First level fMRI data analysis

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Outline

- We learned the general linear model (GLM), preprocessing, and experimental design

- What is next:

  Statistical analysis of the data

Outline

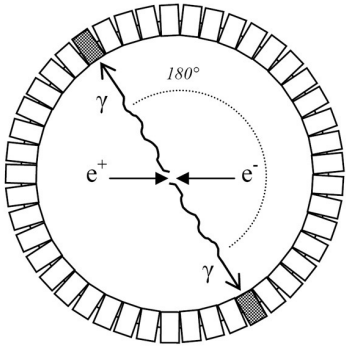
- What is 1st level analysis?
- Statistical models according to tasks
  - Contrasts
  - Operation in SPM12
    - To set the parameters
    - To make contrasts: T contrasts
- Resting state fMRI
- fMRI with movies

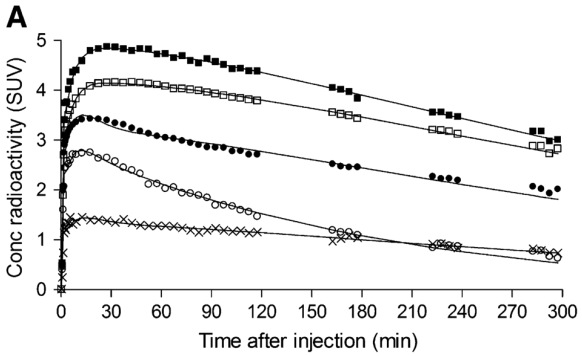
Why the 1st level analysis?

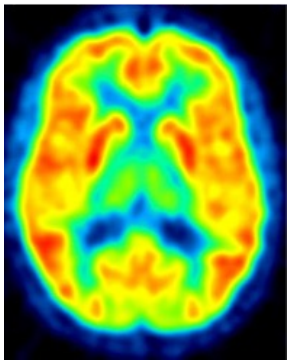
- Only two levels: 1st (within-subject) and 2nd (group-level).
- BOLD signals are dominanted by noise.
- Multiple repeated exposure to stimuli to increase signal-to-noise ratio
- Statistical analysis to extract the signal-associated brain responses
- Brain data is huge with large number of voxels.

