STUDY plotting and statistics

STEP 1

Build a STUDY

STEP 2

Build design(s)

STEP 3

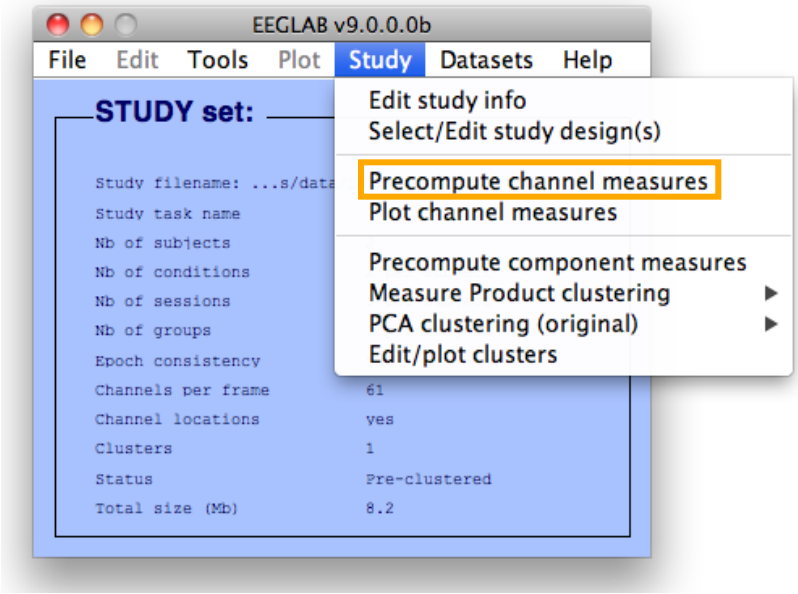
Precompute the data

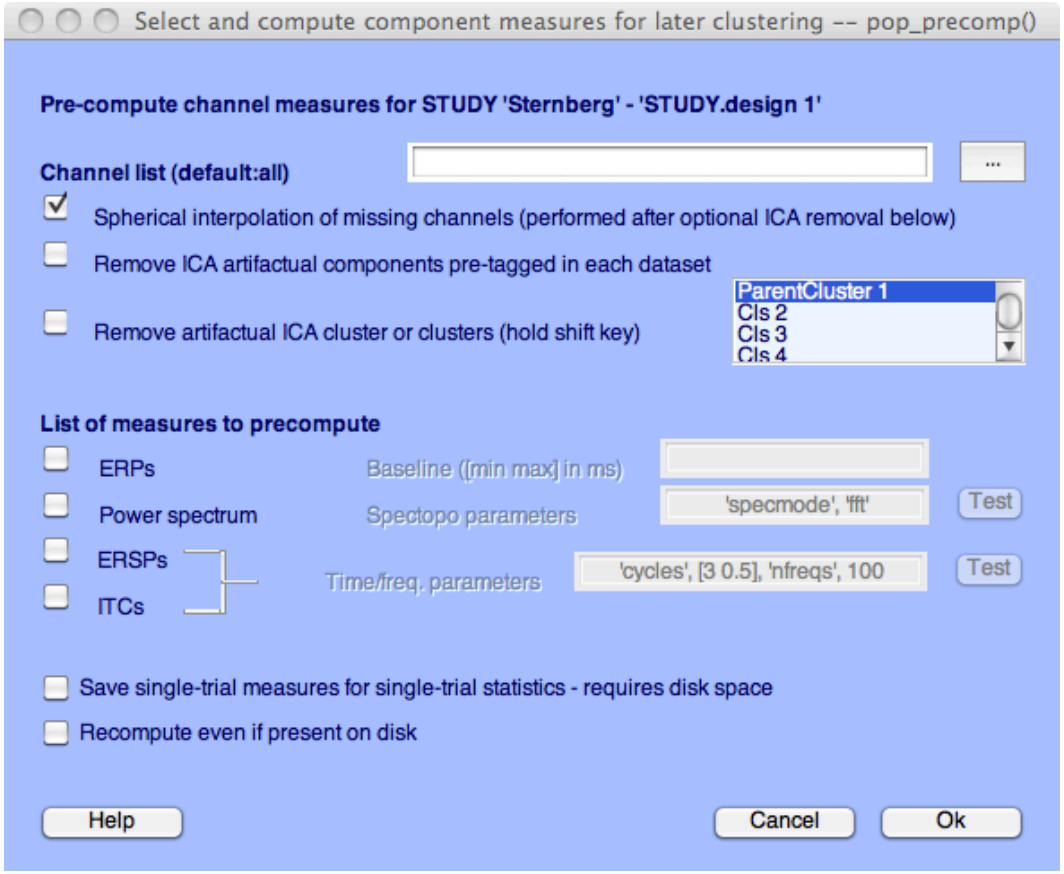
STEP 4

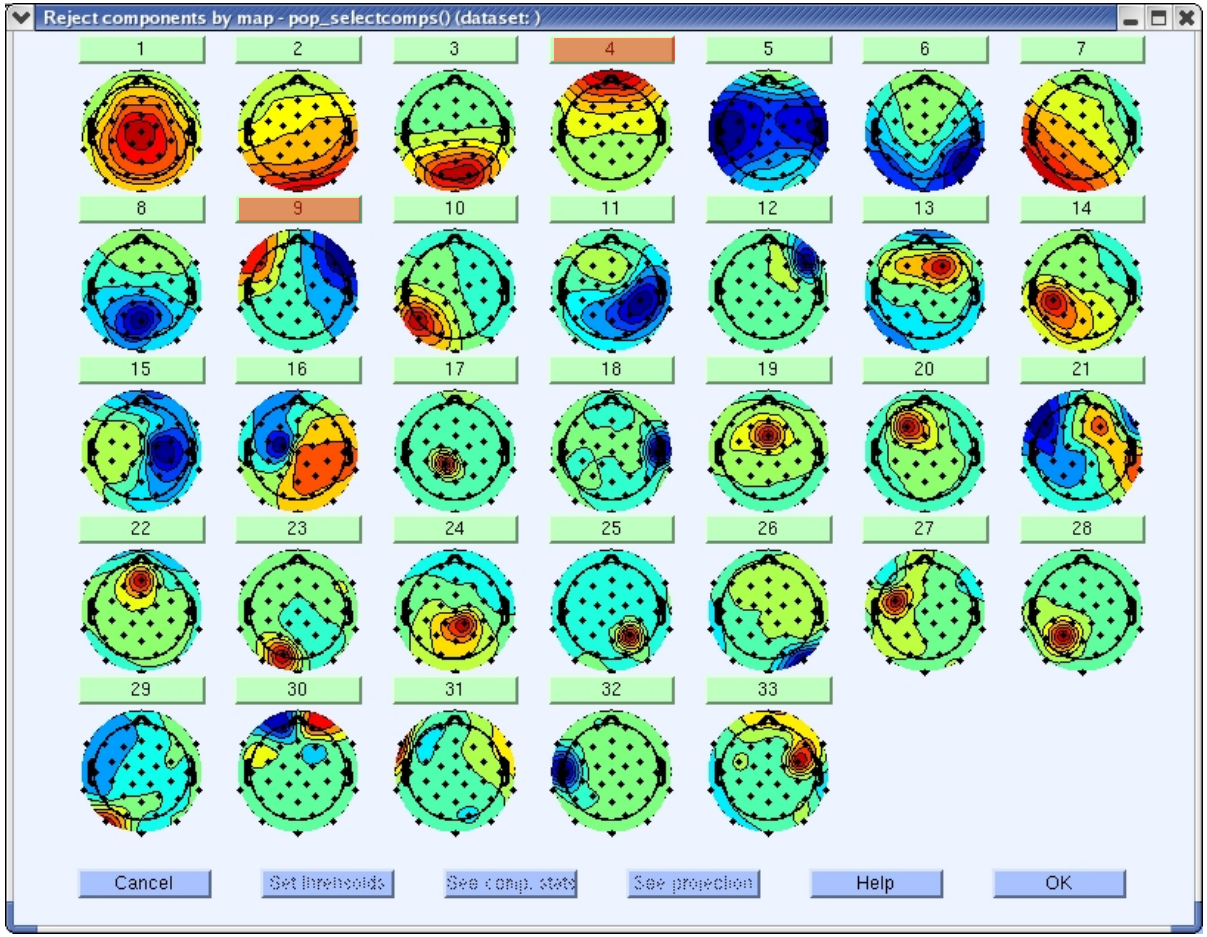
Plot the data

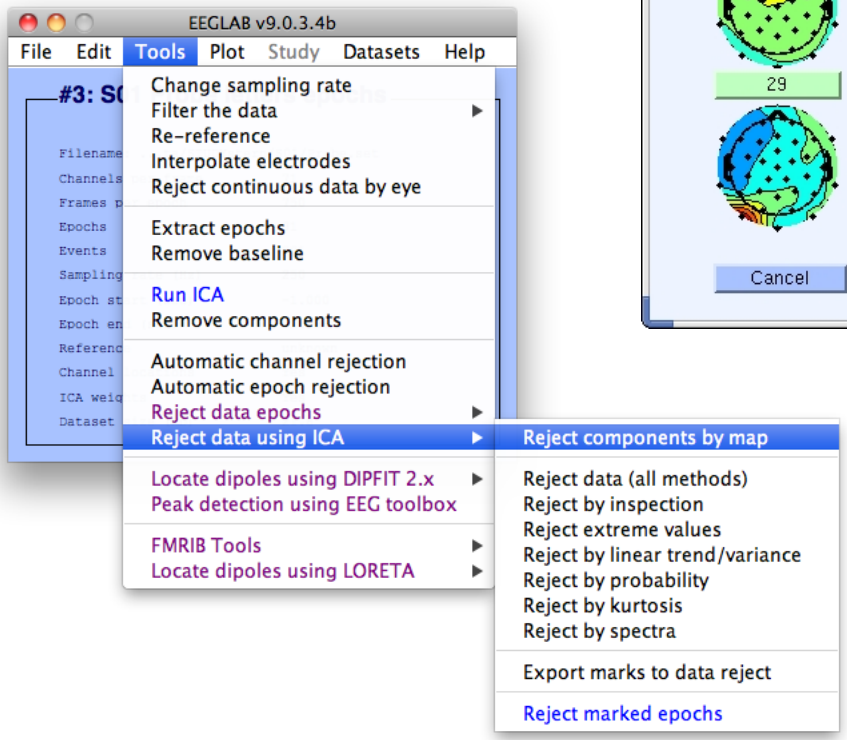
Exercise...

