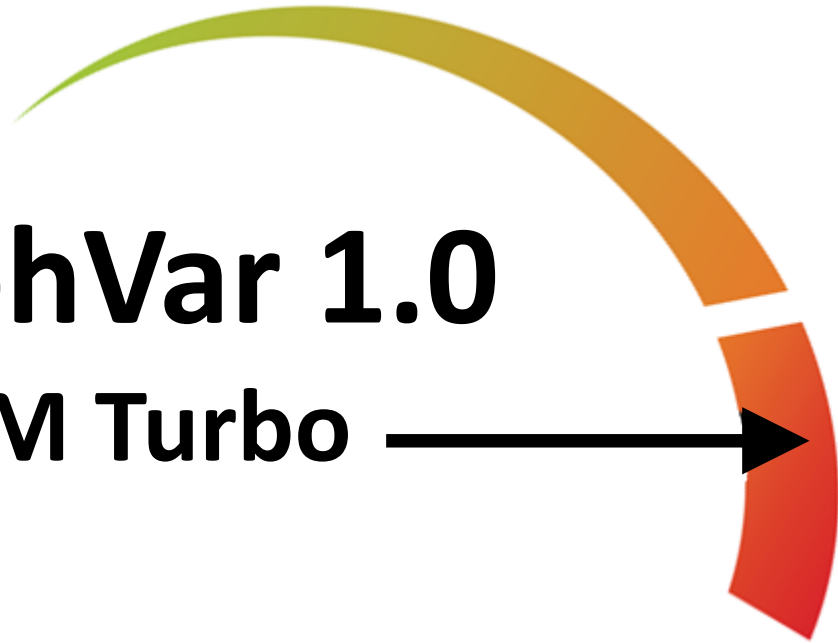
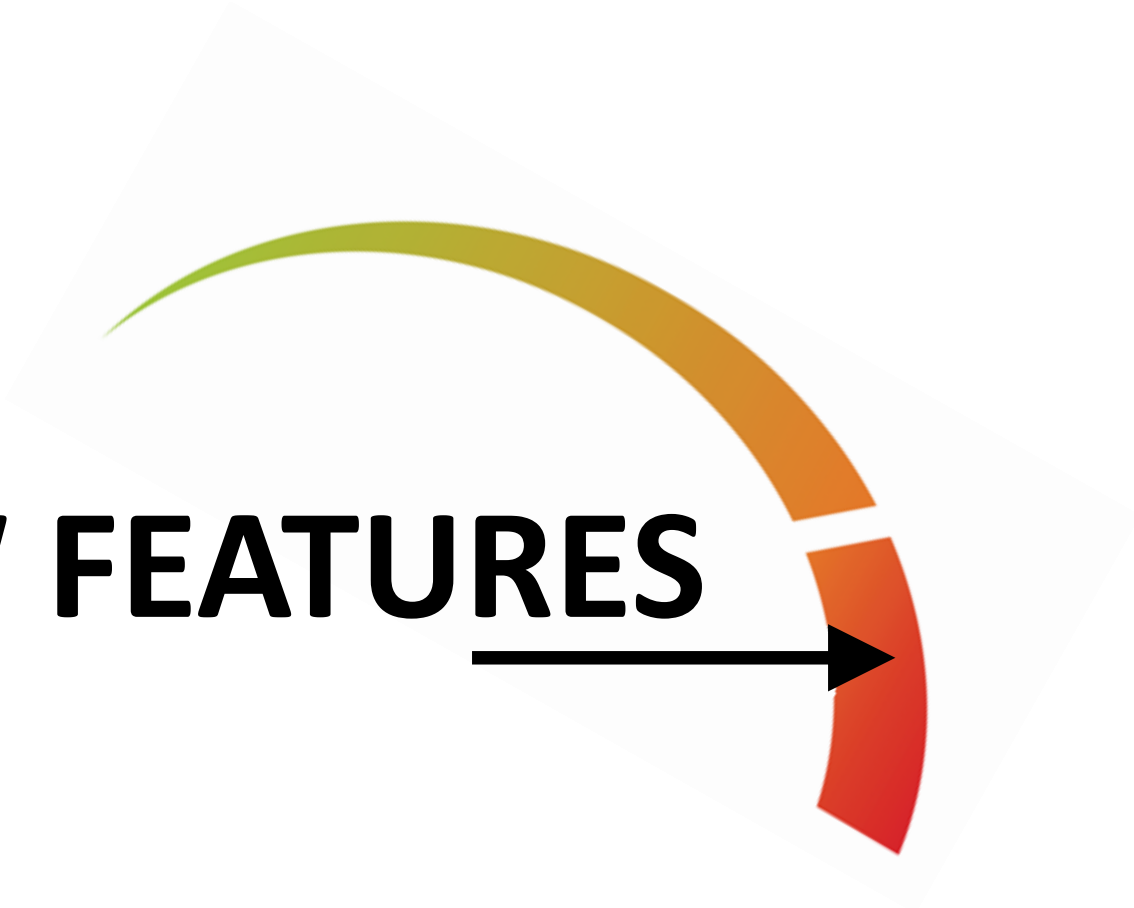


