

General Linear Modeling in EEGLAB/LIMO

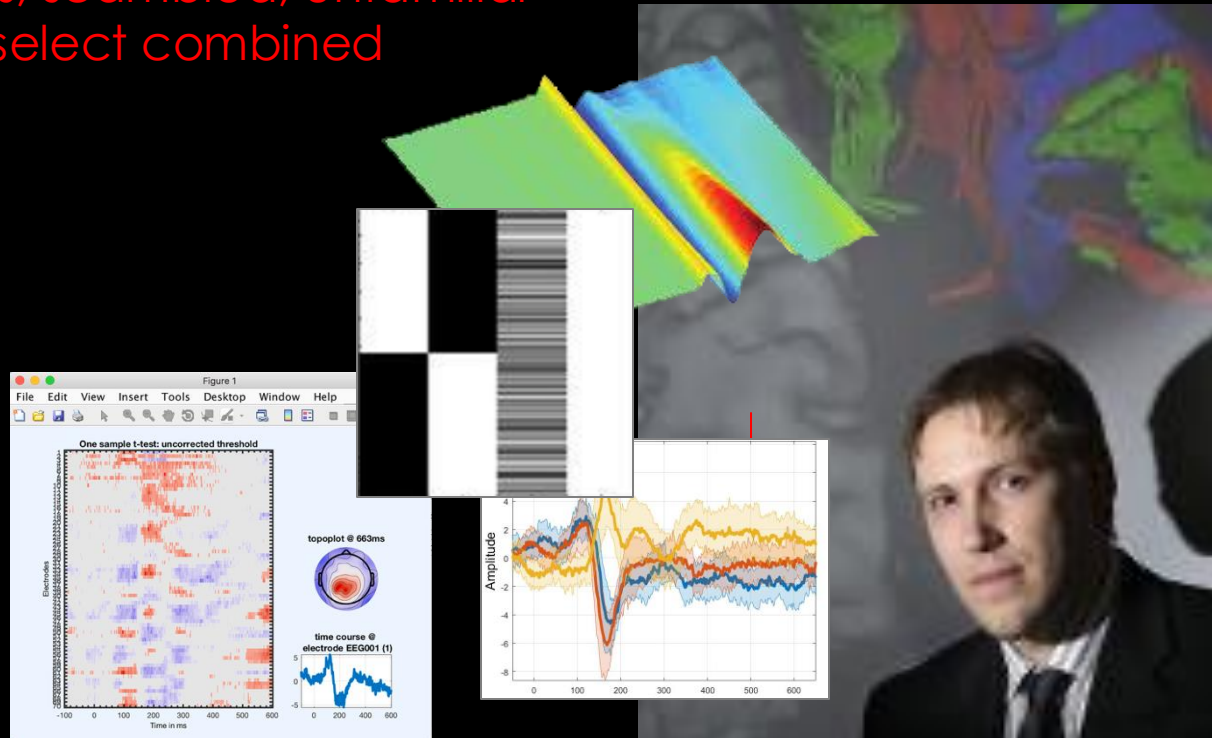
Watch the videos
to be prepared

People cannot reproduce
the video (take screen caps)

Video select famous, scrambled, unfamiliar
while in real life we select combined
values

Practice

Arnaud Delorme



Cyril Pernet

<https://www.nature.com/articles/sdata20151>

www.nature.com/scientificdata

SCIENTIFIC DATA

OPEN

SUBJECT CATEGORIES

- » Electroencephalography
- EEG
- » Brain imaging

A multi-subject, multi-modal human neuroimaging dataset

Daniel G. Wakeman^{1,2} & Richard N. Henson²

Download the data at
<https://openneuro.org/datasets/ds002718>

Face processing EEG dataset | x

openneuro.org/datasets/ds002718/versions/1.0.2

OpenNEURO

MY DASHBOARD PUBLIC DASHBOARD SUPPORT FAQ UPLOAD DATASET

Versions

Draft	2020-05-26
1.0.0	2020-04-21
1.0.1	2020-04-23
1.0.2	2020-05-26

Face processing EEG dataset for EEGLAB

uploaded by Dung Truong on 2020-04-21 - 4 months ago
last modified on 2020-05-26 - 3 months ago
authored by Daniel G. Wakeman, Richard N Henson
17 1057

Download Analyze on brainlife.io

OpenNeuro Accession Number: ds002718
Files: 617, **Size:** 4.19GB, **Subjects:** 18, **Session:** 1
Available Tasks: FaceRecognition
Available Modalities: defacemask, channels, coordsystem, eeg, electrodes, events

README

Multi-subject, multi-modal (sMRI+EEG) neuroimaging dataset on face processing. Original data described at <https://www.nature.com/articles/sdata20151>
This is repackaged version of the EEG data in EEGLAB format. The data has gone through minimal preprocessing including (see wh_extracteeg_BIDS.m):

- Ignoring fMRI and MEG data (sMRI preserved for EEG source localization)
- Extracting EEG channels out of the MEG/EEG fiff data
- Adding fiducials
- Renaming EOG and EKG channels

BIDS Validation

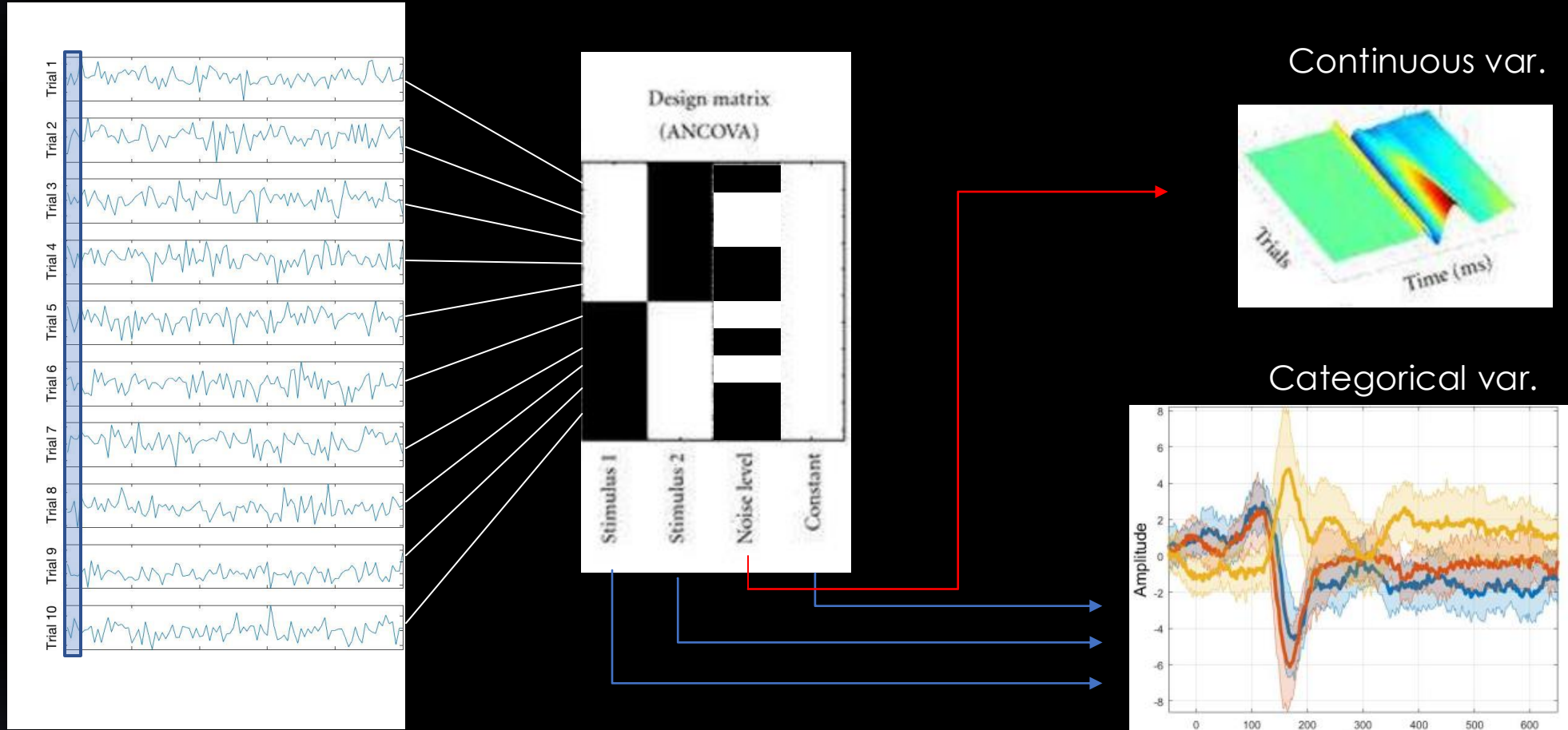
Valid

Dataset File Tree

- Face processing EEG dataset for EEGLAB
 - CHANGES
 - DOWNLOAD VIEW
 - dataset_description.json
 - DOWNLOAD VIEW
 - participants.json
 - DOWNLOAD VIEW
 - participants.tsv
 - DOWNLOAD VIEW
 - README
 - DOWNLOAD VIEW
 - code
 - stimuli
 - sub-002
 - sub-003
 - sub-004
 - sub-005
 - sub-006
 - sub-007

Linear Modeling of EEG data: level 1

Electrode 1



GLM: ordinary least square (OLS) versus weighted least square (WLS)

Significance: bootstrap trials to get confidence interval of beta parameters

The Data



- ▶ 3 types of stimuli: Famous faces, Non-famous faces, Scrambled faces
- ▶ 3 levels of repetition: 1st time, 2nd time (right after), 3rd time (delayed)

We need the conditions computed per subject (1st level) and then do the repeated measure ANOVA to test main effects and interactions.

