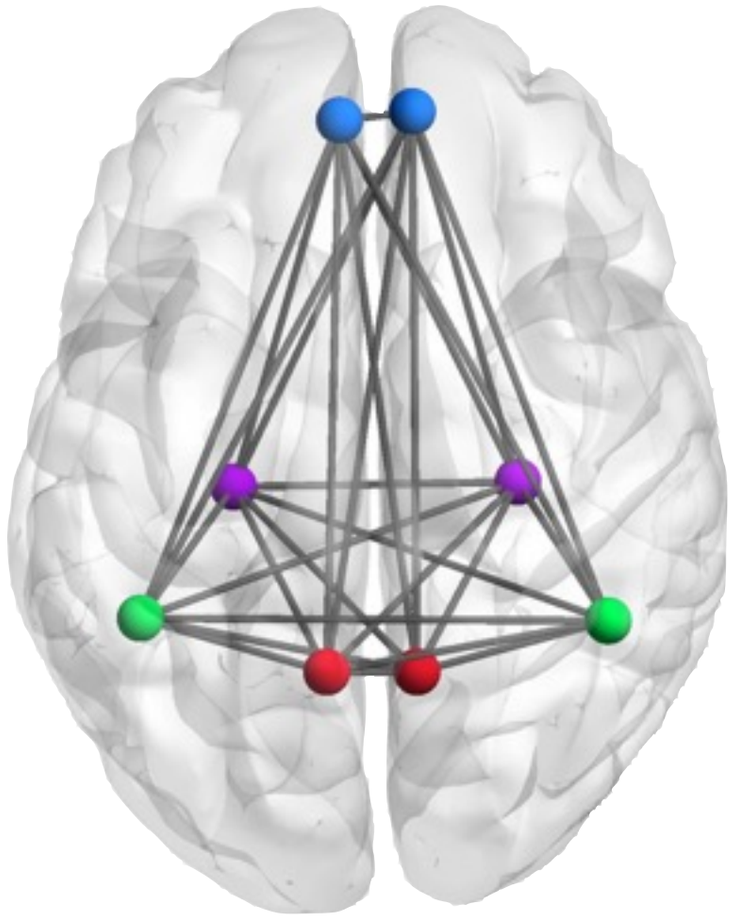
Correlation Analysis between Imaging & Neuropsychological Tests



K.H. Chou, Ph.D (周坤賢)

2016.01.21

Assistant research fellow / Brain Research Center / National Yang Ming University

Where are we now?

Principles of stimulus-evoked fMRI

Principles of resting-state fMRI

Task-fMRI preprocessing

Resting-state functional connectivity

Data modeling & individual analysis

1st

Graph theory & network analysis

Group analysis to factorial design

2nd level

Correlation analysis between imaging & neuropsychological tests

Today's mission

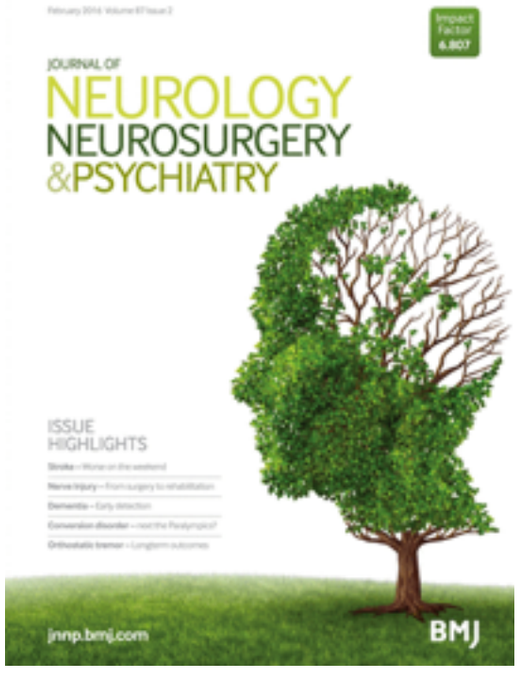
My mission today is to

teach you how to use freeware

to perform basic statistical analysis

of the imaging journal paper

(real world example)



The three basic roles of this course

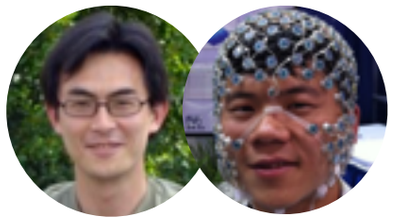
Don’t think any shortcut solutions

Practice, practice and practice

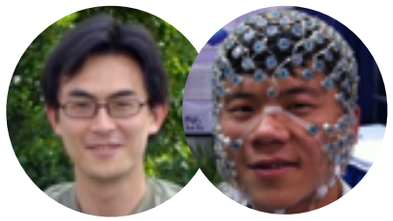
Ask me why when we have free time

From individual pattern to group representation

rsfMRI data



SBFC/ Others



voxel-wised map

Subject 1

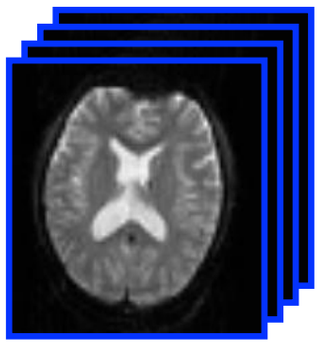
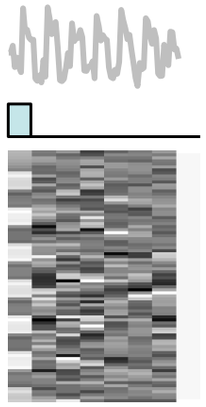
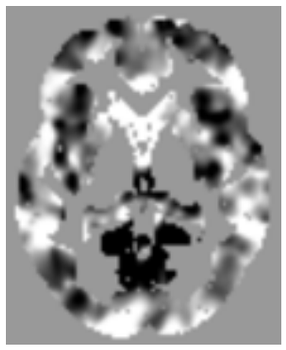


Image preprocessing





rsfMRI data

SBFC/ Others

voxel-wised map

.....

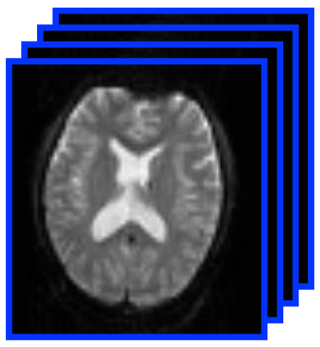
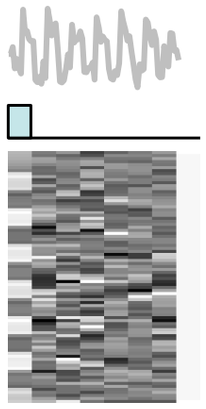
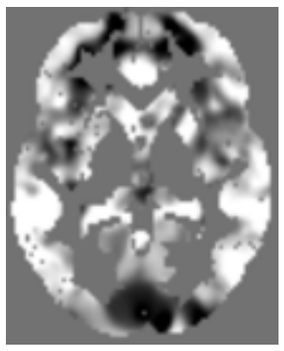


Image preprocessing





rsfMRI data

SBFC/ Others

voxel-wised map

Subject N

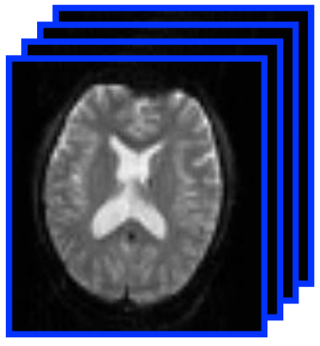
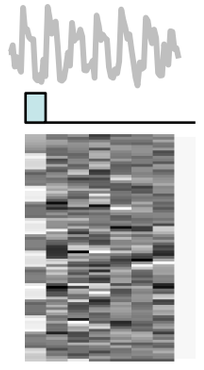
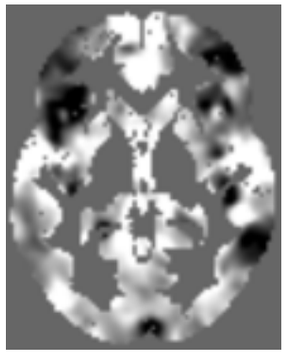
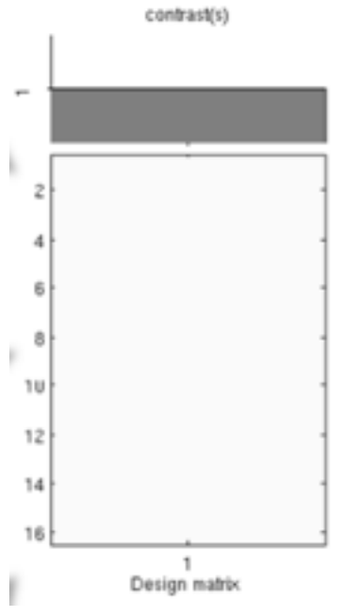