GraphVar 1.0

GLM Turbo



NEW FEATURES



**GraphVar 1.0
GLM Turbo**

General Settings

Brain regions files: BrainRegions.csv [Select]
 File with Variables: Variables.csv [Select]

[Select Subjects (Conn Matrix)]
 [Create Connectivity Matrix]

Subjects

CorrMatrix_sample_01.mat
 CorrMatrix_sample_02.mat
 CorrMatrix_sample_03.mat
 CorrMatrix_sample_04.mat
 CorrMatrix_sample_05.mat
 CorrMatrix_sample_06.mat
 CorrMatrix_sample_07.mat

Subjectname in Filename: CorrMatrix_sample_01.mat

Start: 1 End (remaining characters): 21
 Corr Matrix Array: CorrMatrix

Save interim results Parallel Workers: 0

Network Construction

Threshold: Significant Relative Absolute SICE None

Weights: No Change absolute weights negative weights to zero

Network nodes / Brain areas

Precentral gyrus (Left) 0.1
 Precentral gyrus (Right) 0.11
 Superior frontal gyrus, dorsolate 0.12
 Superior frontal gyrus, dorsolate 0.13
 Superior frontal gyrus, orbital pa 0.14
 Superior frontal gyrus, orbital pa 0.15
 Middle frontal gyrus (Left) 0.16
 Middle frontal gyrus (Right) 0.17
 Middle frontal gyrus (Right) 0.18
 Middle frontal gyrus (Right) 0.19

Generate 1 randomized subject data (null model network) with 1 iterations. [CheckFrag]

Binary Weighted

Raw Matrix (link wise)

Raw matrix Connectivity Thr. r to z Generate 1 random networks

0.5
 .045
 .04
 .035
 .03
 .025
 .02
 .015
 .01
 .009
 .008
 .007
 .006

random_shuffle
 c_null_model_und_s
 null_model_und_sigi
 null_model_dir_sign

with 1 iterations for each subject.

Weights: No Change absolute weights negative weights to zero

GLM

Variables

sex
 eating_contest_chilli

Between covariates

age
 IQ

Between factors

research_site

Within covariates

Nuisance covariates

fantasy_score
 beer_pong_score

No Interactions

Select Within ID

Graph metrics

parametric rand NW permutation #Rep

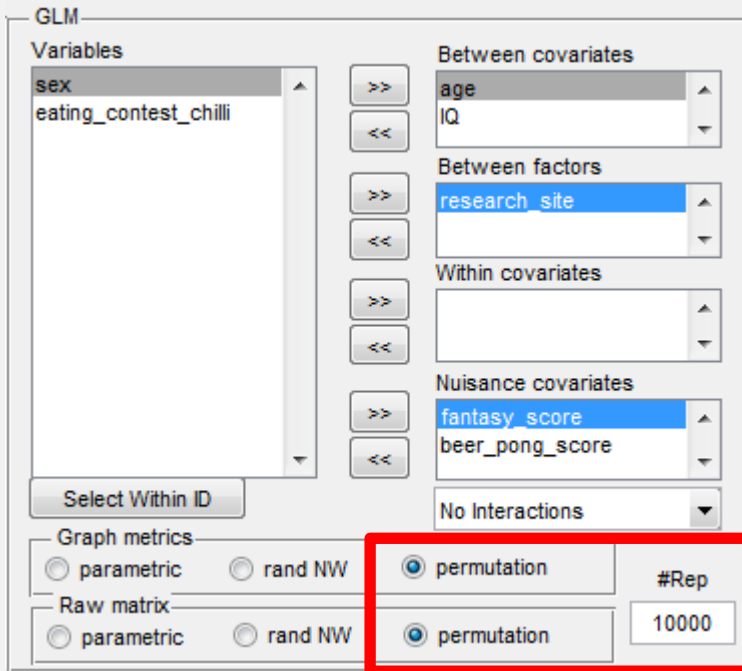
Raw matrix

parametric rand NW permutation #Rep 1

Calculate variables and export

Switch Workspace Open Previous Results Load interim results Statistics with already calculated values Calculate & Statistics