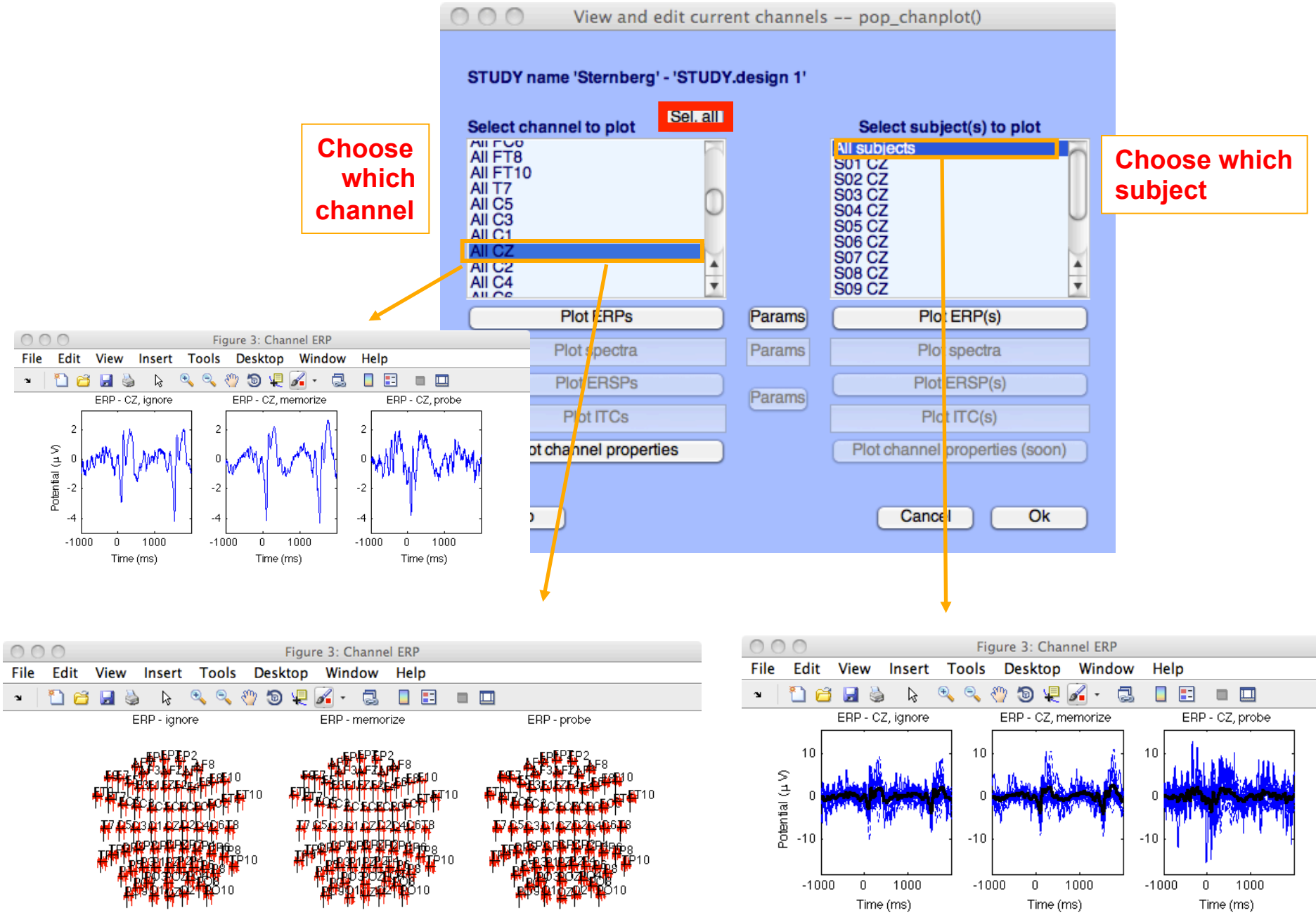
Precompute data measures

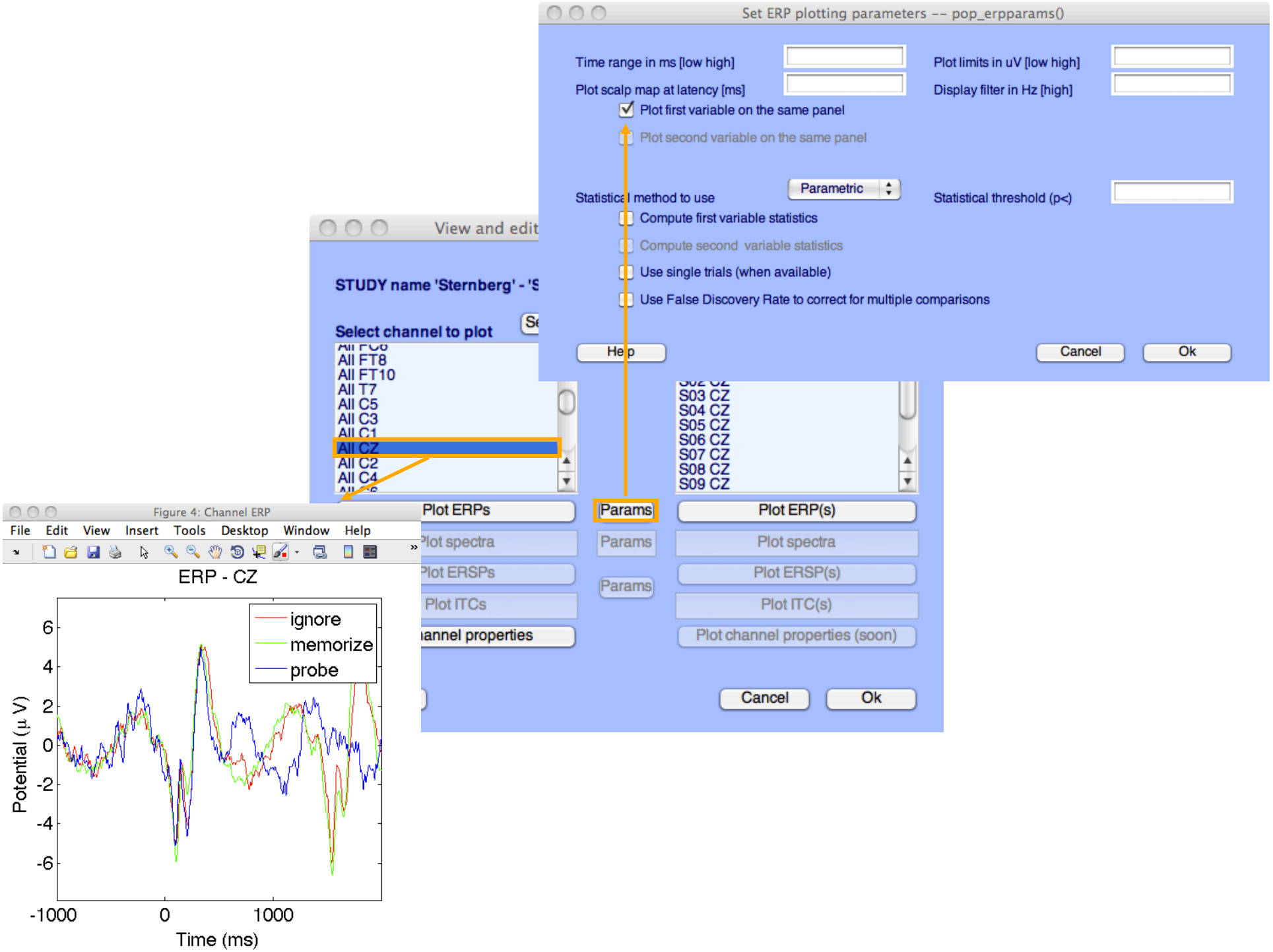


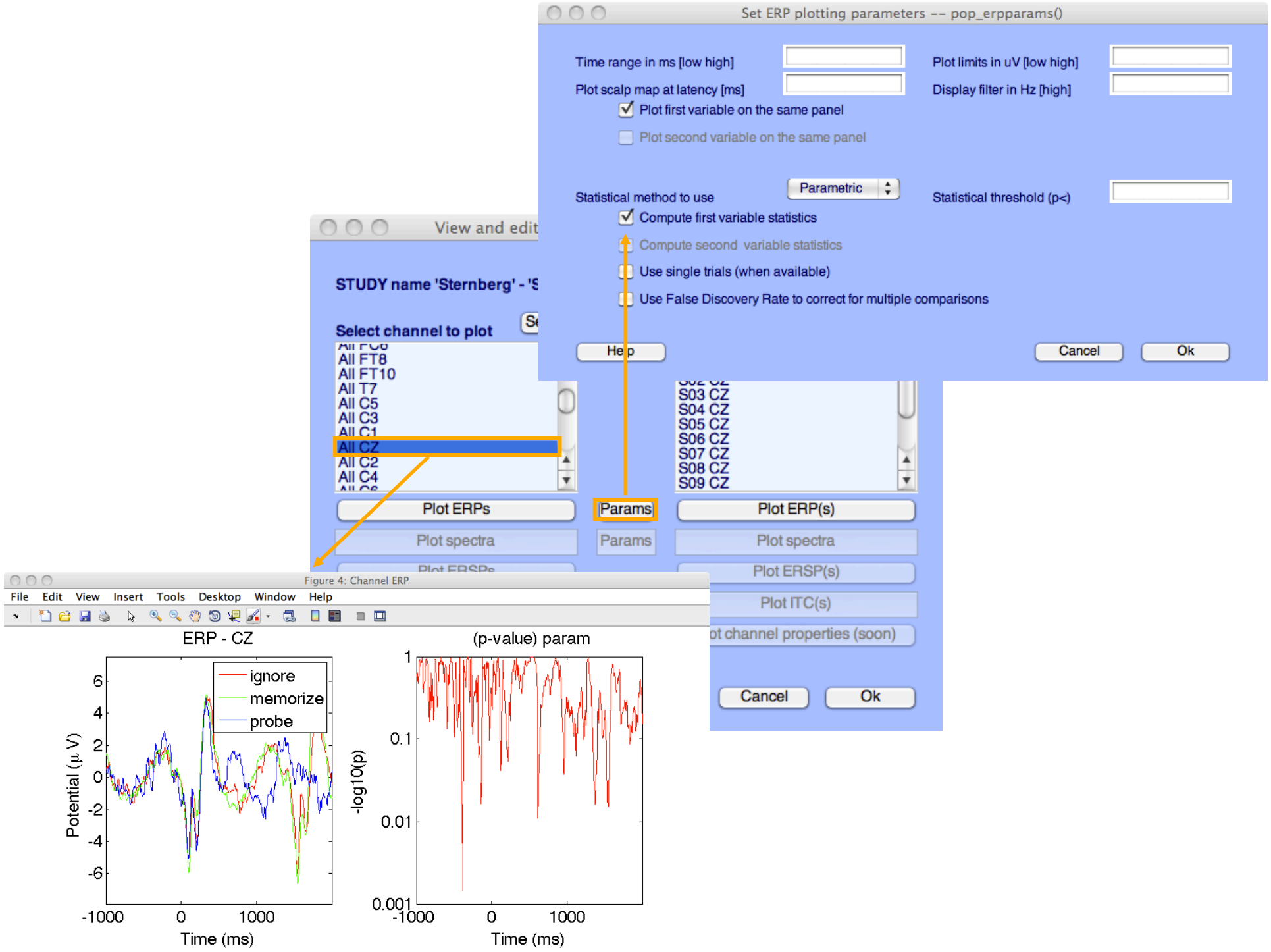


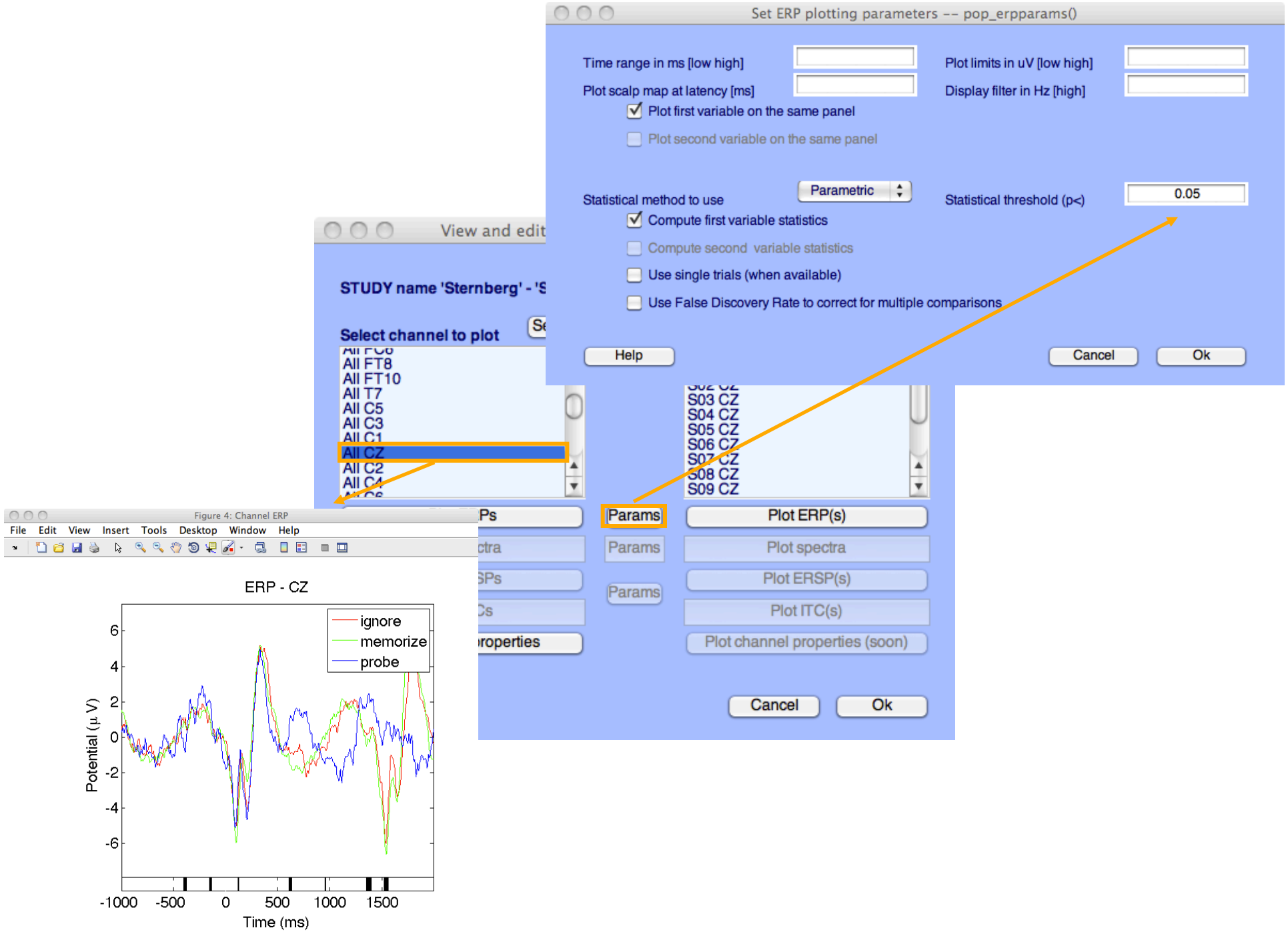

Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
Cancel
Set thresholds
See comp. stats
See projection
Help
OK

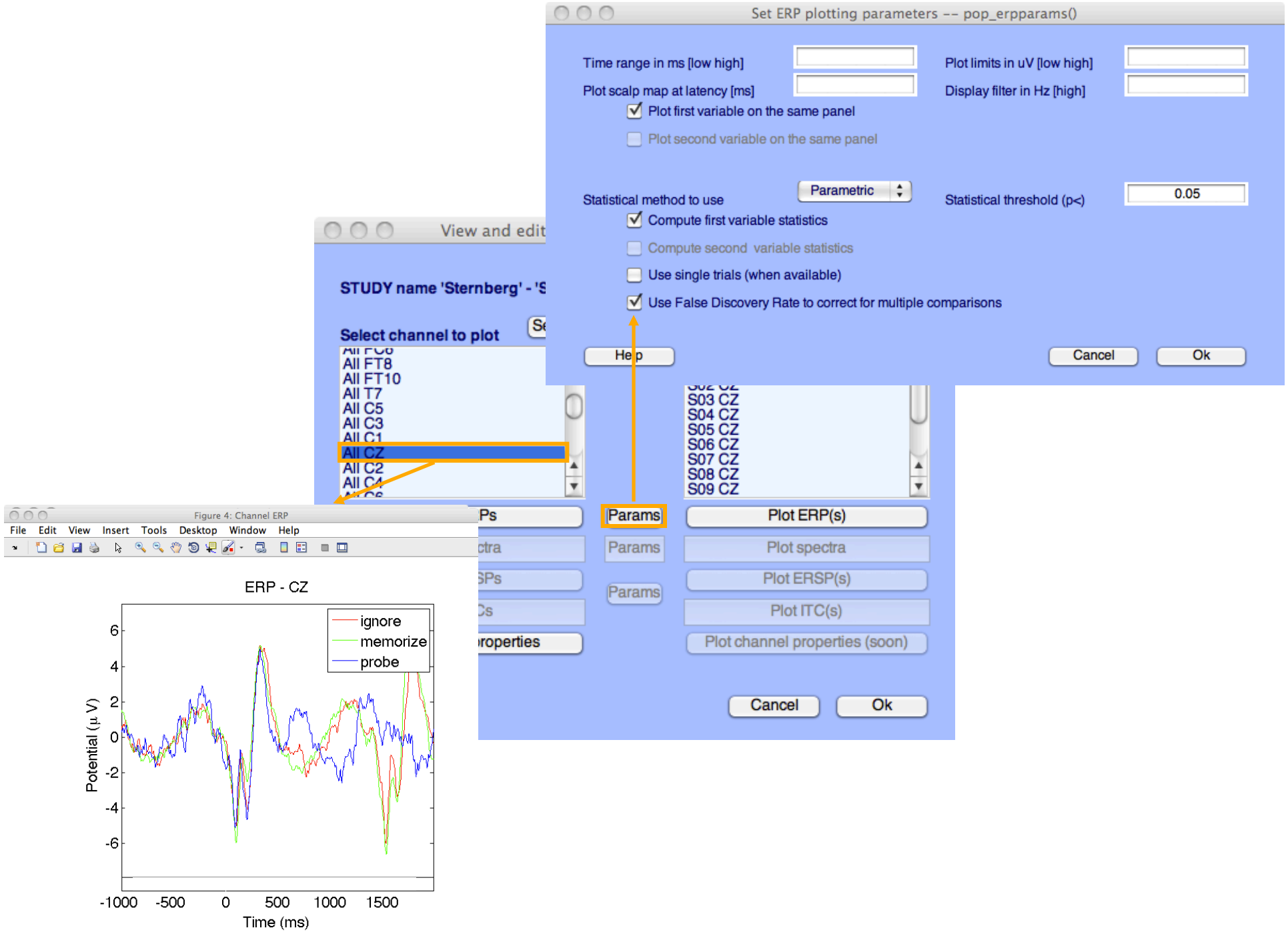

EEGLAB v9.0.3.4b
File
Edit
Tools
Plot
Study
Datasets
Help
Change sampling rate
Filter the data
Re-reference
Interpolate electrodes
Reject continuous data by eye
Extract epochs
Remove baseline
Run ICA
Remove components
Automatic channel rejection
Automatic epoch rejection
Reject data epochs
Reject data using ICA
Locate dipoles using DIPFIT 2.x
Peak detection using EEG toolbox
FMRIB Tools
Locate dipoles using LORETA
Reject components by map
Reject data (all methods)
Reject by inspection
Reject extreme values
Reject by linear trend/variance
Reject by probability
Reject by kurtosis
Reject by spectra
Export marks to data reject
Reject marked epochs

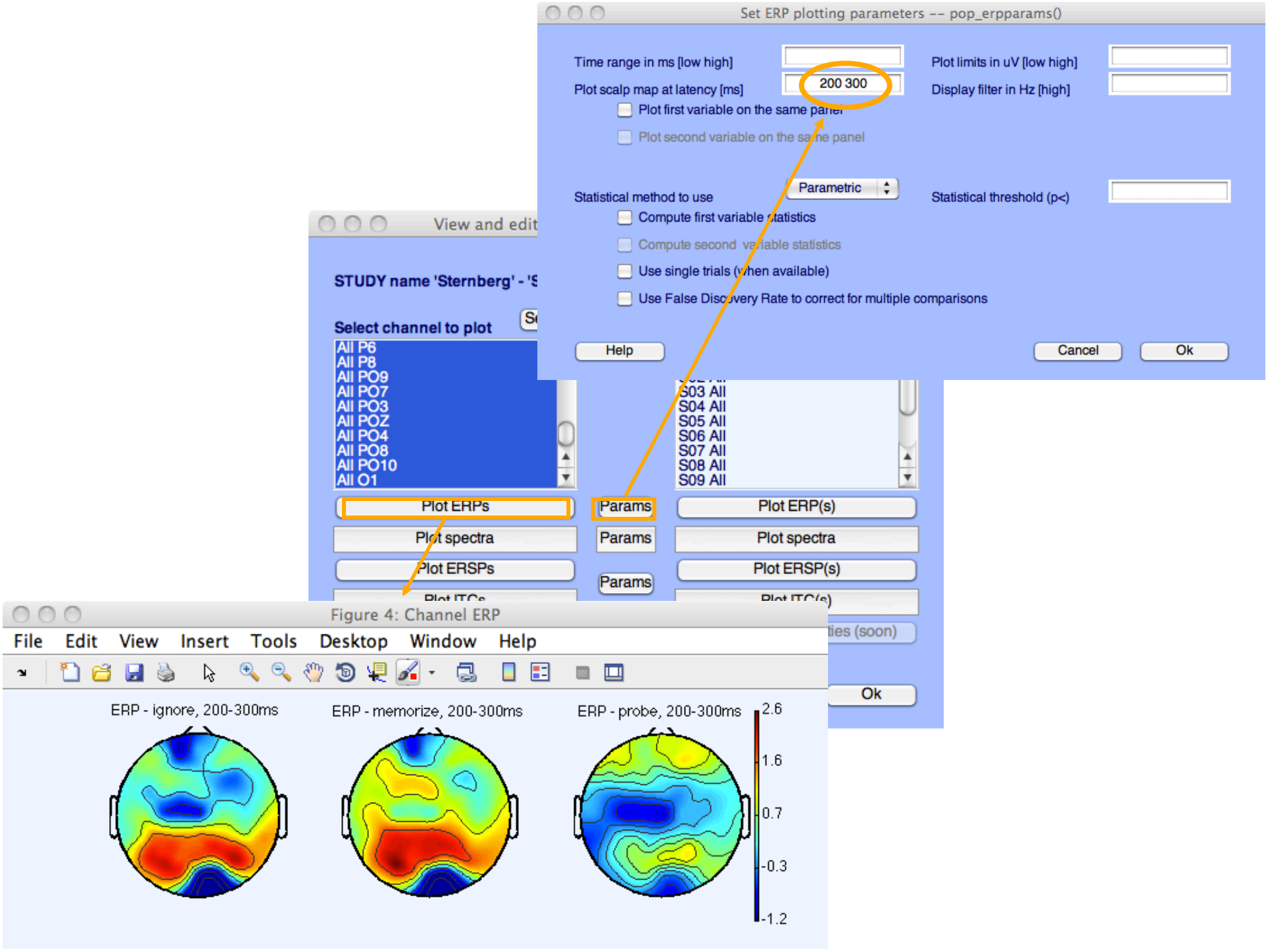

View and edit current channels -- pop_chanplot()
STUDY name 'Sternberg' - 'STUDY.design 1'
Select channel to plot
Sel. all
All FT8
All FT10
All T7
All C5
All C3
All C1
All CZ
All C2
All C4
Select subject(s) to plot
All subjects
S01 CZ
S02 CZ
S03 CZ
S04 CZ
S05 CZ
S06 CZ
S07 CZ
S08 CZ
S09 CZ
Plot ERPs
Params
Plot ERP(s)
Plot spectra
Params
Plot spectra
Plot ERSPs
Params
Plot ERSP(s)
Plot ITCs
Plot ITC(s)
Plot channel properties
Plot channel properties (soon)
Cancel
Ok
Choose which channel
Choose which subject
Figure 3: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - CZ, ignore
ERP - CZ, memorize
ERP - CZ, probe
Potential (μ V)
Time (ms)
Figure 3: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - ignore
ERP - memorize
ERP - probe
Figure 3: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - CZ, ignore
ERP - CZ, memorize
ERP - CZ, probe
Potential (μ V)
Time (ms)

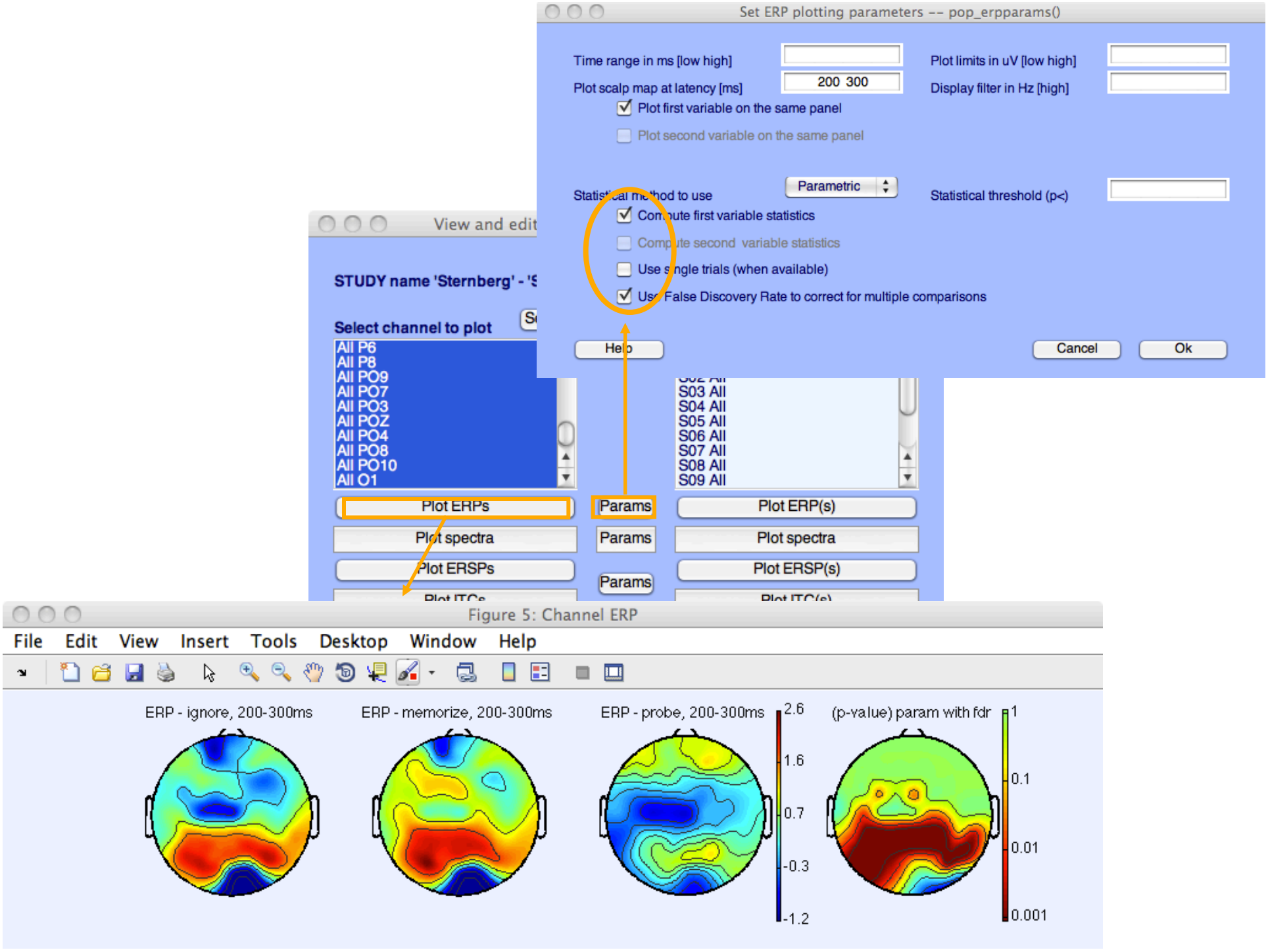

Set ERP plotting parameters -- pop_erpparams()
Time range in ms [low high]
Plot limits in uV [low high]
Plot scalp map at latency [ms]
Display filter in Hz [high]
Plot first variable on the same panel
Plot second variable on the same panel
Statistical method to use
Parametric
Statistical threshold (p<)
Compute first variable statistics
Compute second variable statistics
Use single trials (when available)
Use False Discovery Rate to correct for multiple comparisons
Help
Cancel
Ok
View and edit
STUDY name 'Sternberg' - 'S
Select channel to plot
All FT8
All FT10
All T7
All C5
All C3
All C1
All CZ
All C2
All C4
S03 CZ
S04 CZ
S05 CZ
S06 CZ
S07 CZ
S08 CZ
S09 CZ
Plot ERPs
Params
Plot ERP(s)
Plot spectra
Params
Plot spectra
Plot ERSPs
Plot ERSP(s)
Params
Plot ITCs
Plot ITC(s)
annel properties
Plot channel properties (soon)
Cancel
Ok
Figure 4: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - CZ
ignore
memorize
probe
Potential (μ V)
6
4
2
0
-2
-4
-6
-1000
0
1000
Time (ms)