Let's get started

Name	
▶	sub002
▶	sub003
▶	sub004
▶	sub005
▶	sub006
▶	sub007
▶	sub008
▶	sub009
▶	sub010
▶	sub011
▶	sub012
▶	sub013
▶	sub014
▶	sub015
▶	sub016
▶	sub017
▶	sub018
▶	sub019

- Download the data
<https://openneuro.org/datasets/ds002718>
- Open Matlab
- Start EEGLAB

```

% start EEGLAB
clear
[ALLEEG, EEG, CURRENTSET, ALLCOM] = eeglab;

% import BIDS
filepath = 'XXX\WakemanHenson_Faces\eeeg';
[STUDY, ALLEEG] = pop_importbids(filepath, 'bidsevent', 'on', 'bidschanloc', 'on', ...
    'studyName', 'Face_detection');
ALLEEG = pop_select( ALLEEG, 'nochannel', {'EEG061', 'EEG062', 'EEG063', 'EEG064'});
CURRENTSTUDY = 1; EEG = ALLEEG; CURRENTSET = [1:length(EEG)];

% Remove bad channels
EEG = pop_clean_rawdata( EEG, 'FlatlineCriterion', 5, 'ChannelCriterion', 0.8, ...
    'LineNoiseCriterion', 4, 'Highpass', [0.25 0.75], ...
    'BurstCriterion', 'off', 'WindowCriterion', 'off', 'BurstRejection', 'off', ...
    'Distance', 'Euclidian', 'WindowCriterionTolerances', 'off' );

% Rereference using average reference
EEG = pop_reref( EEG, [], 'interpchan', []);

% Run ICA and flag artifactual components using IClab
EEG = pop_runica(EEG(s), 'icatype', 'runica', 'concatcond', 'on', 'options', {'pca', -1});
EEG = pop_iclabel(EEG(s), 'default');
EEG = pop_icflag(EEG(s), [NaN NaN; 0.8 1; 0.8 1; NaN NaN; NaN NaN; NaN NaN; NaN NaN]);
EEG = pop_subcomp(EEG(s), []); % remove bad components

% clear data using ASR – just the bad epochs
EEG = pop_clean_rawdata( EEG, 'FlatlineCriterion', 'off', 'ChannelCriterion', 'off', ...
    'LineNoiseCriterion', 'off', 'Highpass', 'off', 'BurstCriterion', 20, ...
    'WindowCriterion', 0.25, 'BurstRejection', 'on', 'Distance', 'Euclidian', ...
    'WindowCriterionTolerances', [-Inf 7] );

% Extract data epochs (no baseline removed)
EEG = pop_epoch( EEG, {'famous_new', 'famous_second_early', 'famous_second_late', ...
    'scrambled_new', 'scrambled_second_early', 'scrambled_second_late', 'unfamiliar_new', ...
    'unfamiliar_second_early', 'unfamiliar_second_late'}, [-0.5 1] , 'epochinfo', 'yes');
EEG = pop_saveset(EEG, 'savemode', 'resave');
ALLEEG = EEG;

% Create study design
STUDY = std_checkset(STUDY, ALLEEG);
STUDY = std_makedesign(STUDY, EEG, 1, 'name', 'Faces', 'delfiles', 'off', ...
    'defaultdesign', 'off', 'variable1', 'type', 'values1', {});

eeglab redraw

```

Import BIDS
dataset/remove
unwanted channels

Clean data
lightly

Re-reference

Run/Remove
ICA

Clean data
aggressively

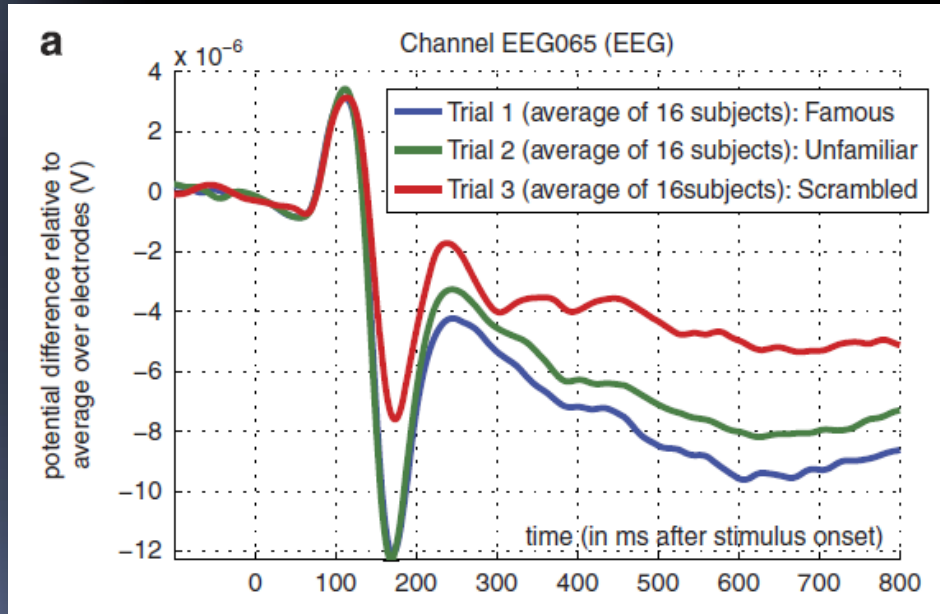
Extract epochs

Create STUDY and STUDY design

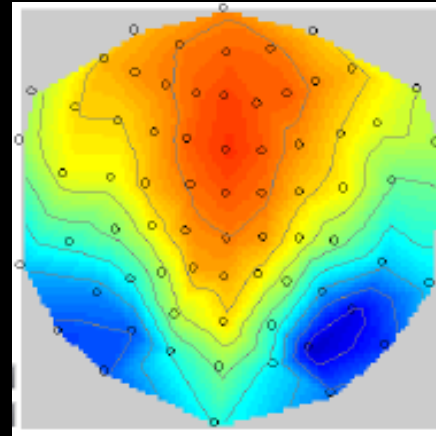
Watch movie
Session_5.2_movie_1.mp4

What are we going to do?

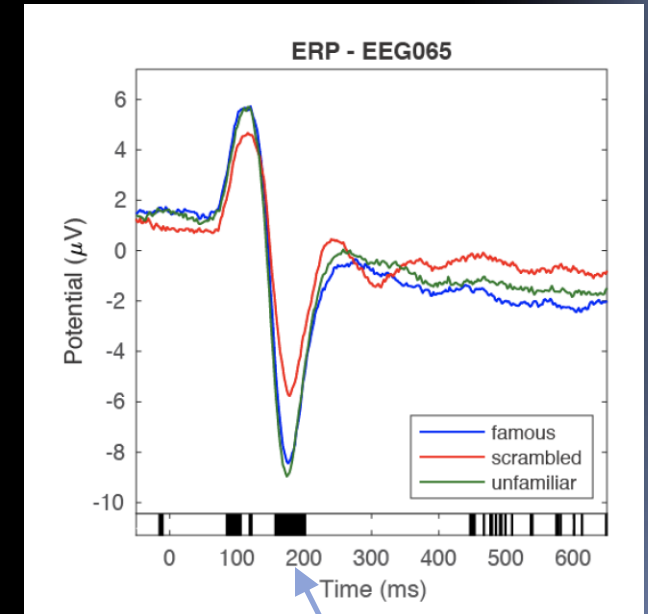
- ▶ 1 – Replicate Henson et al. – faces vs. scrambled