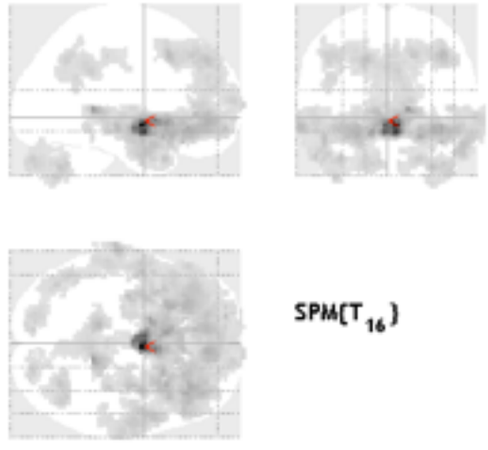
Image preprocessing



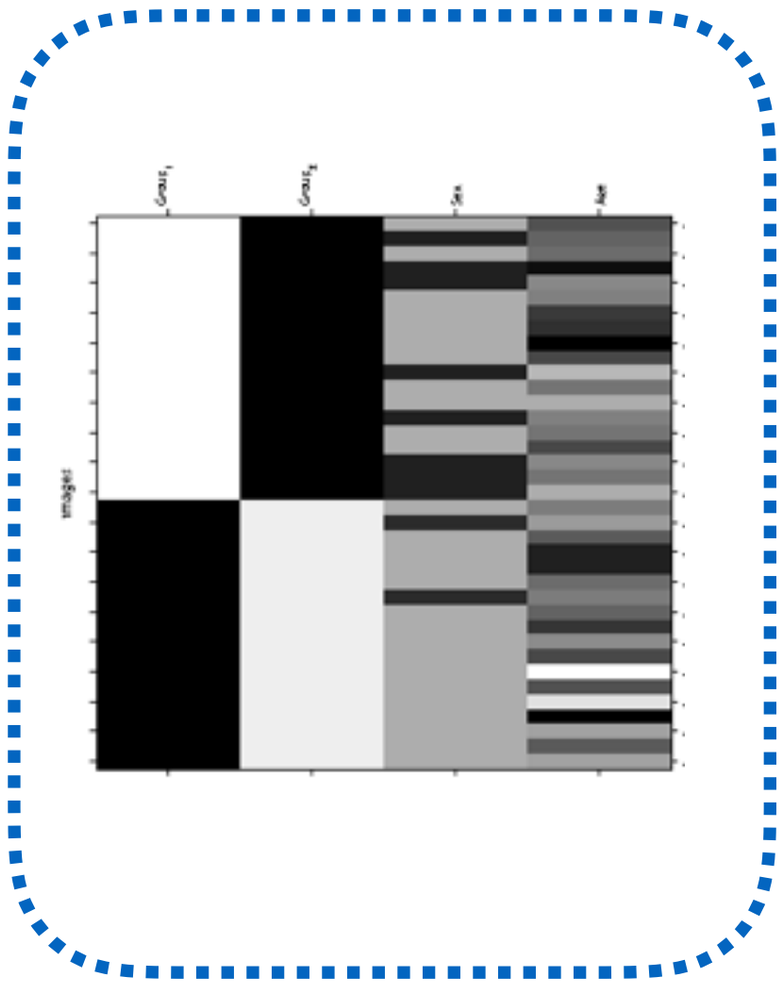


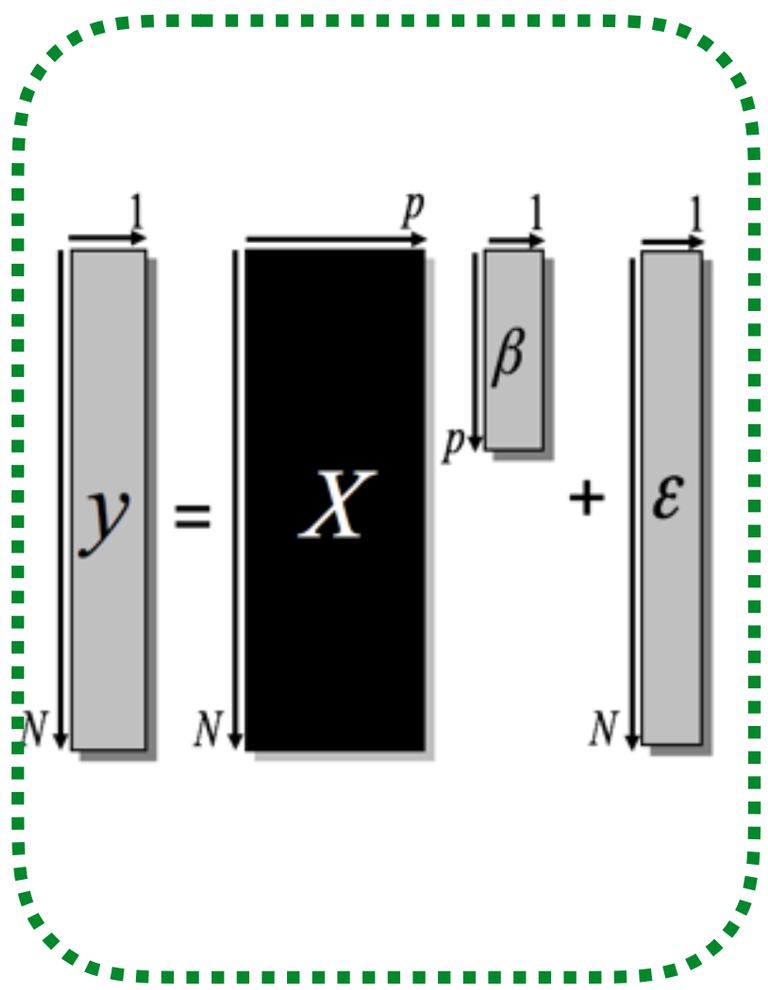


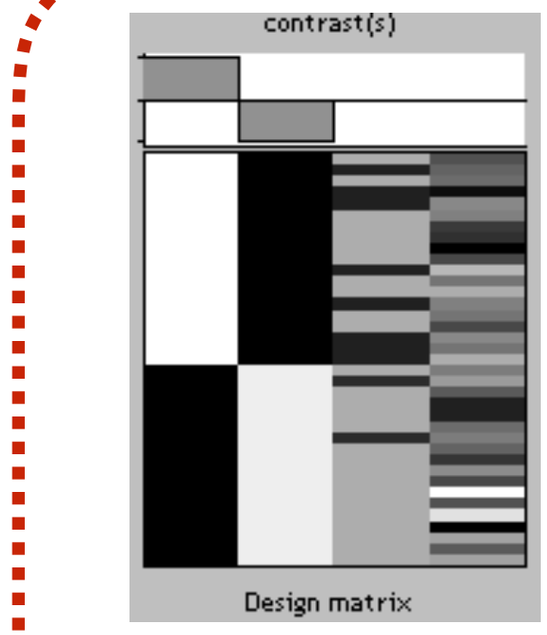
Group level statistics



The basic statistical pipeline of Statistical Parametric Mapping







Model construction

Model estimation

Statistical inference

General Linear Model - Modeling the measured signal

Why? Make inferences about effects of interest

How?
- Decompose data into effects and error
- Form statistic using estimates of effects and error

$$Y = X \times \beta + E$$

Dependent Variable (What you are measuring)

Independent Variable (What you are manipulating)

Relative Contribution (These need to be estimated)

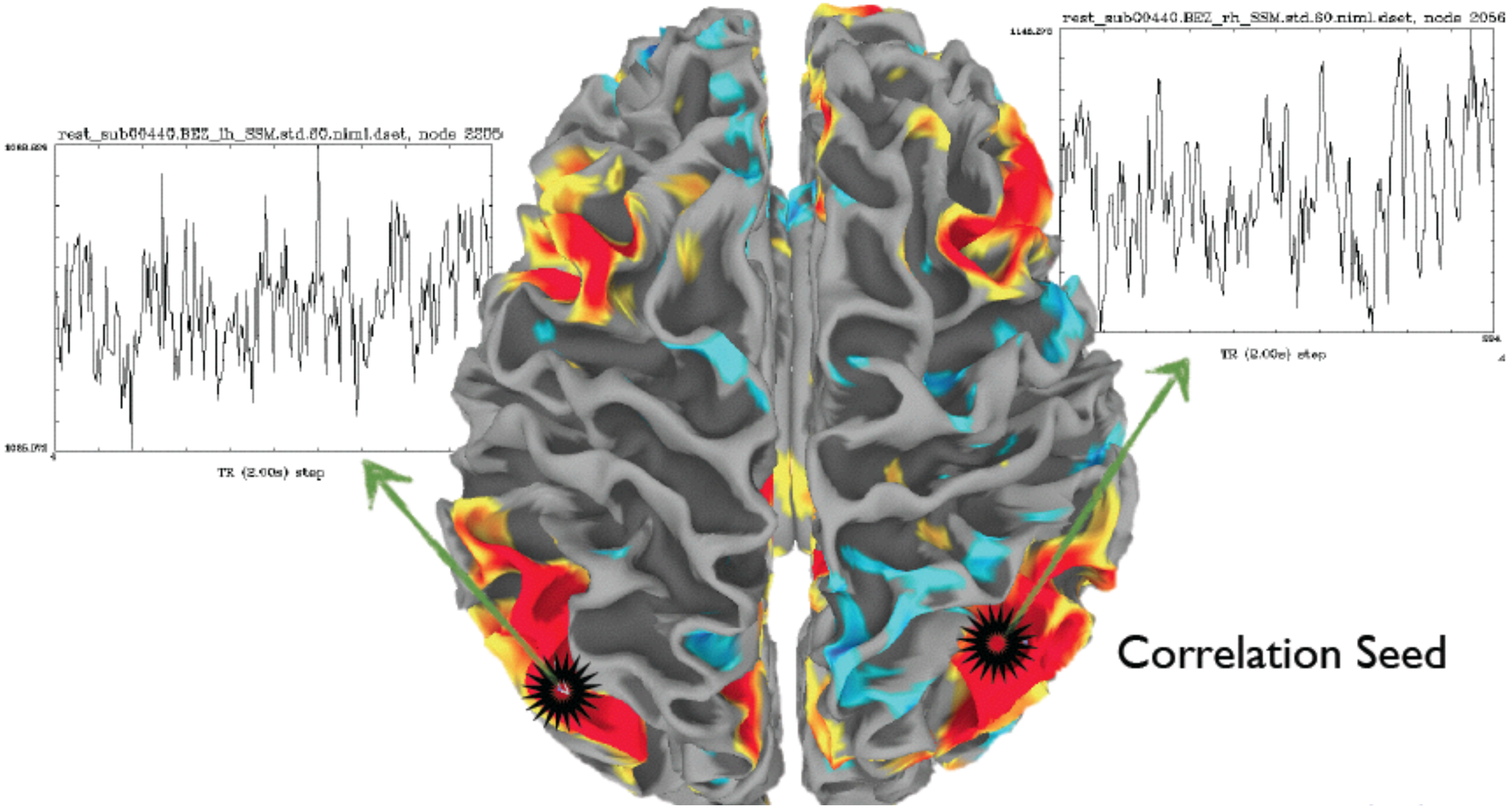
Error (The difference between the observed data and that which is predicted by the model)

Aim: To explain as much of the variance in Y by using X, and thus reducing E

More than 1 EV ? $Y = X_1\beta_1 + X_2\beta_2 + \ldots X_n\,\beta_n \ldots + E$

Univariate analysis !!

Recall your memory - The definition of functional connectivity



- Functional connectivity in rsfMRI

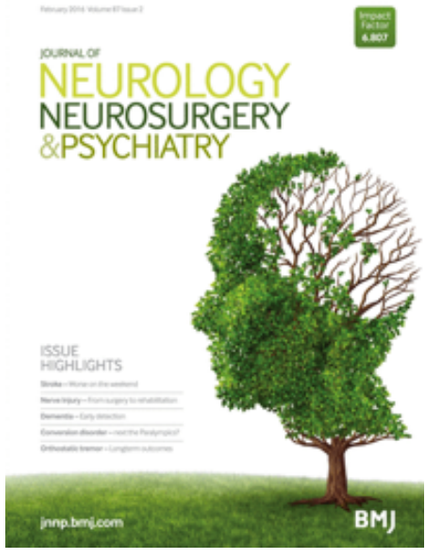
Temporal correlation of biophysical signal measured in distributed brain areas

The material of today's course

RESEARCH PAPER

Altered hypothalamic functional connectivity in cluster headache: a longitudinal resting-state functional MRI study

Fu-Chi Yang,[1,2] Kun-Hsien Chou,[3,4] Jong-Ling Fuh,[5,6] Pei-Lin Lee,[7] Jiing-Feng Lirng,[8,9] Yung-Yang Lin,[1,4,5,6] Ching-Po Lin,[1,3,4,7] Shuu-Jiun Wang[1,4,5,6]



Subjects:

19 HCs ; 18 CH-In-bout (baseline) ; 18 CH-out-bout (follow-up)

Hypothesis:

(1) Alteration of hypothalamic functional connectivity in CH

(2) Bout associated alteration in hypothalamic functional connectivity

(3) The relationship between clinical evaluation and hypothalamic functional connectivity

Image approach:

Whole brain voxel-wise seed based functional connectivity analysis

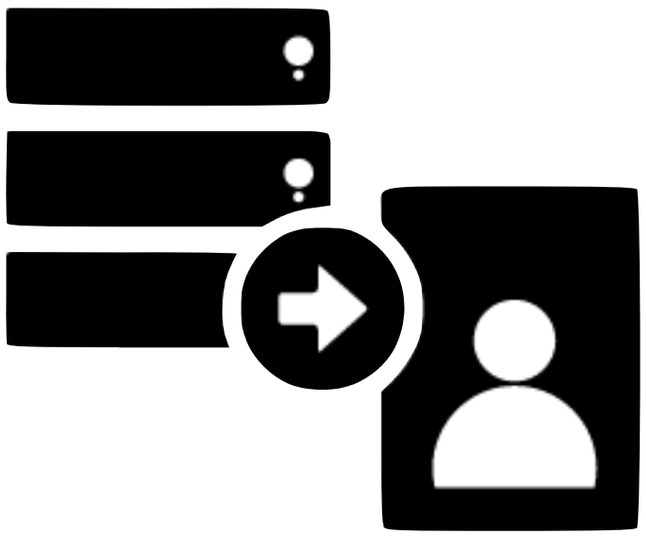
Statistical approach: (General Linear Model)

(1)Two-sample T-test (Analysis of covariance ; ANCOVA test)