Within-subject modelling

Positron emission tomography



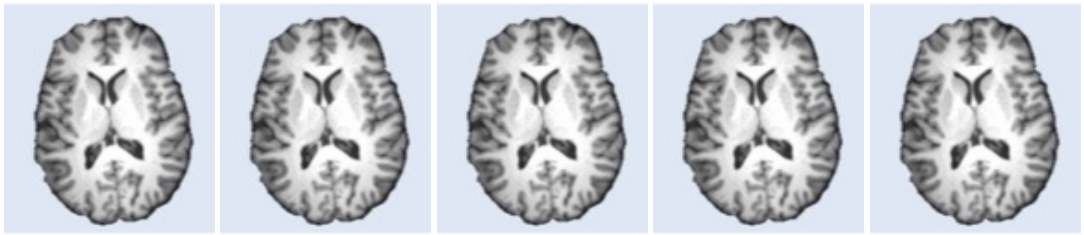




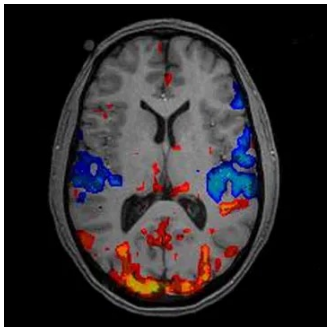
Density

fMRI

Time

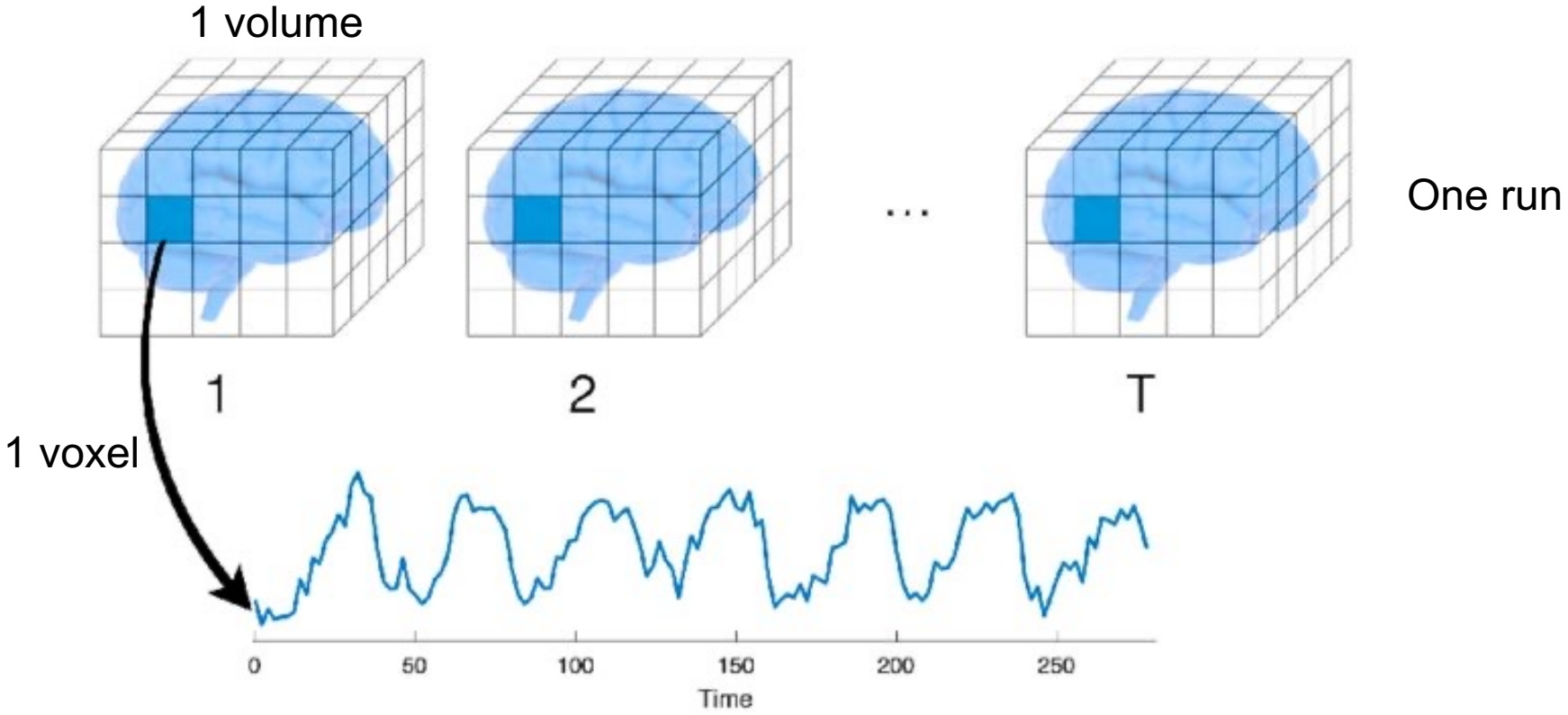


Task



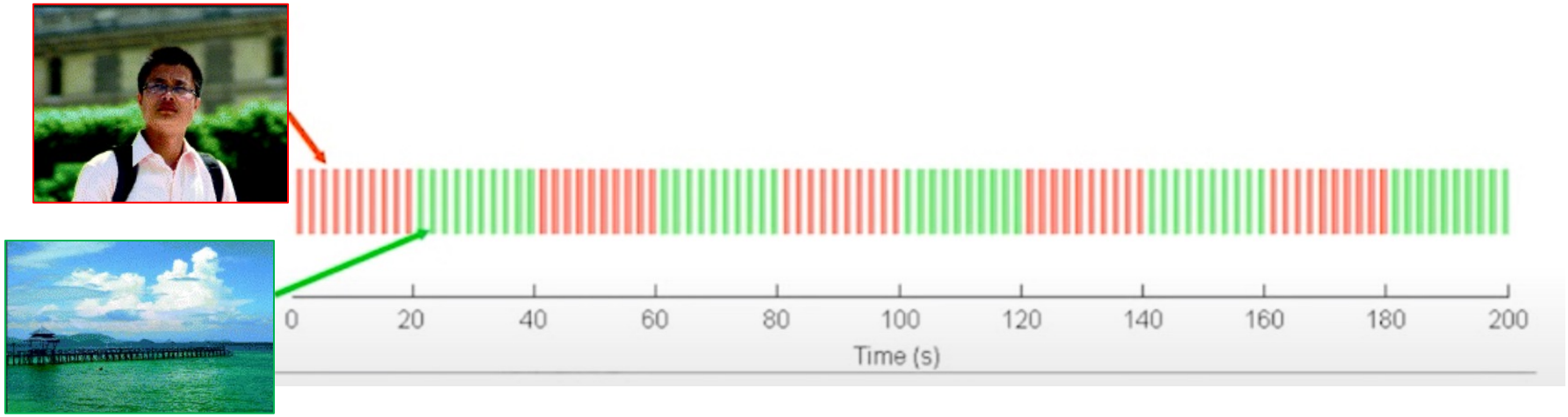
Statistical map

4D Data

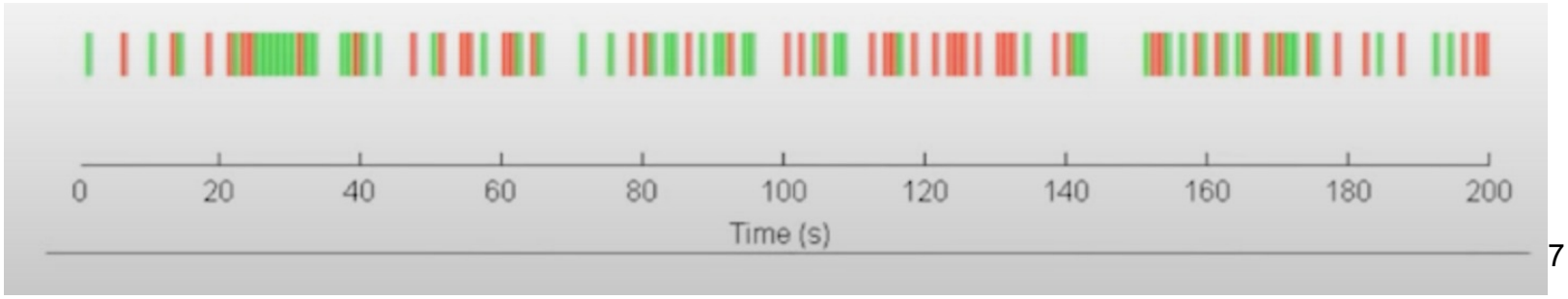


Experimental design

1. Block design



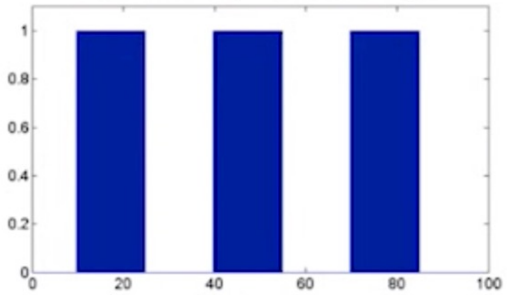
2. Event-related design



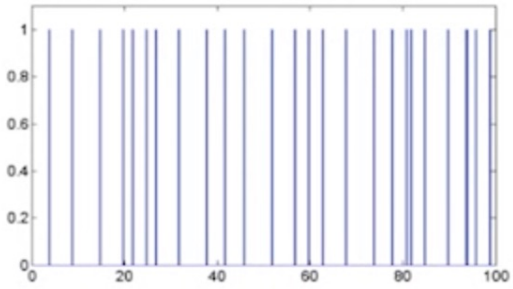
To build the regressor

- BOLD responses are delayed: **peak at 4-6 s** and **baseline 20-30 s**.
- Convolved with the hemodynamic response function (**HRF**)
- The linear time-invariant (**LTI)** system