Topography 170 ms



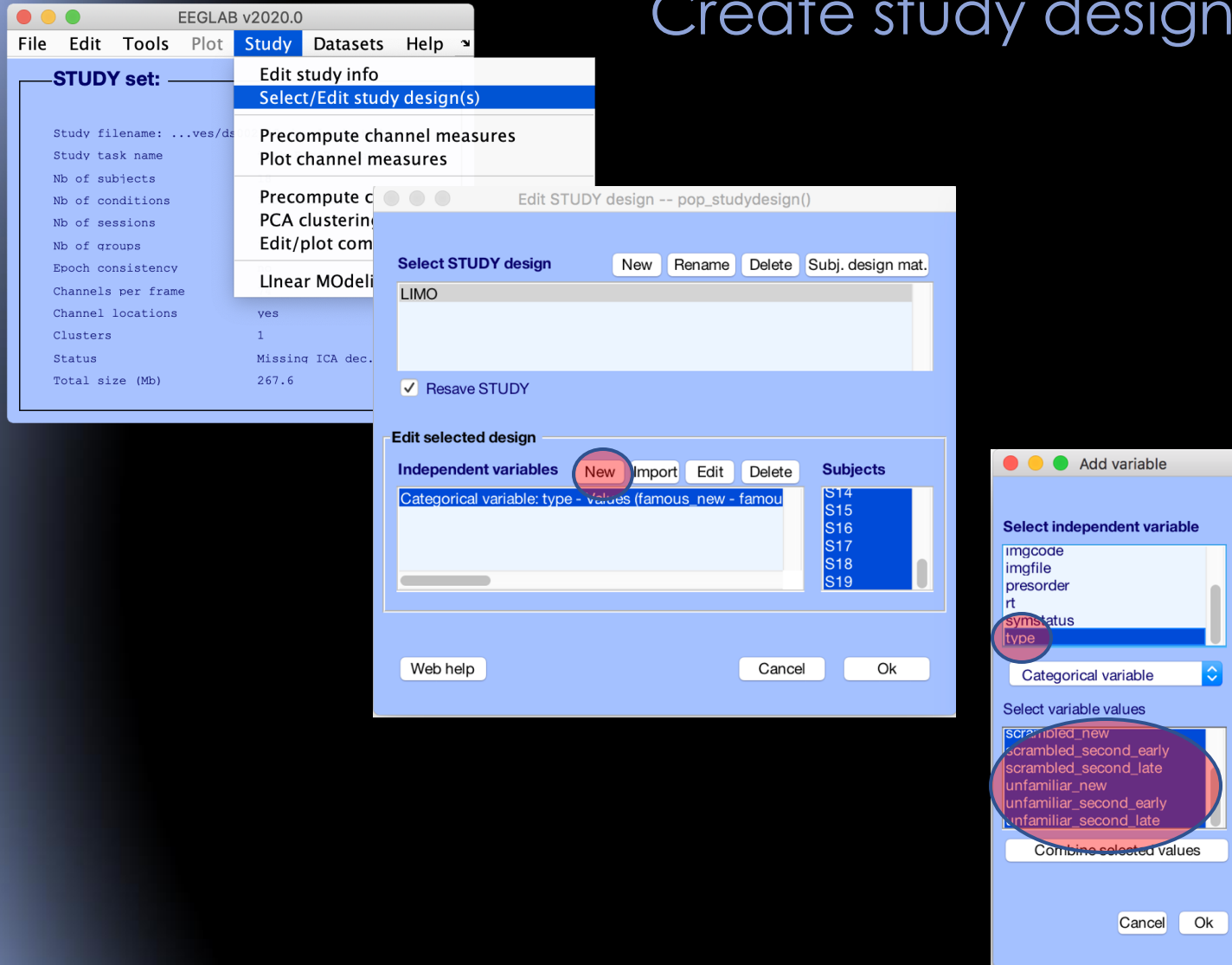
EEGLAB



$p < 0.001$

Watch movie
Session_5.2_movie_2.mp4

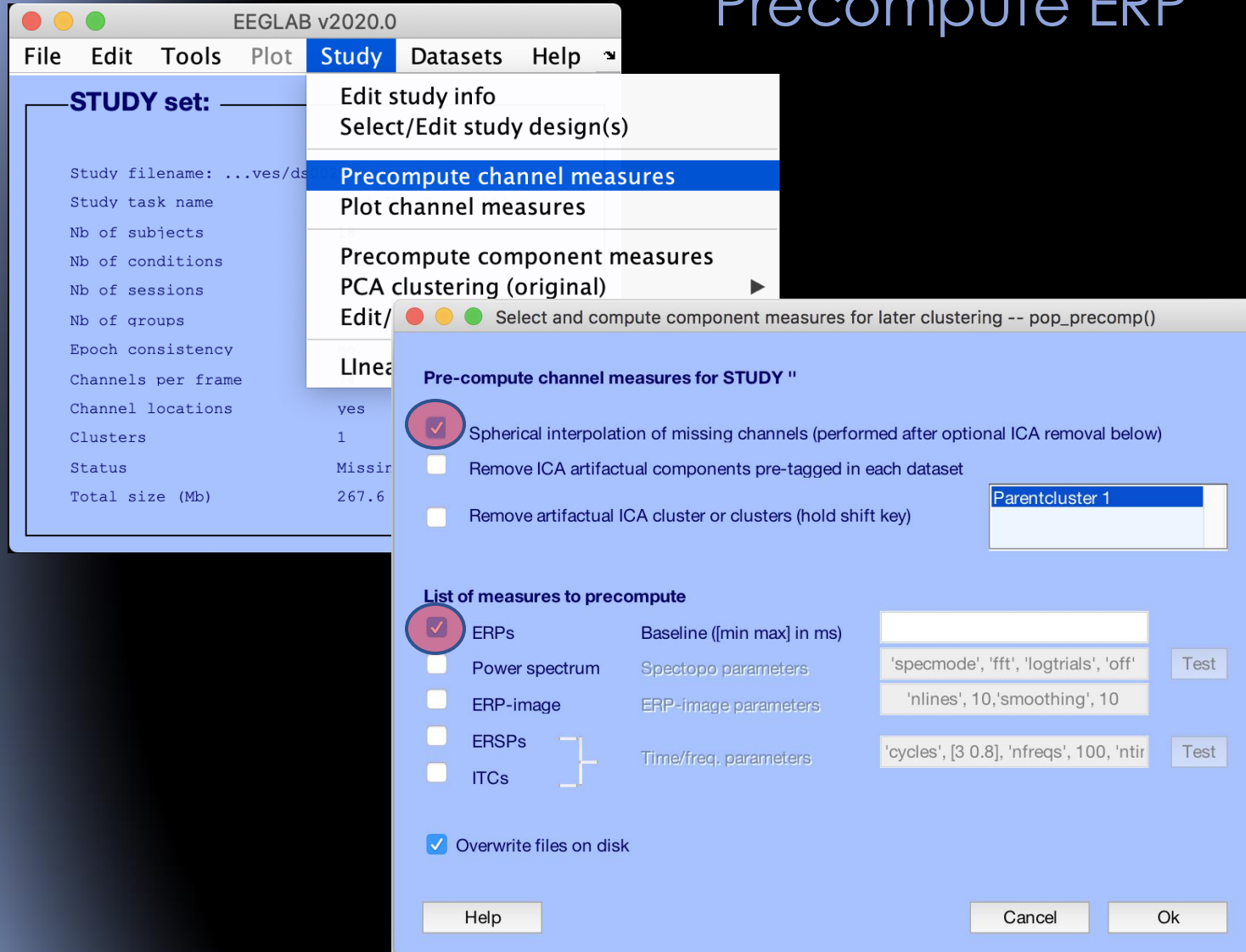
Create study designs



Here, we pick the 'type'
and select all 9 conditions

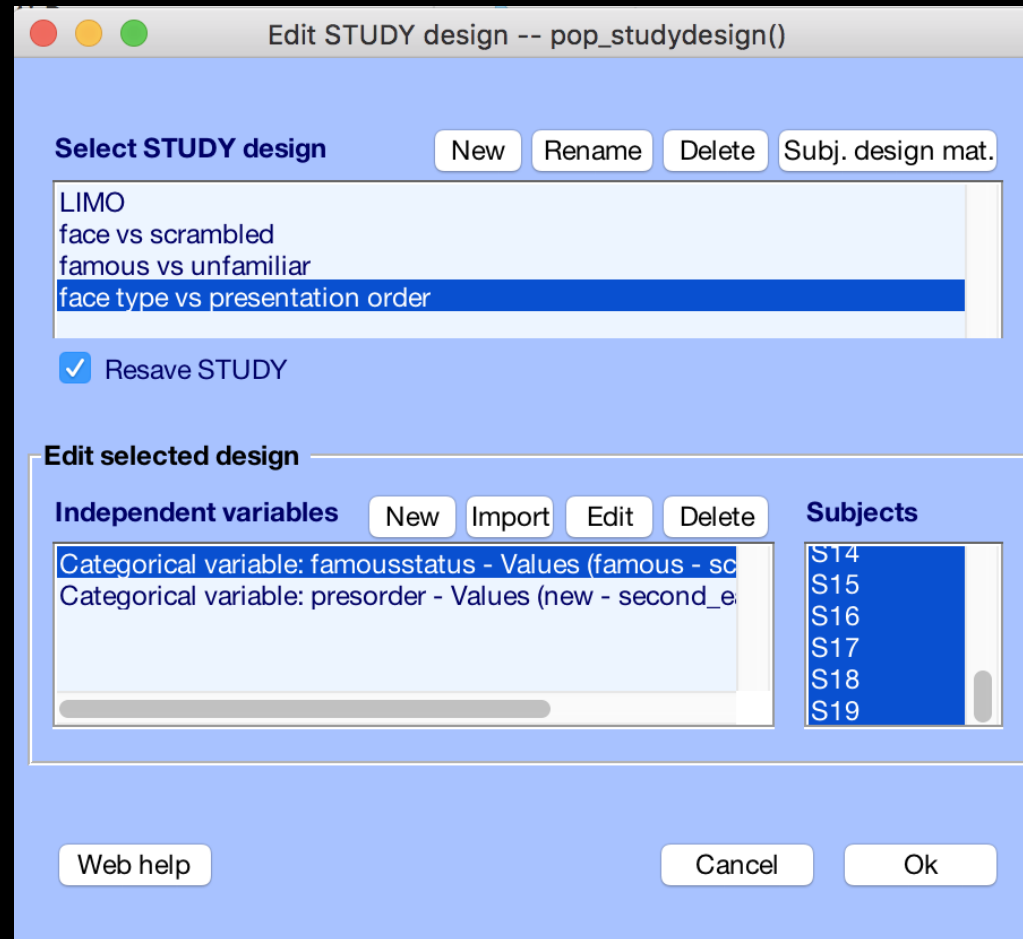
The new STUDY interface allows all sorts of designs. By default, you model each and any