New general linear model (GLM) framework



GraphVar calls C++ functions which enable fast permutation testing

-> This feature allows for large-scale non-parametric testing of the connectome (e.g. NBS on the fully connected association matrices)

Fast permutation testing via C++ functions

**GraphVar 1.0
GLM Turbo**

General Settings
 Brain regions files: BrainRegions.csv [Select]
 File with Variables: 'thin_Design.xlsx' [Select]
 Select Subjects (Conn Matrix)
 Create Connectivity Matrix

Subjects
 CorrMatrix_sample_01.mat
 CorrMatrix_sample_02.mat
 CorrMatrix_sample_03.mat
 CorrMatrix_sample_04.mat
 CorrMatrix_sample_05.mat
 CorrMatrix_sample_06.mat
 CorrMatrix_sample_07.mat
 Subjectname in Filename: CorrMatrix_sample_01.mat
 Start: 1 End (remaining characters): 21
 Corr Matrix Array: CorrMatrix
 Save interim results Parallel Workers: 0

Network Construction
 Threshold: Significant Relative Absolute SICE None
 Weights: No Change absolute weights negative weights to zero
 Network nodes / Brain areas: Precentral gyrus (Left), Precentral gyrus (Right), Superior frontal gyrus, dorsolate, Superior frontal gyrus, orbital pa, Middle frontal gyrus (Left), Middle frontal gyrus (Right)
 Network thresholds: 0.1, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16, 0.17, 0.18, 0.19
 Generate 1 with 1 iterations.
 Binary Weighted [CheckFrag]

Raw Matrix (link wise)
 Raw matrix Connectivity Thr. r to z Generate 1000 random networks
 0.05, 0.045, 0.04, 0.035, 0.03, 0.025, 0.02, 0.015, 0.01, 0.009, 0.008, 0.007, 0.006
 random_shuffle
 c_null_model_und_s
 null_model_und_sign
 null_model_dir_sign
 with 1 iterations for each subject.
 Weights: No Change absolute weights negative weights to zero

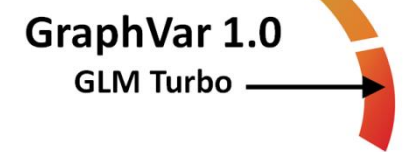
GLM
 Variables: eating_contest_chilli
 Between covariates: age, IQ
 Between factors: research_site
 Within covariates:
 Nuisance covariates: fantasy_score, beer_pong_score, sex
 No Interactions
 Graph metrics: parametric rand NW permutation #Rep
 Raw matrix: parametric rand NW permutation 10000

Switch Workspace Open Previous Results Load interim results Statistics with already calculated values Calculate & Statistics

Fast C++ implementation of „null_model_und_sign“

Neural, electrophysiological and anatomical basis of brain-network variability and its characteristic changes in mental disorders

Jie Zhang,^{1,2,*} Wei Cheng,^{1,*} Zhaowen Liu,^{1,3,*} Kai Zhang,^{4,*} Xu Lei,^{5,6} Ye Yao,¹ Benjamin Becker,⁷ Yicen Liu,¹ Keith M. Kendrick,⁷ Guangming Lu^{2,8} and Jianfeng Feng^{1,9,10,11}



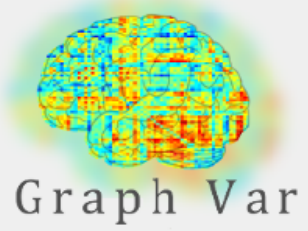
Start: 12 End (remaining characters): 4
Corr Matrix Array: CorrMatrix
 Save interim results Parallel Workers: 0

randomized subject data (null model network)

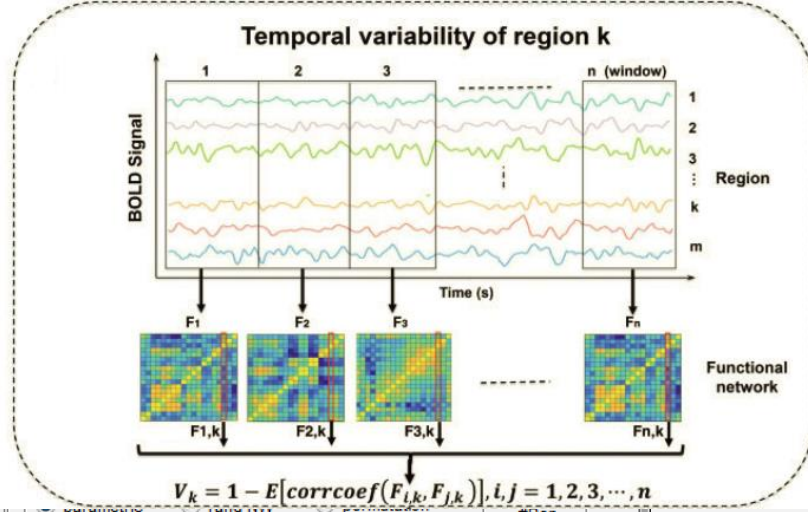
Raw Matrix (link wise)
 Raw matrix
 Connectivity Thr.
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.009
0.008
0.007
0.006