(2)Pair T-test

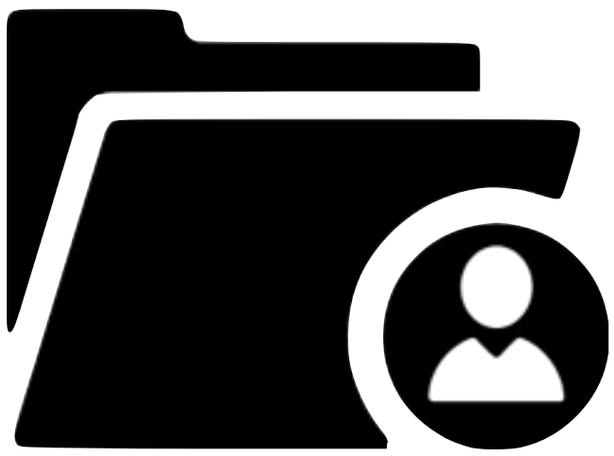
(3)Multiple regression (Partial correlation)

Before playing data



Copy “Image dataset” to your personal folder

Right_Hypothalamus_FC



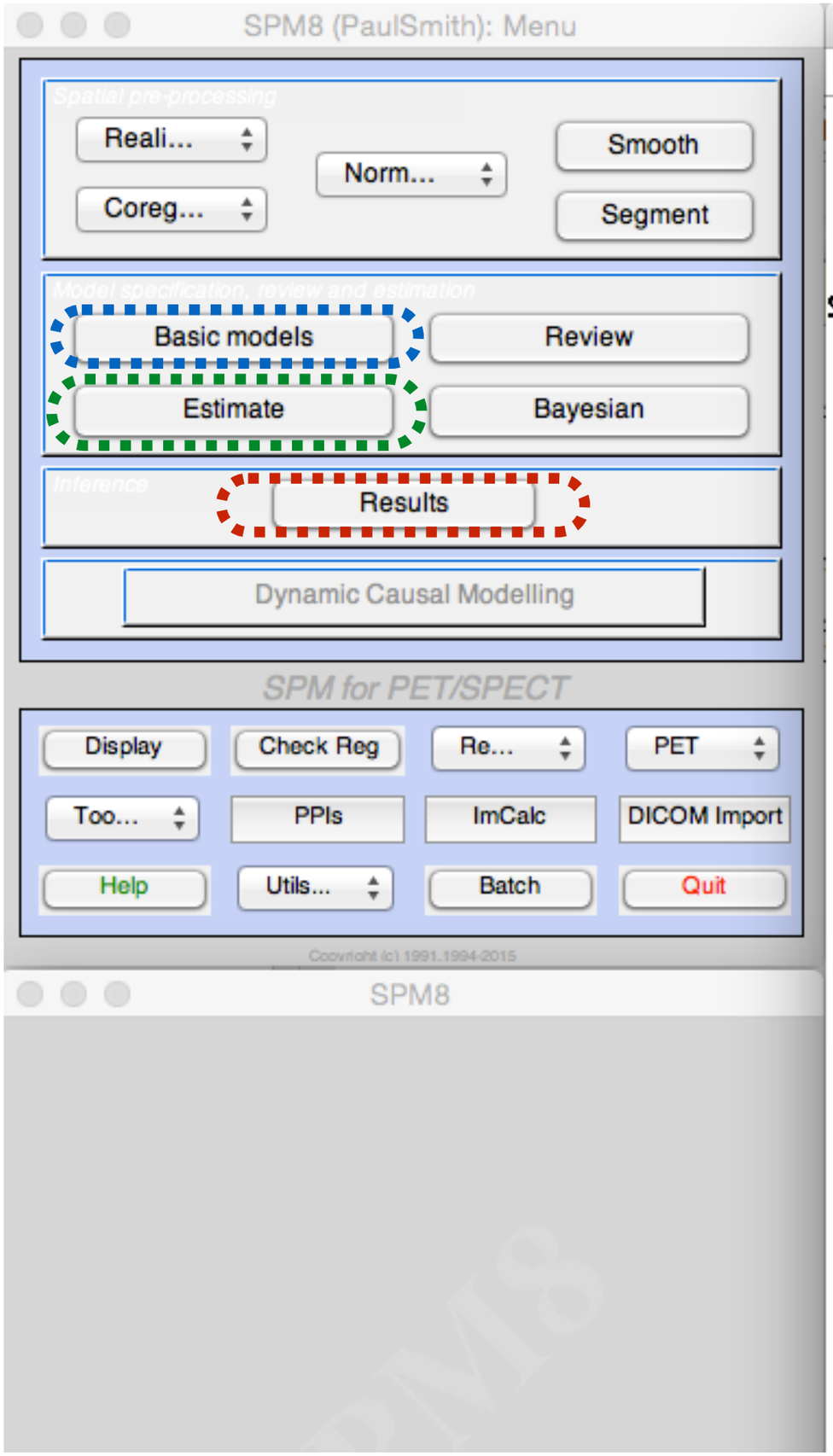
Make three new folder for following practice

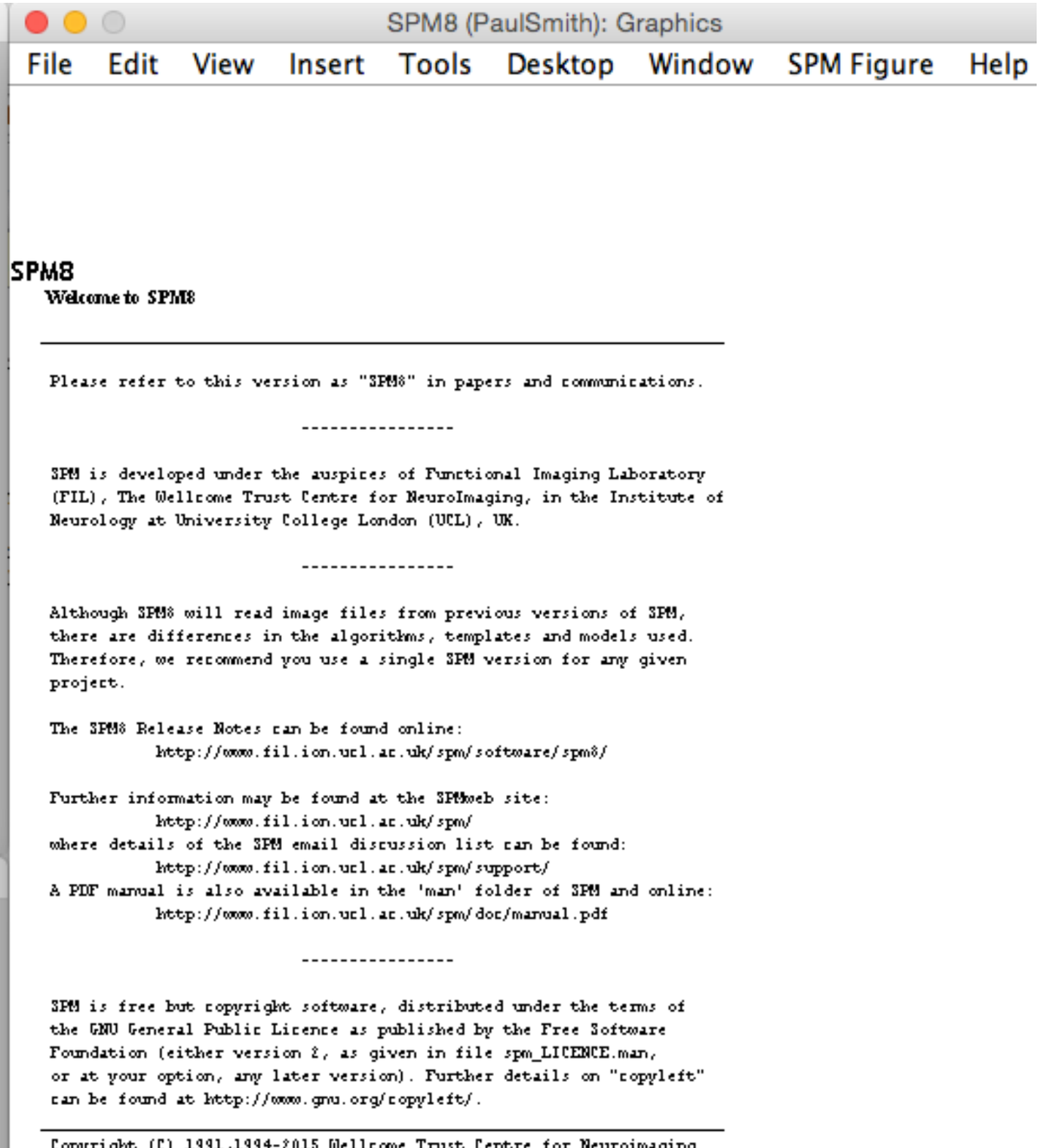
Two_Sample_T_NC_Baseline

Pair_T_Baseline_Followup

Multiple_Regression

The interface of Statistical Parametric Mapping



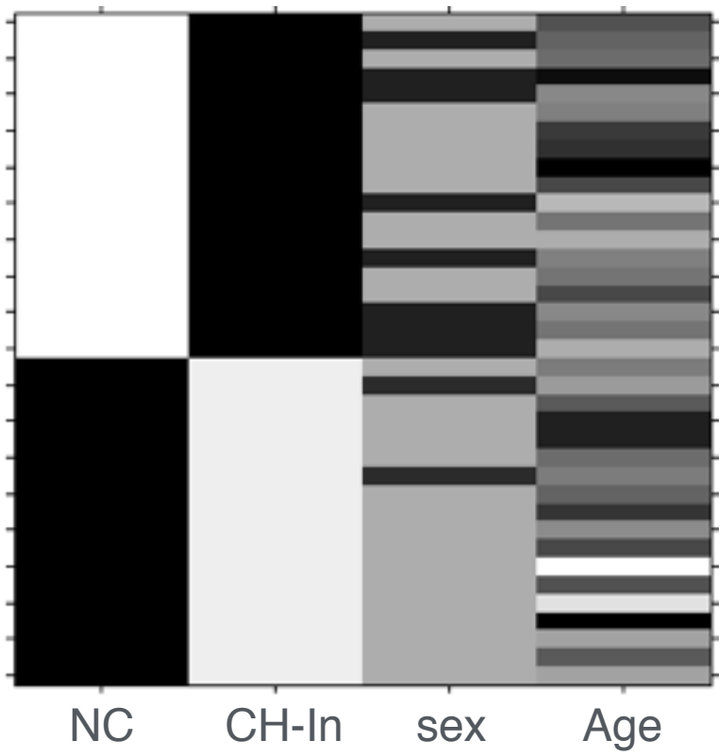


Alteration of hypothalamic functional connectivity in CH

"For hypothalamic functional connectivity, is there significantly higher FC in the healthy controls than in the patient with cluster headache after adjusting age and gender effect ? (two sample T-test)"

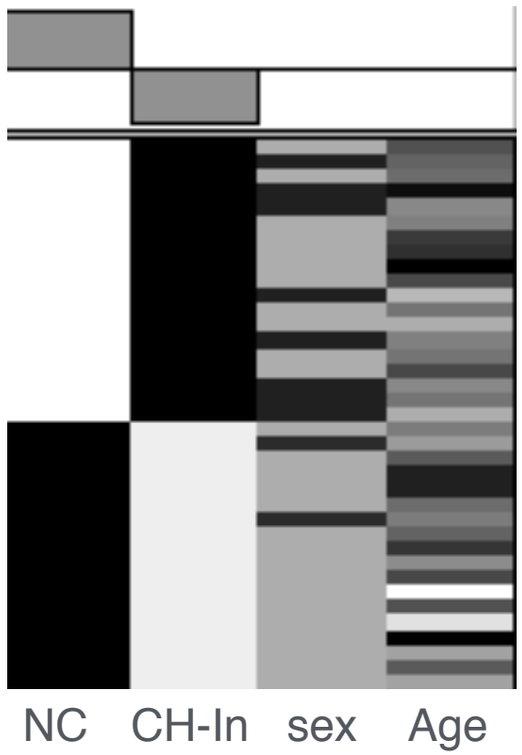
$$Y = \beta_1(NC) + \beta_2(CH\text{-}In\text{-}bout) + \beta3(sex) + \beta4(age) + \varepsilon$$