condition / covariate (the more complete the model the better)

Precompute ERP



Precompute channel measures (single trials)
with or without interpolation of missing channels

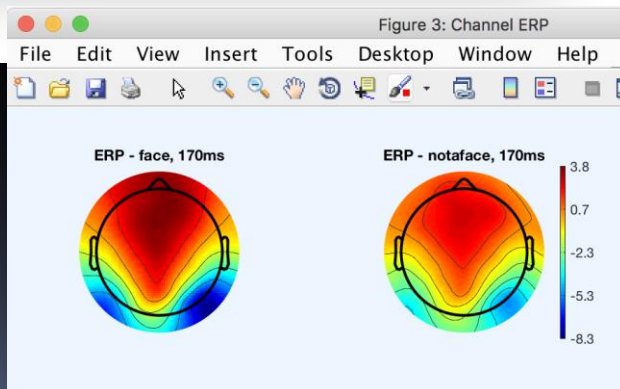
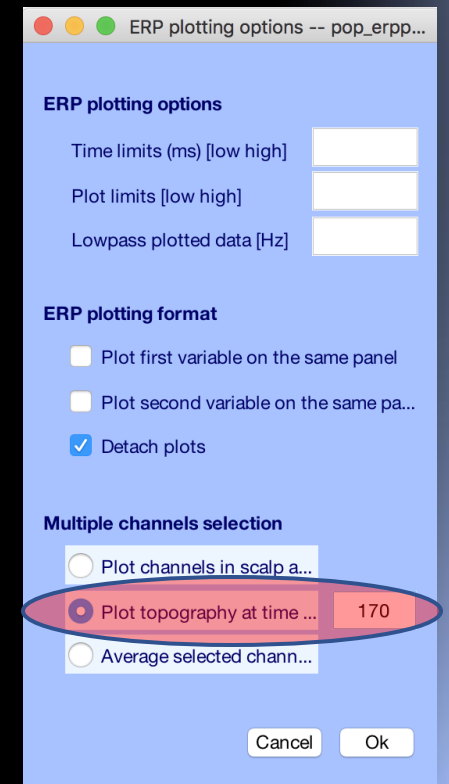
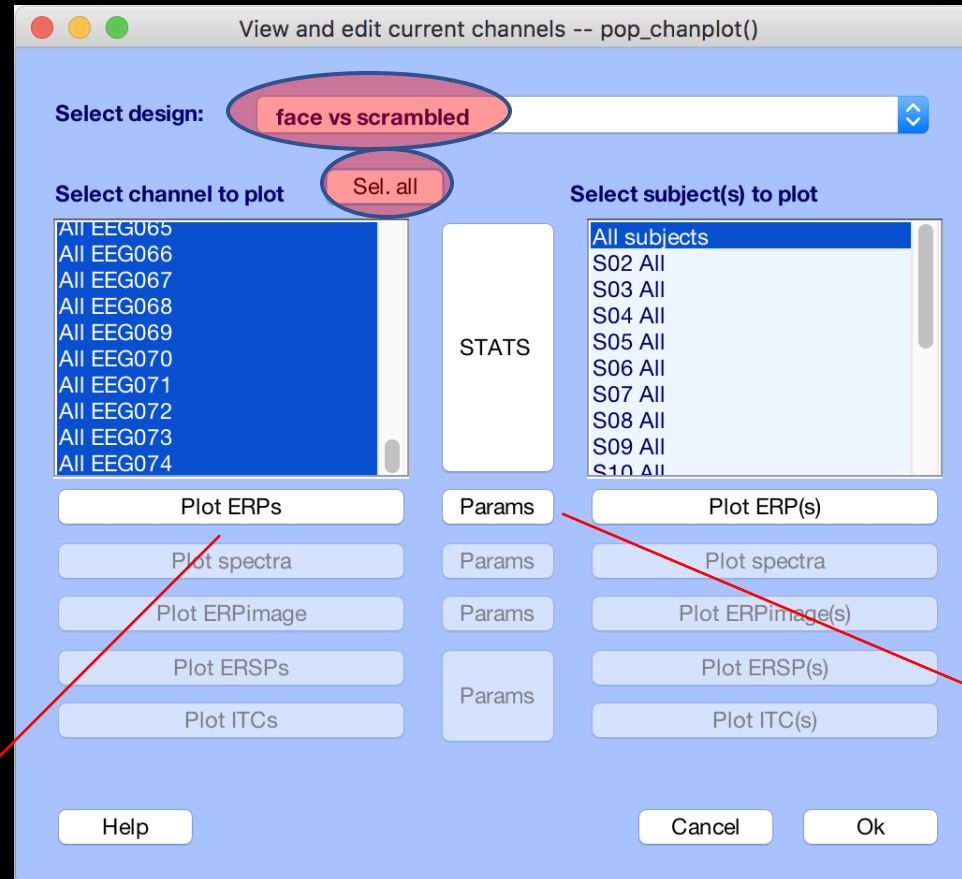
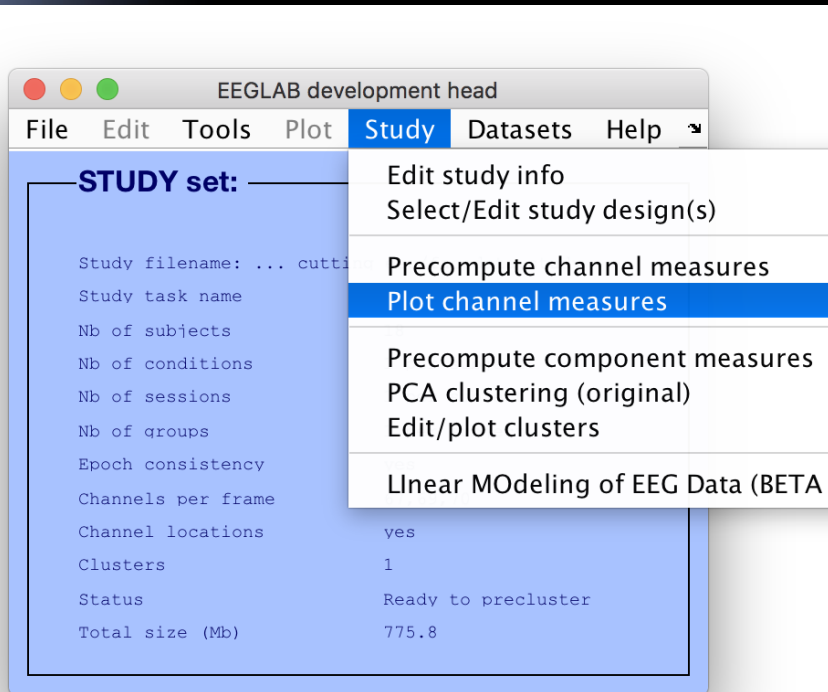
Create other study designs



