroup\_1\_Binary\_Affiliation\_Vectors\_0.1

|    | 1 | 2 | 3 | 4 |
|----|---|---|---|---|
| 1  | 0 | 1 | 0 | 0 |
| 2  | 0 | 1 | 0 | 0 |
| 3  | 1 | 0 | 0 | 0 |
| 4  | 1 | 0 | 0 | 0 |
| 5  | 1 | 0 | 0 | 0 |
| 6  | 1 | 0 | 0 | 0 |
| 7  | 1 | 0 | 0 | 0 |
| 8  | 1 | 0 | 0 | 0 |
| 9  | 1 | 0 | 0 | 0 |
| 10 | 1 | 0 | 0 | 0 |
| 11 | 1 | 0 | 0 | 0 |
| 12 | 1 | 0 | 0 | 0 |
| 13 | 1 | 0 | 0 | 0 |
| 14 | 1 | 0 | 0 | 0 |
| 15 | 1 | 0 | 0 | 0 |
| 16 | 1 | 0 | 0 | 0 |
| 17 | 0 | 1 | 0 | 0 |
| 18 | 0 | 1 | 0 | 0 |
| 19 | 0 | 1 | 0 | 0 |
| 20 | 0 | 1 | 0 | 0 |
| 21 | 0 | 0 | 1 | 0 |
| 22 | 0 | 0 | 1 | 0 |
| 23 | 1 | 0 | 0 | 0 |
| 24 | 1 | 0 | 0 | 0 |
| 25 | 1 | 0 | 0 | 0 |
| 26 | 1 | 0 | 0 | 0 |
| 27 | 1 | 0 | 0 | 0 |
| 28 | 1 | 0 | 0 | 0 |
| 29 | 0 | 1 | 0 | 0 |
| 30 | 0 | 1 | 0 | 0 |
| 31 | 1 | 0 | 0 | 0 |
| 32 | 1 | 0 | 0 | 0 |

| 1  | 0   | recentral_L         | Precentral gyrus (Left)                     | -40 | -6  | 51  |
|----|-----|---------------------|---|-----|-----|-----|
| 2  | 0   | recentral_R         | Precentral gyrus (Right)                    | 40  | -8  | 52  |
| 3  | 1   | rontal_Sup_L        | Superior frontal gyrus, dorsolateral (Lef   | -19 | 35  | 42  |
| 1  | 1   | rontal_Sup_R        | Superior frontal gyrus, dorsolateral (Rig   | 20  | 31  | 44  |
| 5  | 0   | rontal_Sup_Orb_L    | Superior frontal gyrus, orbital part (Left  | -18 | 47  | -13 |
| 5  | 1   | rontal_Sup_Orb_R    | Superior frontal gyrus, orbital part (Righ  | 17  | 48  | -14 |
| 7  | 1   | rontal_Mid_L        | Middle frontal gyrus (Left)                 | -34 | 33  | 35  |
| в  | 1   | rontal_Mid_R        | Middle frontal gyrus (Right)                | 37  | 33  | 34  |
| •  | 0   | rontal_Mid_Orb_L    | Middle frontal gyrus orbital part (Left)    | -32 | 50  | -10 |
| 10 | 0   | rontal_Mid_Orb_R    | Middle frontal gyrus orbital part (Right)   | 32  | 53  | -11 |
| 1  | 0   | rontal Inf Oper L   | Inferior frontal gyrus, opercular part (Le  | -49 | 13  | 19  |
| 2  | 1   | rontal_Inf_Oper_R   | Inferior frontal gyrus, opercular part (Ri  | 49  | 15  | 21  |
| 13 | 1   | rontal_Inf_Tri_L    | Inferior frontal gyrus, triangular part (Le | -47 | 30  | 14  |
| 14 | 1   | rontal_Inf_Tri_R    | Inferior frontal gyrus, triangular part (Ri | 49  | 30  | 14  |
| 15 | 1   | rontal_Inf_Orb_L    | Inferior frontal gyrus, orbital part (Left) | -37 | 31  | -12 |
| 16 | 1   | rontal_Inf_Orb_R    | Inferior frontal gyrus, orbital part (Right | 40  | 32  | -12 |
| L7 | 0   | olandic Oper L      | Rolandic operculum (Left)                   | -48 | -8  | 14  |
| 18 | 1   | olandic_Oper_R      | Rolandic operculum (Right)                  | 52  | -6  | 15  |
| 19 | 1   | upp_Motor_Area_L    | Supplementary motor area (Left)             | -6  | 5   | 61  |
| 20 | 1   | upp_Motor_Area_R    | Supplementary motor area (Right)            | 8   | 0   | 62  |
| 21 | 0   | Ifactory L          | Olfactory cortex (Left)                     | -9  | 15  | -12 |
| 22 | 0   | lfactory_R          | Olfactory cortex (Right)                    | 8   | 16  | -11 |
| 23 | 0   | rontal_Sup_Medial_L | Superior frontal gyrus, medial (Left)       | -6  | 49  | 31  |
| 24 | 0   | rontal Sup Medial R | Superior frontal gyrus, medial (Right)      | 8   | 51  | 30  |
| 25 | 0   | rontal_Med_Orb_L    | Superior frontal gyrus, medial orbital (L   | -6  | 54  | -7  |
| 26 | 0   | rontal Med Orb R    | Superior frontal gyrus, medial orbital (F   | 7   | 52  | -7  |
| 27 | 0   | ectus L             | Gyrus rectus (Left)                         | -6  | 37  | -18 |
| 28 | 1   | ectus_R             | Gyrus rectus (Right)                        | 7   | 36  | -18 |
| 29 | 1   | nsula_L             | Insula (Left)                               | -36 | 7   | 3   |
| 30 | 1   | nsula_R             | Insula (Right)                              | 38  | 6   | 2   |
| 31 | 0 ( | ingulum_Ant_L       | Anterior cingulate and paracingulate gy     | -5  | 35  | 14  |
| 32 | 1   | ingulum_Ant_R       | Anterior cingulate and paracingulate gy     | 7   | 37  | 16  |
| 33 | 0 ( | ingulum_Mid_L       | Median cingulate and paracingulate gyr      | -6  | -15 | 42  |
| 34 | 0   | ingulum_Mid_R       | Median cingulate and paracingulate gyr      | 7   | -9  | 40  |
| 35 | 1   | ingulum_Post_L      | Posterior cingulate gyrus (Left)            | -6  | -43 | 25  |
| 36 | 1   | ingulum_Post_R      | Posterior cingulate gyrus (Right)           | 6   | -42 | 22  |
| 37 | 0   | ippocampus_L        | Hippocampus (Left)                          | -26 | -21 | -10 |
| 38 | 1   | ippocampus_R        | Hippocampus (Right)                         | 28  | -20 | -10 |
|    |     |                     | 6 11 1 0 00                                 | ~~  |     | ~   |



| Precentral gyrus (Left)             | * |  |  |
|-------------------------------------|---|--|--|
| Precentral gyrus (Right)            |   |  |  |
| Superior frontal gyrus, dorsolate   |   |  |  |
| Superior frontal gyrus, dorsolate   |   |  |  |
| Superior frontal gyrus, orbital par |   |  |  |
| Superior frontal gyrus, orbital par |   |  |  |
| Middle frontal gyrus (Left)         |   |  |  |
| Middle frontal gyrus (Right)        | Ŧ |  |  |
| 4                                   |   |  |  |

Simply use (one of) the binary affiliation vectors as input to the BrainRegions xlsx sheet (first column) for subnetwork analyses