Select Dynamic
Select Dynamic
Variance over time
Standard Deviation
Periodicity
PointProcess: rate
PointProcess: interval
Brain-Network Variability

Weights
 No Change absolute weights
 negative weights to zero



Network
 Calculate
Brain graph
Binary:
Binary:
Binary: Assortativity in-degree/out-degree corre
Binary: Assortativity out-degree/out-degree corre
Binary: Assortativity in-degree/in-degree correlati
Binary: Betweenness centrality - UND/DIR
Binary: Clustering coefficient global - UND
Binary: Clustering coefficient global - DIR
Binary: Clustering coefficient local - UND
Binary: Clustering coefficient local - DIR
 Normalize graph metric with random networks
 Use random network to calc smallworldness

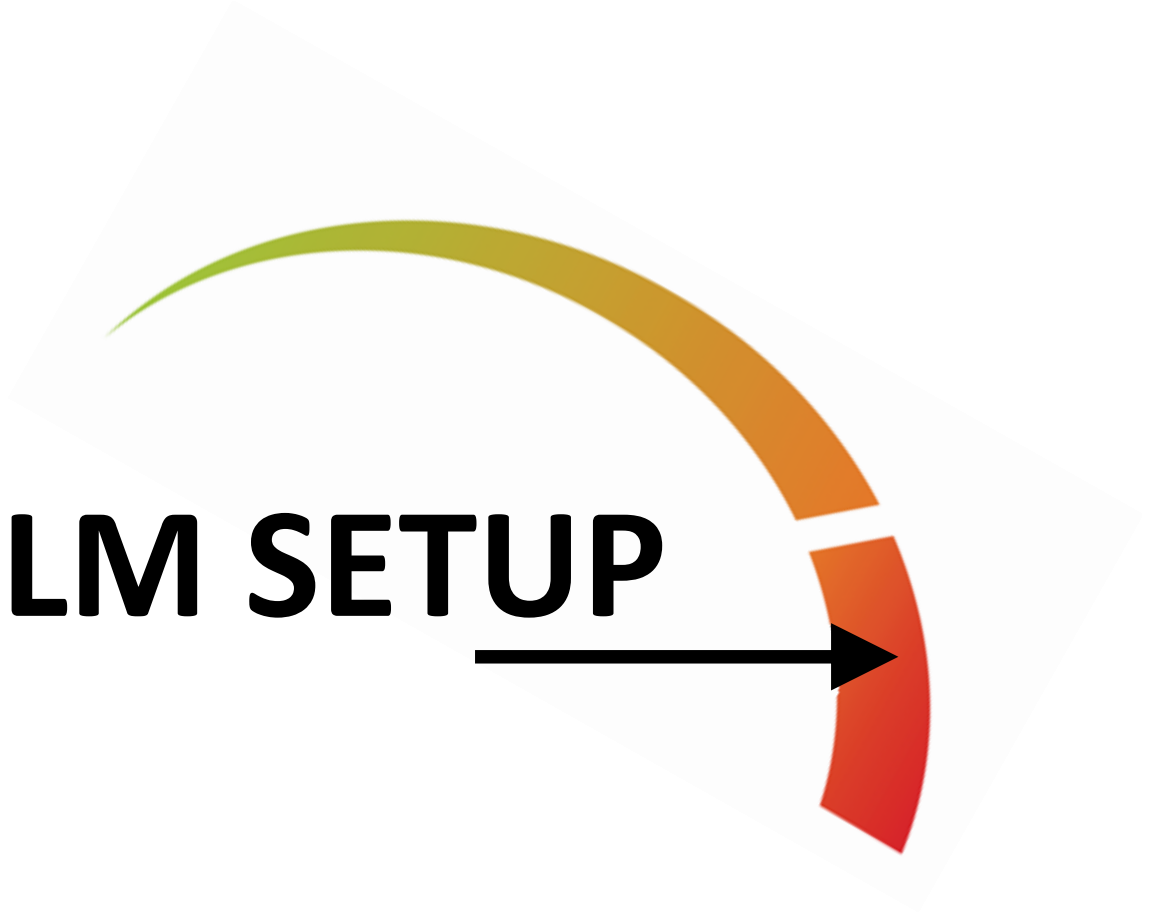


Raw matrix
 parametric rand NW permutation #Rep: 1

Switch Workspace Open Previous Results < Load interim results > Statistics with already calculated values Calculate & Statistics