Select/edit study design

The new STUDY interface allows all sorts of designs. By default, you model each and any condition / covariate (the more complete the model the better)

Standard EEGLAB statistics



Standard EEGLAB statistics

Set statistical parameters -- pop_statparams()

General statistical parameters

- ☒ Compute 1st independent variable statistics if any
- ☐ Compute 2nd independent variable statistics if any
- ☐ Plot marginal statistics (uncheck to plot main effect)
- ☐ Use single trials for statistics (not recommended if more than 1 subject in the study)

☒ **Use EEGLAB statistics**

Use parametric statistics Statistical threshold (p-value)

Use FDR correction Randomization (n)

☐ **Use Fieldtrip statistics**

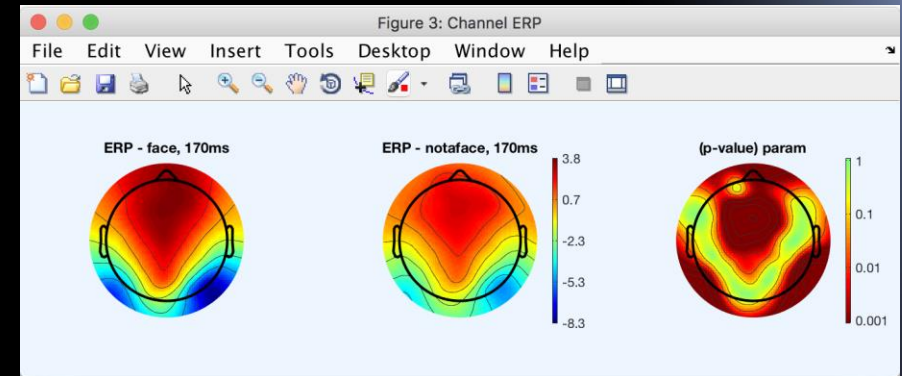
Use montecarlo/permutation statistics Statistical threshold (p-value)

Use cluster correction (CC) Randomization (n)