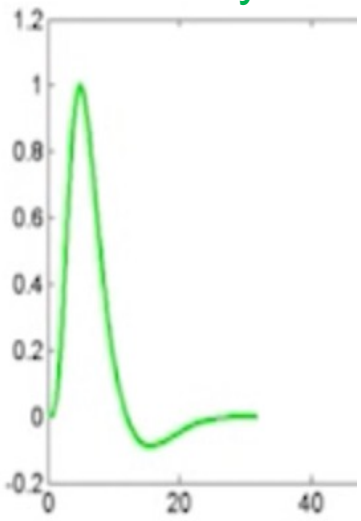
Block design

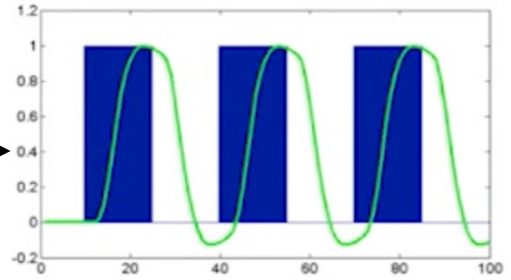


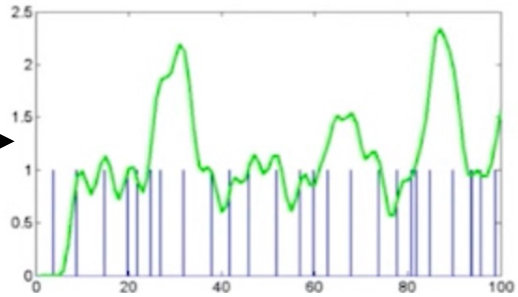
Event-related design



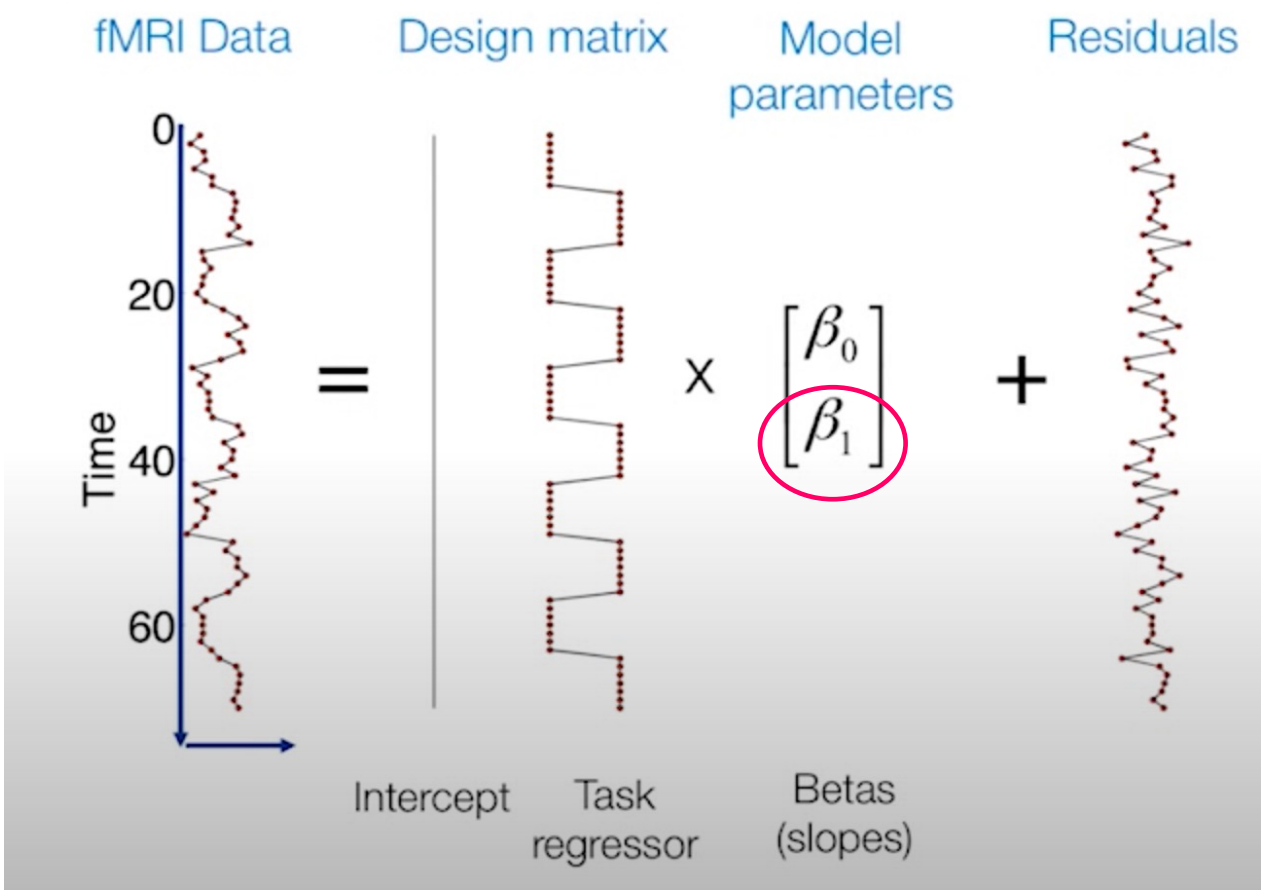
Hemodynamic delay



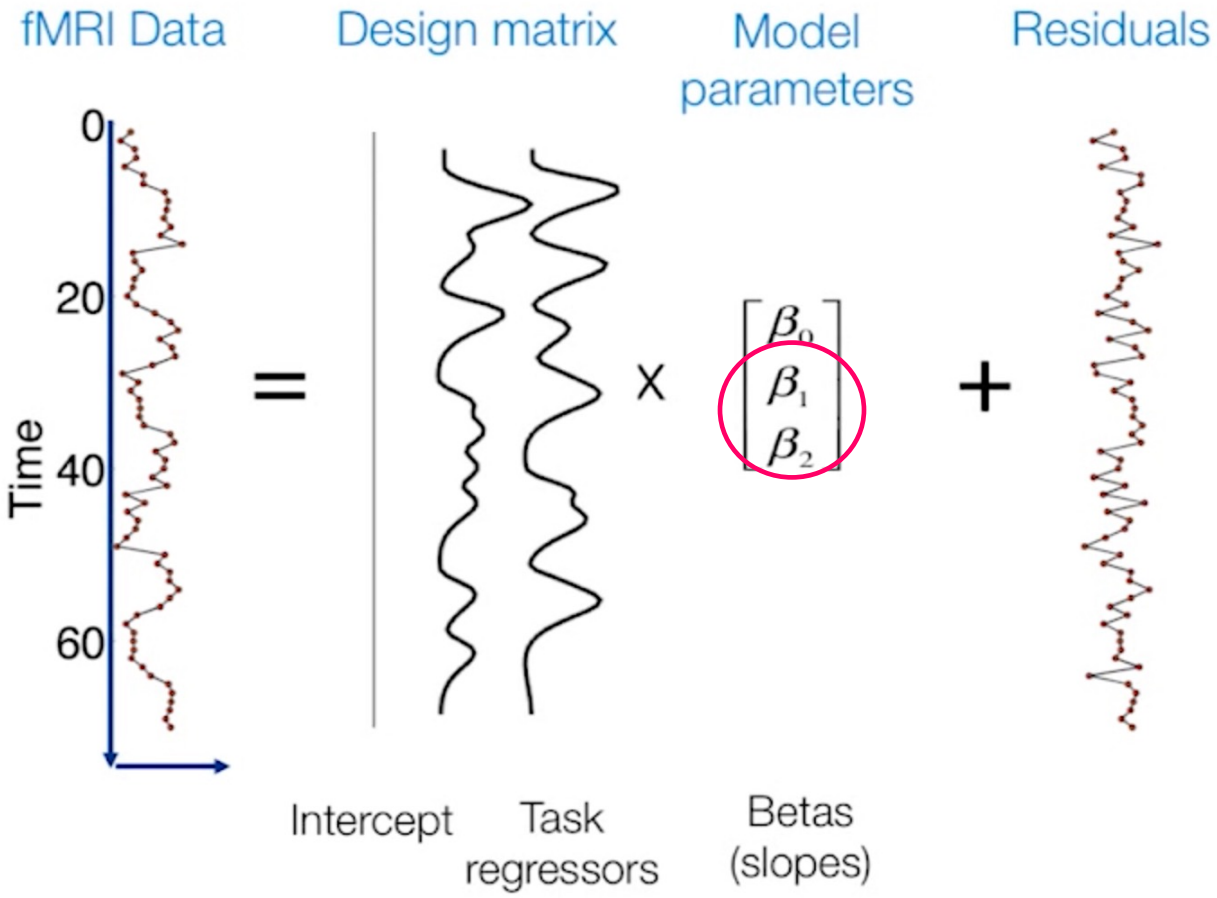




Block design: one regressor of interest (e.g. people vs. landscape)



Event-related design: two continuous regressors (people vs. landscape)

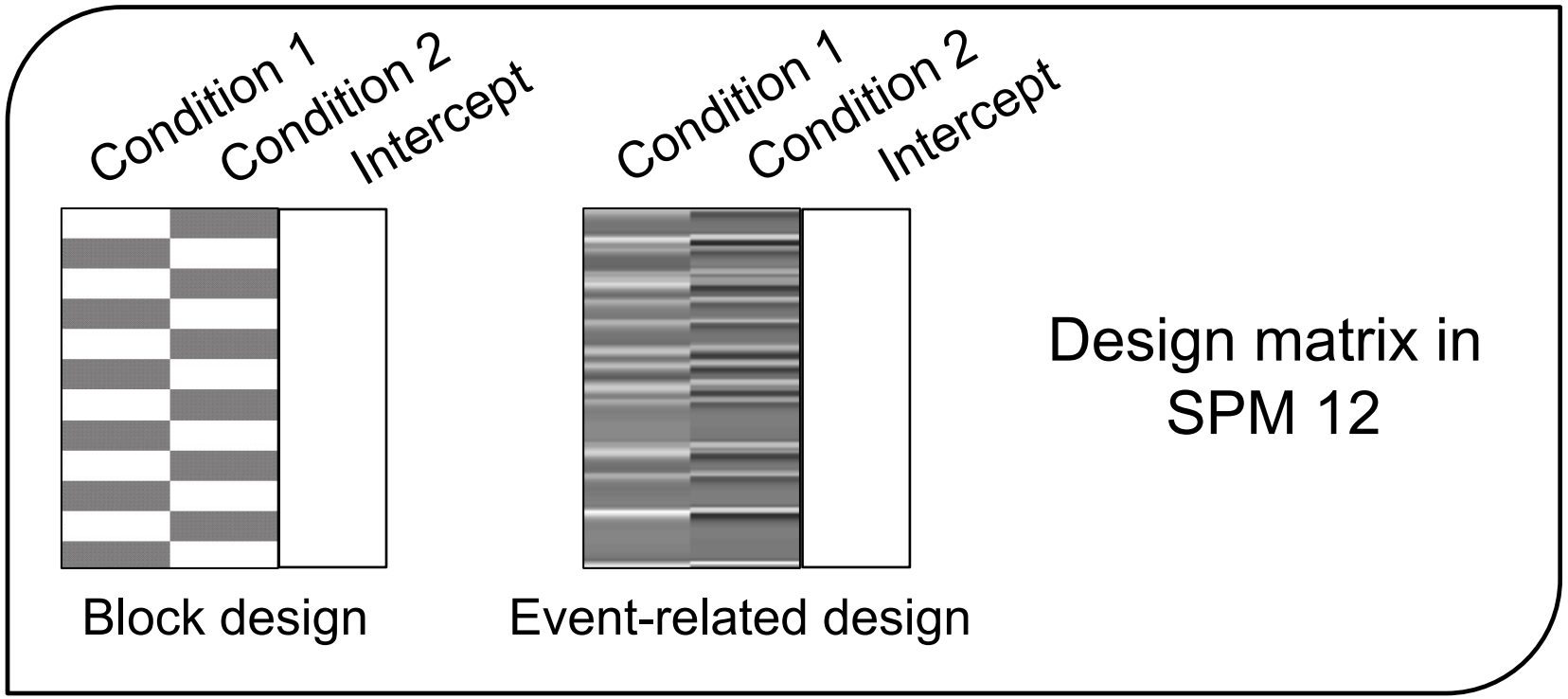


Contrasts

Experimental conditions: people vs. landscape

- Your interest is often the difference between the two conditions, which is "contrast"
- You can calculate the difference, sum or separately each conditions, which are calculated by different linear contrasts.

- We only focus on T contrast in this lecture ! !



Difference between conditions

[1 -1] = “Con1 > Con2”

[-1 1] = “Con1 < Con2”

Separately

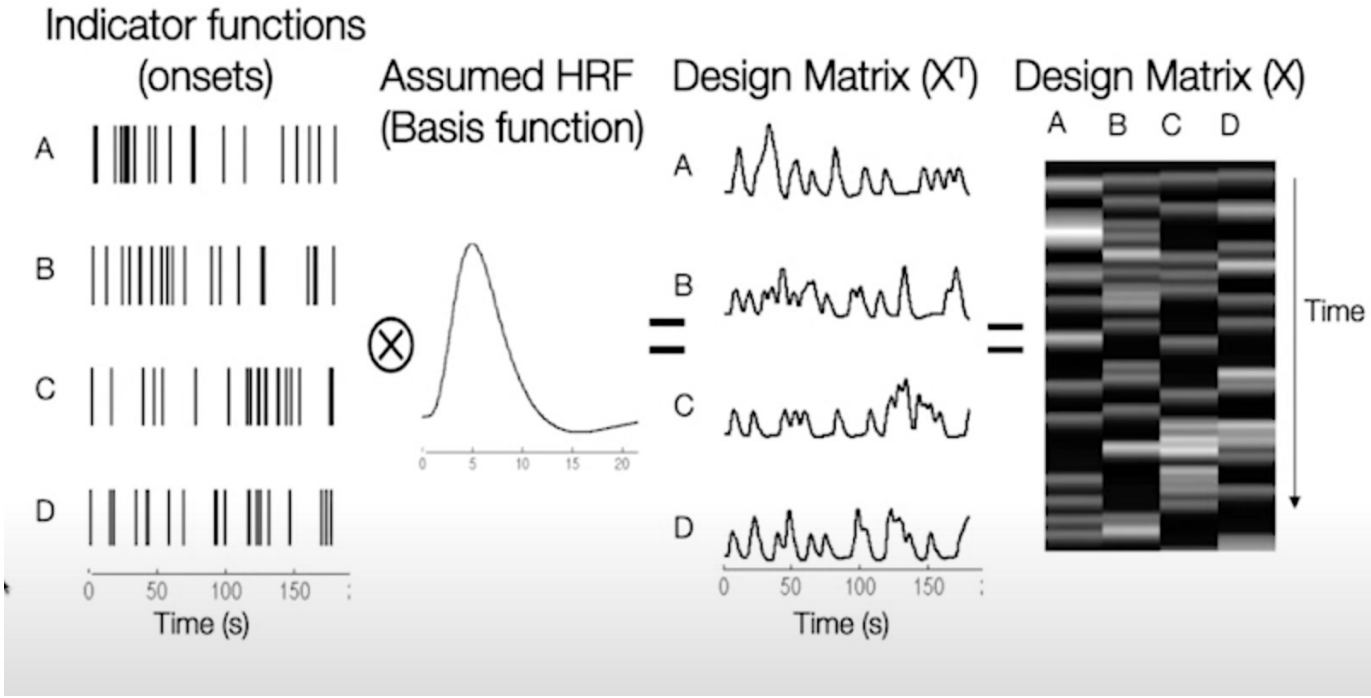
[1 0] or [-1 0] = “main effect Con1”