Brain-Network Variability (Zhang et al. 2016)

GLM SETUP



GLM

Variables
eating_contest_chilli

Between covariates
age
IQ

between factors
research_site

Within covariates

Nuisance covariates
fantasy_score
beer_pong_score
sex

No Interactions

Select Within ID

Graph metrics
 parametric rand NW permutation #Rep

Raw matrix
 parametric rand NW permutation 10000

Covariates (continuous)

Estimates regression coefficients with regard to the dependent variables. Prior to analysis, the covariates are demeaned to eliminate collinearity with the intercept term

Building the model - Covariates

GLM

Variables
eating_contest_chilli

Between covariates
age
IQ

Between factors
research_site

Within covariates

Nuisance covariates
fantasy_score
beer_pong_score
sex

No Interactions

Select Within ID

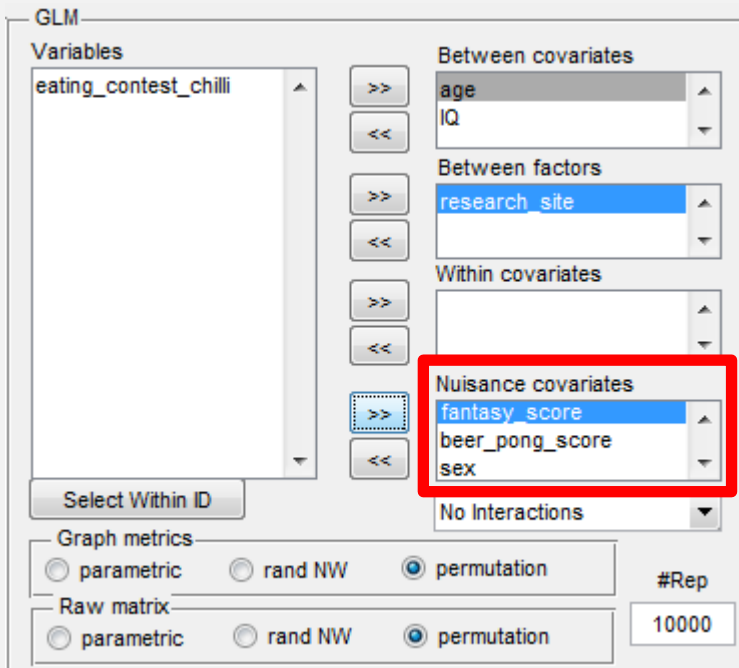
Graph metrics
 parametric rand NW permutation #Rep

Raw matrix
 parametric rand NW permutation 10000

Between factors (categorical)

Estimates the effects of categorical variables, individual group means and pairwise differences between groups.

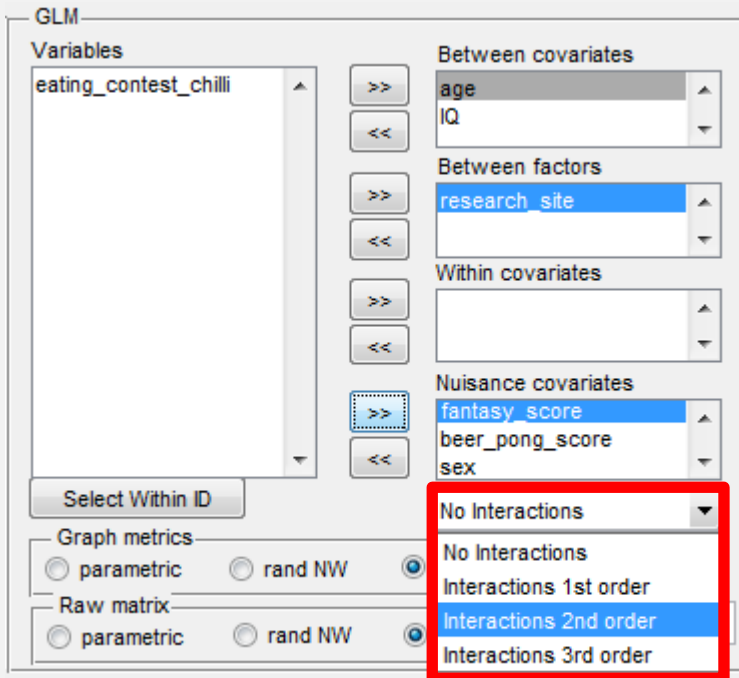
Building the model – Between factors



Nuisance covariates

Prior to all analyses, the nuisance covariates are partialled out from the dependent variables.