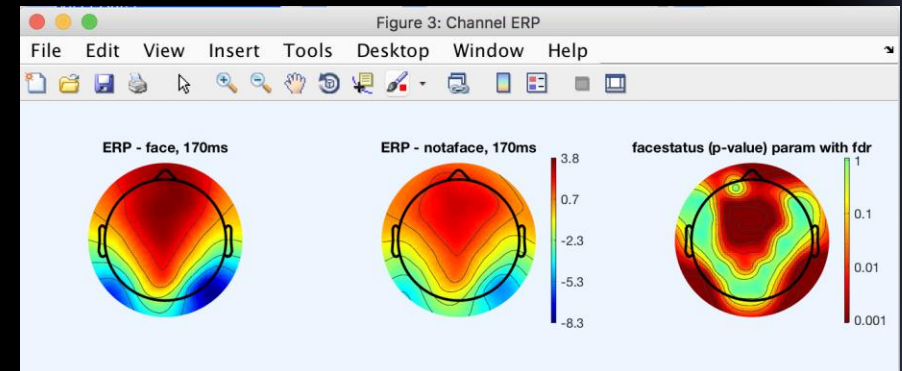
CC channel neighbor parameters

CC clustering parameters

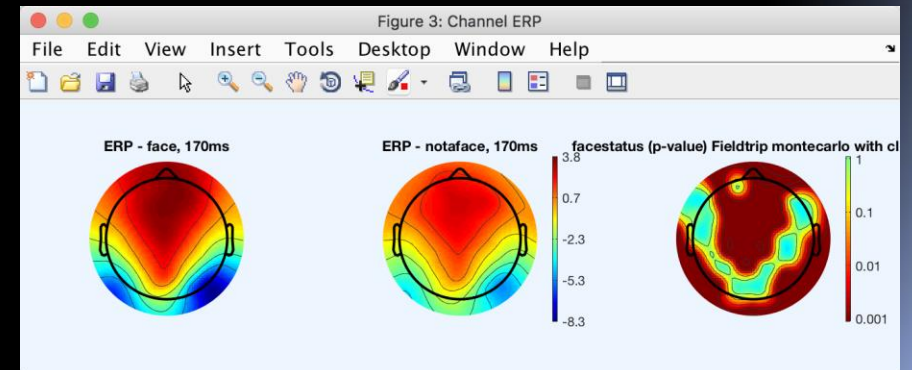
Uncorrected

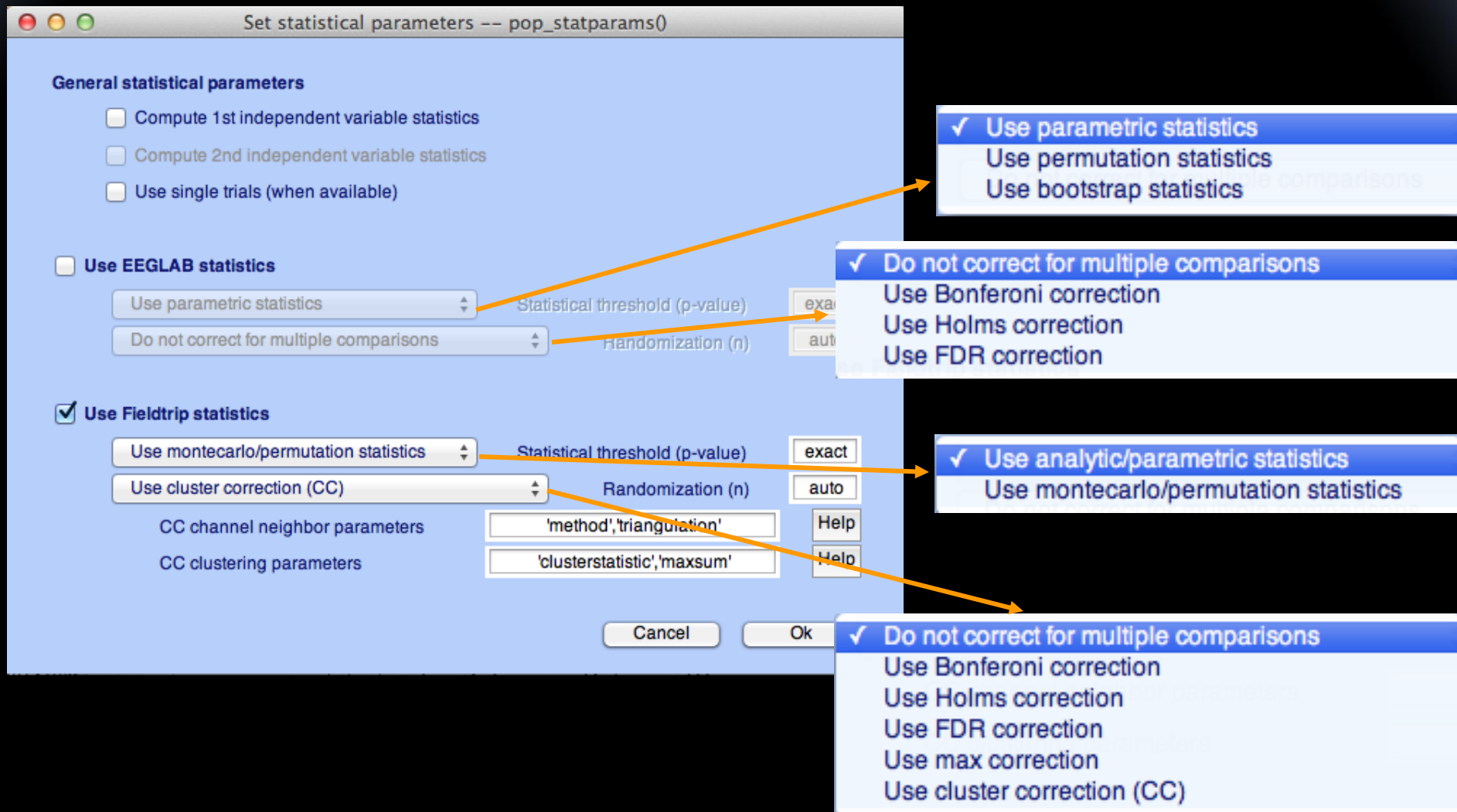


FDR corrected



Cluster corrected



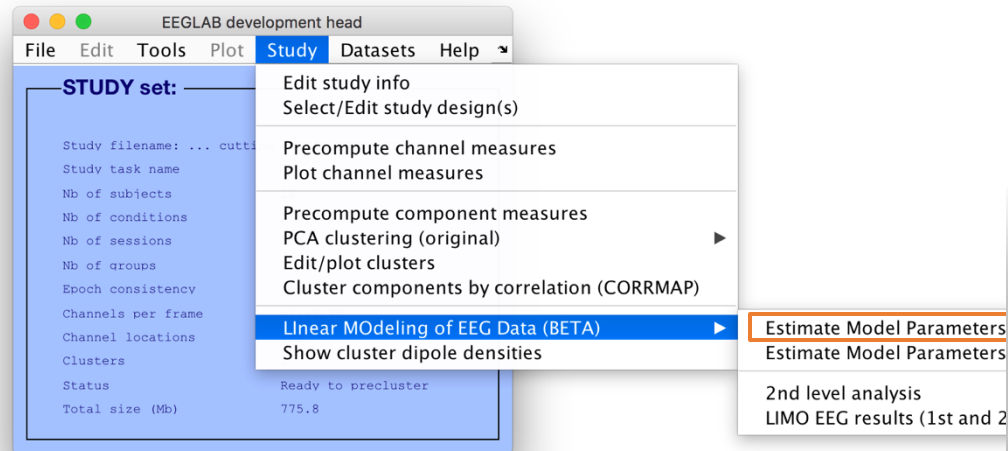


std_stat() function in EEGLAB

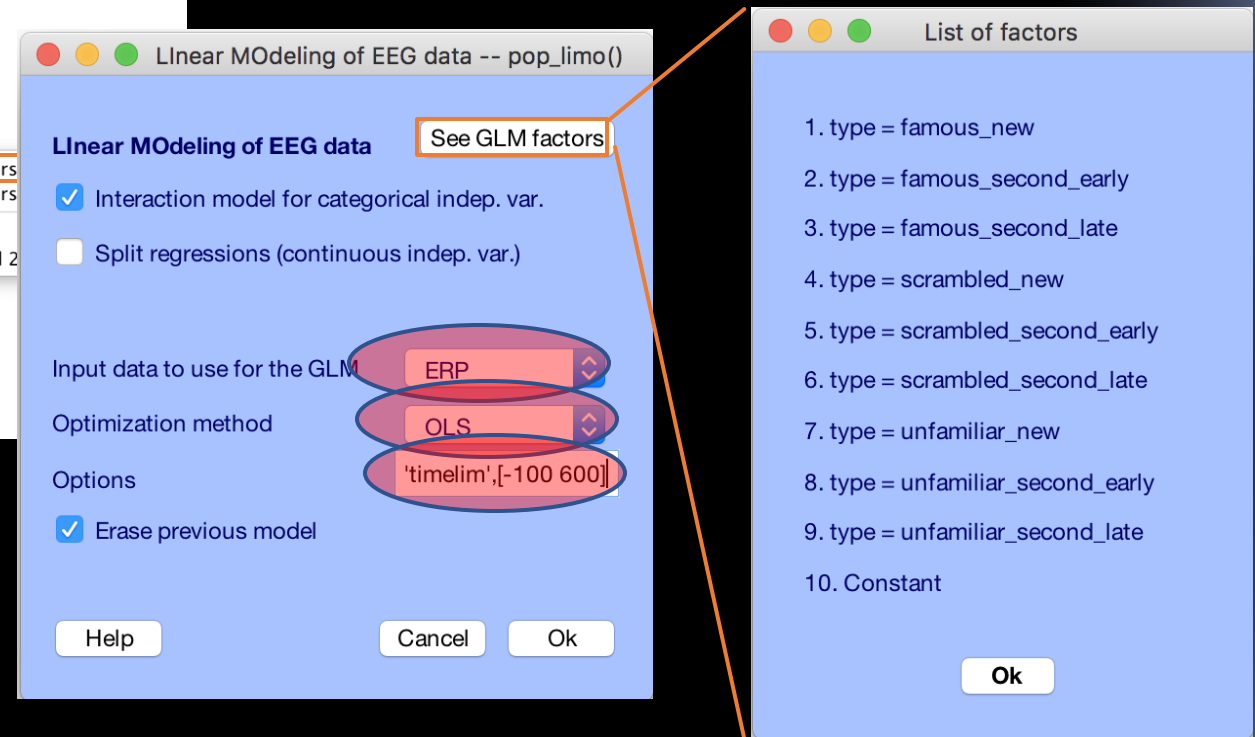
Exercise

1. Load “ds002718processed/Face_detection.study” file
2. Edit STUDY design and delete current variable(s) (menu item *STUDY > Select/Edit STUDY design(s)*) – Do not resave STUDY
3. Create a new indep. Variable design to compare Famous vs. Unfamiliar stimuli
4. Recompute spectrum and ERP (remove labeled ICA comp.) (menu item *STUDY > Precompute channel measures*)
5. Plot ERP for Electrode 65 (menu item *STUDY > Plot channel measures*)
6. Plot scalp topography at 170 ms (ERP) for both conditions
7. Compare using no correction, FDR correction and permutation statistics cluster correction (Fieldtrip – statistics)

Estimate model parameters



Only the current design is pooled in the GLM



Estimate Model Parameter

Have generated single trials, specified the model, we now do the stats
→ Restrict 'timelim', [-50 650]

Are Beta significant?

The image is a collage of screenshots from EEGLAB and LIMO software interfaces, illustrating the workflow for performing a linear modeling analysis on EEG data.

EEGLAB development head: The top-left screenshot shows the EEGLAB development head window. The 'Study' menu is open, highlighting 'Linear Modeling of EEG Data (BETA)'. The 'STUDY set:' panel on the left lists various study parameters, including 'Study filename', 'Study task name', 'Nb of subjects', 'Nb of conditions', 'Nb of sessions', 'Nb of groups', 'Epoch consistency', 'Channels per frame', 'Channel locations', 'Clusters', 'Status', and 'Total size (Mb)'. The 'Linear Modeling of EEG Data (BETA)' option is highlighted in the menu, and the 'Estimate Model Parameters (channel)' option is highlighted in the sub-menu.

limo_random_effect: The top-right screenshot shows the LIMO random effect window. The 'Basic stats' section is active, displaying 'Central tendency and CI'. The 'Tests' section is also visible, with 'One Sample t-test' highlighted.

File Explorer: The bottom-left screenshot shows a file explorer window. The 'LIMO_facedata' folder is selected. The file list includes 'Con4_files_GLM1OLS_Time_Channels.txt', 'Con3_files_GLM1OLS_Time_Channels.txt', 'Ess2_files_GLM1OLS_Time_Channels.txt', 'Con_files_GLM1OLS_Time_Channels.txt', 'Beta_files_GLM1OLS_Time_Channels.txt' (highlighted), 'LIMO_files_GLM1OLS_Time_Channels.txt', 'EEGLAB_set_GLM1OLS_Time_Channels.txt', 'S19', and 'S18'. The 'Options' button is visible at the bottom.

File Explorer: The bottom-right screenshot shows a file explorer window. The 'whdata_processed_cuttin...' folder is selected. The file list includes 'limo_gp_level_chanlocs.mat' (highlighted), 'facedata.study', 'recode_events.m', 'sub019', 'sub018', 'sub017', and 'sub016'. The 'Options' button is visible at the bottom.

Linear Modeling Toolbox: Random Effects: The bottom-right screenshot shows the 'Linear Modeling Toolbox: Random Effects' window. The 'Basic stats' section is active, displaying 'Central tendency and CI'. The 'Tests' section is also visible, with 'One Sample t-test' highlighted. The 'Load expected chan / neighbours' button is highlighted, and an arrow points to it from the 'ANOVA/ANCOVA' section.

Other Windows: A 'Rdx option' dialog box is visible in the center, with 'Full scalp analysis' highlighted. A 'type' dialog box is also visible, with 'Full scalp analysis' highlighted.

Copyright: The bottom-right screenshot includes the copyright notice: 'Copyright (C) LIMO Team 2015 - GNU GPL'.

EEGLAB development head

File Edit Tools Plot Study Datasets Help

STUDY set:

Study filename: ... cutt...