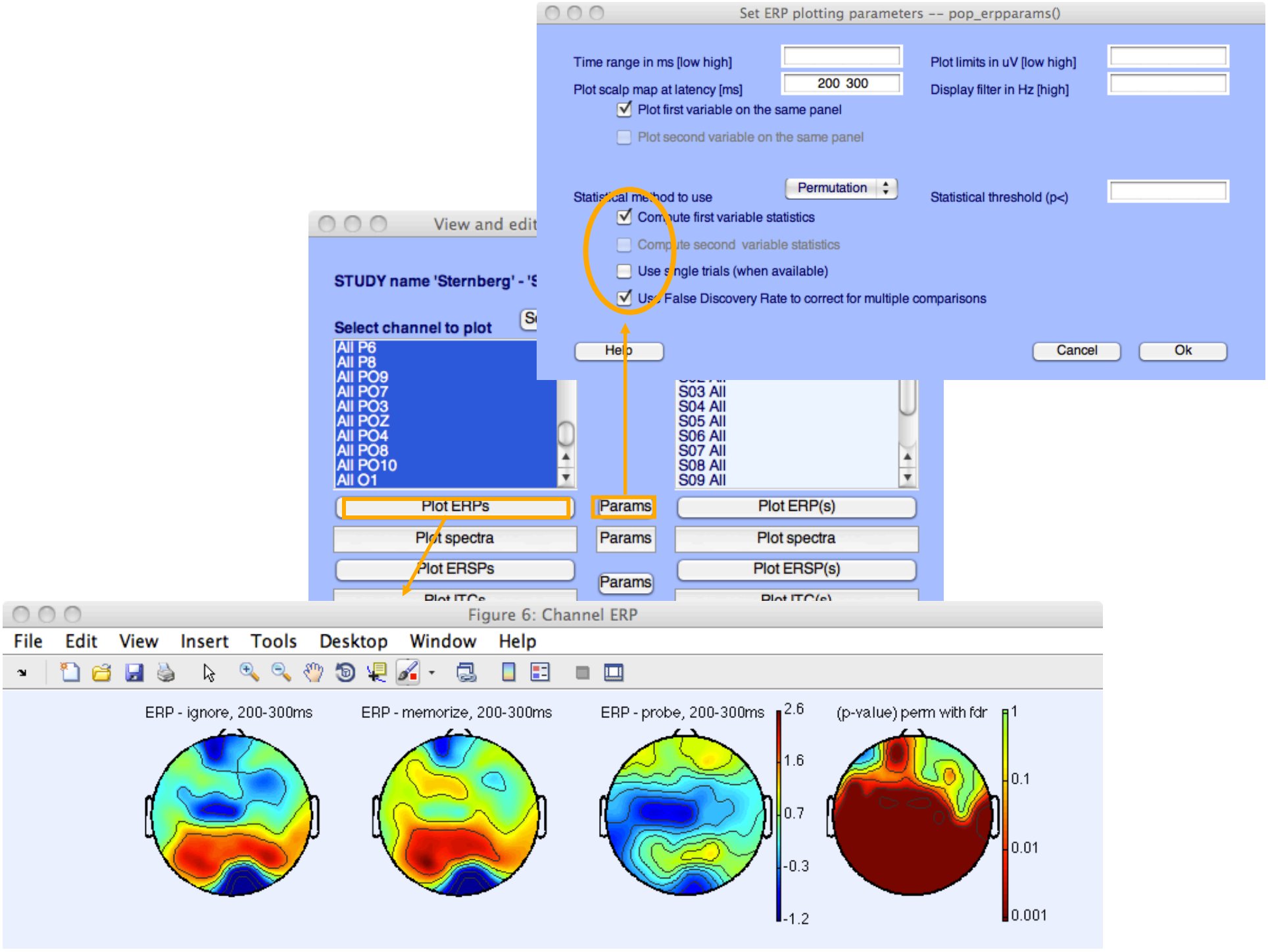

Set ERP plotting parameters -- pop_erpparams()
Time range in ms [low high]
Plot limits in uV [low high]
Plot scalp map at latency [ms]
Display filter in Hz [high]
Plot first variable on the same panel
Plot second variable on the same panel
Statistical method to use
Parametric
Statistical threshold (p<)
Compute first variable statistics
Compute second variable statistics
Use single trials (when available)
Use False Discovery Rate to correct for multiple comparisons
Help
Cancel
Ok
View and edit
STUDY name 'Sternberg' - 'S
Select channel to plot
All FT8
All FT10
All T7
All C5
All C3
All C1
All CZ
All C2
All C4
S03 CZ
S04 CZ
S05 CZ
S06 CZ
S07 CZ
S08 CZ
S09 CZ
Plot ERPs
Params
Plot ERP(s)
Plot spectra
Params
Plot spectra
Plot ERSP(s)
Plot ITC(s)
ot channel properties (soon)
Cancel
Ok
Figure 4: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - CZ
(p-value) param
ignore
memorize
probe
Potential (μ V)
-log10(p)
Time (ms)
Time (ms)


Set ERP plotting parameters -- pop_erpparams()
Time range in ms [low high]
Plot limits in uV [low high]
Plot scalp map at latency [ms]
Display filter in Hz [high]
Plot first variable on the same panel
Plot second variable on the same panel
Statistical method to use
Parametric
Statistical threshold (p<)
0.05
Compute first variable statistics
Compute second variable statistics
Use single trials (when available)
Use False Discovery Rate to correct for multiple comparisons
Help
Cancel
Ok
View and edit
STUDY name 'Sternberg' - 'S
Select channel to plot
All FT8
All FT10
All T7
All C5
All C3
All C1
All CZ
All C2
S03 CZ
S04 CZ
S05 CZ
S06 CZ
S08 CZ
S09 CZ
Params
Plot ERP(s)
Plot spectra
Plot ERSP(s)
Plot ITC(s)
Plot channel properties (soon)
Cancel
Ok
Figure 4: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - CZ
ignore
memorize
probe
Potential (μ V)
Time (ms)

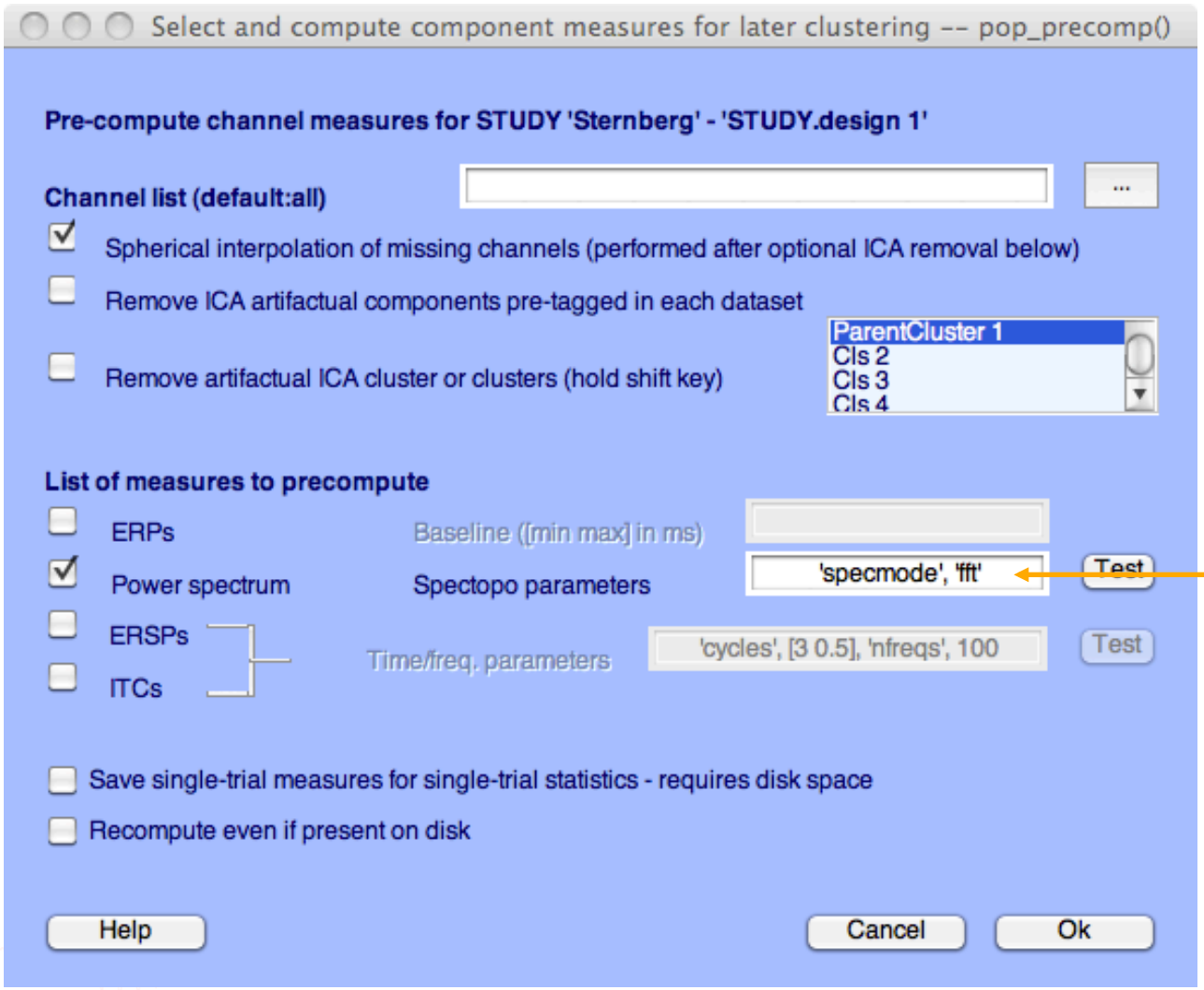

Set ERP plotting parameters -- pop_erpparams()
Time range in ms [low high]
Plot limits in uV [low high]
Plot scalp map at latency [ms]
Display filter in Hz [high]
Plot first variable on the same panel
Plot second variable on the same panel
Statistical method to use
Parametric
Statistical threshold (p<)
0.05
Compute first variable statistics
Compute second variable statistics
Use single trials (when available)
Use False Discovery Rate to correct for multiple comparisons
Help
Cancel
Ok
View and edit
STUDY name 'Sternberg' - 'S
Select channel to plot
All FT8
All FT10
All T7
All C5
All C3
All C1
All CZ
All C2
S03 CZ
S04 CZ
S05 CZ
S06 CZ
S07 CZ
S08 CZ
S09 CZ
Params
Plot ERP(s)
Plot spectra
Plot ERSP(s)
Plot ITC(s)
Plot channel properties (soon)
Cancel
Ok
Figure 4: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - CZ
ignore
memorize
probe
Potential (μ V)
Time (ms)


Set ERP plotting parameters -- pop_erpparams()
Time range in ms [low high]
Plot limits in uV [low high]
Plot scalp map at latency [ms]
200 300
Display filter in Hz [high]
Plot first variable on the same panel
Plot second variable on the same panel
Statistical method to use
Parametric
Statistical threshold (p<)
Compute first variable statistics
Compute second variable statistics
Use single trials (when available)
Use False Discovery Rate to correct for multiple comparisons
Help
Cancel
Ok
View and edit
STUDY name 'Sternberg' - 'S
Select channel to plot
All P6
All P8
All PO9
All PO7
All PO3
All POZ
All PO4
All PO8
All PO10
All O1
S03 All
S04 All
S05 All
S06 All
S07 All
S08 All
S09 All
Plot ERPs
Params
Plot ERP(s)
Plot spectra
Params
Plot spectra
Plot ERSPs
Params
Plot ERSP(s)
Plot ITCs
Plot ITC(s)
ties (soon)
Ok
Figure 4: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - ignore, 200-300ms
ERP - memorize, 200-300ms
ERP - probe, 200-300ms
2.6
1.6
0.7
-0.3
-1.2

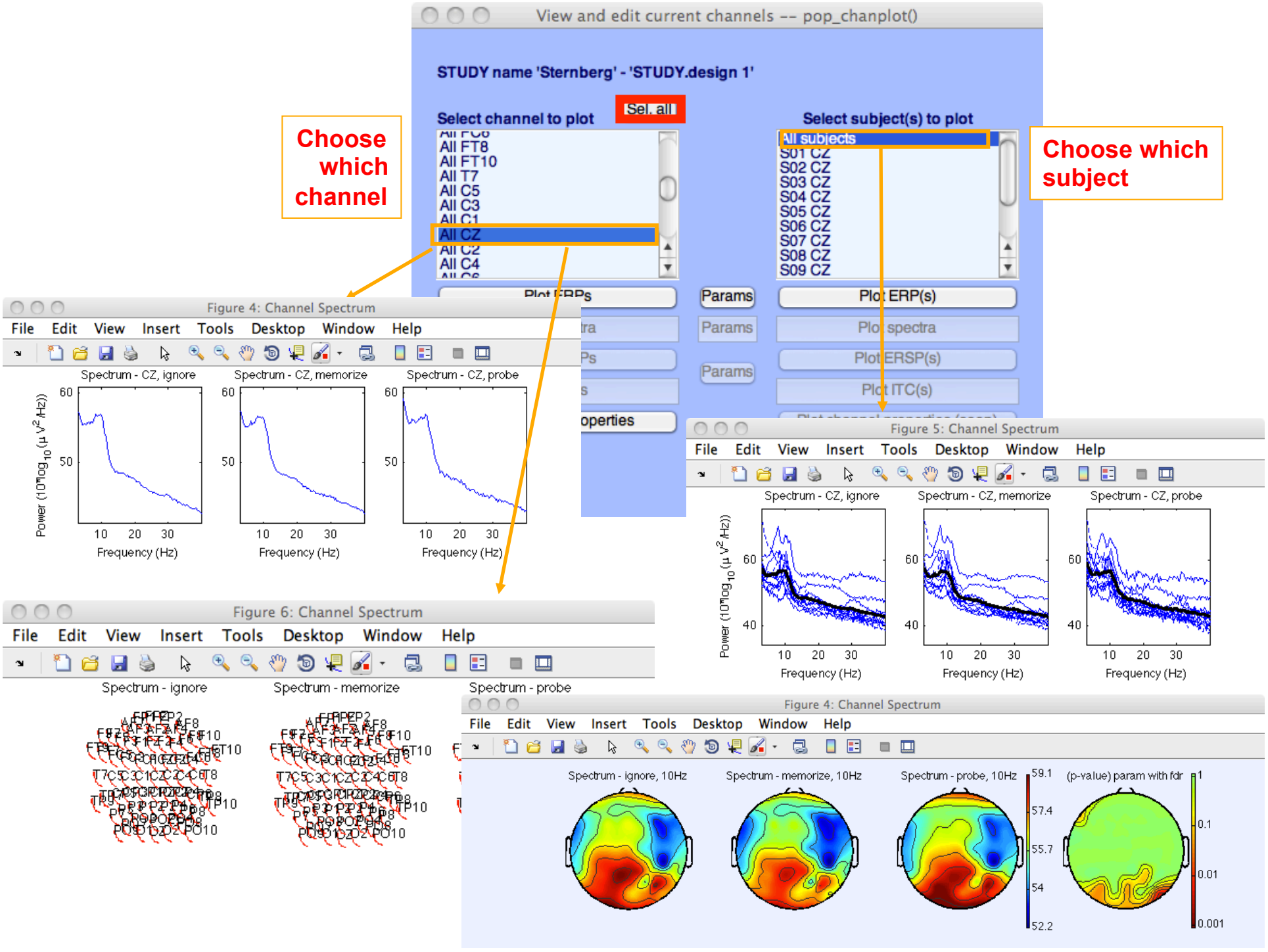

Set ERP plotting parameters -- pop_erpparams()
Time range in ms [low high]
Plot limits in uV [low high]
Plot scalp map at latency [ms]
200 300
Display filter in Hz [high]
Plot first variable on the same panel
Plot second variable on the same panel
Parametric
Statistical threshold (p<)
Use single trials (when available)
Use False Discovery Rate to correct for multiple comparisons
Help
Cancel
Ok
View and edit
STUDY name 'Sternberg' - 'S
Select channel to plot
All P6
All P8
All PO9
All PO7
All PO3
All POZ
All PO4
All PO8
All PO10
All O1
S03 All
S04 All
S05 All
S06 All
S07 All
S08 All
S09 All
Plot ERPs
Params
Plot ERP(s)
Plot spectra
Params
Plot spectra
Plot ERSPs
Params
Plot ERSP(s)
Figure 5: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - ignore, 200-300ms
ERP - memorize, 200-300ms
ERP - probe, 200-300ms
2.6
1.6
0.7
-0.3
-1.2
(p-value) param with fdr
1
0.1
0.01
0.001


Set ERP plotting parameters -- pop_erpparams()
Time range in ms [low high]
Plot limits in uV [low high]
Plot scalp map at latency [ms]
200 300
Display filter in Hz [high]
Plot first variable on the same panel
Plot second variable on the same panel
Statistical method to use
Permutation
Statistical threshold (p<)
Compute first variable statistics
Compute second variable statistics
Use single trials (when available)
Use False Discovery Rate to correct for multiple comparisons
Help
Cancel
Ok
View and edit
STUDY name 'Sternberg' - 'S
Select channel to plot
All P6
All P8
All PO9
All PO7
All PO3
All POZ
All PO4
All PO8
All PO10
All O1
S03 All
S04 All
S05 All
S06 All
S07 All
S08 All
S09 All
Plot ERPs
Params
Plot ERP(s)
Plot spectra
Params
Plot spectra
Plot ERSPs
Params
Plot ERSP(s)
Figure 6: Channel ERP
File Edit View Insert Tools Desktop Window Help
ERP - ignore, 200-300ms
ERP - memorize, 200-300ms
ERP - probe, 200-300ms
2.6
1.6
0.7
-0.3
-1.2
(p-value) perm with fdr
1
0.1
0.01
0.001

Computing Spectrum

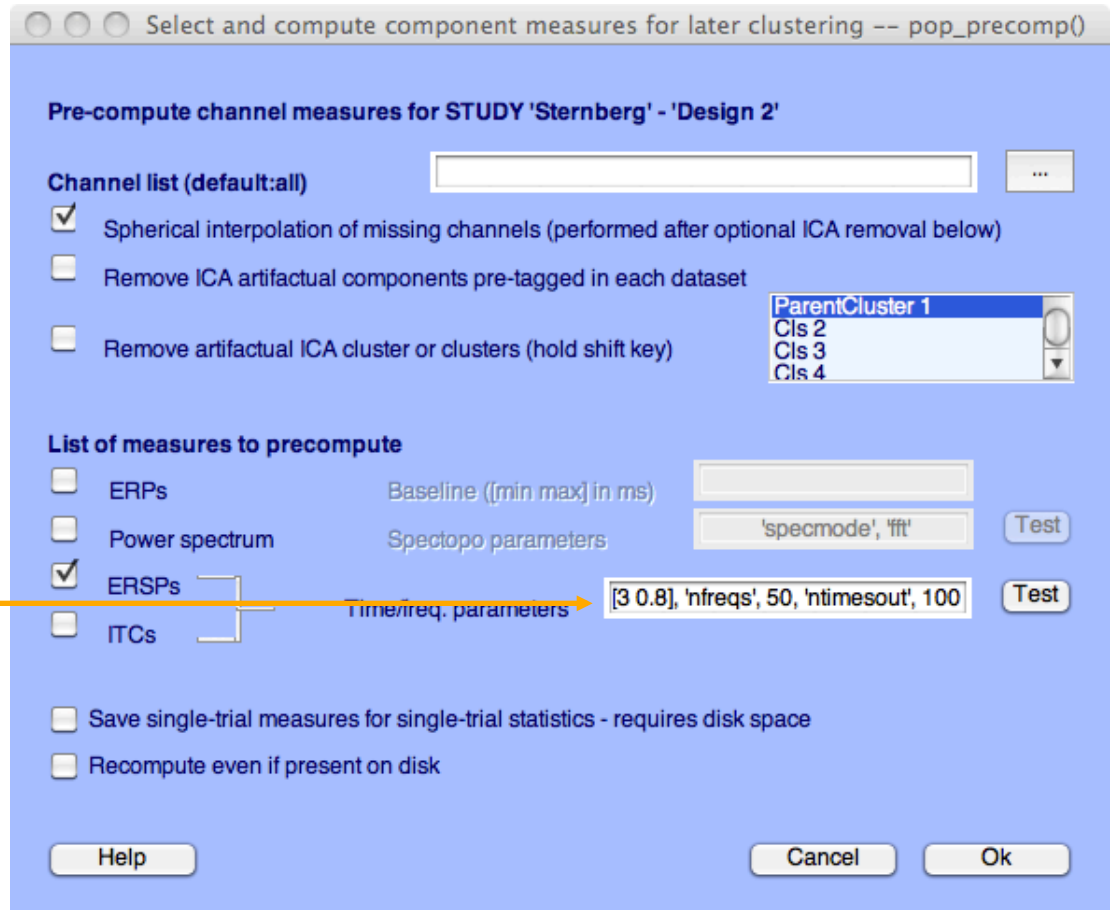


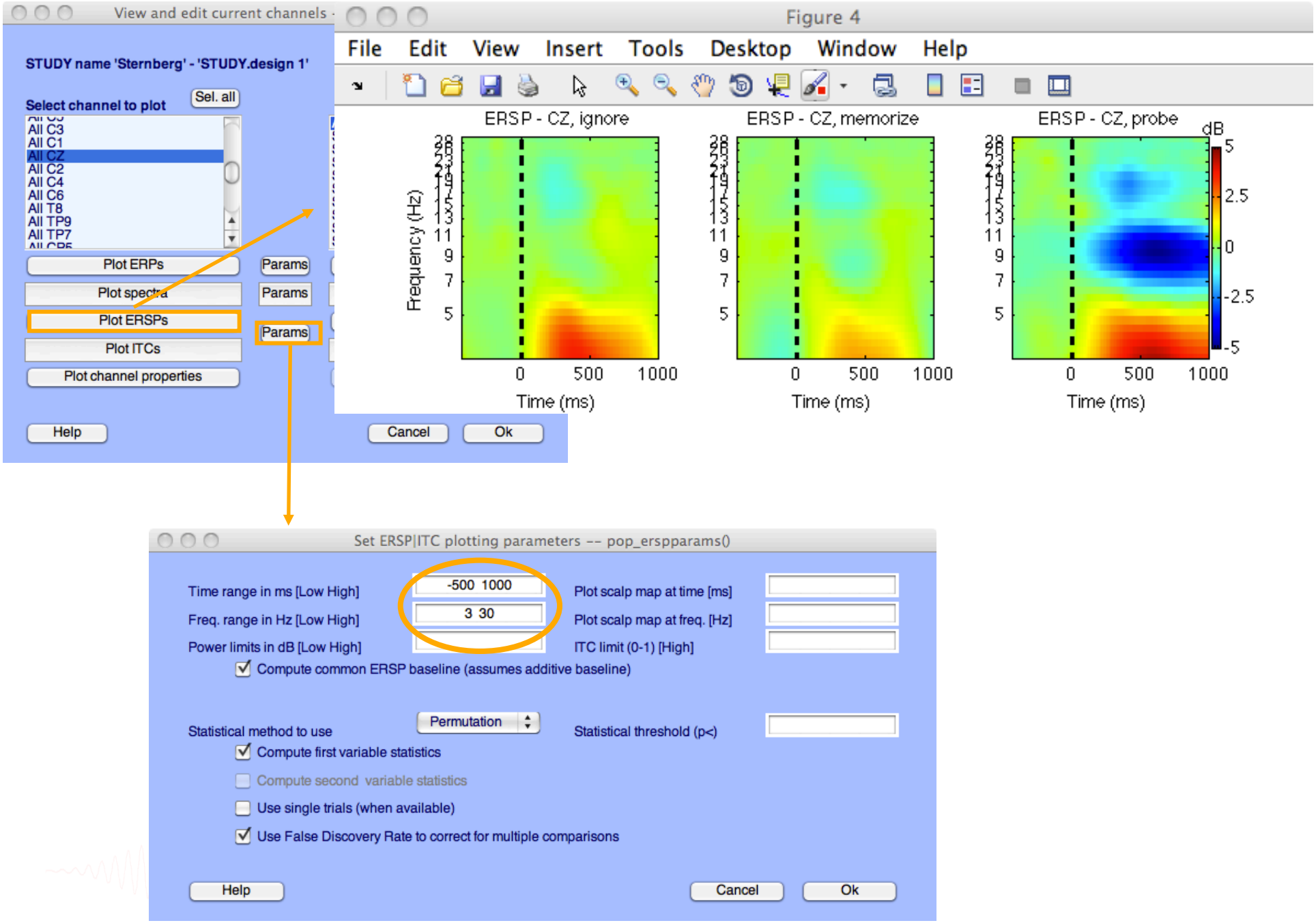
Use ‘timerange’ option to select time range, see “help std_spec”