Two sample T-test

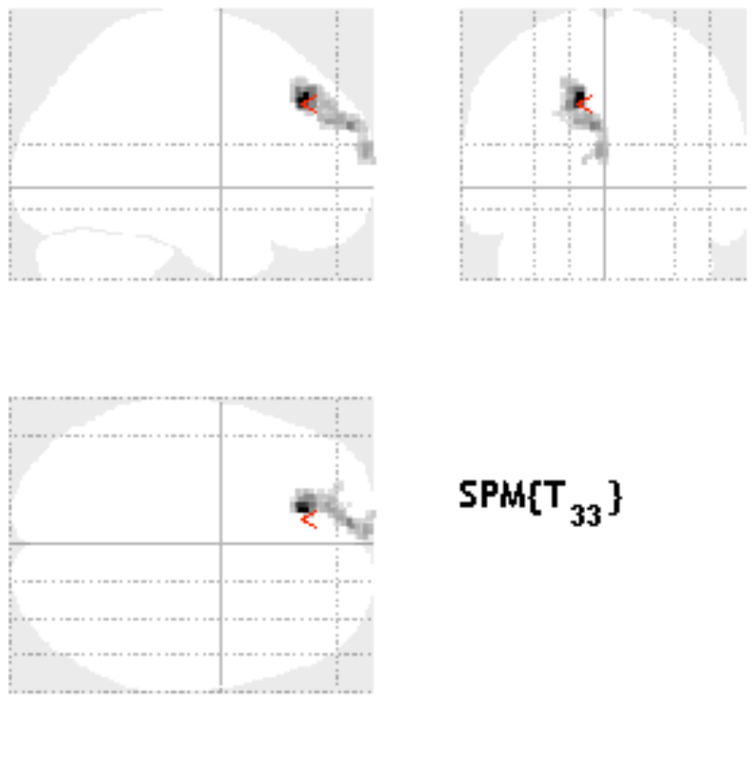


Model construction

Contrast

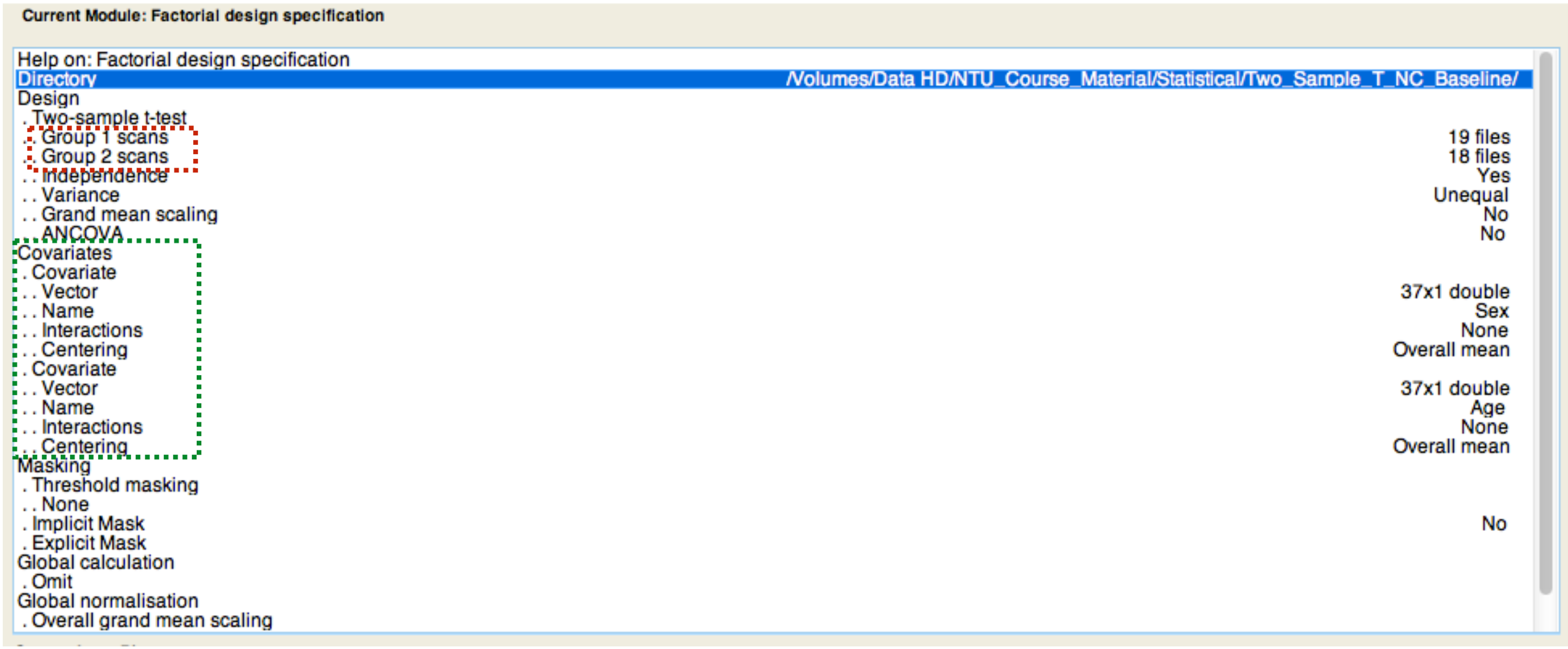


Statistical inference



Result visualization

Demo - Two Sample T-test (Model construction)



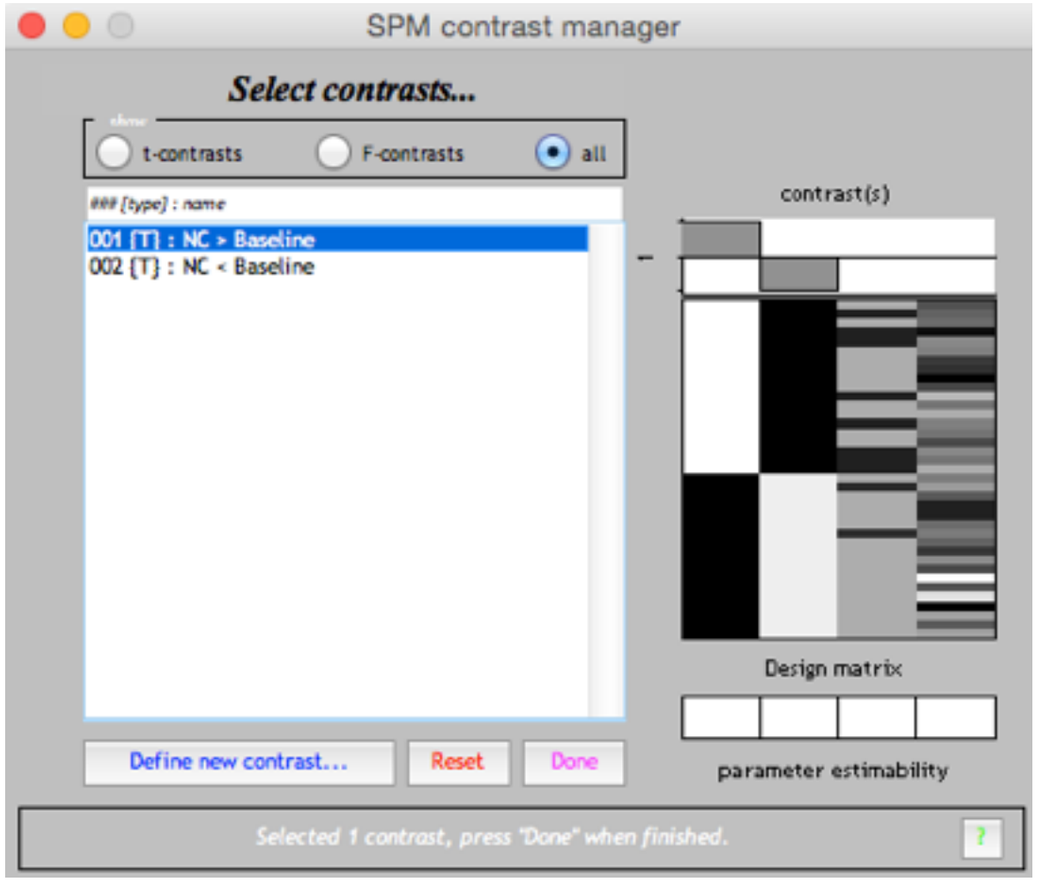
Directory: The output directory of your statistical model

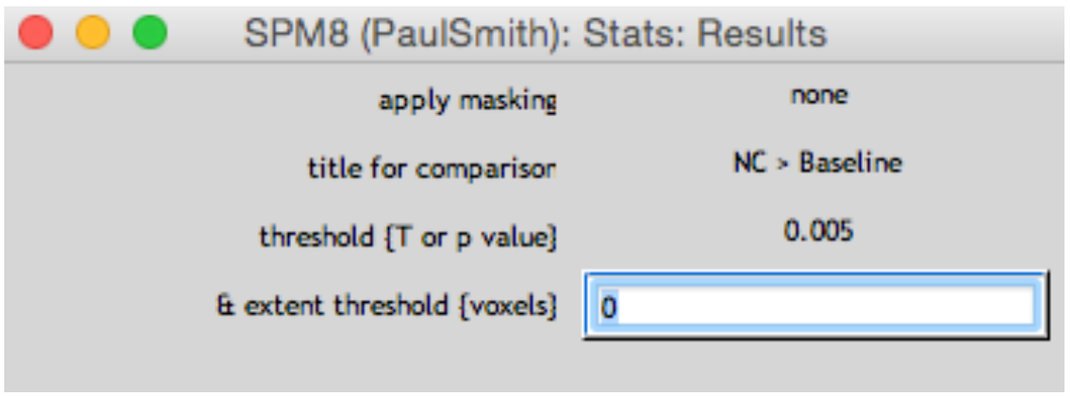
Design: The statistical model you want to use (Two sample T-test)

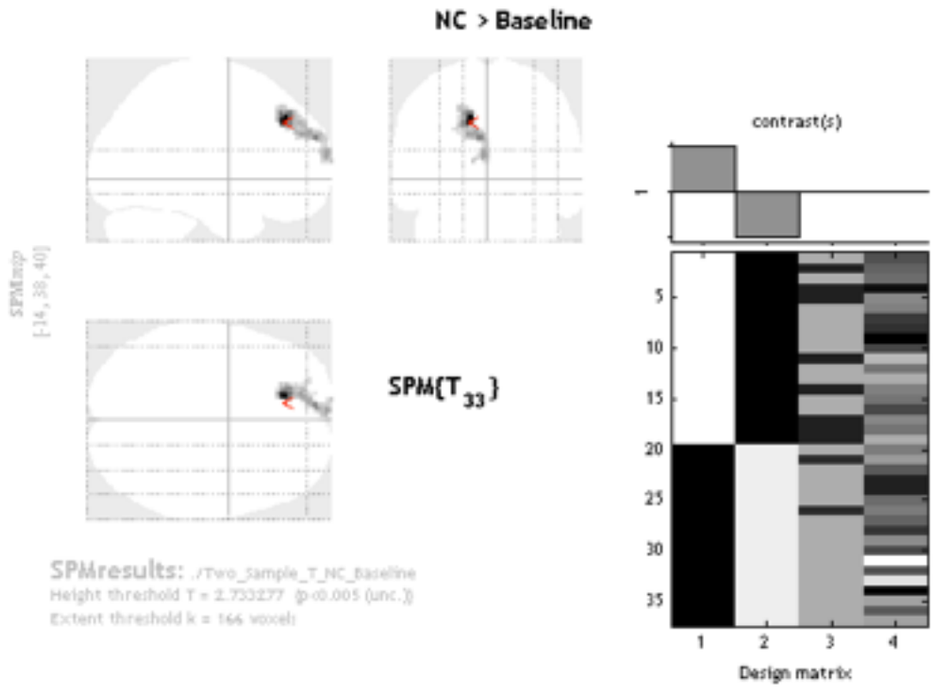
Covariates: The effect you want to adjust (sex and age)