Building the model – Nuisance covariates



Interactions

Allows categorical, continuous and categorical-continuous interactions (i.e., differences in regression weights between groups) up to the 3rd order.

Building the model – Interactions



GLM

Variables

Between covariates
age
IQ

Between factors
research_site

Within covariates
eating_contest_chilli

Noisiness covariates
fantasy_score
beer_pong_score
sex

No Interactions

Select Within ID

Graph metrics
 parametric rand NW permutation

Raw matrix
 parametric rand NW permutation

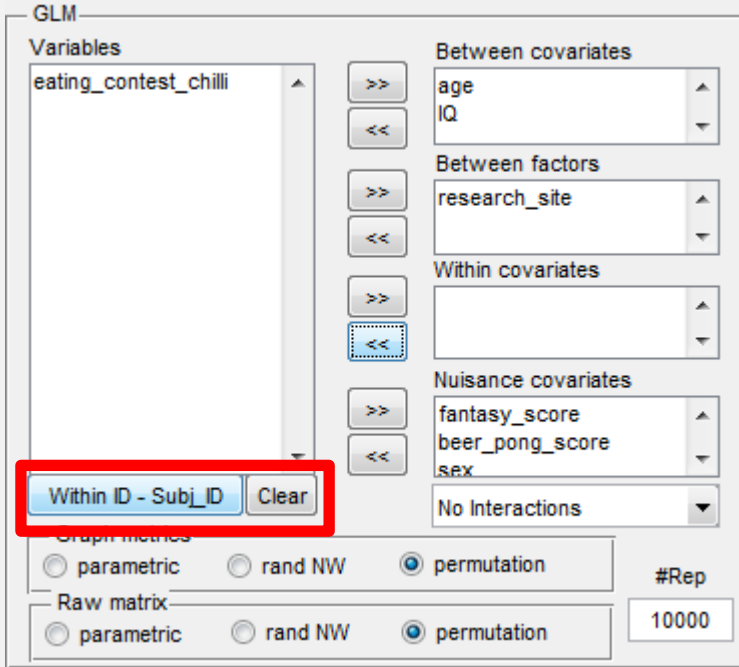
#Rep
10000

Within covariates *

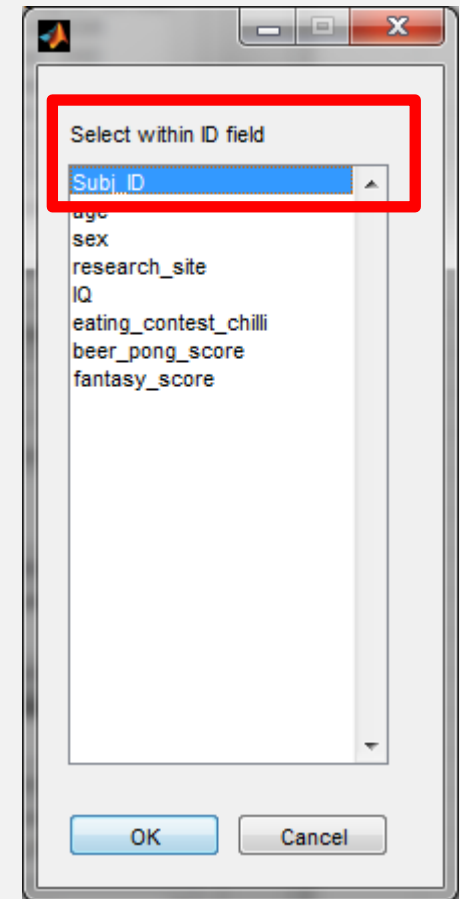
Estimates regression coefficients in repeated measures analyses with two time points. Prior to analysis, the covariates are demeaned to eliminate collinearity with the intercept term