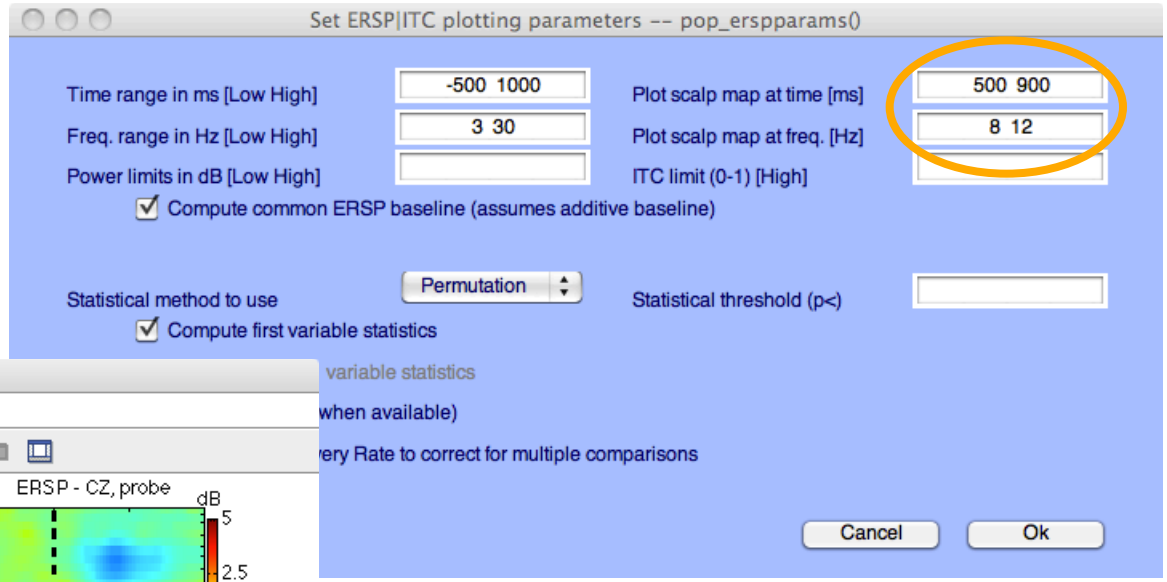

View and edit current channels -- pop_chanplot()
STUDY name 'Sternberg' - 'STUDY.design 1'
Select channel to plot
Sel. all
All FT8
All FT10
All T7
All C5
All C3
All C1
All CZ
All C4
Select subject(s) to plot
All subjects
S01 CZ
S02 CZ
S03 CZ
S04 CZ
S05 CZ
S06 CZ
S07 CZ
S08 CZ
S09 CZ
Params
Plot ERP(s)
Plot spectra
Plot ERSP(s)
Plot ITC(s)
Choose which channel
Choose which subject
Figure 4: Channel Spectrum
File Edit View Insert Tools Desktop Window Help
Spectrum - CZ, ignore
Spectrum - CZ, memorize
Spectrum - CZ, probe
Power (10*log10 (μ V2/Hz))
Frequency (Hz)
Figure 5: Channel Spectrum
Figure 6: Channel Spectrum
Spectrum - ignore
Spectrum - memorize
Spectrum - probe
Figure 4: Channel Spectrum
Spectrum - ignore, 10Hz
Spectrum - memorize, 10Hz
Spectrum - probe, 10Hz
(p-value) param with fdr

Computing ERSP

'cycles', [3 0.8], 'nfreqs', 50, 'ntimesout', 100




View and edit current channels
STUDY name 'Sternberg' - 'STUDY.design 1'
Select channel to plot
Sel. all
All C3
All C1
All CZ
All C2
All C4
All C6
All T8
All TP9
All TP7
Plot ERPs
Params
Plot spectra
Params
Plot ERSPs
Params
Plot ITCs
Plot channel properties
Help
Cancel
Ok
Figure 4
File Edit View Insert Tools Desktop Window Help
ERSP - CZ, ignore
ERSP - CZ, memorize
ERSP - CZ, probe
Frequency (Hz)
Time (ms)
dB
Set ERSP|ITC plotting parameters -- pop_erspparams()
Time range in ms [Low High]
-500 1000
Freq. range in Hz [Low High]
3 30
Power limits in dB [Low High]
Plot scalp map at time [ms]
Plot scalp map at freq. [Hz]
ITC limit (0-1) [High]
Compute common ERSP baseline (assumes additive baseline)
Statistical method to use
Permutation
Statistical threshold (p<)
Compute first variable statistics
Compute second variable statistics
Use single trials (when available)
Use False Discovery Rate to correct for multiple comparisons
Help
Cancel
Ok


Set ERSP|ITC plotting parameters -- pop_erspparams()
Time range in ms [Low High]
-500 1000
Plot scalp map at time [ms]
500 900
Freq. range in Hz [Low High]
3 30
Plot scalp map at freq. [Hz]
8 12
Power limits in dB [Low High]
ITC limit (0-1) [High]
Compute common ERSP baseline (assumes additive baseline)
Statistical method to use
Permutation
Statistical threshold (p<)
Compute first variable statistics
variable statistics
when available)
ery Rate to correct for multiple comparisons
Cancel
Ok

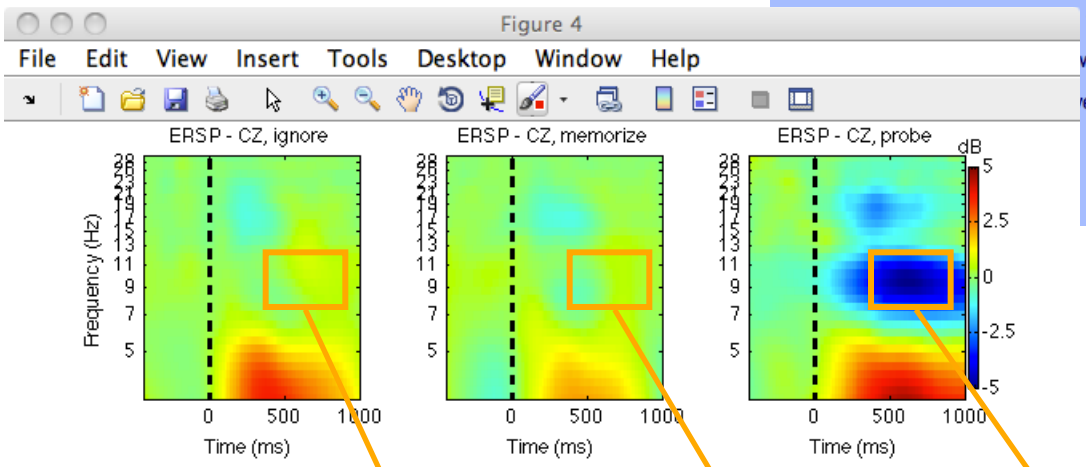


Figure 4
File Edit View Insert Tools Desktop Window Help
ERSP - CZ, ignore
ERSP - CZ, memorize
ERSP - CZ, probe
dB
Frequency (Hz)
Time (ms)

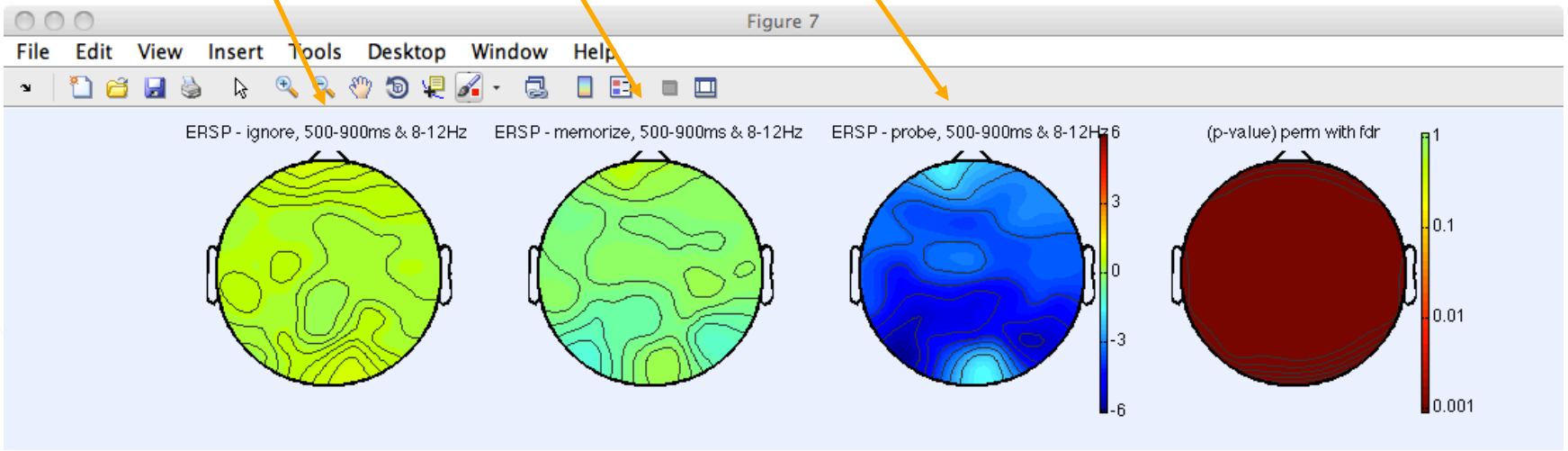
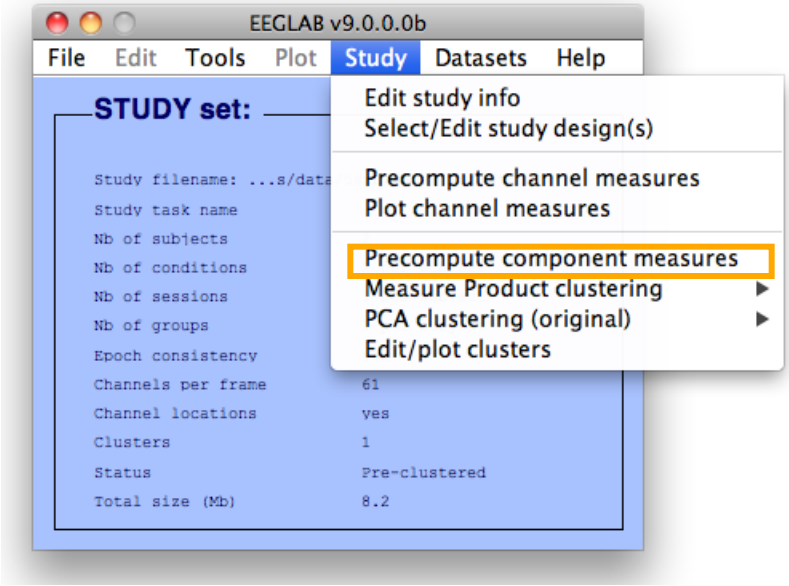
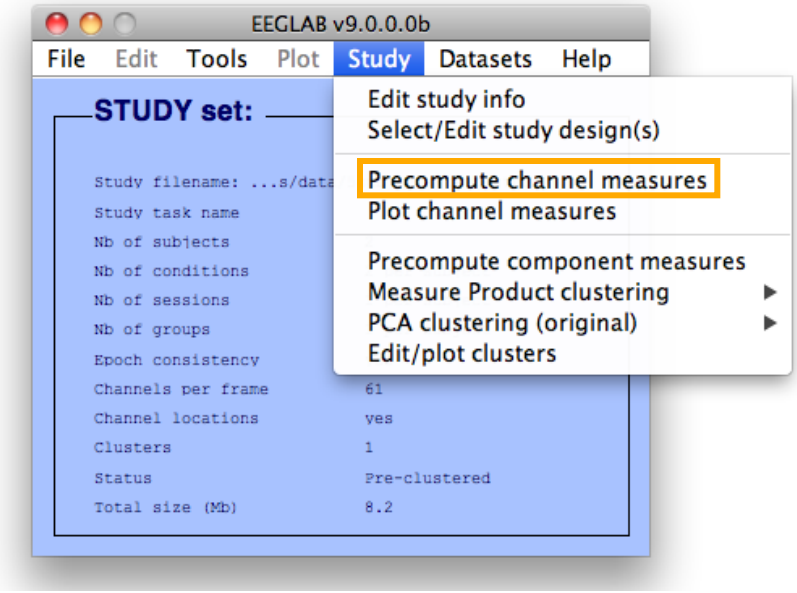
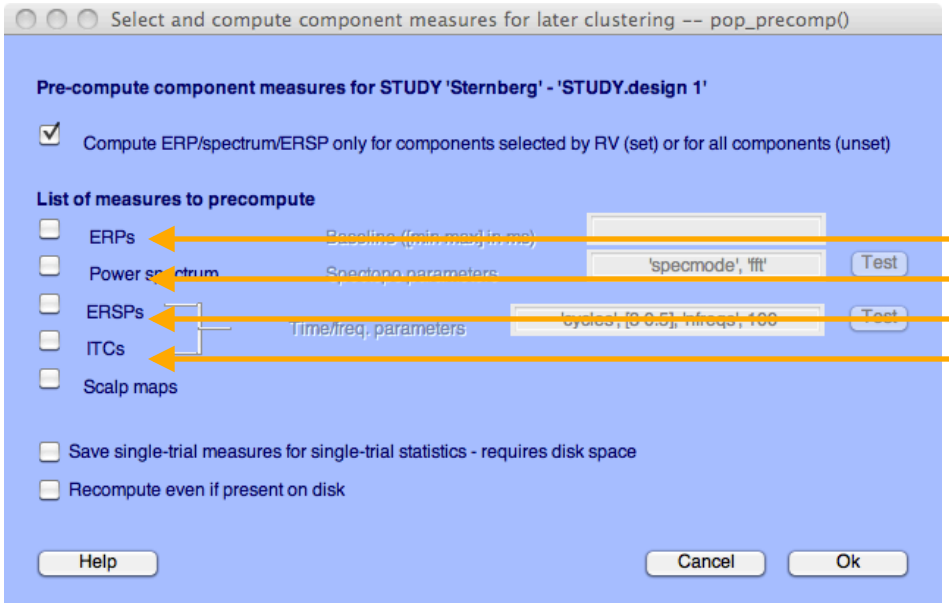


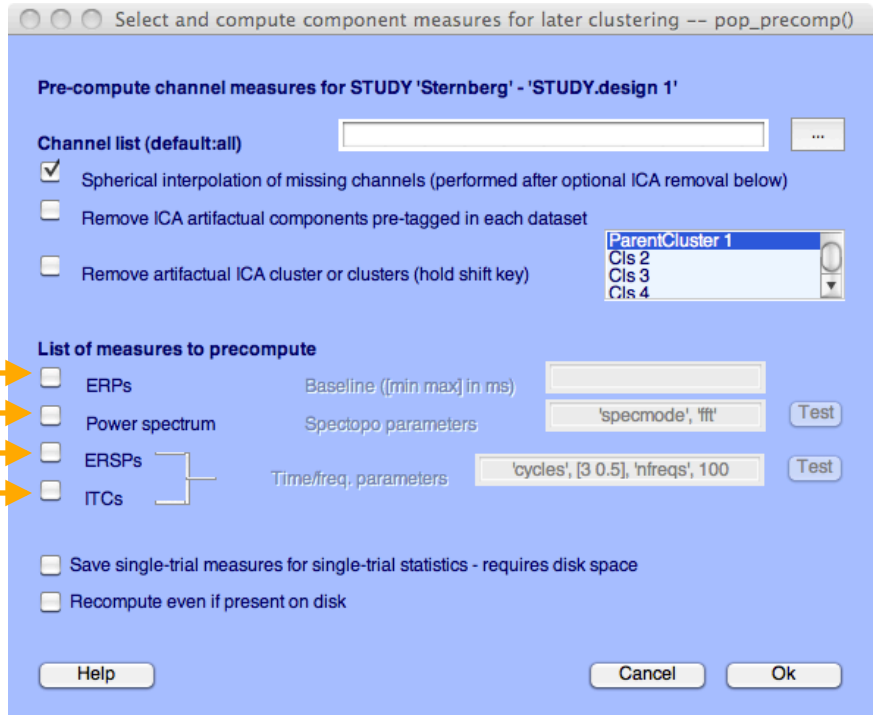
Figure 7
File Edit View Insert Tools Desktop Window Help
ERSP - ignore, 500-900ms & 8-12Hz
ERSP - memorize, 500-900ms & 8-12Hz
ERSP - probe, 500-900ms & 8-12Hz
(p-value) perm with fdr