[0 1] or [0 -1] = “main effect Con2”

Sum

[1 1] or [-1 -1]

More regressors

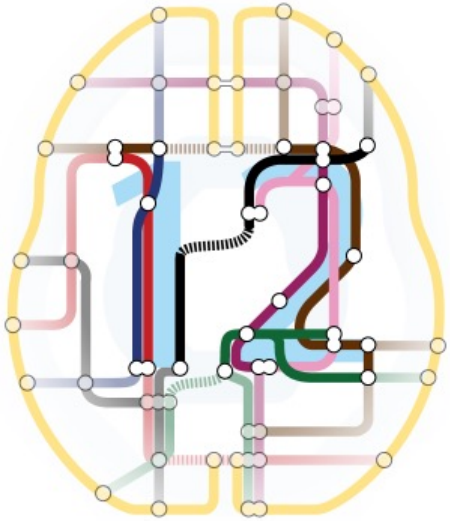


- [1 1 -1 -1] : (A+B) > (C+D)
- [1 -1 1 -1] : (A+C) > (B+D)
- [1 0 0 0] : main effect of A
- [1 1 0 0] : Sum of (A+B) vs the mean of the signal

  ….

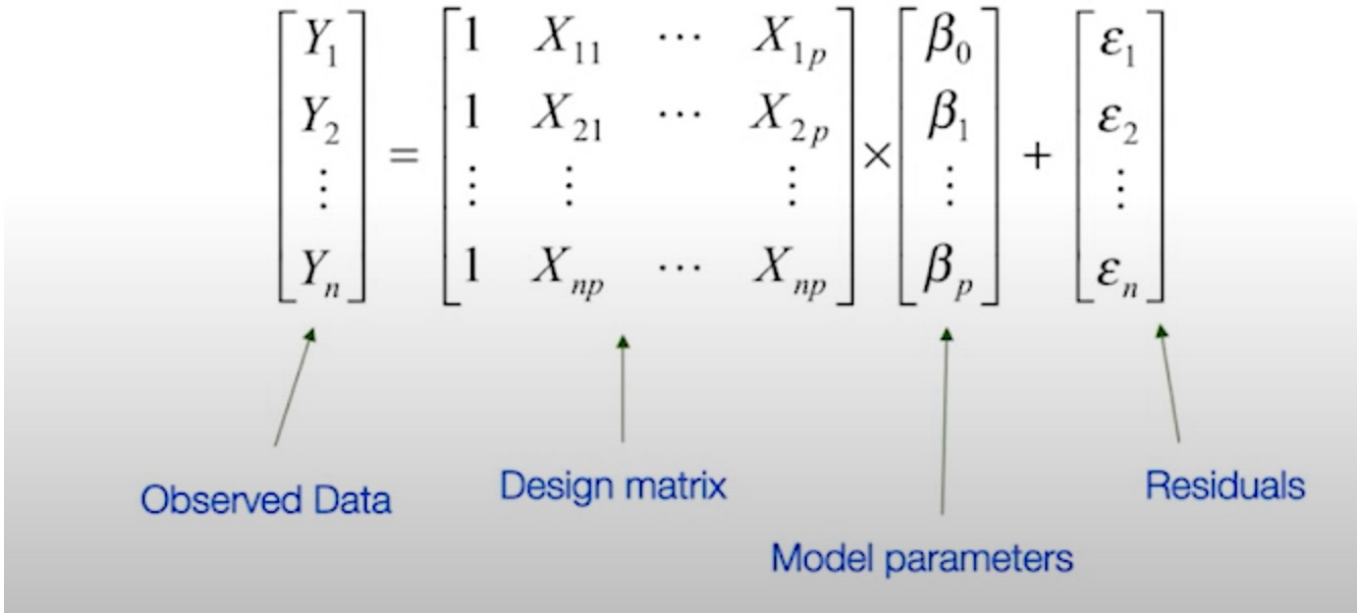
SPM12

- SPM - theoretical concepts of Statistical Parametric Mapping in a complete analysis package.
- Run in matlab
- See more information: https://www.fil.ion.ucl.ac.uk/spm/software/spm12/



Simple or multiple regression, t-tests, ANOVA, ANCOVA

$$\mathbf{Y} = \mathbf{X}\beta + \varepsilon$$

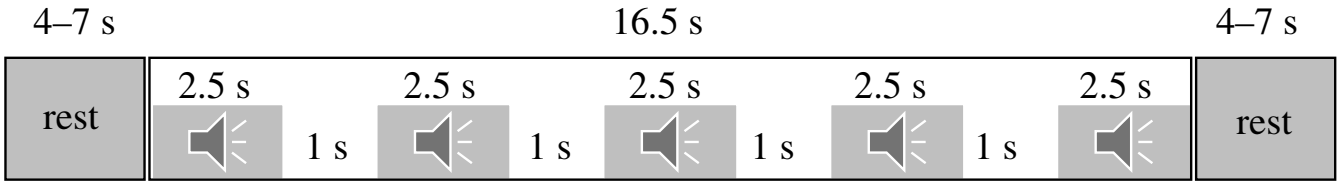


The laughter experiment

Four stimuli types:

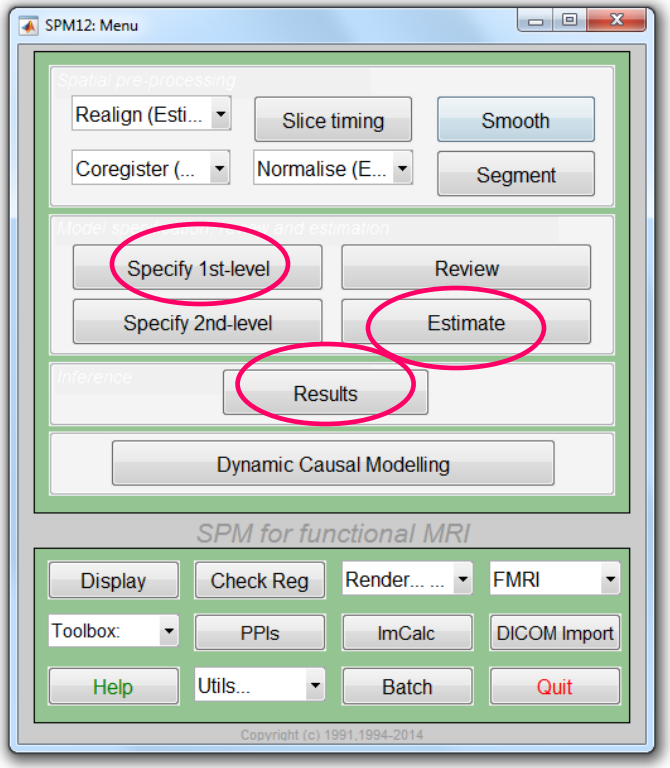
Laughter / Crying vocalization /
Scrambled laughter / Scrambled Crying