** please refer to the tutorial for how to structure the Variable sheet*

Building the model – Within covariates



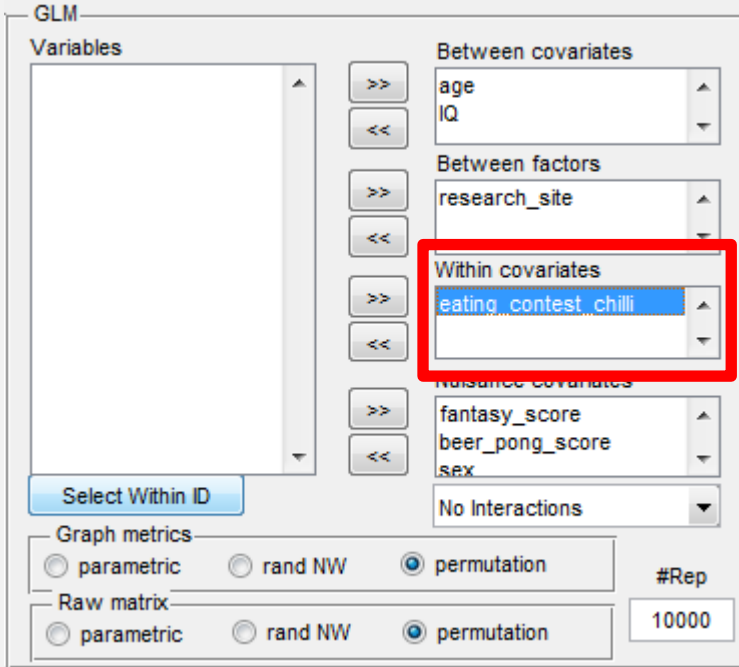
**Within covariates
field is blank**



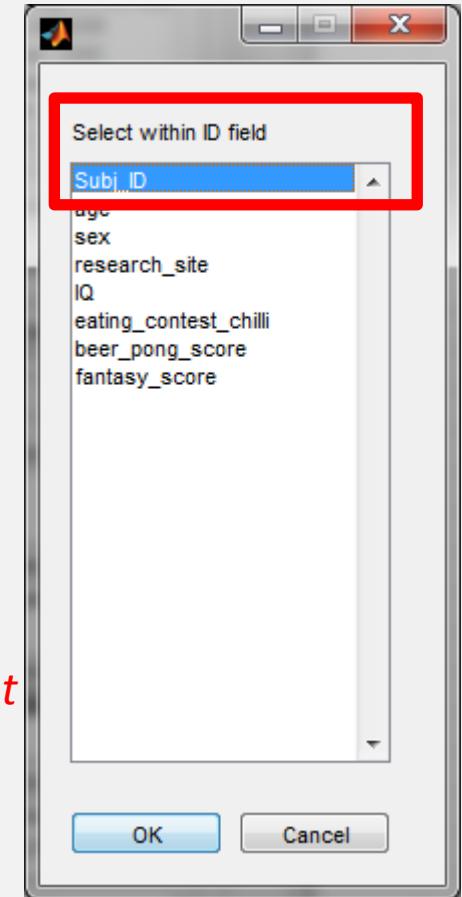
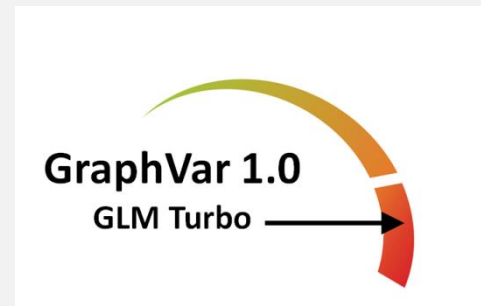
Research option 1 - example:

Investigate the association between a constant independent variable (e.g. sex or genotype) and a changing dependent network variable (e.g. efficiency in T1 and T2)