2. Pre-compute measures

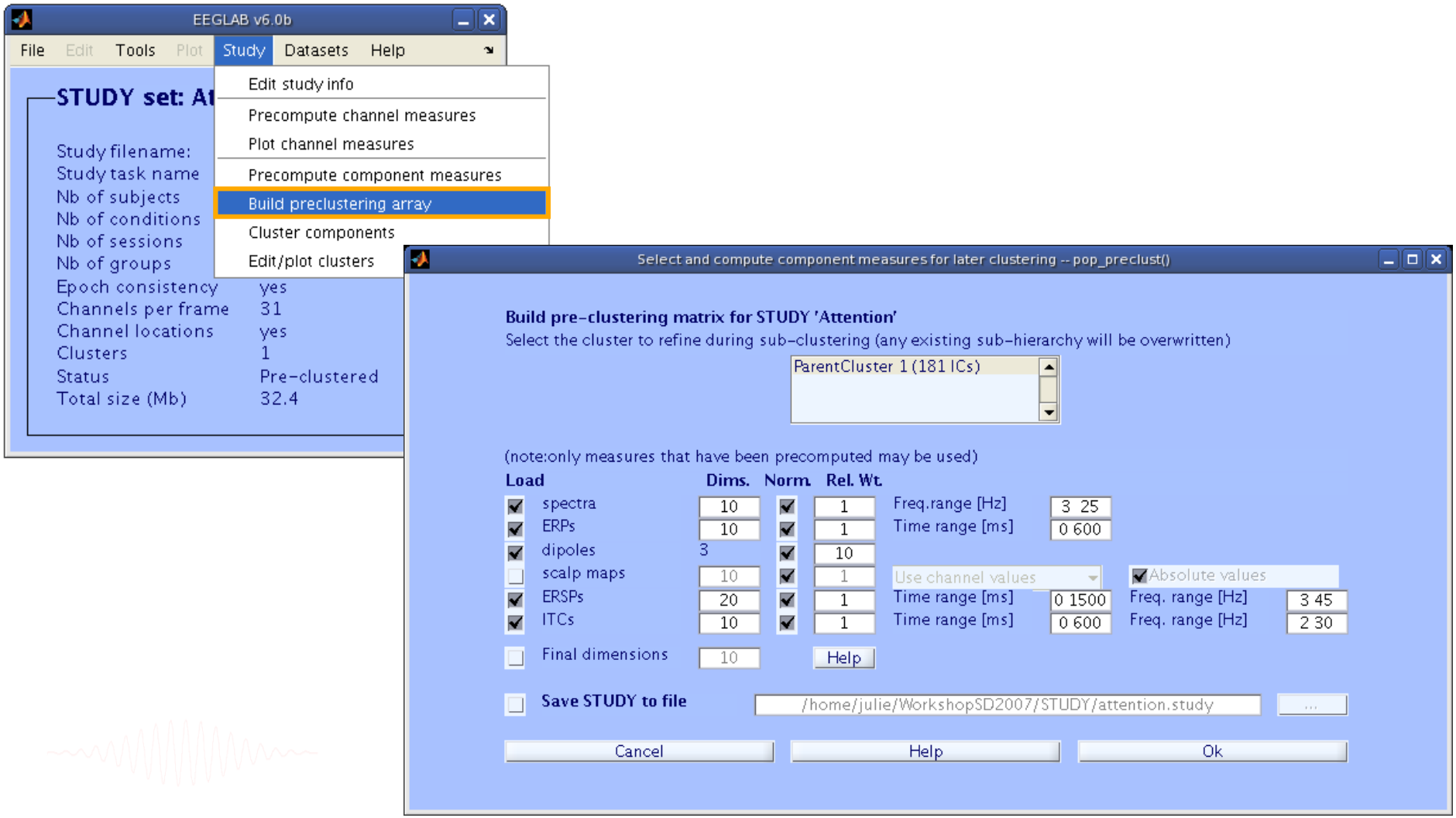




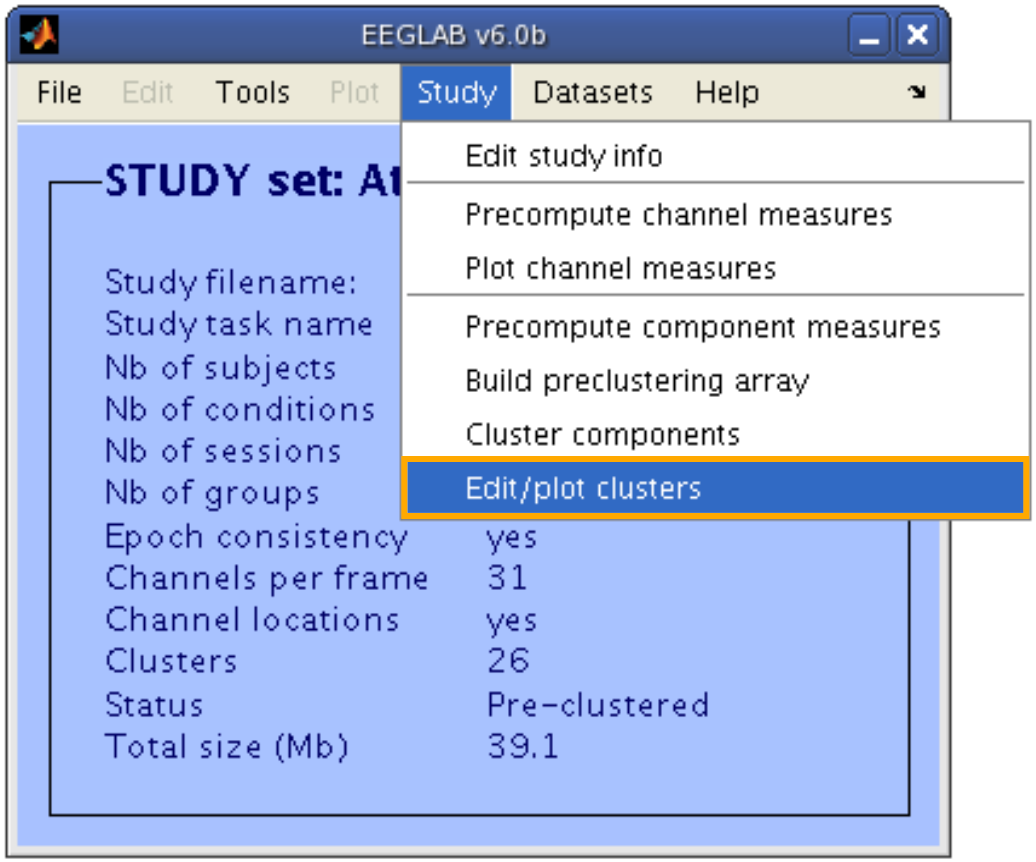




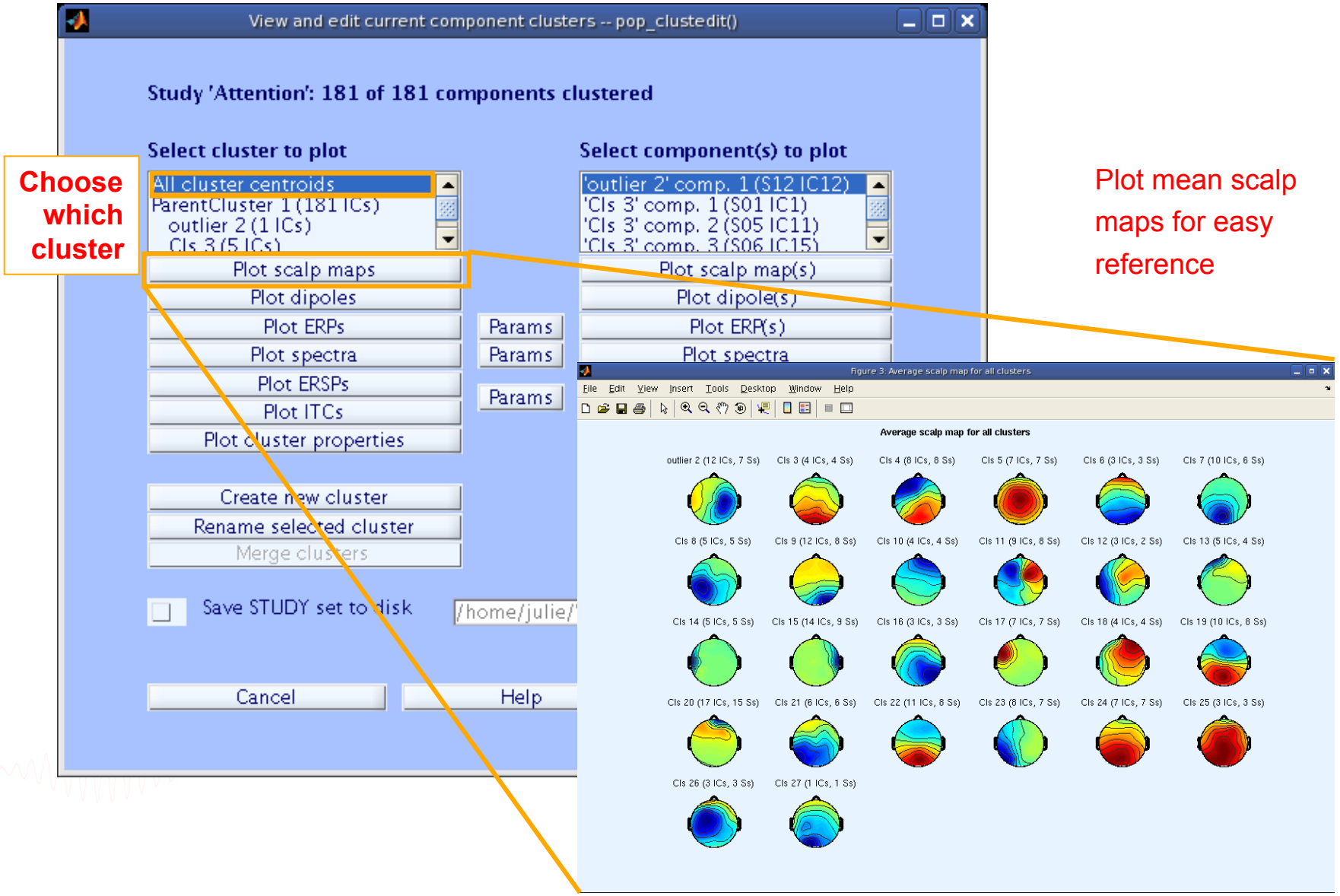
3. Cluster components



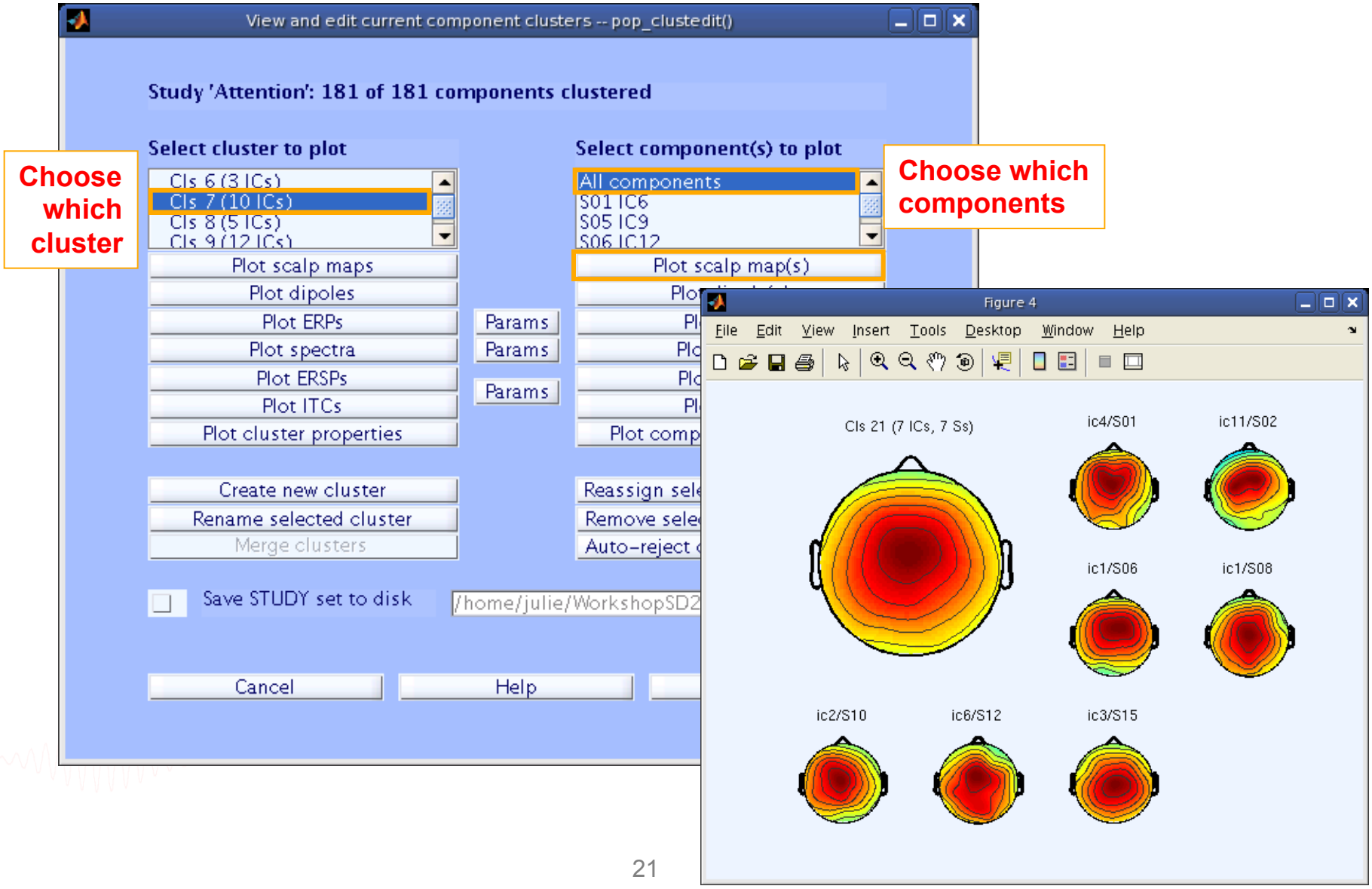
View and edit clusters



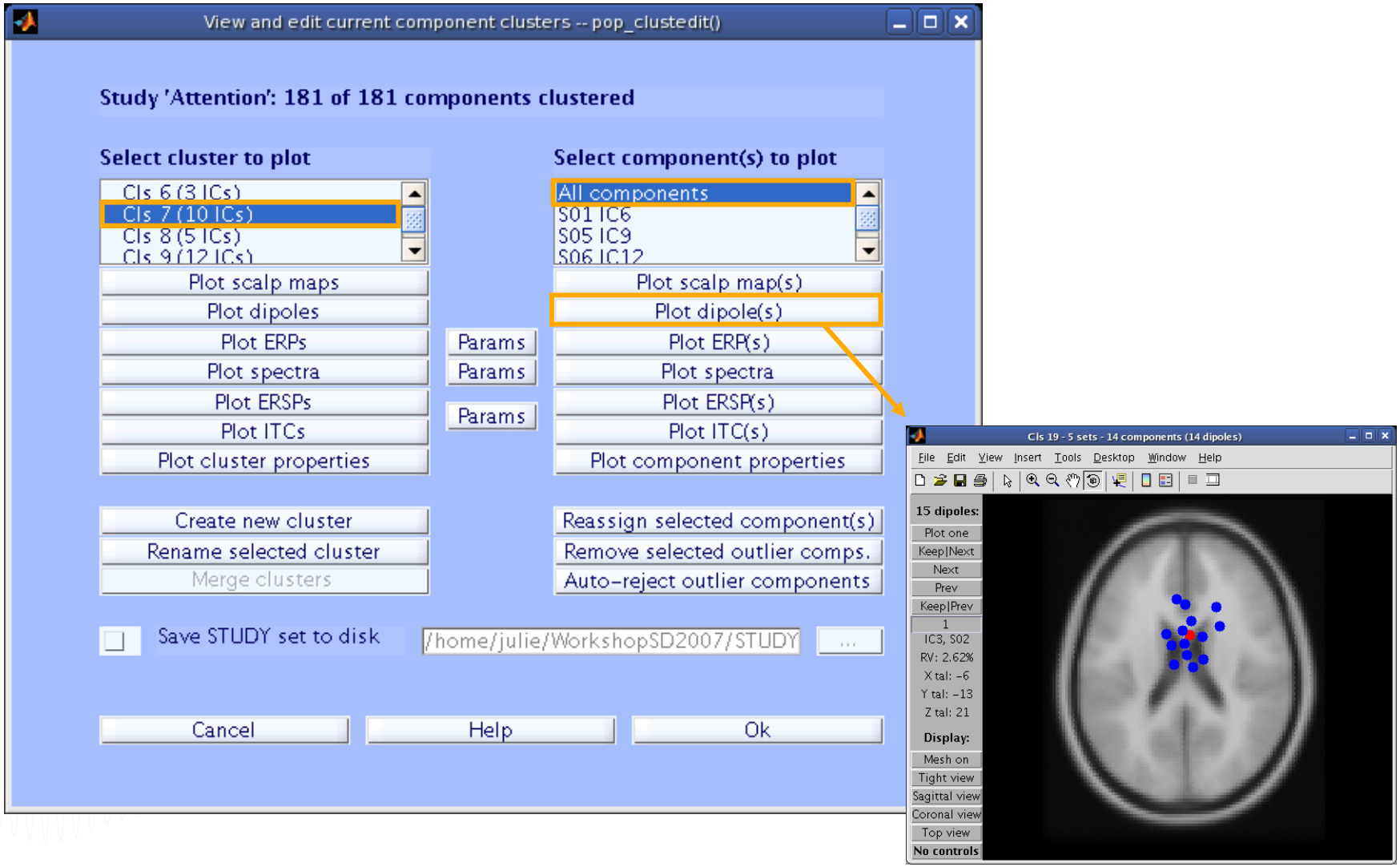
Plot cluster data



Plot cluster data



Plot cluster data



Parametric statistics

Assume gaussian distribution of data

T-test: Compare paired/ unpaired

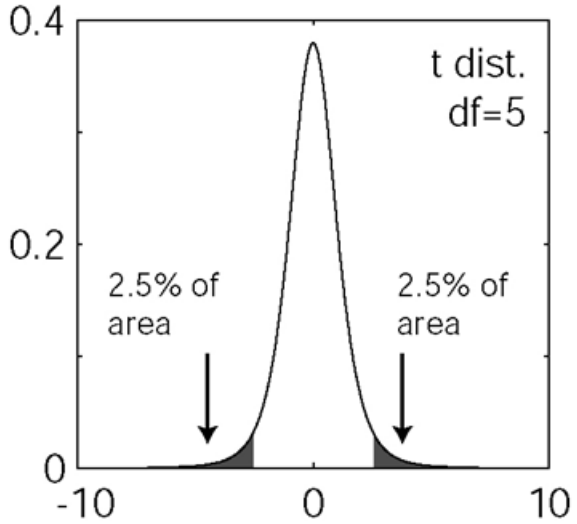
Samples for continuous data. In EEGLAB, used for grand-average ERPs.

Paired

$$t = \frac{Mean\_difference}{Standard\_deviation}\sqrt{N-1}$$

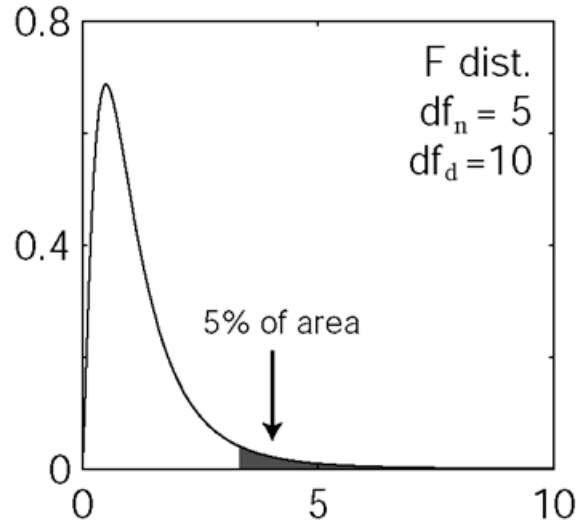
Unpaired

$$t = \sqrt{N}\,\frac{Mean_A - Mean_B}{\sqrt{(SD_A)^2 - (SD_B)^2}}$$



ANOVA: compare several groups (can test interaction between two factors for the repeated measure ANOVA)

$$F = \frac{Variance_{interGroup} \,/\, N_{Group} - 1}{Variance_{WithinGroup} \,/\, N - N_{Group}}$$



Non-parametric statistics

Paired t-test	→	Wilcoxon
Unpaired t-test	→	Mann-Whitney
One way ANOVA	→	Kruskal Wallis
Values		Ranks

BOTH ASSUME NORMAL DISTRIBUTIONS

Problems

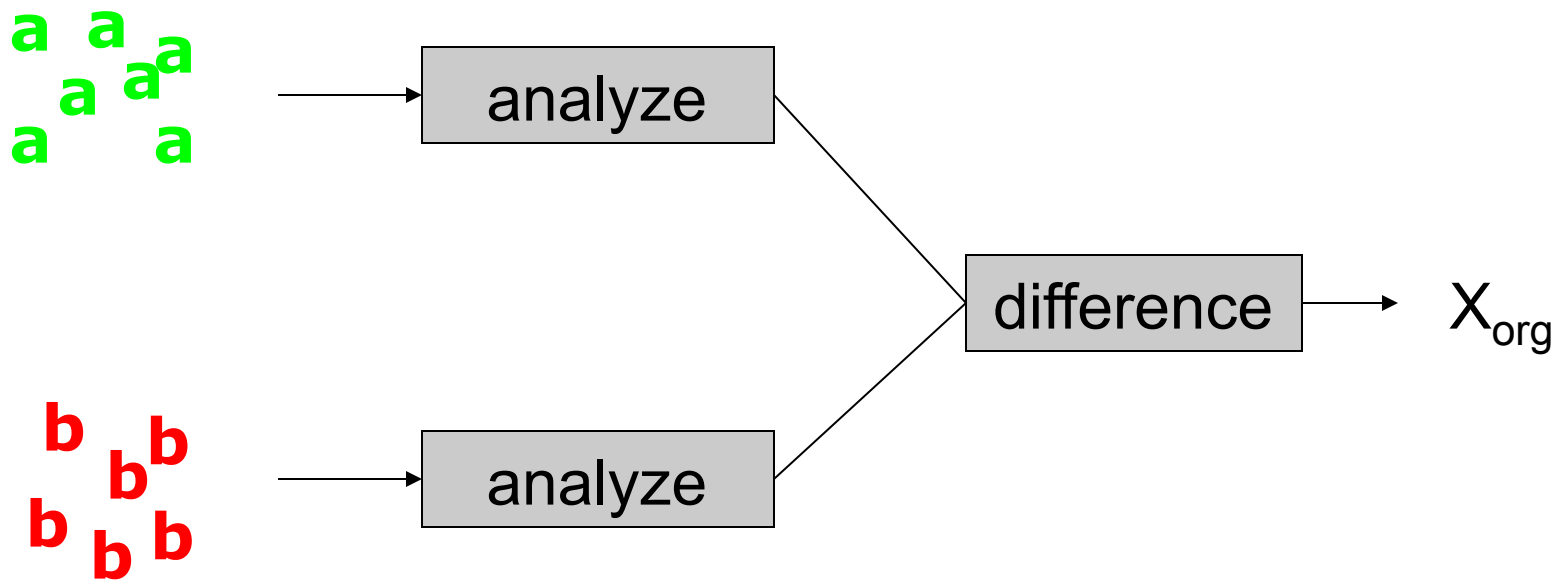
- Not resistant against outliers
- For ANOVA and t-test non-normality is an issue when distributions differ or when variances are not equal.
- Slight departure from normality can have serious consequences