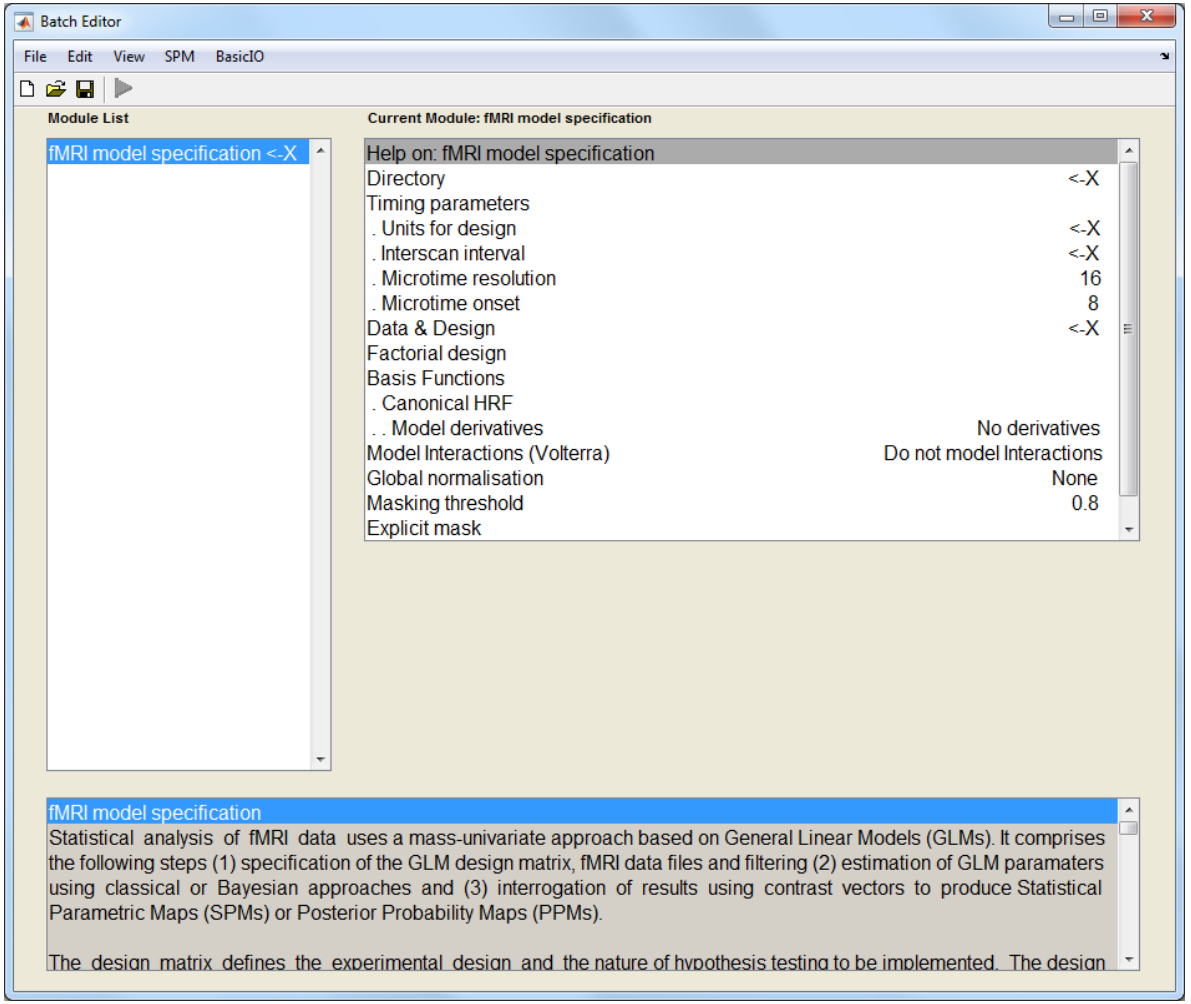
Block design



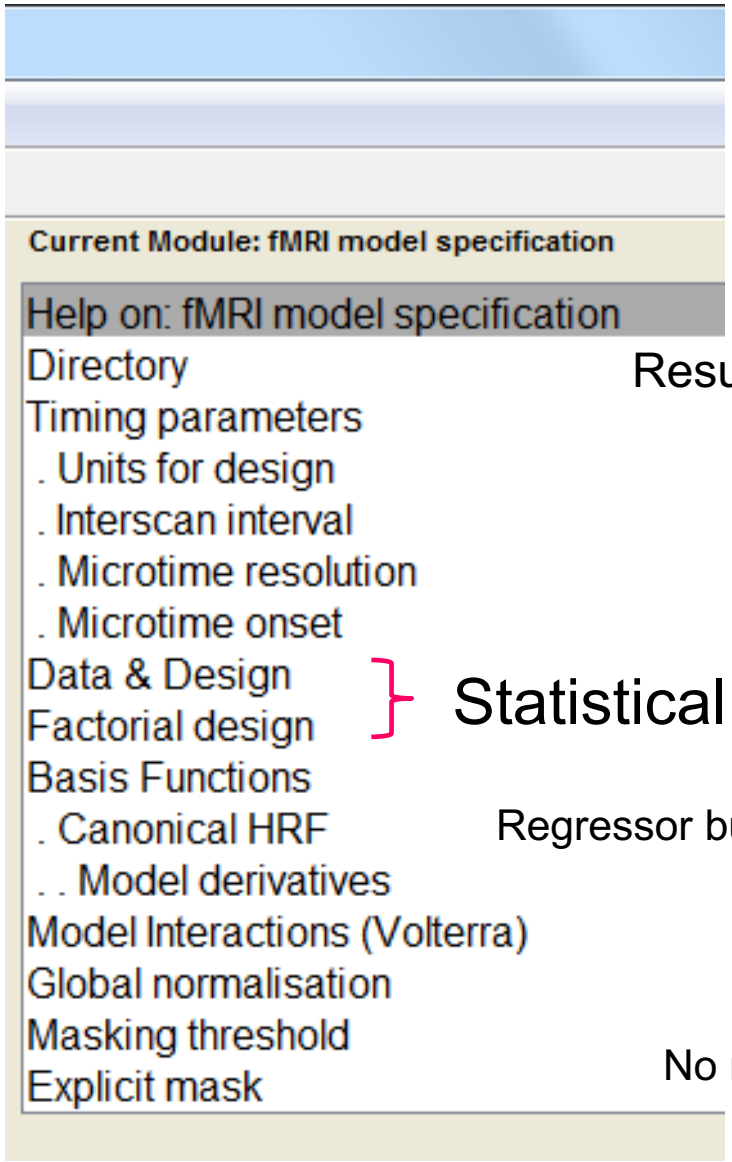
The 16.5 s block contains Laughter, crying, or scrambled sound.