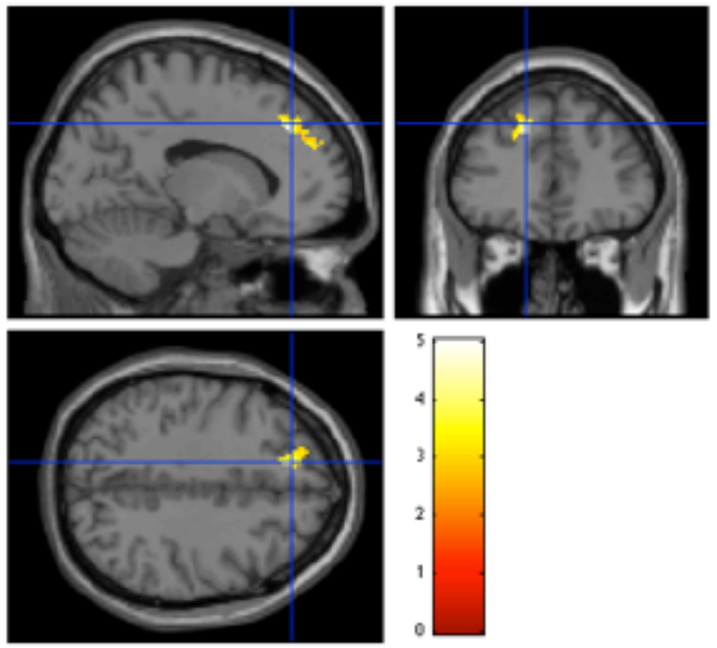
Masking: The region you want to do statistical inference

Demo - Two Sample T-test (Statistical inference & Result visualization)









Statistical criteria:

Uncorrected voxel $p < 0.005$ with 166 extended voxels

(Page 3)

Cluster location:

(x,y,z) = (-14 , 38 , 40)

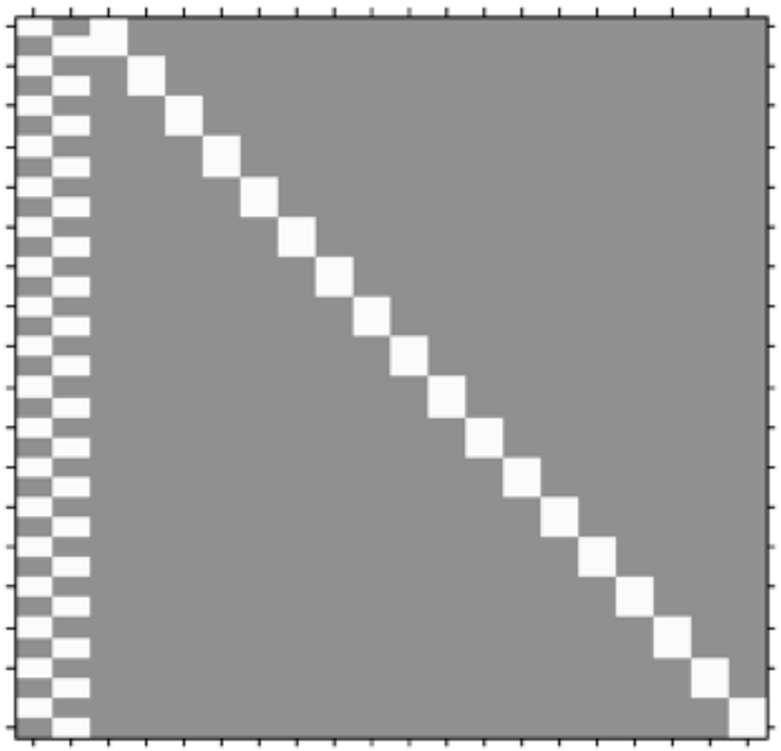
(Page 6 , Table 2)

Bout associated alteration in hypothalamic functional connectivity

"For hypothalamic functional connectivity, is there significantly higher FC in the follow-up scan than in the baseline scan of the patient with cluster headache ? (pair T-test)"

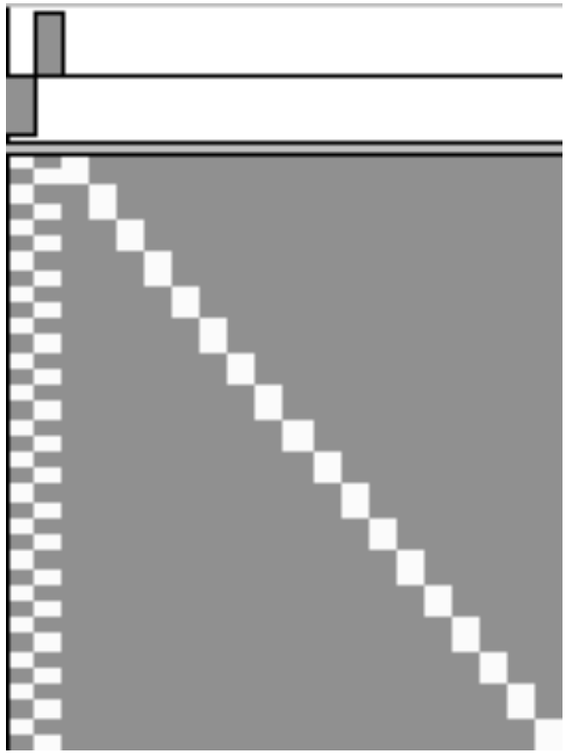
$$Y = \beta_1(\text{baseline}) + \beta_2(\text{follow-up}) + \beta3(\text{within-subject 1 effect }) + ..+\beta n(\text{within-subject n effect}) + \varepsilon$$

Pair T-test

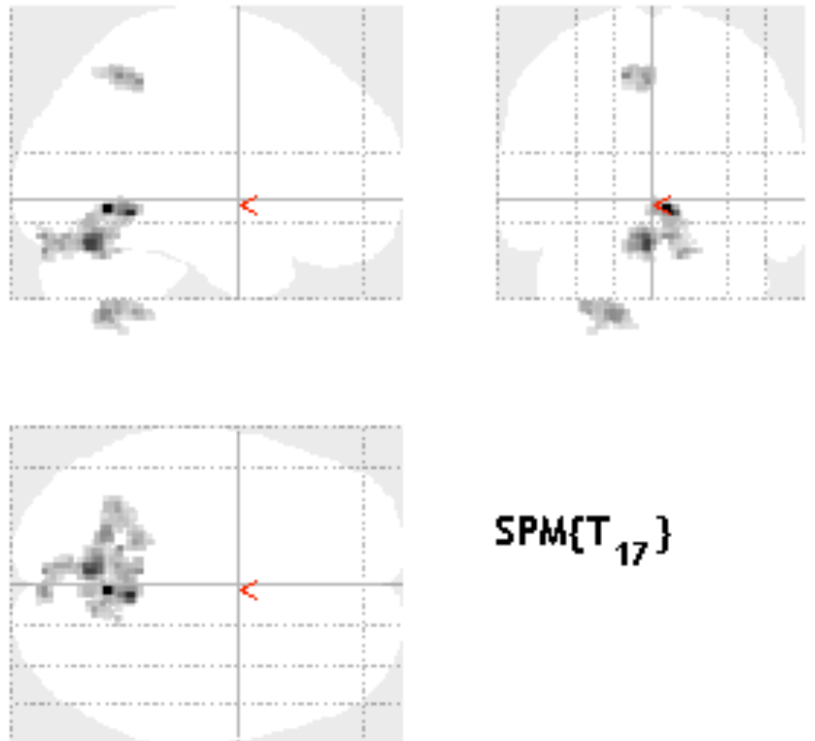


Model construction

Contrast

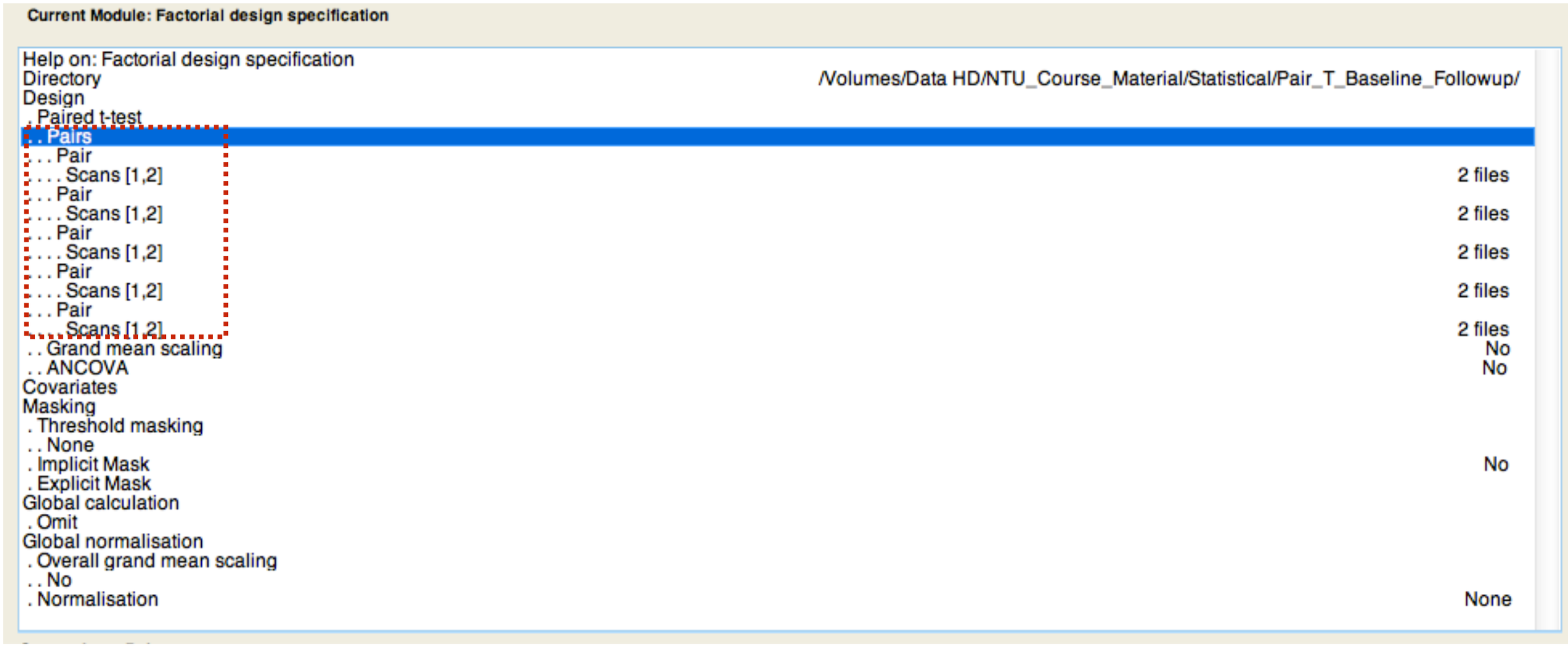


Statistical inference



Result visualization

Demo - Pair T-test (Model construction)