---

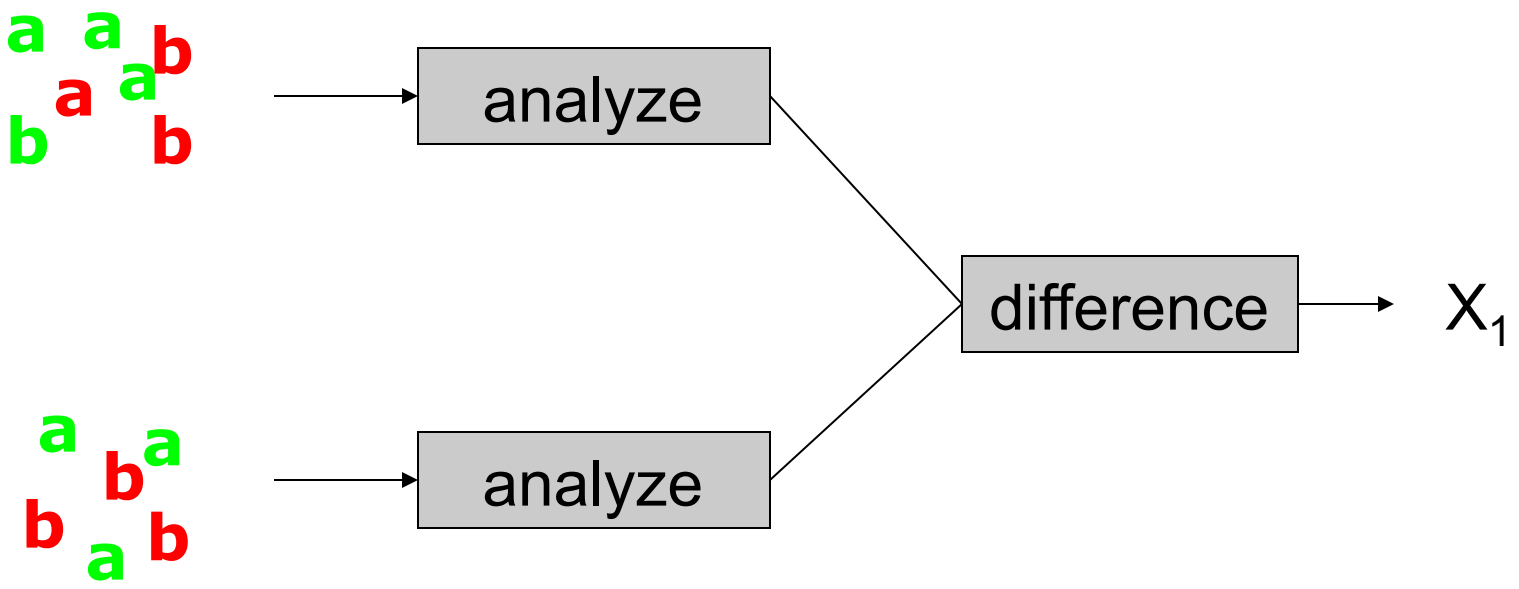
Solutions

1. Randomization approach
2. Bootstrap approach

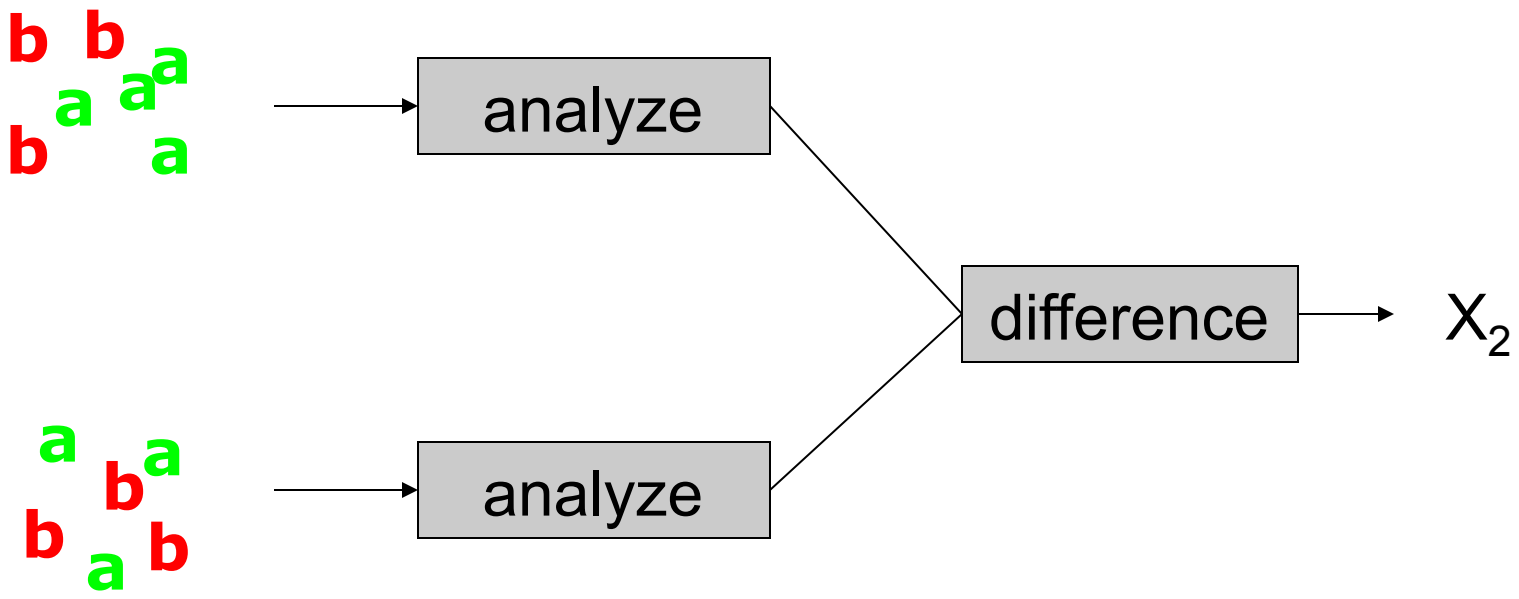
Randomization approach



Randomization approach



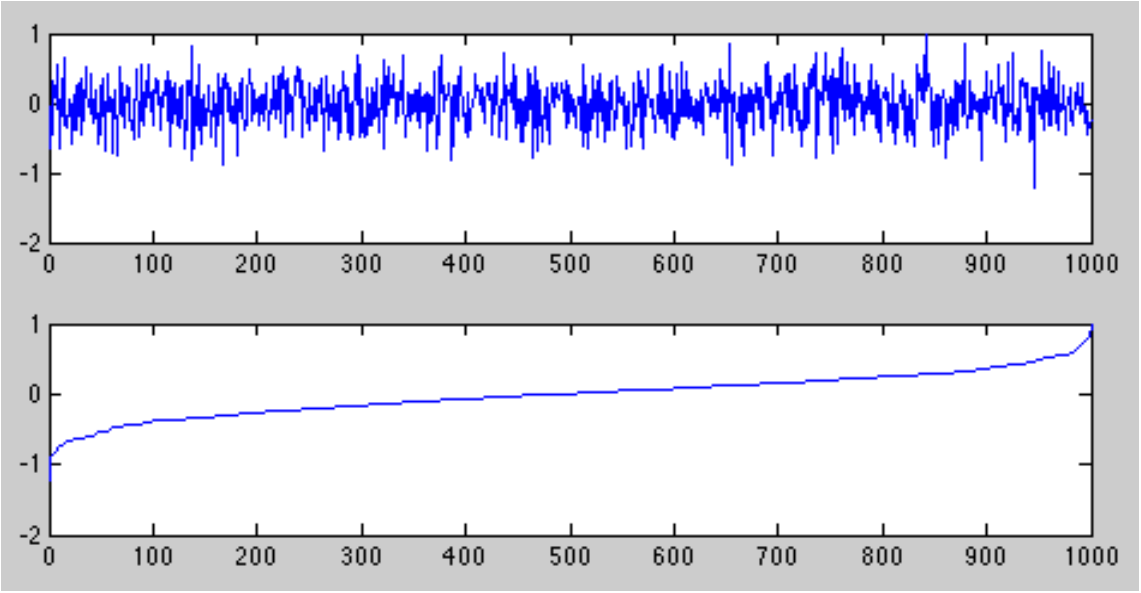
Randomization approach



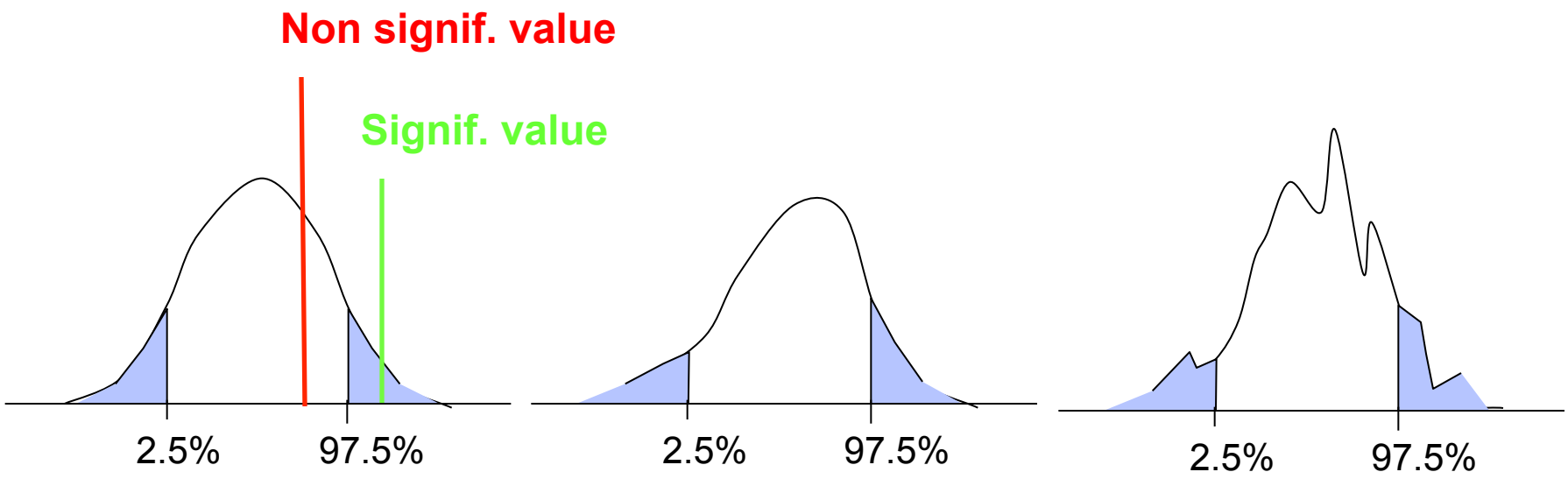
Inferences based on percentile bootstrap method

Permutation /bootstrap

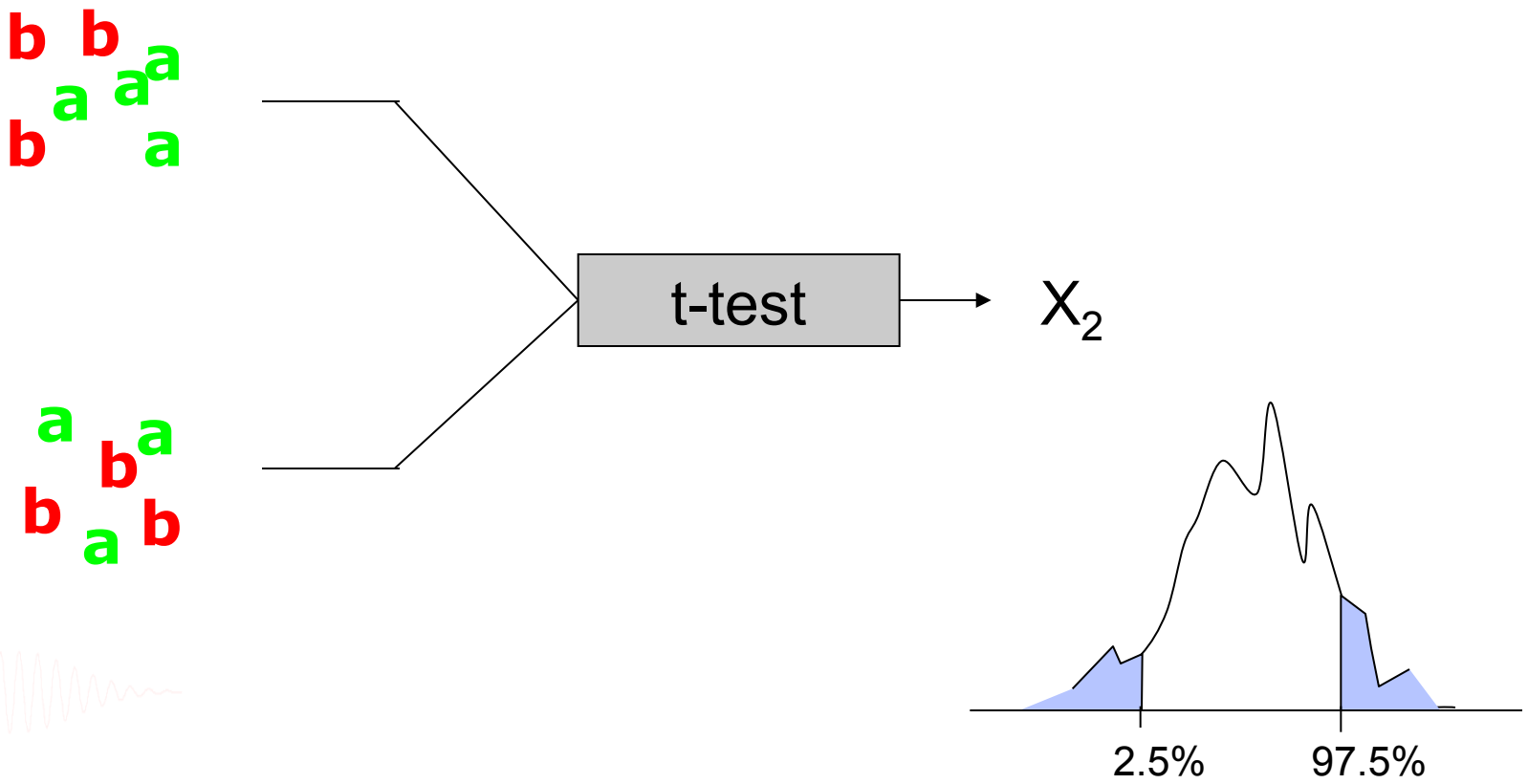
Sorted values



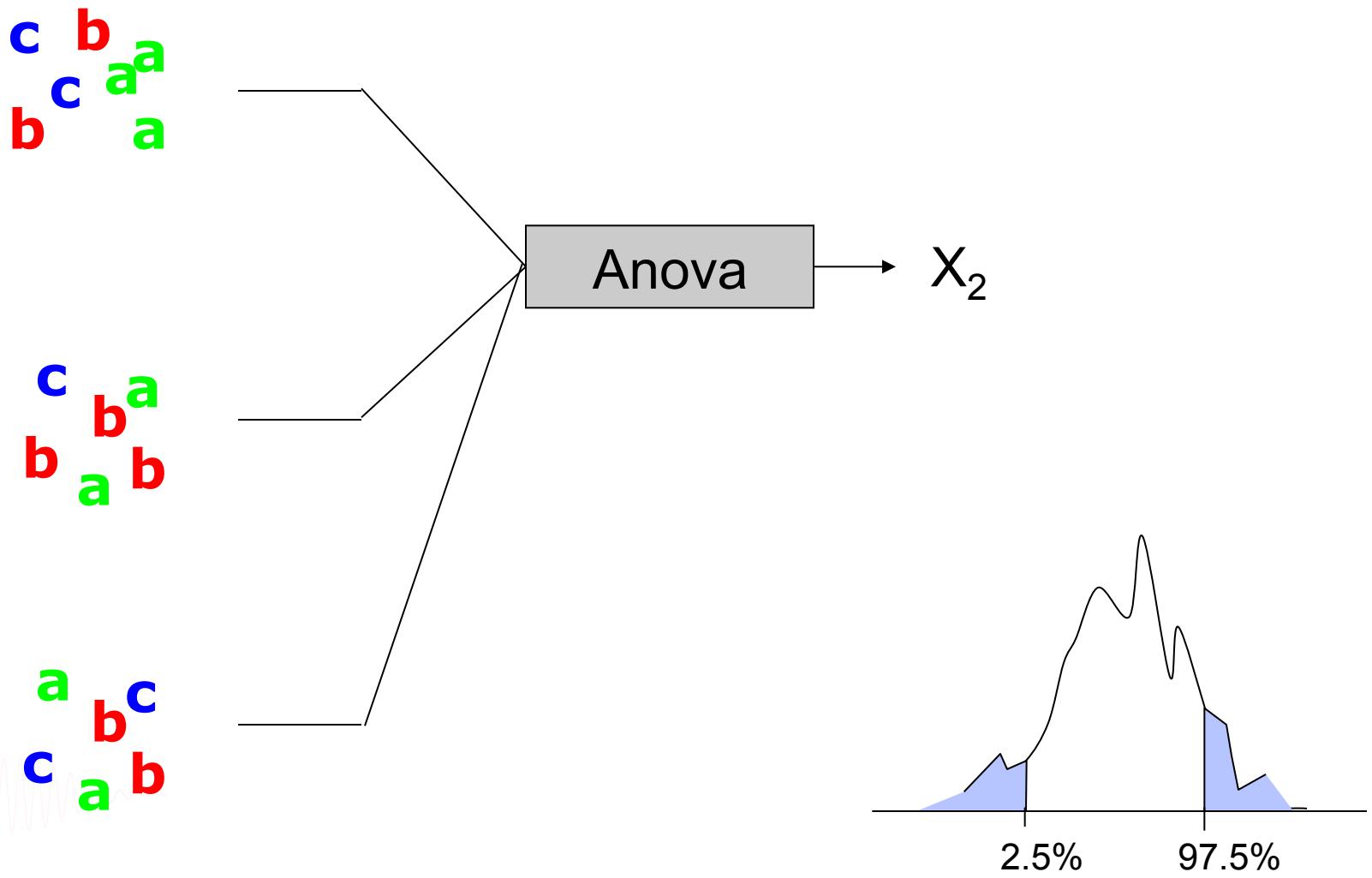
Distribution can take any shape



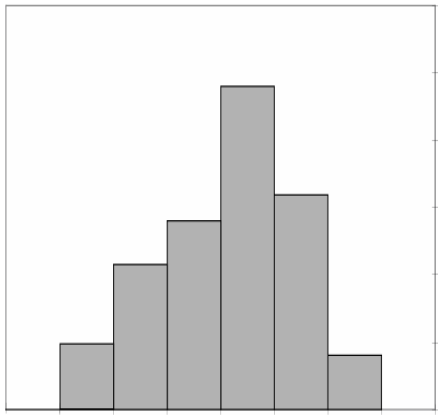
Randomization approach



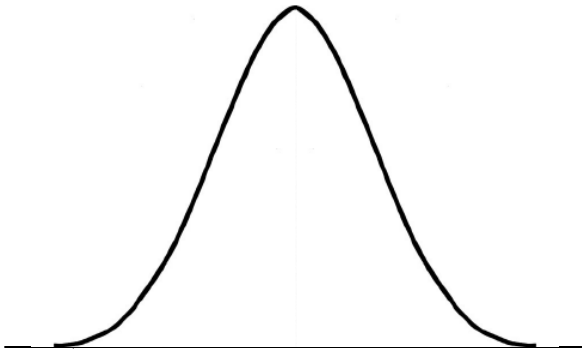
Randomization approach



Sample and population



Sample



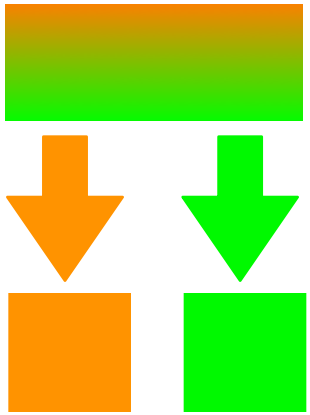
Population

H0: the mean is not 0 for the population

given that we have no other information about the population, the sample is our best single estimate of the population