Study task name

Nb of subjects

Nb of conditions

Nb of sessions

Nb of groups

Epoch consistency

Channels per frame

Channel locations

Clusters

Status

Total size (Mb)

Edit study info

Select/Edit study design(s)

Precompute channel measures

Plot channel measures

Precompute component measures

PCA clustering (original)

Edit/plot clusters

Cluster components by correlation (CORRMAP)

Linear Modeling of EEG Data (BETA)

Show cluster dipole densities

Ready to precluster

775.8

Estimate Model Parameters (channel)

Estimate Model Parameters (components)

2nd level analysis

LIMO EEG results (1st and 2nd level)

List of factors

1. type = famous_new

2. type = famous_second_early

3. type = famous_second_late

4. type = scrambled_new

5. type = scrambled_second_early

6. type = scrambled_second_late

7. type = unfamiliar_new

8. type = unfamiliar_second_early

9. type = unfamiliar_second_late

10. Constant

Ok

whdata_processed_cuttin...

Favorites

Recents

Applications

data

arno

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Downloads

MailDownload

Documents

GoogleDrive

Name

Kind

parameter_5

Folder

parameter_4

Folder

parameter_3

Folder

parameter_2

Folder

parameter_1

Folder

H0

Folder

one_sample_ttest_parameter_1.mat

MATLAB

Yr.mat

MATLAB

LIMO.mat

MATLAB

LIMO.mat

MATLAB

betas_ci_Mean_of_Betas.mat

MATLAB

Options

Cancel

Open

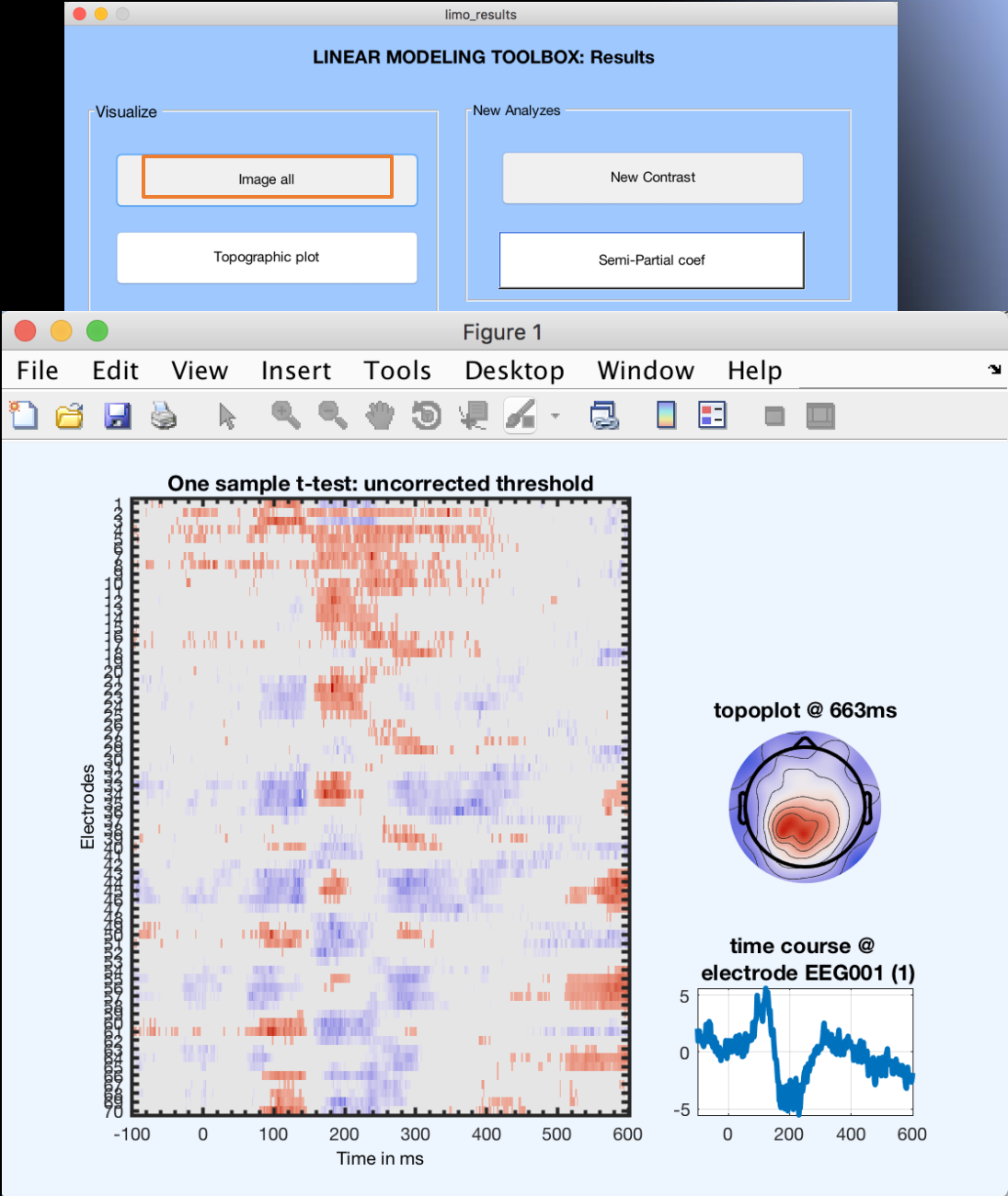


Figure 1

File Edit View Insert Tools Desktop Window Help

One sample t-test: uncorrected threshold

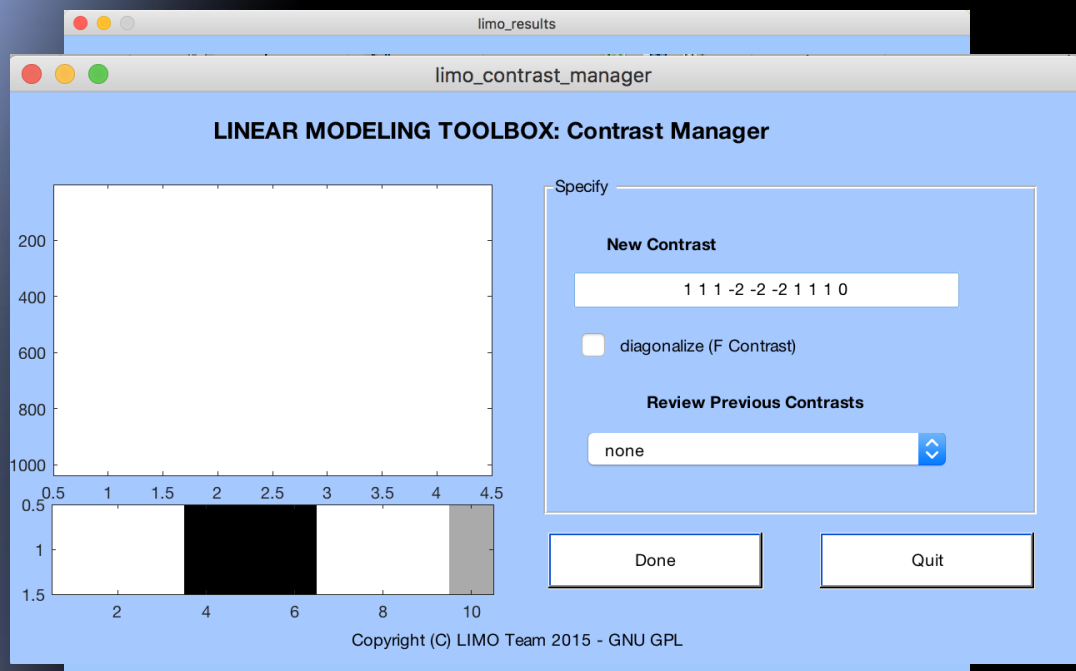
Electrodes

Time in ms

topoplot @ 663ms

time course @ electrode EEG001 (1)

Grouping betas and differences between conditions



List of factors	
1. type = famous_new	
2. type = famous_second_early	
3. type = famous_second_late	
4. type = scrambled_new	
5. type = scrambled_second_early	
6. type = scrambled_second_late	
7. type = unfamiliar_new	
8. type = unfamiliar_second_early	
9. type = unfamiliar_second_late	
10. Constant	
Ok	

Faces vs non-faces Famous Scrambled Unfamiliar

1. type = famous_new	1	1	0	0
2. type = famous_second_early	1	1	0	0
3. type = famous_second_late	1	1	0	0
4. type = scrambled_new	-2	0	1	0
5. type = scrambled_second_early	-2	0	1	0
6. type = scrambled_second_late	-2	0	1	0
7. type = unfamiliar_new	1	0	0	1
8. type = unfamiliar_second_early	1	0	0	1
9. type = unfamiliar_second_late	1	0	0	1
10. Constant	0	0	0	0