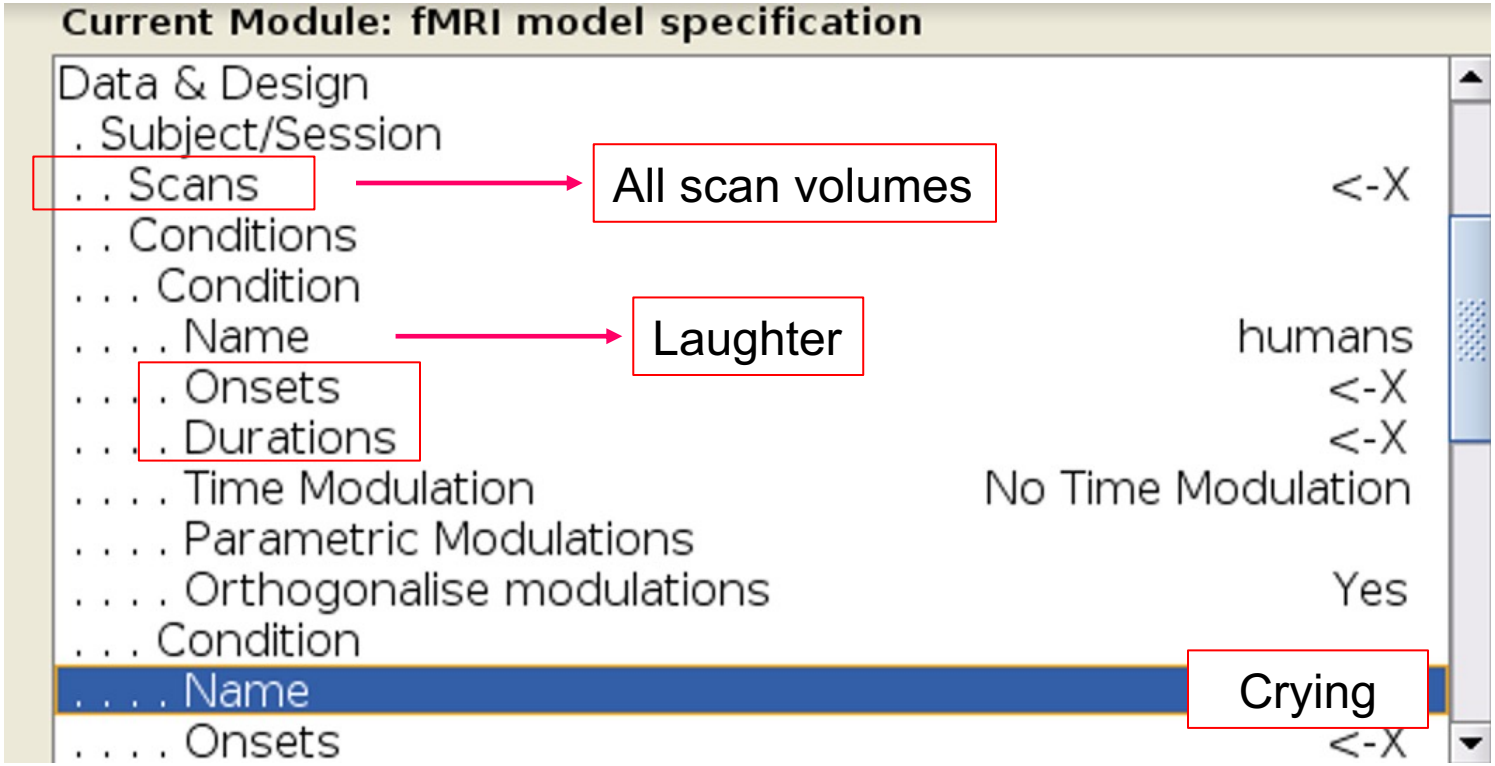
Operation in SPM12



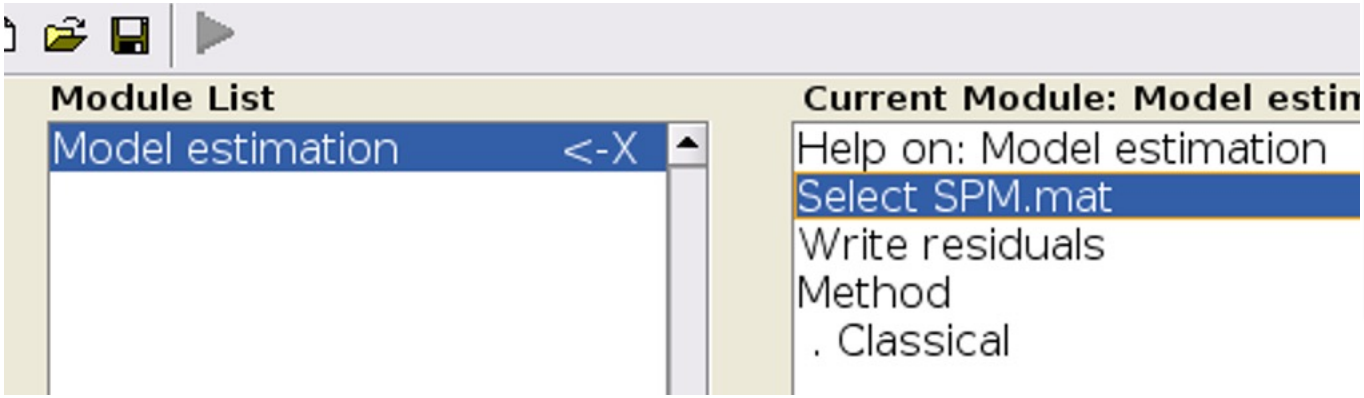


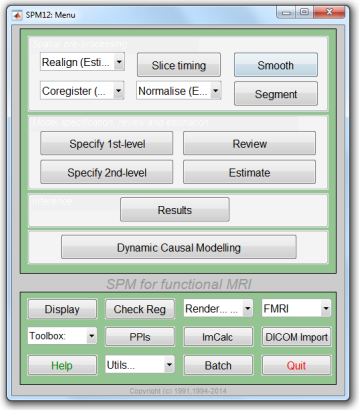
SPM12: parameter setting



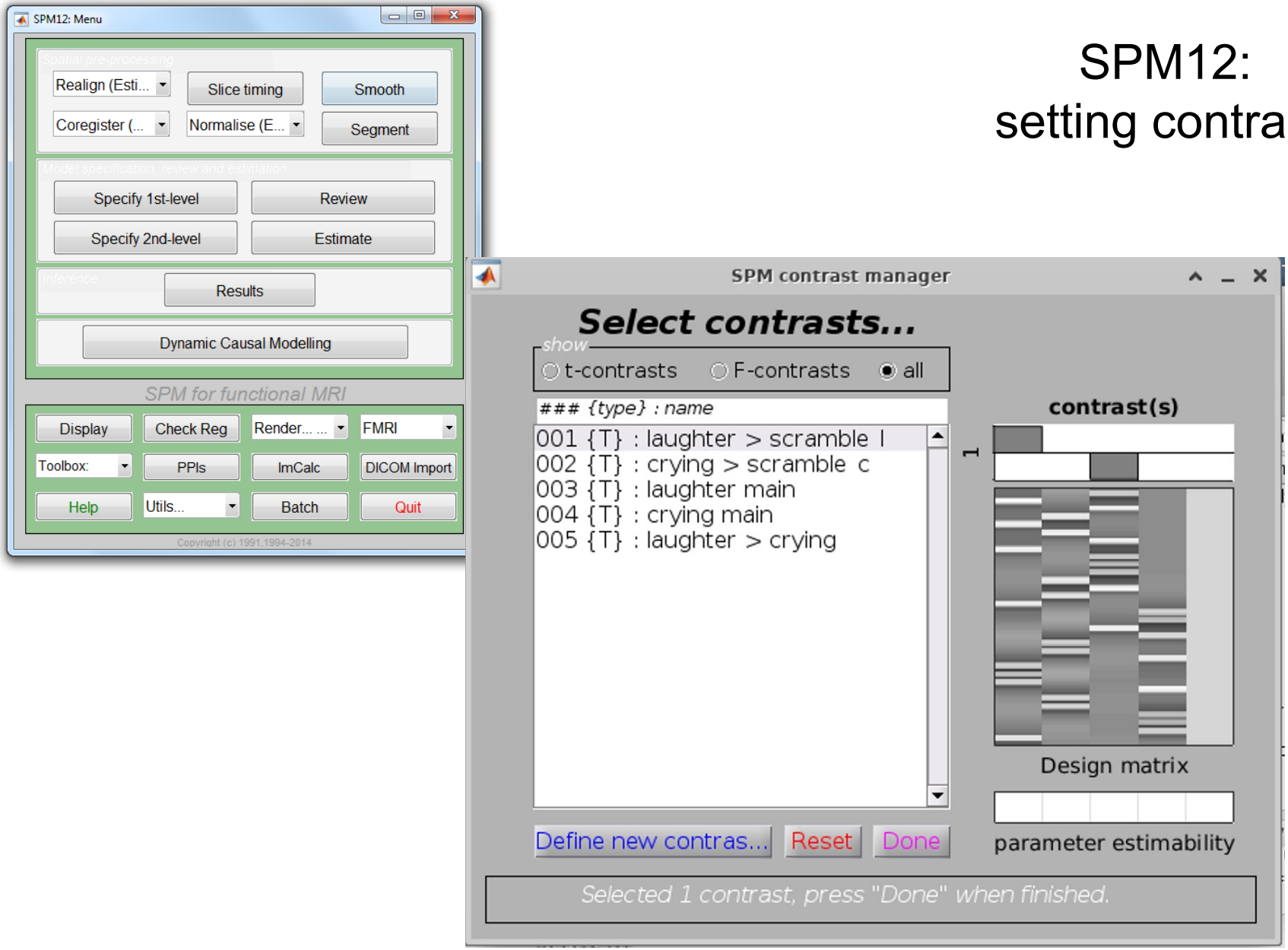


Data estimation

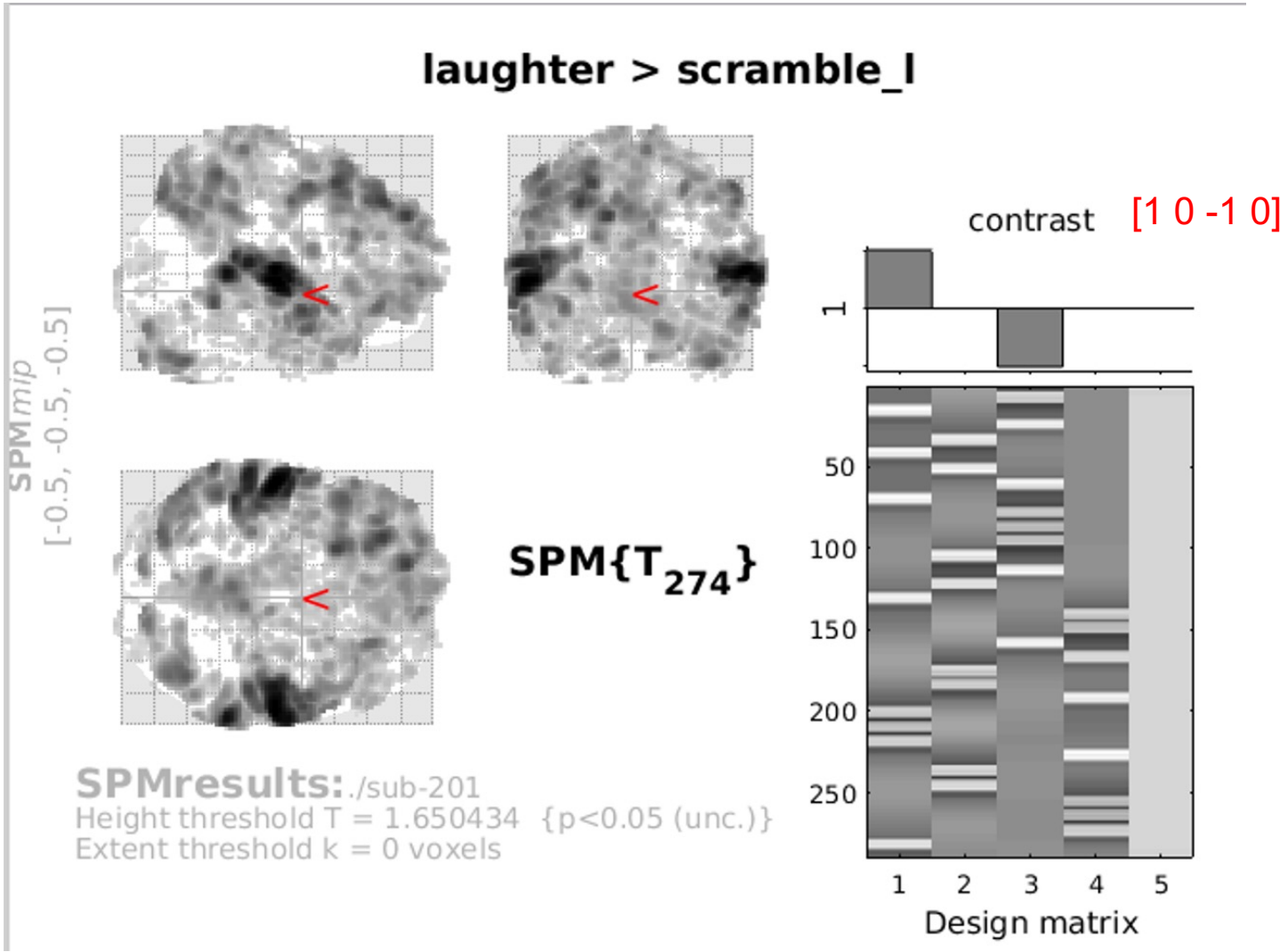




SPM12: setting contrasts



SPM12: result

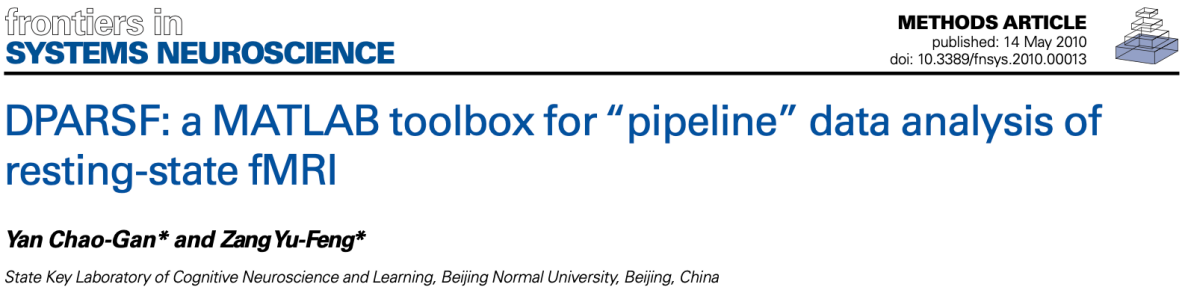


Outline

- What is 1st level analysis?
- Statistical models according to tasks
  - Contrasts
  - Operation in SPM12
    - To set the parameters
    - To make contrasts: T contrasts
- Resting state fMRI
- fMRI with movies

Measures in resting state fMRI