Building the model – Within covariates I



Select the variable that clearly identifies subjects in the two time points

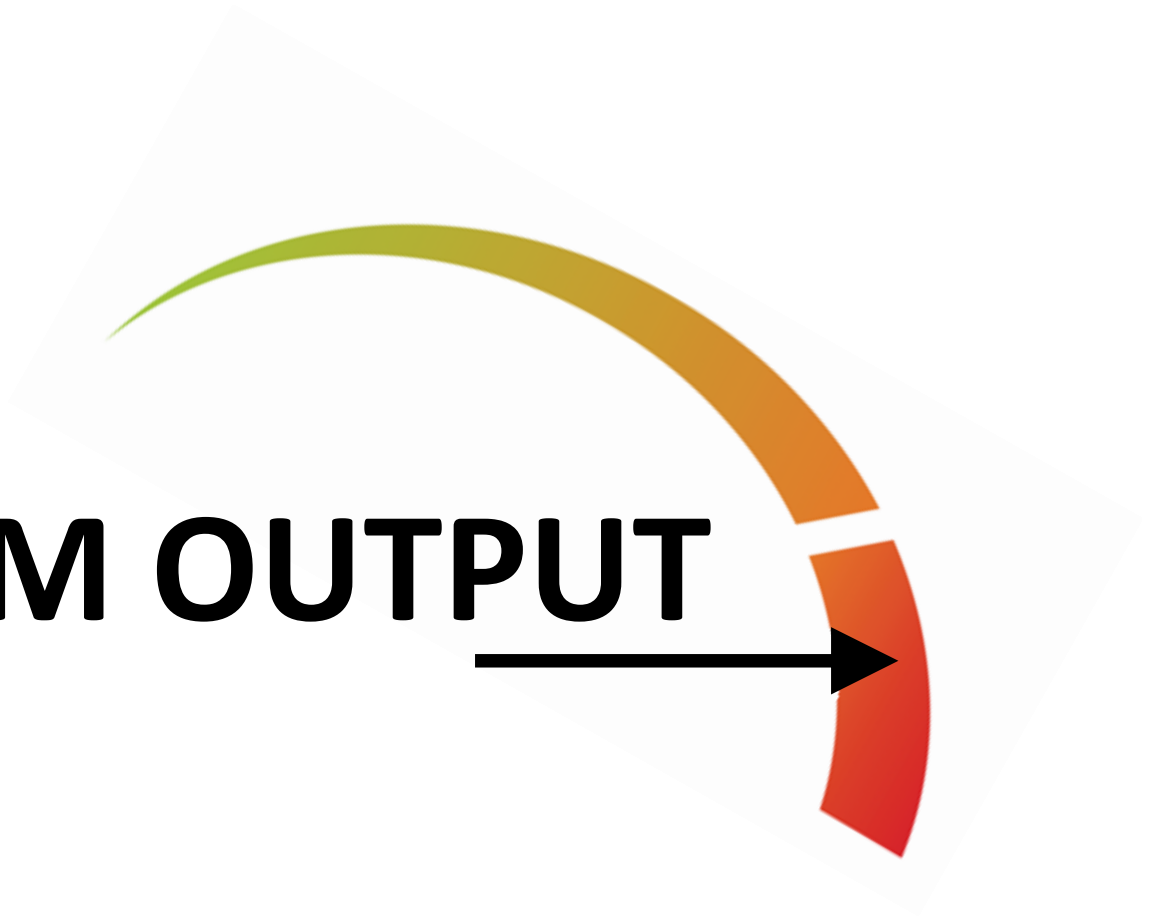


Research option 2 - example:

Investigate the association between the change of an independent variable (e.g. cognitive function in T1 and T2) and the change of a dependent network variable (e.g. network efficiency in T1 T2)

Building the model – Within covariates II

GLM OUTPUT



Frontal_Sup_Orb_L
Variable: sex
d = 0.067693
t(16) = 0.365046
p = 0.719857

d: Difference between Group Means
F(df1,df2): F-value

Frontal_Inf_Orb_L
Variable: age*sex
d(b) = 0.047272
t(16) = 0.090257
p = 0.929203

d(b): Difference between Standardized Regression Weights

Cingulum_Ant_R
Variable: beer_pong_score
b = 0.491152
t(13) = 2.032979
p = 0.062999

b: Standardized Regression Weight

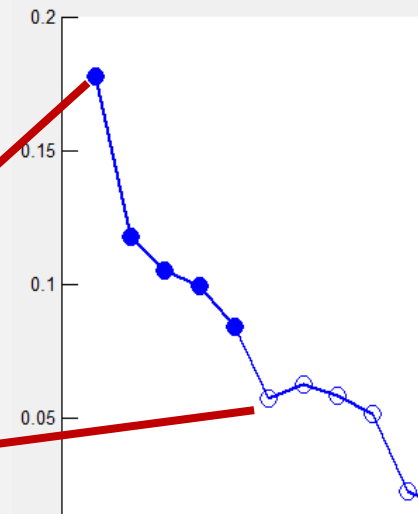
t(df): t-Value

p: p-Value

Rolandic_Oper_R
Variable: Intercept
m = 0.688668
t(16) = 6.904489
p = 0.000004

m: Mean

significant
not-significant



Interpreting GraphVar output

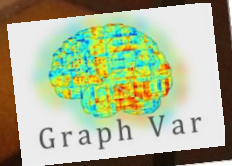


Lea

Johann

David

Lena



GraphVar -Team



Acknowledgements

- GLM – *Lea Waller*
- Brain Network Variability implementation – *Lena Dorfschmidt*
- Testing and coffee – *Johann Kruschwitz, David List*