Bootstrap versus permutation

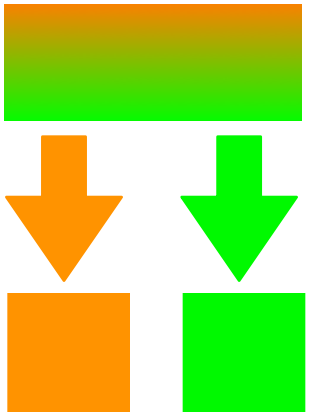
Permutation



each element only get picked once

Draws are dependent of each others

Bootstrap

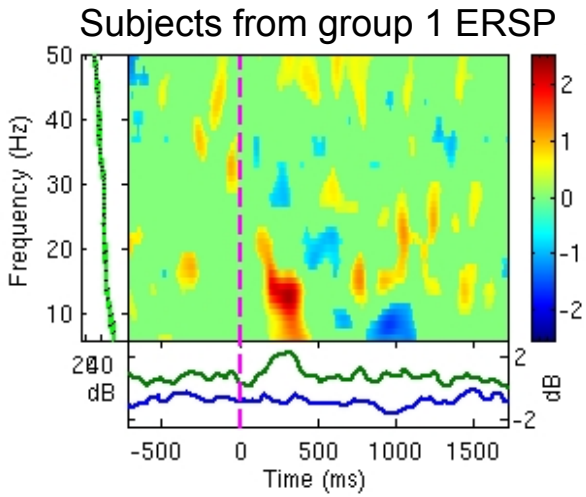


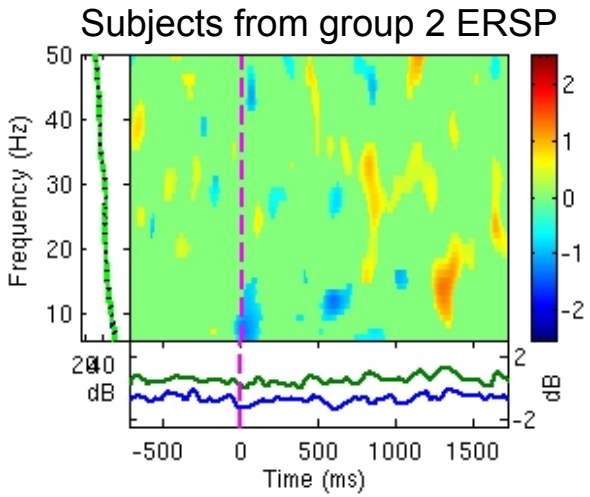
each element can get picked several times

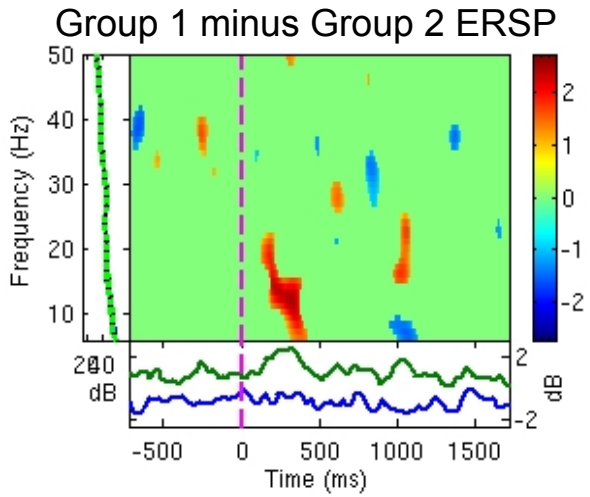
Draws are independent of each others

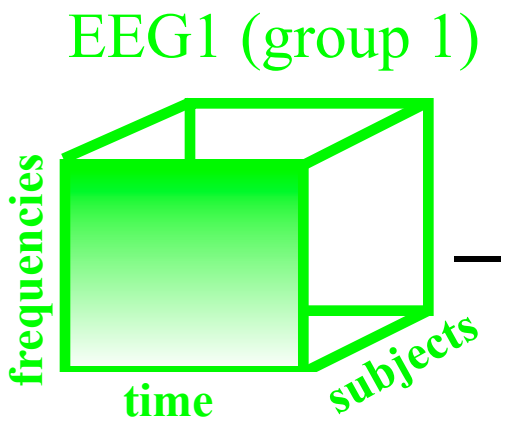
Bootstrap is more rigorous!

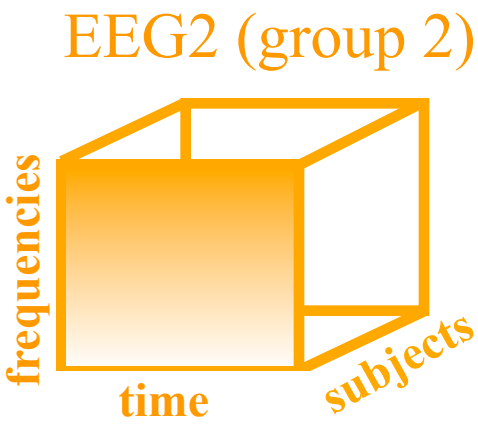
UNPAIRED STATISTICS IN EEGLAB

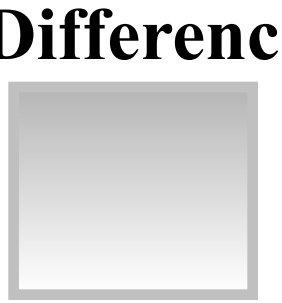

Subjects from group 1 ERSP
Frequency (Hz)
50
40
30
20
10
2
1
0
-1
-2
dB
-500
0
500
1000
1500
Time (ms)

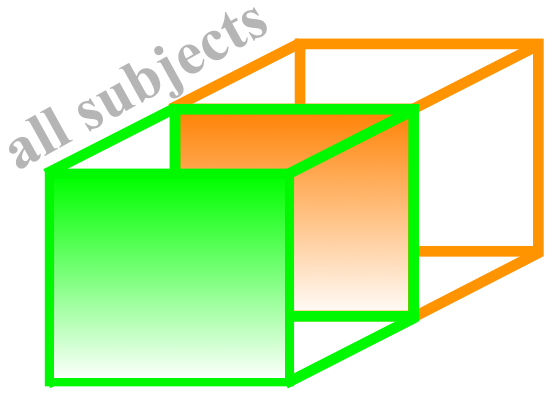

Subjects from group 2 ERSP
Frequency (Hz)
50
40
30
20
10
2
1
0
-1
-2
dB
-500
0
500
1000
1500
Time (ms)


Group 1 minus Group 2 ERSP
Frequency (Hz)
50
40
30
20
10
2
1
0
-1
-2
dB
-500
0
500
1000
1500
Time (ms)

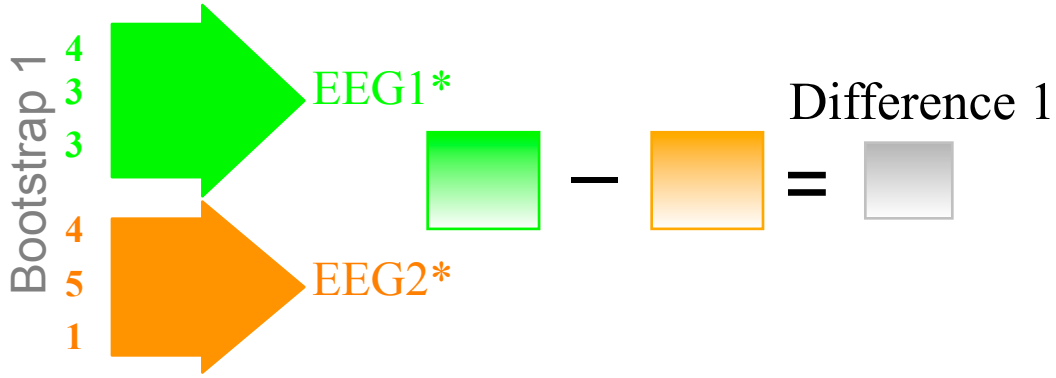

EEG1 (group 1)
frequencies
time
subjects

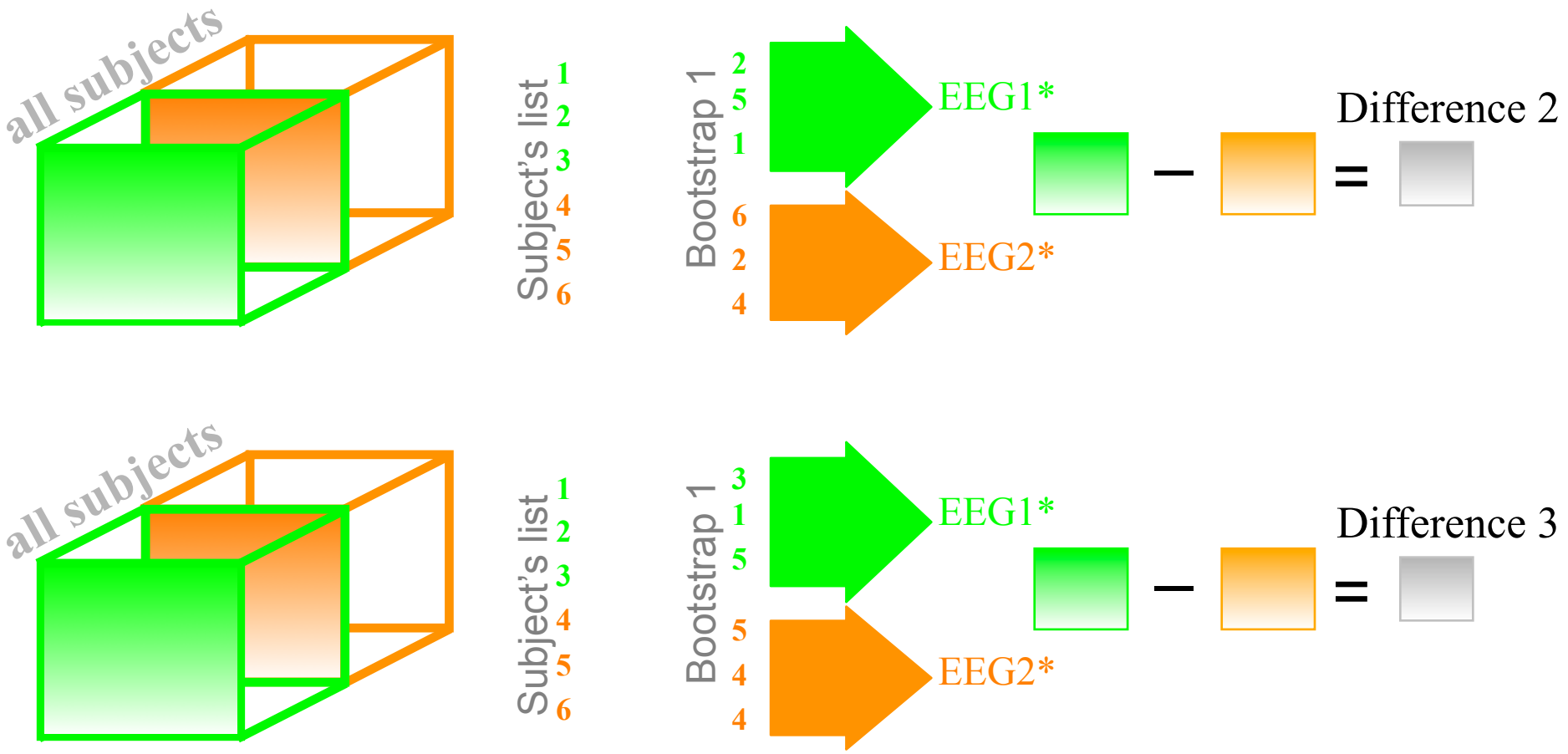

EEG2 (group 2)
frequencies
time
subjects


Difference

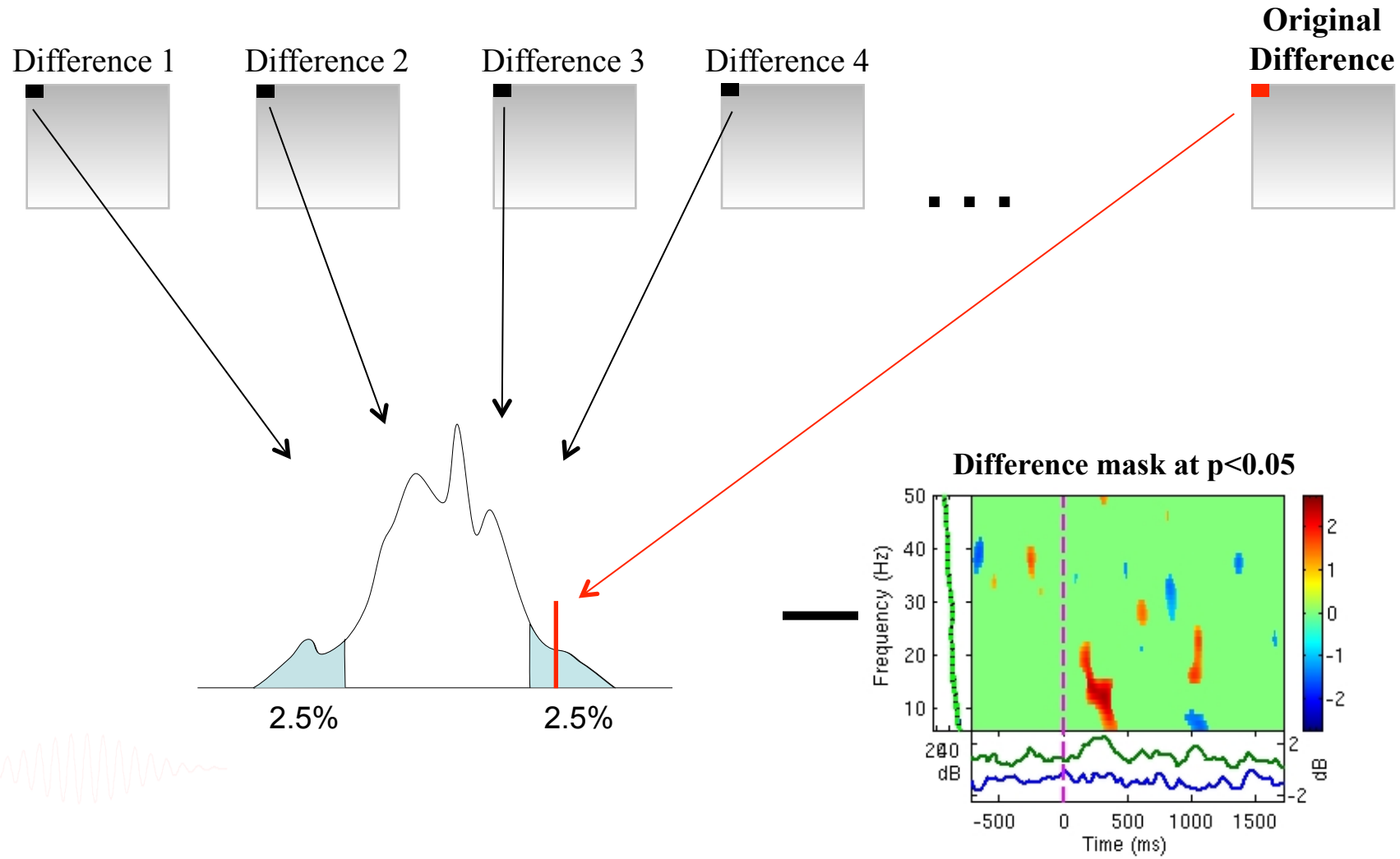

all subjects


Subject's list
1
2
3
4
5
6


Bootstrap 1
4
3
3
4
5
1
EEG1*
EEG2*
Difference 1


all subjects
Subject's list
1
2
3
4
5
6
Bootstrap 1
2
5
1
6
2
4
EEG1*
EEG2*
Difference 2
all subjects
Subject's list
1
2
3
4
5
6
Bootstrap 1
3
1
5
5
4
4
EEG1*
EEG2*
Difference 3

Assessing significance



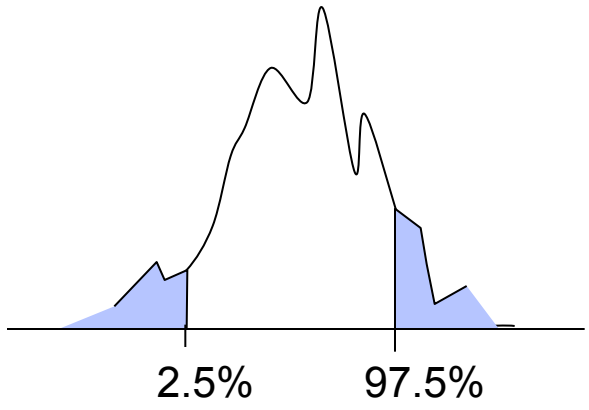
PAIRED STATISTICS IN EEGLAB

Husband	Wifes
22	**25**
32	**25**
50	**51**
25	**25**
33	**38**
27	**30**
45	**60**
47	**54**
30	**31**
44	**54**
23	**23**
39	**34**
24	**25**
22	**23**
16	**19**
73	**71**
27	**26**
36	**31**
24	**26**
60	**62**
26	**29**
23	**31**
28	**29**
36	**35**

Median

Are the two groups different: that's an unpaired test (comparing the median of husband and the median of wife)

Are husbands older than wifes: that's a paired test. Compute difference between the two and change sign to bootstrap.

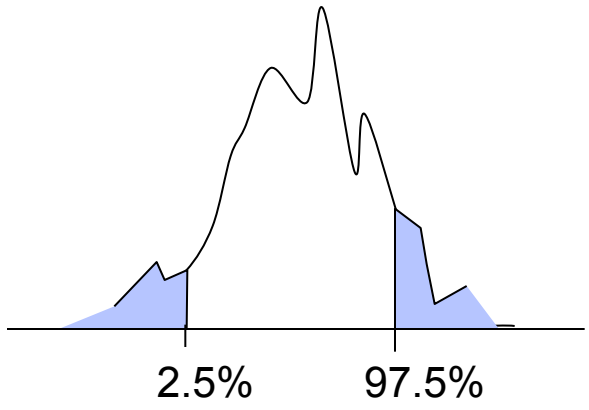


Husband	Wifes	Difference
22	**25**	**-3**
32	**25**	**7**
50	**51**	**-1**
25	**25**	**0**
33	**38**	**-5**
27	**30**	**-3**
45	**60**	**-15**
47	**54**	**-7**
30	**31**	**-1**
44	**54**	**-10**
23	**23**	**0**
39	**34**	**5**
24	**25**	**-1**
22	**23**	**-1**
16	**19**	**-3**
73	**71**	**2**
27	**26**	**1**
36	**31**	**5**
24	**26**	**-2**
60	**62**	**-2**
26	**29**	**-3**
23	**31**	**-8**
28	**29**	**-1**
36	**35**	**1**

Median **-1**

Are the two groups different: that's an unpaired test (comparing the median of husband and the median of wife)

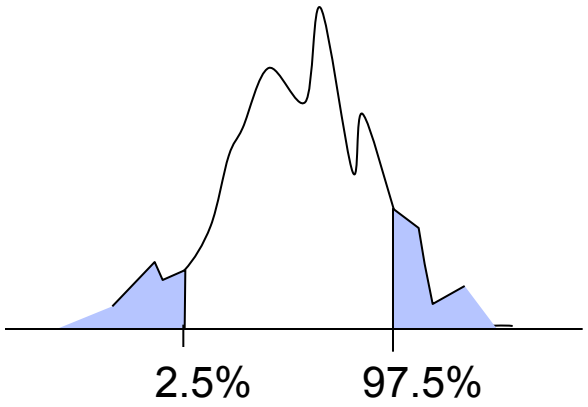
Are husbands older than wifes: that's a paired test. Compute difference between the two and change sign to bootstrap.