- ReHo = regional homogeneity: larger value indicates a higher regional synchronization.
- ALFF = amplitude of low-frequency fluctuation: indicate the magnitude of neural activity
- **FC = functional connectivity (between ROIs): inter-regional correlations**


frontiers in
SYSTEMS NEUROSCIENCE

METHODS ARTICLE
published: 14 May 2010
doi: 10.3389/fnsys.2010.00013

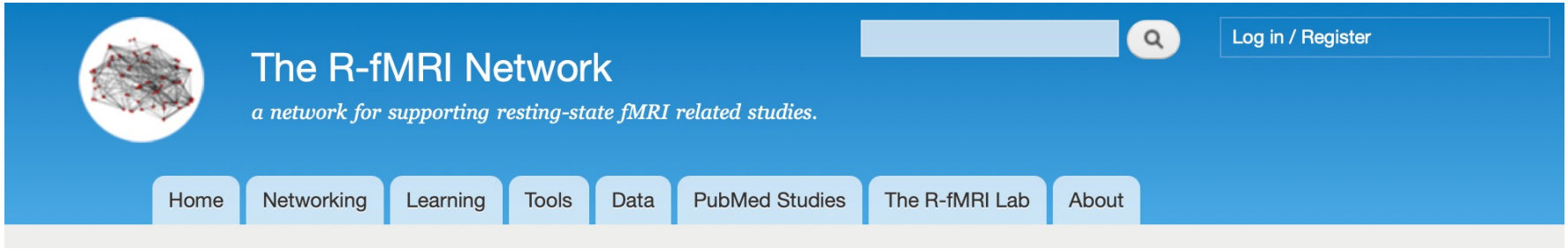
DPARSF: a MATLAB toolbox for "pipeline" data analysis of resting-state fMRI

Yan Chao-Gan and Zang Yu-Feng**

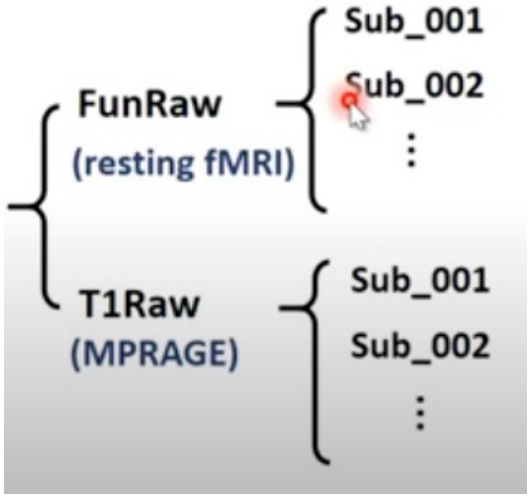
State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, Beijing, China