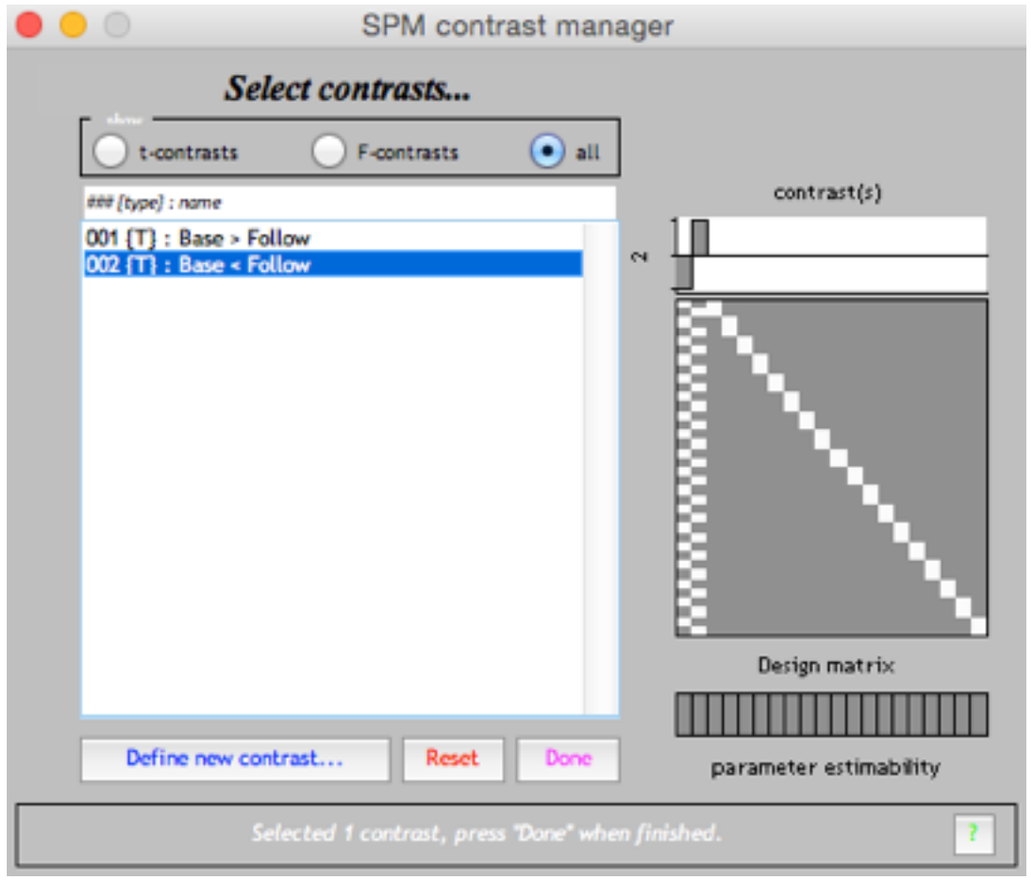


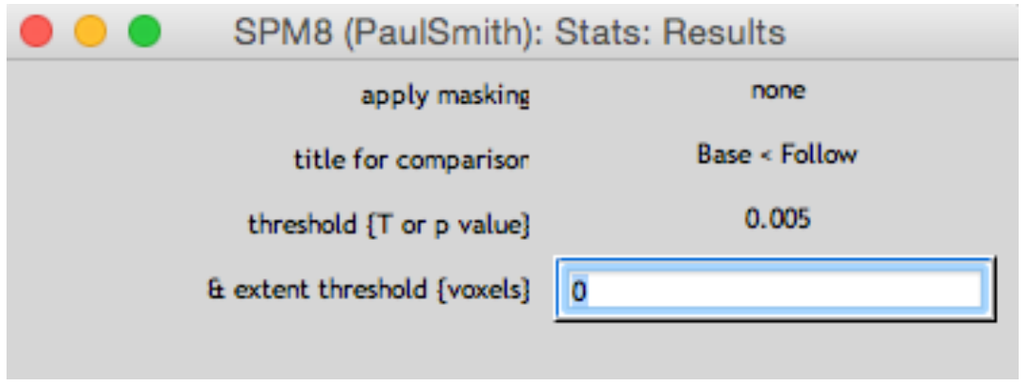
Directory: The output directory of your statistical model

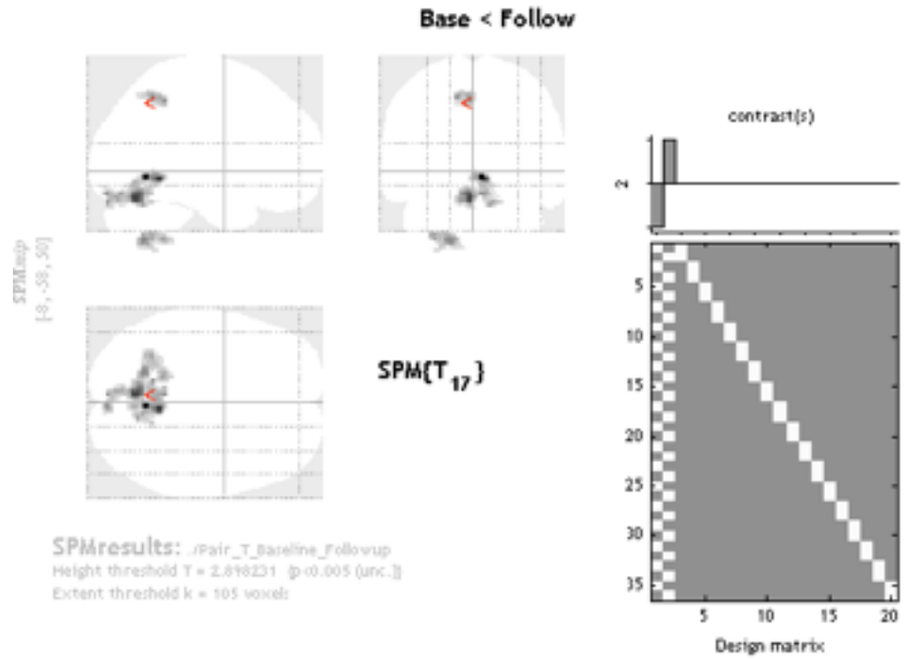
Design: The statistical model you want to use (Pair T-test)

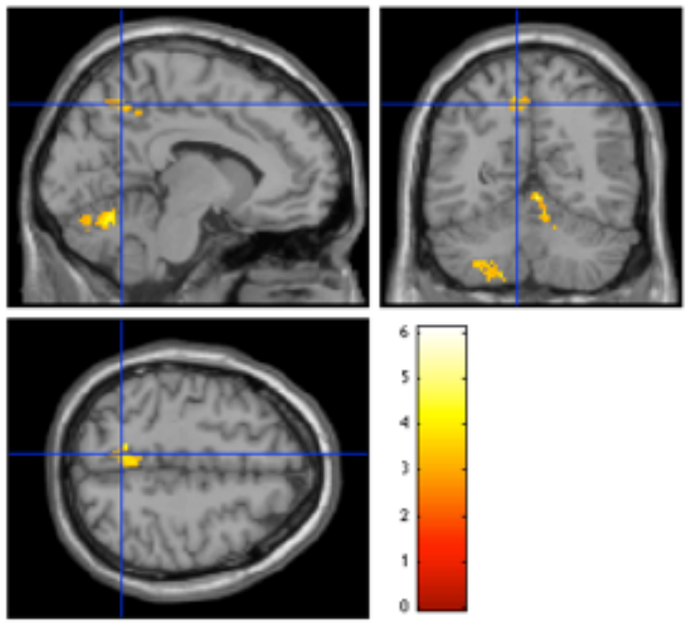
Masking: The region you want to do statistical inference

Demo - Pair T-test (Statistical inference & Result visualization)









Statistical criteria:

Uncorrected voxel p < 0.005 with 105 extended voxels

(Page 3)

Cluster location:

(x,y,z) = (-8 , -58 , 50)

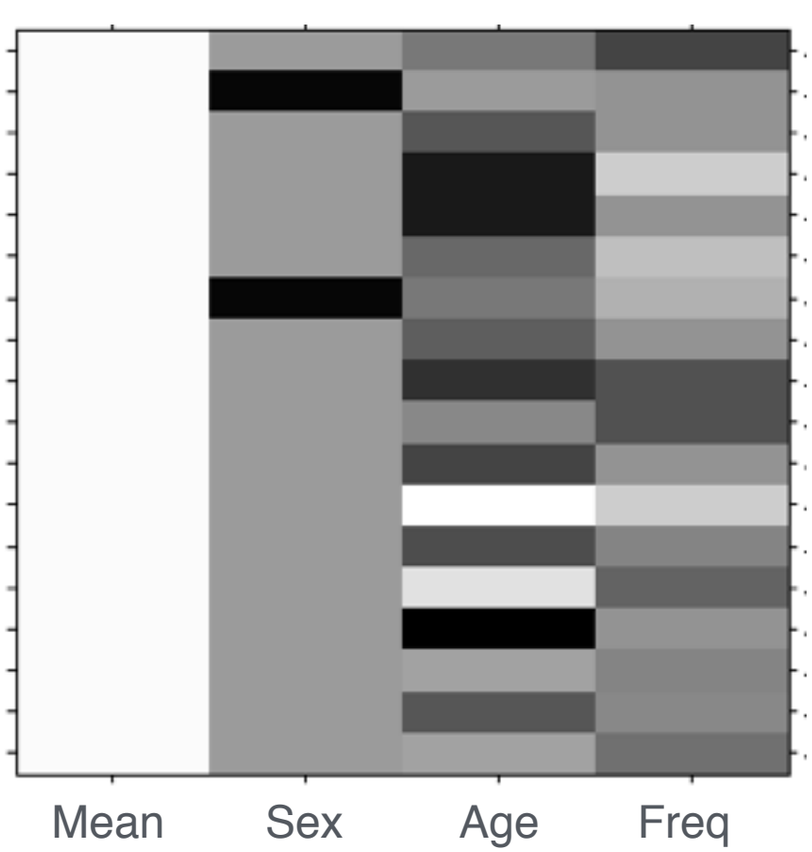
(Page 7 , Table 3)

The relationship between clinical evaluation and hypothalamic functional connectivity

"Is there any significantly negative correlation between headache frequency and hypothalamic functional connectivity after adjusting age and sex effect in patient with cluster headache ? (multiple regression test)"

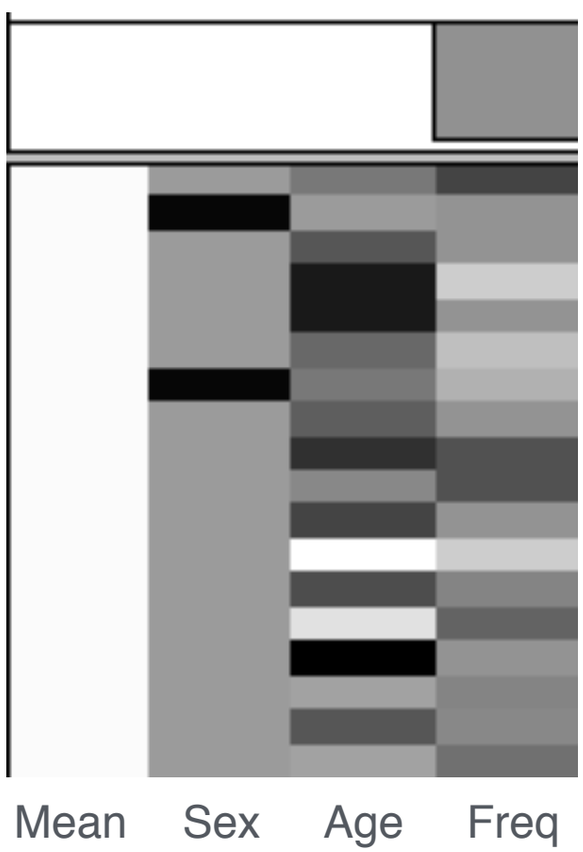
$$Y = \text{Mean} + \beta_1(\text{sex}) + \beta_2(\text{age}) + \beta_3(\text{headache frequency}) + \varepsilon$$