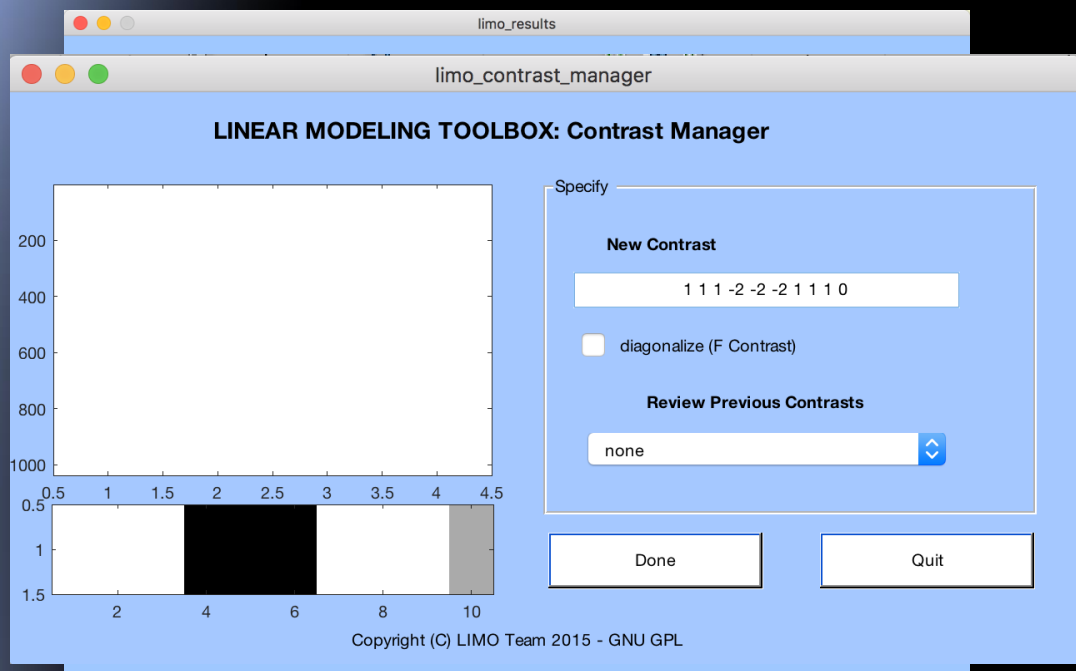
1	0	0
1	0	0
1	0	0
0	1	0
0	1	0
0	1	0
0	0	1
0	0	1
0	0	1
0	0	0

1	0	0
0	1	0
0	0	1
1	0	0
0	1	0
0	0	1
1	0	0
0	1	0
0	0	1
0	0	0

ANOVA (famous/scambled/unfamiliar)

ANOVA (new/early/late)

Grouping betas and differences between conditions



Contrasts were automatically created when we combined variables

List of factors	
1. type = famous_new	
2. type = famous_second_early	
3. type = famous_second_late	
4. type = scrambled_new	
5. type = scrambled_second_early	
6. type = scrambled_second_late	
7. type = unfamiliar_new	
8. type = unfamiliar_second_early	
9. type = unfamiliar_second_late	
10. Constant	
Ok	

Faces vs non-faces Famous Scrambled Unfamiliar

1. type = famous_new	1	1	0	0
2. type = famous_second_early	1	1	0	0
3. type = famous_second_late	1	1	0	0
4. type = scrambled_new	-2	0	1	0
5. type = scrambled_second_early	-2	0	1	0
6. type = scrambled_second_late	-2	0	1	0
7. type = unfamiliar_new	1	0	0	1
8. type = unfamiliar_second_early	1	0	0	1
9. type = unfamiliar_second_late	1	0	0	1
10. Constant	0	0	0	0

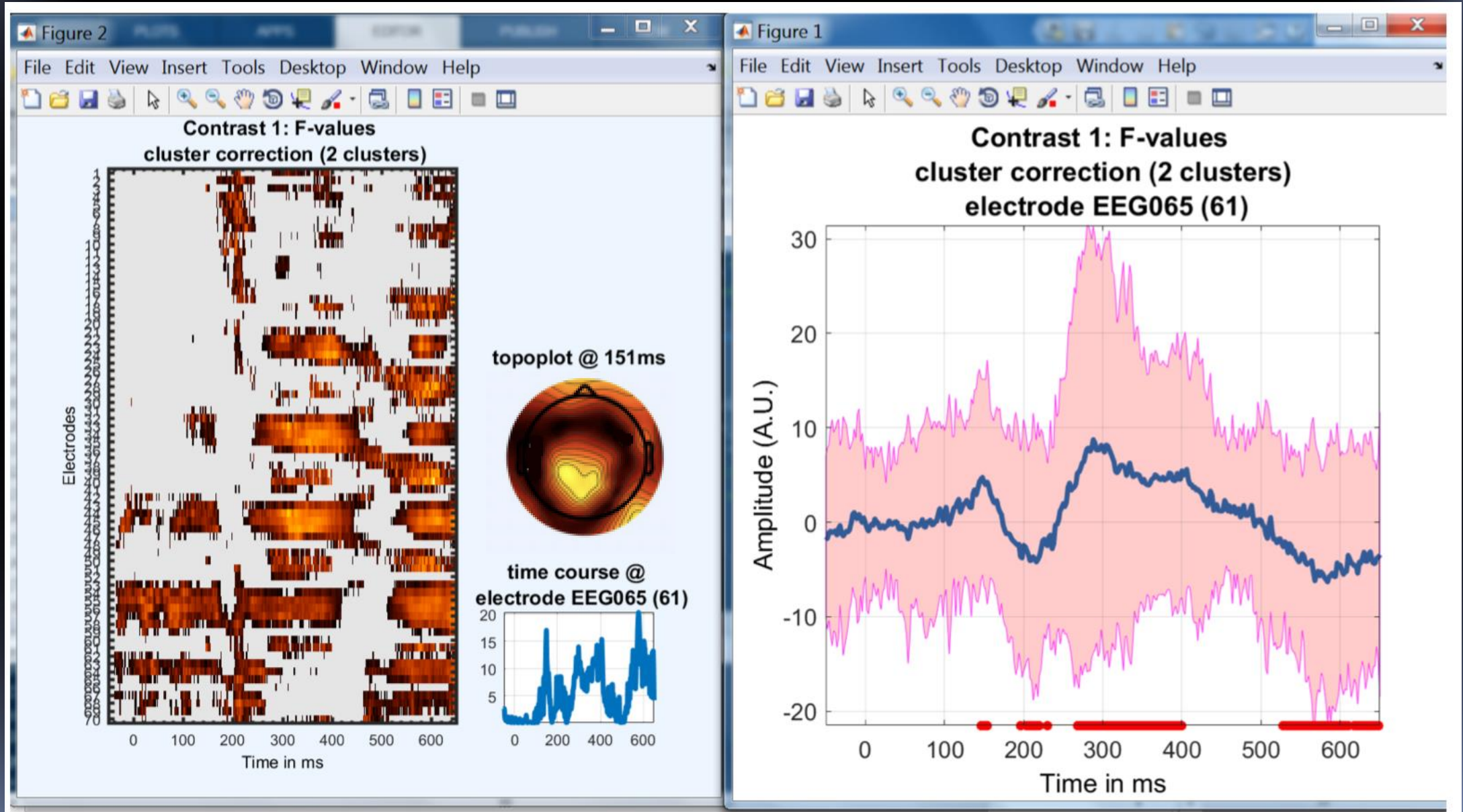
1	0	0
1	0	0
1	0	0
0	1	0
0	1	0
0	1	0
0	0	1
0	0	1
0	0	1
0	0	0

1	0	0
0	1	0
0	0	1
1	0	0
0	1	0
0	0	1
1	0	0
0	1	0
0	0	1
0	0	0

ANOVA (famous/scrambled/unfamiliar)

ANOVA (new/early/late)

ANOVA (famous/scambled/unfamiliar)



Exercise

1. Install LIMO plugin
2. Reload “ds002718processed/Face_detection.study” file
3. NOT NEEDED HERE -- Edit STUDY and create design (menu item *STUDY > Select/Edit STUDY design(s)*)
4. NOT NEEDED HERE -- Recompute ERP (remove labeled ICA comp.) (menu item *STUDY > Precompute channel measures*)
5. Compute LIMO for all subjects (Menu *STUDY > Linear Modeling of EEG data > Estimate Model Parameters (channel)*)
6. Compute and plot group level measures (Menu *STUDY > Linear Modeling of EEG data > 2nd Level analysis*)