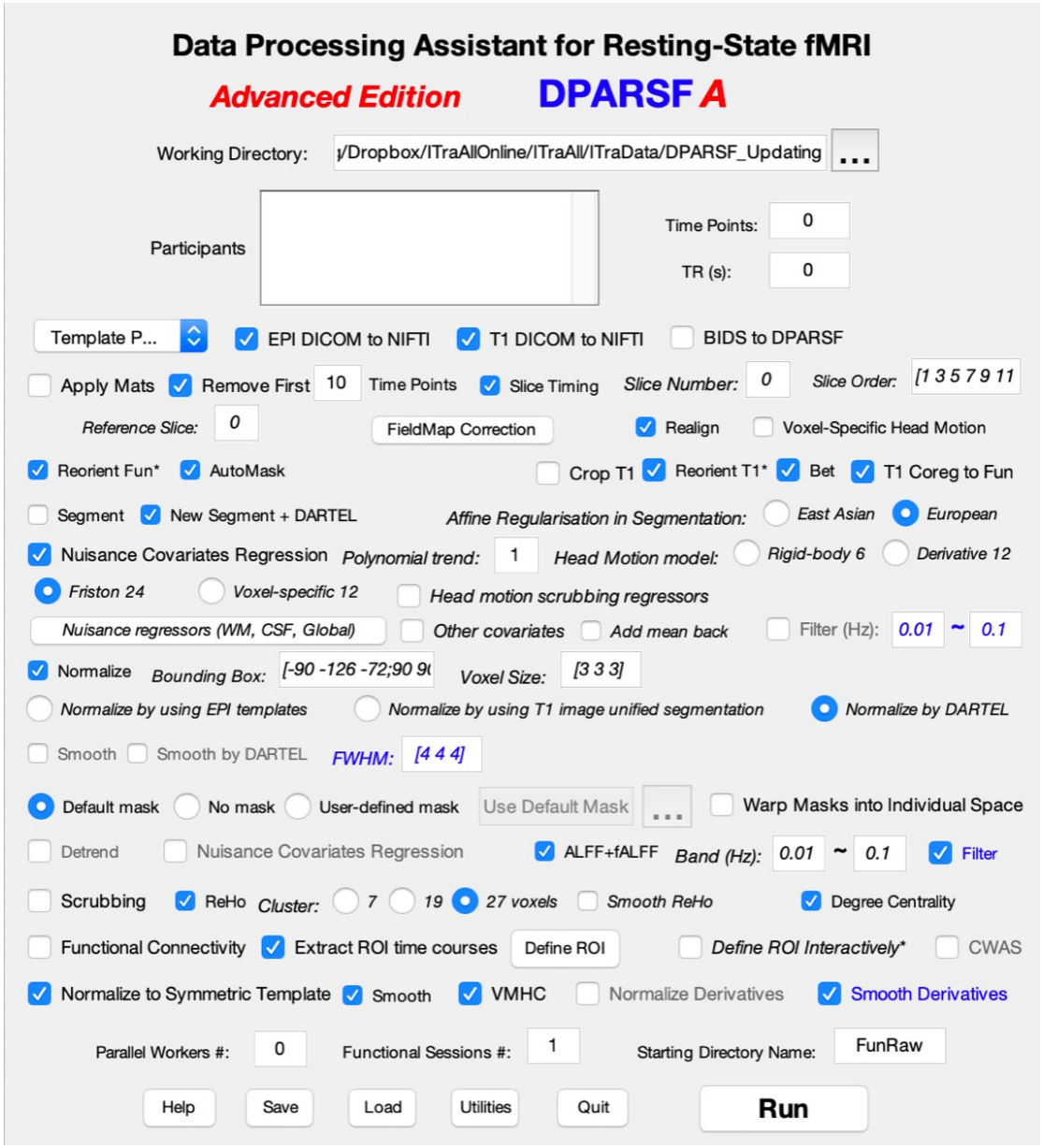
Toolbox for rs-fMRI analysis

- Matlab based
- Download DPARSF from: http://rfmri.org/DPARSF



Data folder

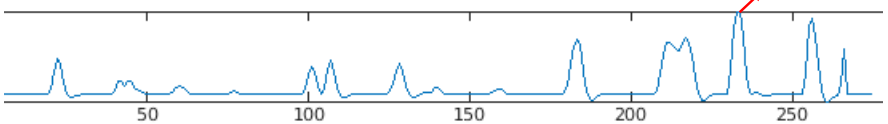

FunRaw
(resting fMRI)
Sub_001
Sub_002
T1Raw
(MPRAGE)
Sub_001
Sub_002


Data Processing Assistant for Resting-State fMRI
Advanced Edition
DPARSF A
Working Directory:
/Dropbox/ITraAllOnline/ITraAll/ITraData/DPARSF_Updating
Participants
Time Points: 0
TR (s): 0
Template P...
EPI DICOM to NIFTI
T1 DICOM to NIFTI
BIDS to DPARSF
Apply Mats
Remove First 10 Time Points
Slice Timing
Slice Number: 0
Slice Order: [1 3 5 7 9 11
Reference Slice: 0
FieldMap Correction
Realign
Voxel-Specific Head Motion
Reorient Fun*
AutoMask
Crop T1
Reorient T1*
Bet
T1 Coreg to Fun
Segment
New Segment + DARTEL
Affine Regularisation in Segmentation:
East Asian
European
Nuisance Covariates Regression
Polynomial trend: 1
Head Motion model:
Rigid-body 6
Derivative 12
Friston 24
Voxel-specific 12
Head motion scrubbing regressors
Nuisance regressors (WM, CSF, Global)
Other covariates
Add mean back
Filter (Hz): 0.01 ~ 0.1
Normalize
Bounding Box: [-90 -126 -72;90 9(
Voxel Size: [3 3 3]
Normalize by using EPI templates
Normalize by using T1 image unified segmentation
Normalize by DARTEL
Smooth
Smooth by DARTEL
FWHM: [4 4 4]
Default mask
No mask
User-defined mask
Use Default Mask
Warp Masks into Individual Space
Detrend
Nuisance Covariates Regression
ALFF+fALFF
Band (Hz): 0.01 ~ 0.1
Filter
Scrubbing
ReHo
Cluster: 7 19 27 voxels
Smooth ReHo
Degree Centrality
Functional Connectivity
Extract ROI time courses
Define ROI
Define ROI Interactively*
CWAS
Normalize to Symmetric Template
Smooth
VMHC
Normalize Derivatives
Smooth Derivatives
Parallel Workers #: 0
Functional Sessions #: 1
Starting Directory Name: FunRaw
Help
Save
Load
Utilities
Quit
Run

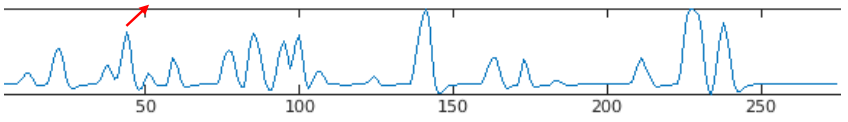
Movie-based fMRI

- ✓ Ratings of different dimensions (social, emotional, neutral, objective…)
- ✓ Each regressor should contain certain number of stimuli. CAN NOT be too small number!

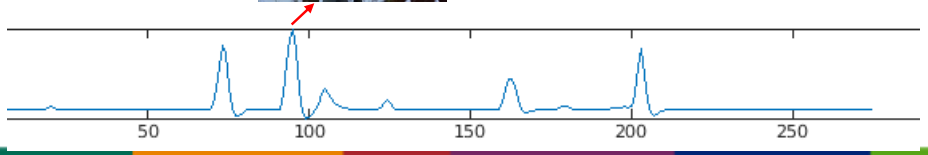
Self-control



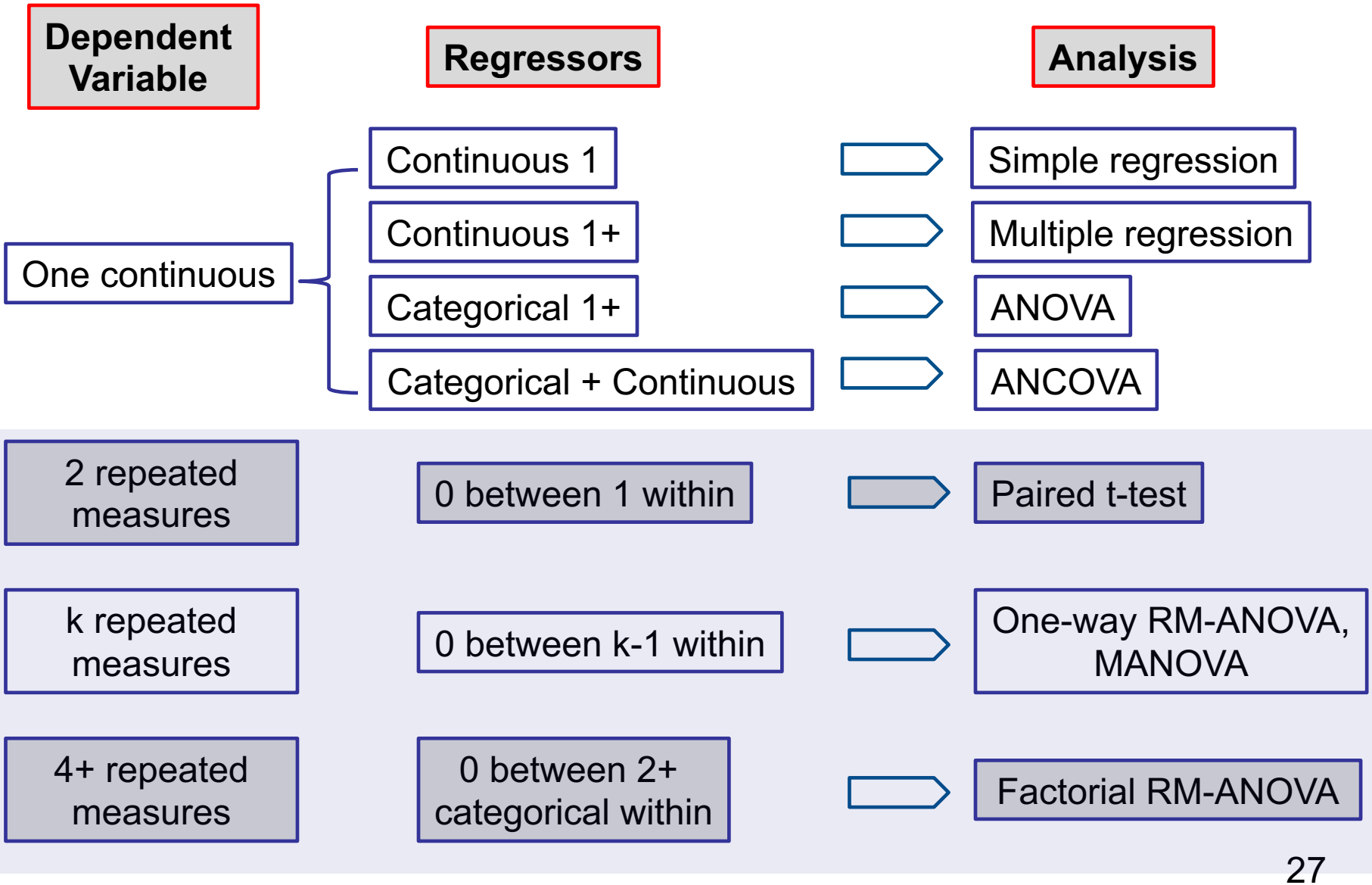
Wanting



Pleasure



The general linear model (GLM) family



Resources

- Principles of fMRI: https://youtu.be/OyLKMb9FNhg
- Spm12 manual: https://www.fil.ion.ucl.ac.uk/spm/doc/spm12_manual.pdf

- Behav Res (2014) 46:596–610