Multiple regression

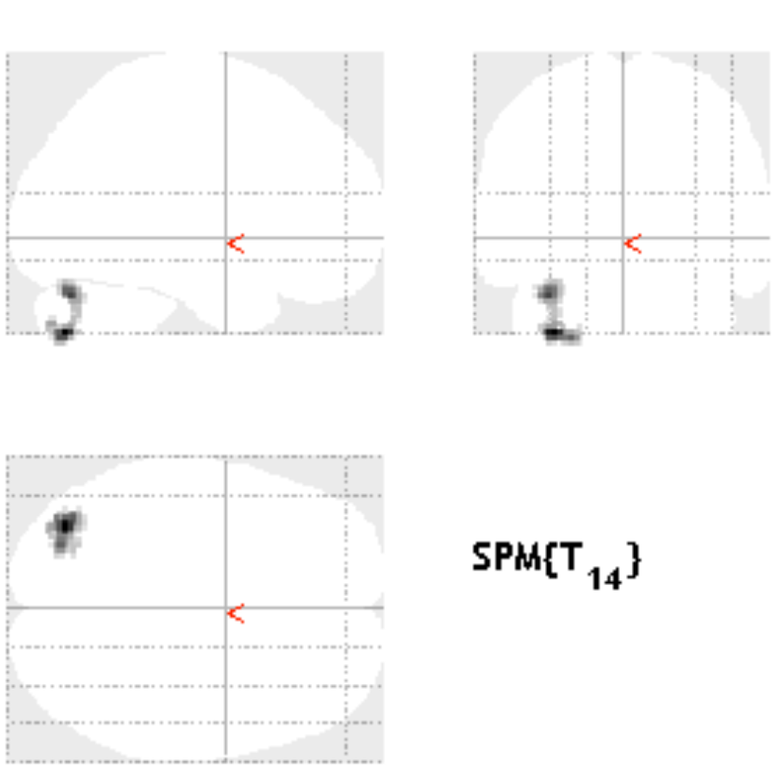


Model construction

Contrast



Statistical inference



Result visualization

Demo - Multiple regression analysis (Model construction)

Current Module: Factorial design specification

Help on: Factorial design specification

Directory	/Volumes/Data HD/NTU_Course_Material/Statistical/Correlation_Baseline_Frequency/
Design	
. Multiple regression	
. . Scans	18 files
. . Covariates	
. . . Covariate	
. . . . Vector	18x1 double
. . . . Name	Frequency
. . . . Centering	Overall mean
. . Intercept	Include Intercept
Covariates	
. Covariate	
. . Vector	18x1 double
. . Name	Sex
. . Interactions	None
. . Centering	Overall mean
. Covariate	
. . Vector	18x1 double
. . Name	Age
. . Interactions	None
. . Centering	Overall mean
Masking	
. Threshold masking	
. . None	
. Implicit Mask	No
. Explicit Mask	
Global calculation	
. Omit	
Global normalisation	

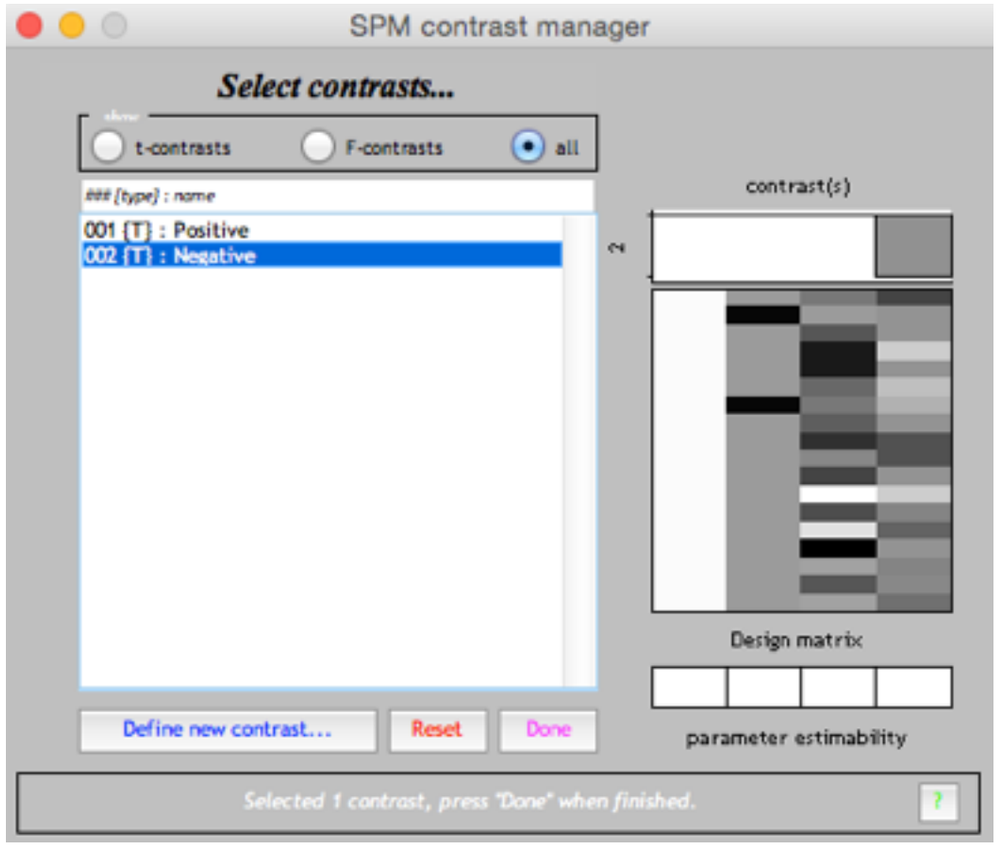
Directory: The output directory of your statistical model

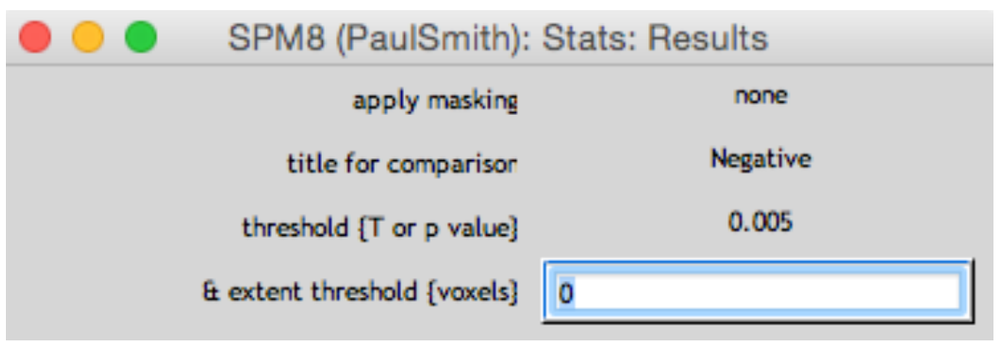
Design: The statistical model you want to use (Multiple regression)

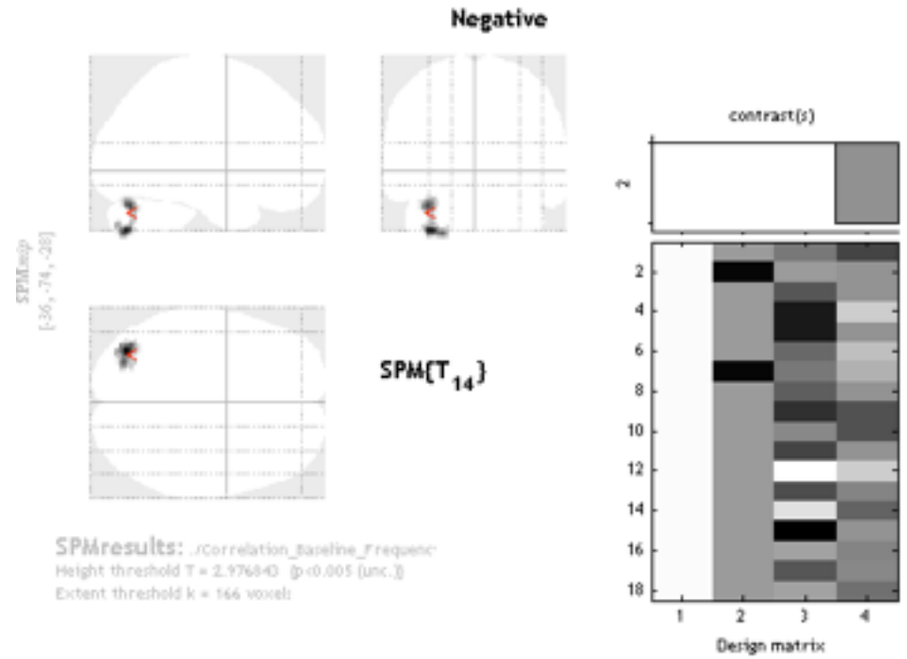
Covariates: Covariate of interest (headache frequency) and non-interest (sex & age)

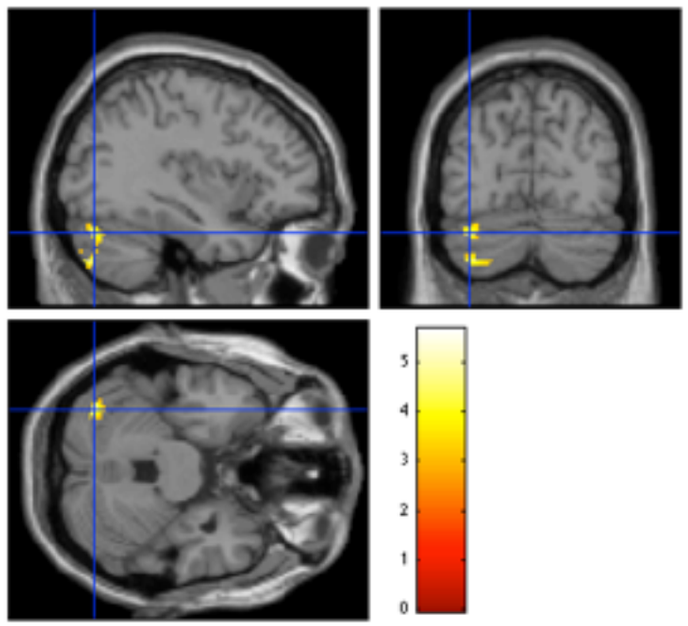
Masking: The region you want to do statistical inference

Demo - Multiple regression analysis (Statistical inference & Result visualization)









Statistical criteria:

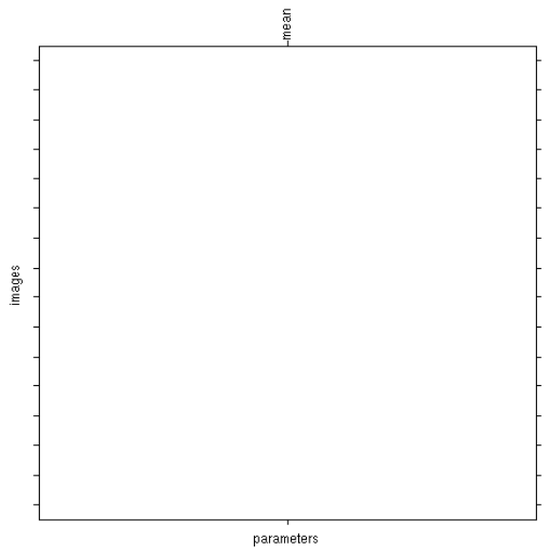
Uncorrected voxel $p < 0.005$ with 166 extended voxels

Cluster location:

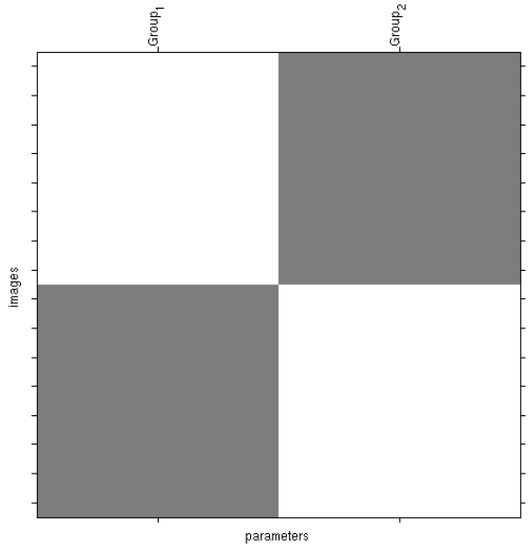
(x,y,z) = (-36 , -74 , -28) [Page 4]

Using different design matrices to answer different scientific questions

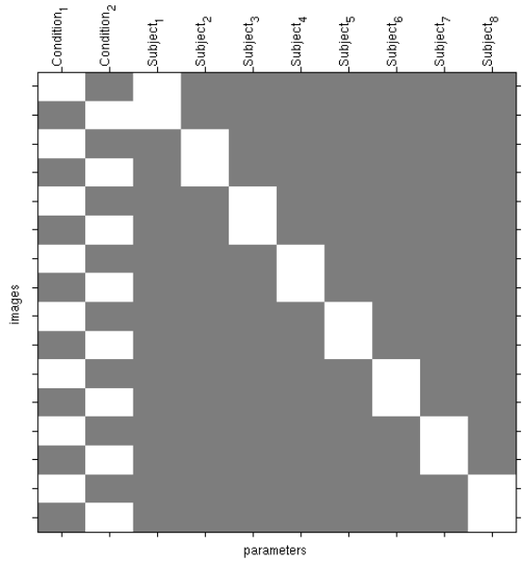
One-sample t-test



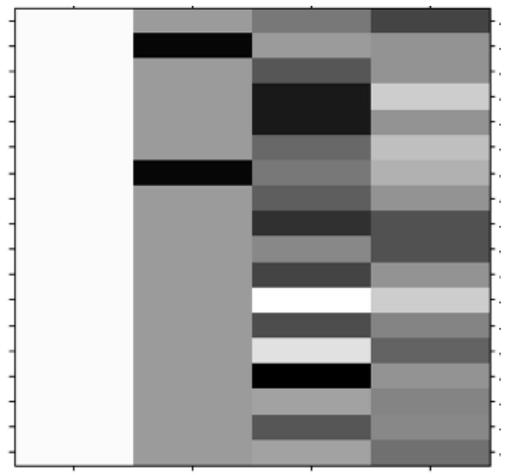
Two-sample t-test

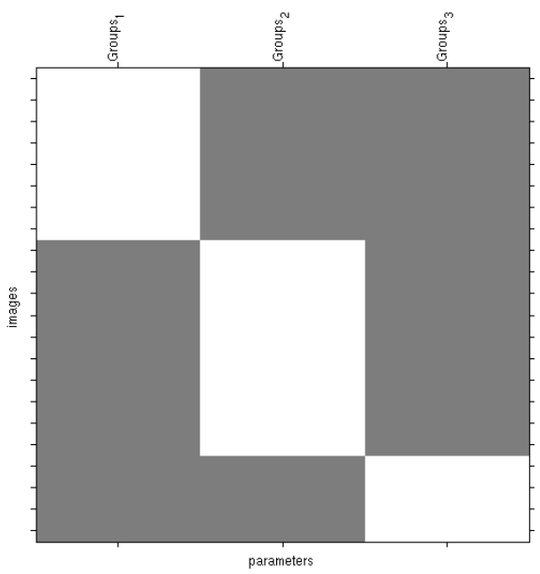


Pair t-test

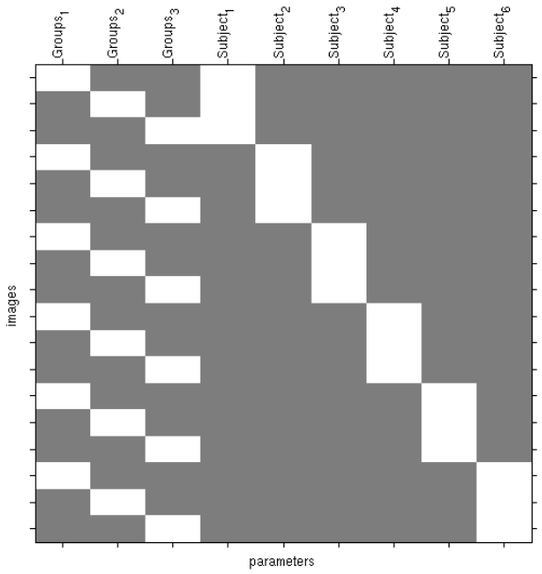


Multiple regression

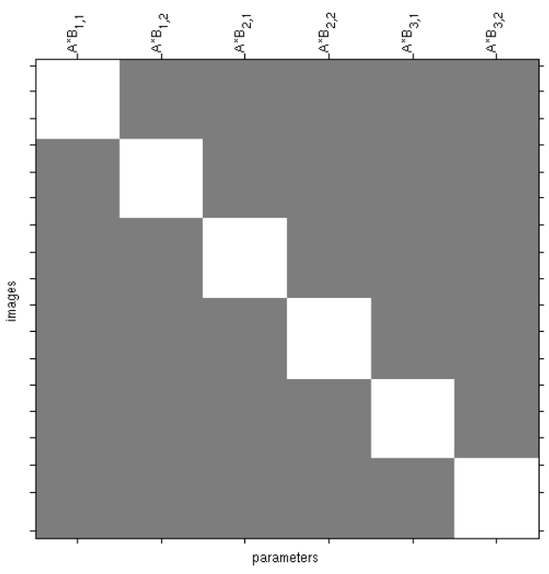




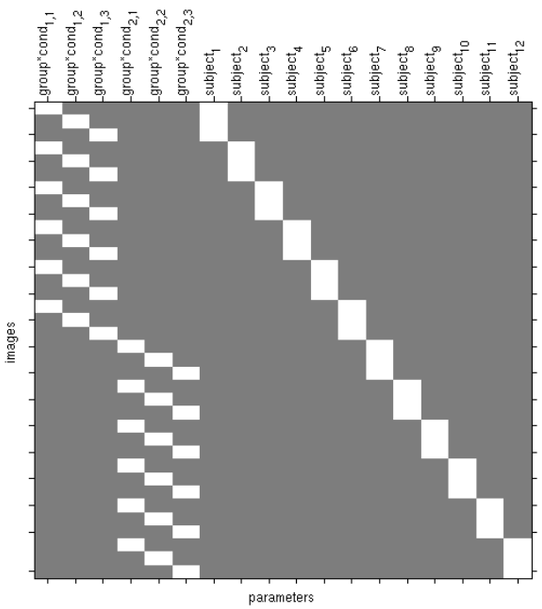
One-way ANOVA (1F3L)



One-way ANOVA within-subject (1F3L)



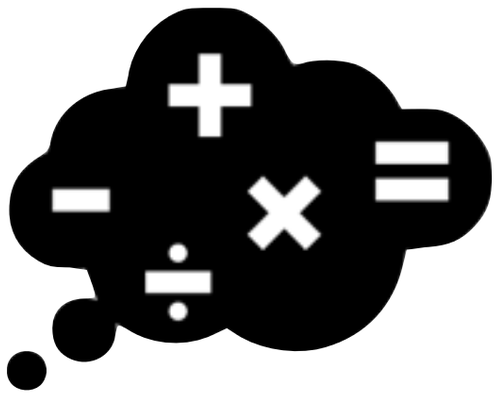
Full factorial



Flexible factorial

Take home message

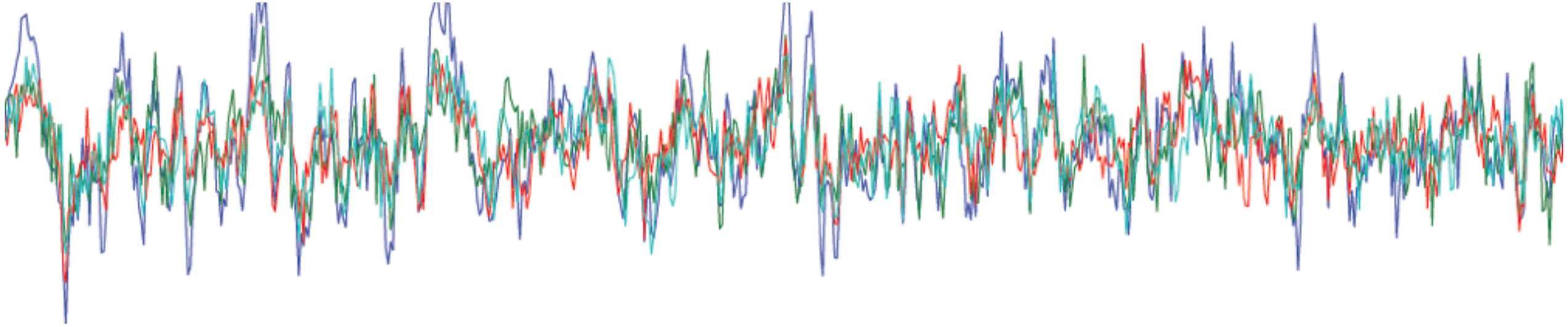
What’s your scientific question ?

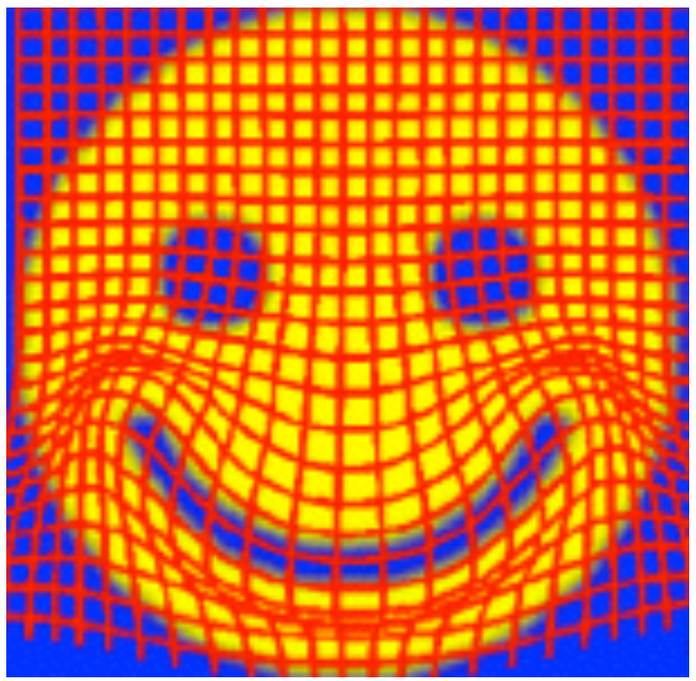


Redefine your question

using statistical language

Practice, practice and practice





Analyzing your data for fun ! !

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