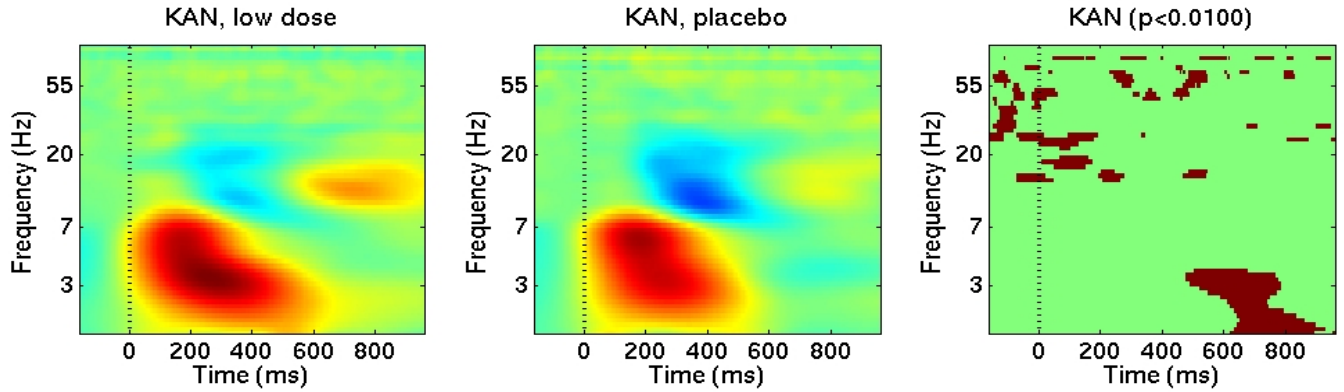


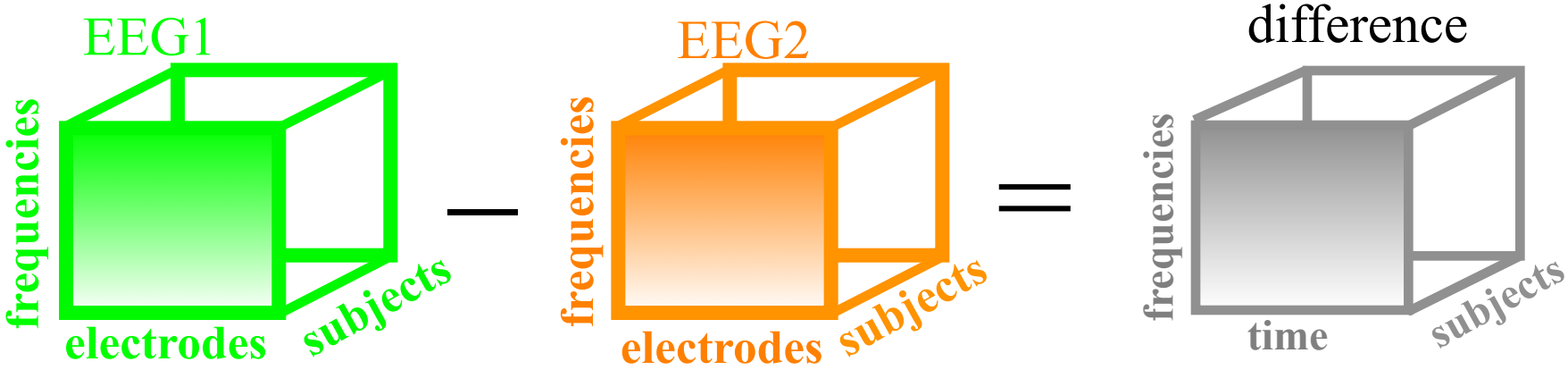
Husband	Wifes	Difference	Sign boot.	Sign boot.	Sign boot.
22	**25**	**-3**	3	3	-3
32	**25**	**7**	-7	7	7
50	**51**	**-1**	-1	-1	1
25	**25**	**0**	0	0	0
33	**38**	**-5**	5	5	5
27	**30**	**-3**	3	3	3
45	**60**	**-15**	15	15	15
47	**54**	**-7**	-7	7	7
30	**31**	**-1**	-1	1	-1
44	**54**	**-10**	-10	-10	-10
23	**23**	**0**	0	0	0
39	**34**	**5**	5	5	-5
24	**25**	**-1**	1	1	-1
22	**23**	**-1**	1	-1	1
16	**19**	**-3**	-3	3	3
73	**71**	**2**	-2	-2	-2
27	**26**	**1**	-1	1	1
36	**31**	**5**	5	5	-5
24	**26**	**-2**	-2	2	2
60	**62**	**-2**	-2	2	-2
26	**29**	**-3**	-3	3	3
23	**31**	**-8**	8	-8	8
28	**29**	**-1**	1	1	1
36	**35**	**1**	-1	-1	-1
	Median	**-1**	-0.5	1.5	1

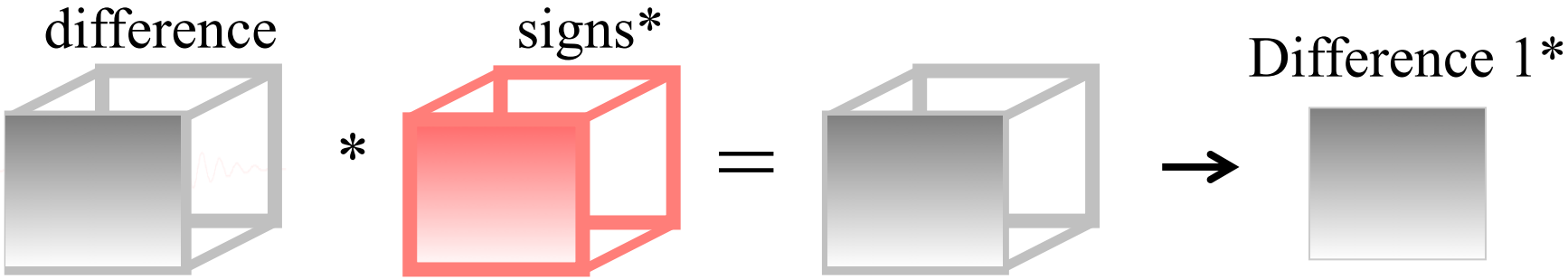
Are the two groups different: that's an unpaired test (comparing the median of husband and the median of wife)

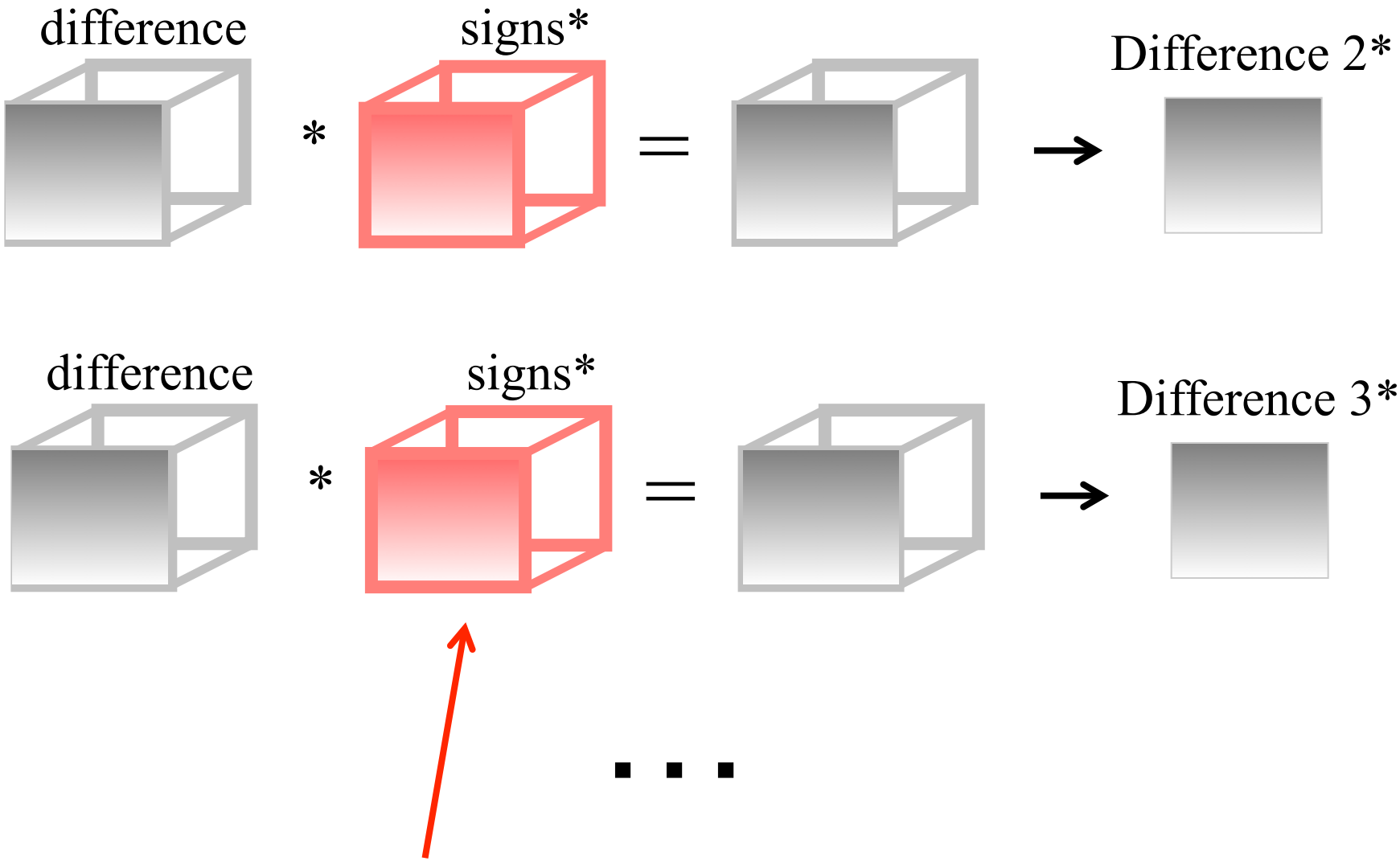
Are husbands older than wifes: that's a paired test. Compute difference between the two and change sign to bootstrap.



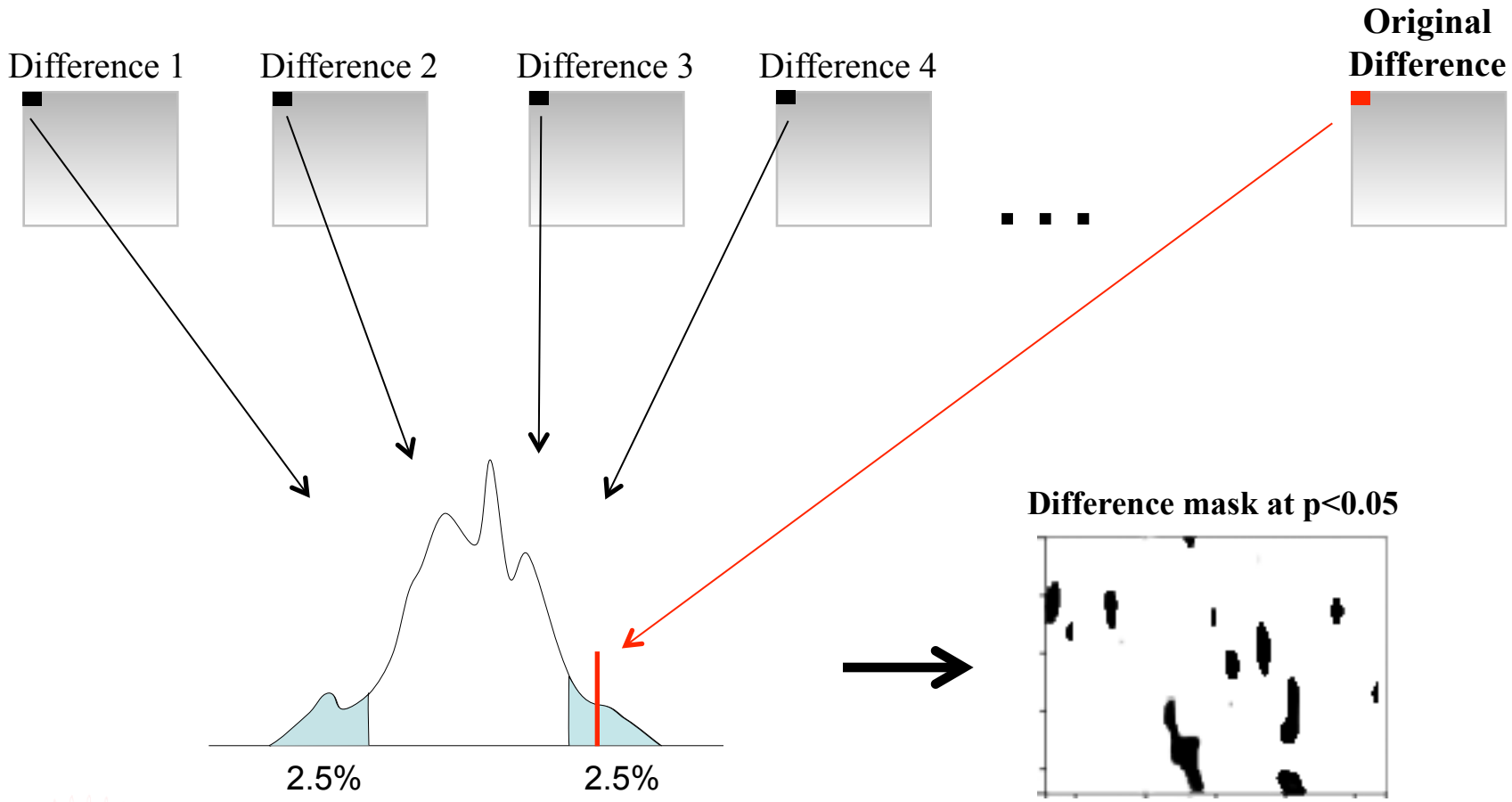

KAN, low dose
KAN, placebo
KAN (p<0.0100)
Frequency (Hz)
55
20
7
3
0
200
400
600
800
Time (ms)


EEG1
frequencies
electrodes
subjects
EEG2
frequencies
electrodes
subjects
difference
frequencies
time
subjects


difference
signs*
Difference 1*


difference
signs*
Difference 2*
difference
signs*
Difference 3*
Simply invert polarity at random location
in the 3-D difference matrix

Assessing significance



Correcting for multiple comparisons

- Bonferoni correction: divide by the number of comparisons (Bonferroni CE. Sulle medie multiple di potenze. Bollettino dell'Unione Matematica Italiana, 5 third series, 1950; 267-70.)

- Holms correction: sort all p values. Test the first one against α/N, the second one against α/(N-1)

- Max method

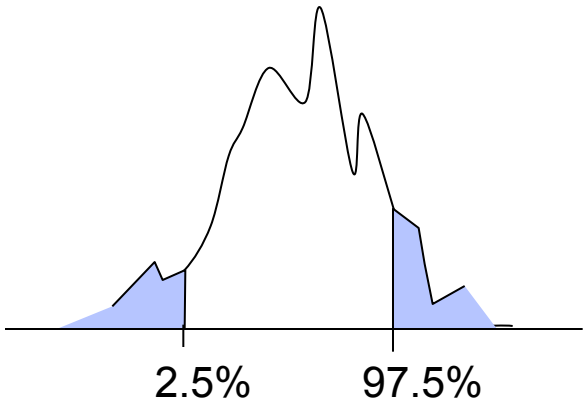
- False detection rate

- Clusters

Max procedure

• for each permutation or bootstrap loop, simply take the MAX of the absolute value of your estimator (e.g. mean difference) across electrodes and/or time frames and/or temporal frequencies.

• compare absolute original difference to this distribution



FDR procedure

Procedure:

- Sort all p values (column C1)
C3

- Create column C2 by computing $j^* \alpha / N$

- Subtract column C1 from C2 to build column C3

- Find the highest negative index in C3
and
find the corresponding p-value in C1
(*p_fdr)*

- Reject all null hypothesis whose p-value are less than or equal to *p_fdr*

Bonferoni

Holms

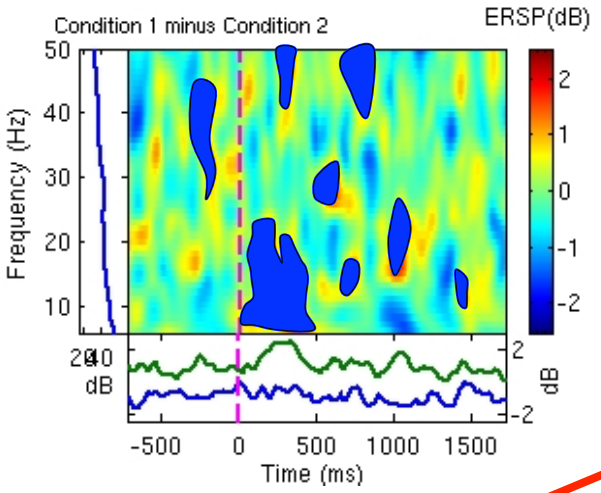
FDR

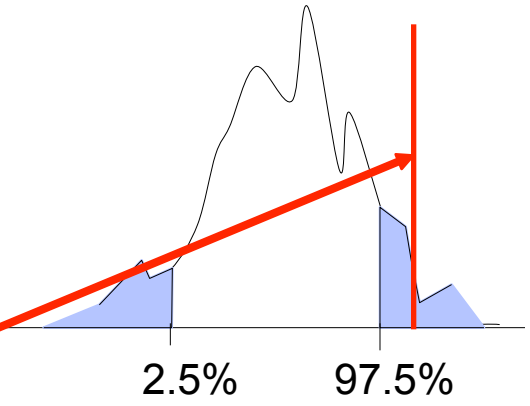
	C1	C2	C3
Index "j"	Actual	j*0.05/10	C2-C1
1	0.001	0.005	-0.004
2	0.002	0.01	-0.008
3	0.01	0.015	-0.005
4	0.03	0.02	0.01
5	0.04	0.025	0.015
6	0.045	0.03	0.015
7	0.05	0.035	0.015
8	0.1	0.04	0.06
9	0.2	0.045	0.155
10	0.6	0.05	0.55

Uncorrected

Cluster correction for multiple comparisons

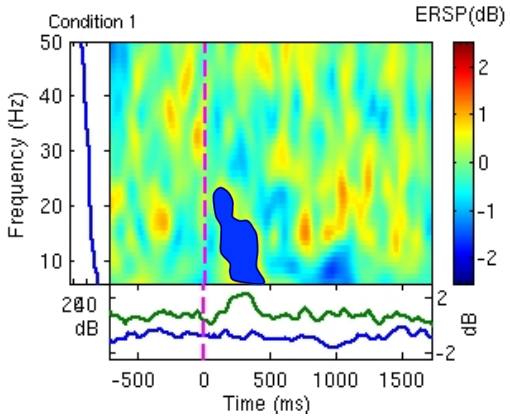
Original difference



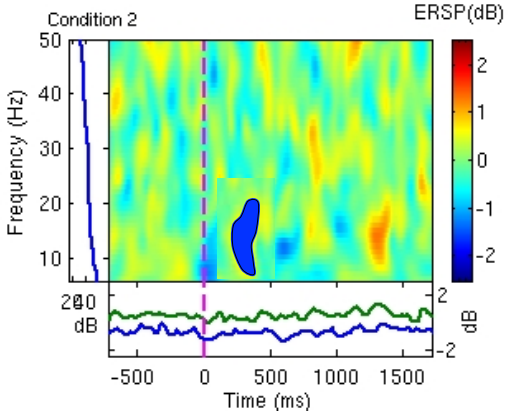


44 pixels

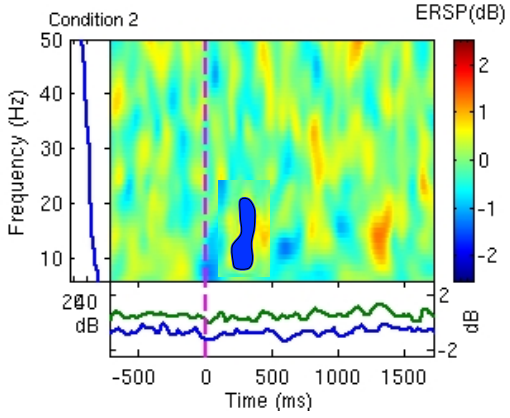
Difference bootstrap 1



Difference bootstrap 2



Difference bootstrap 3



....

statcond function in EEGLAB

```
a = { rand(1,10) rand(1,10)+0.5 }; % pseudo 'paired' data vectors

[t df pvals] = statcond(a , 'mode', 'perm'); % perform paired t-test
pvals = 5.2807e-04 % standard t-test probability value

% Note: for different rand() outputs, results will differ.
[t df pvals surog] = statcond(a, 'mode', 'perm', 'naccu', 2000);
pvals = 0.0065 % nonparametric t-test using 2000 permuted data sets

a = { rand(2,11) rand(2,10) rand(2,12)+0.5 };
[F df pvals] = statcond(a , 'mode', 'perm'); % perform an unpaired ANOVA

pvals =
    0.00025 % p-values for difference between columns
    0.00002 % for each data row
```

statcond function in EEGLAB

```
a = { rand(3,4,10) rand(3,4,10) rand(3,4,10); ...
      rand(3,4,10) rand(3,4,10) rand(3,4,10)+0.5 };

% pseudo (2,3)-condition data array, each entry containing
% ten (3,4) data matrices
[F df pvals] = statcond(a , 'mode', 'perm');
                                % paired 2-way ANOVA

% Output:
pvals{1} % a (3,4) matrix of p-values; effects across columns
pvals{2} % a (3,4) matrix of p-values; effects across rows
pvals{3} % a (3,4) matrix of p-values; interaction effects across
   rows and columns
```

Exercice

- Experiment with the statcond function
  - Create 2 random vectors of values
  - Add “signal” to one of the variable
  - Use statcond and compare permutation and parametric results
  - Repeat 100 times and plot the histogram of p-values
- Experiment with STUDY statistics
  - Load the Stern STUDY
  - Look at significant difference between probe and memorize in component clusters (time-frequency plot, ERSP)

Exercises

Suggestion for exercises:

Load stern.study in STUDY folder

From the GUI, plot grand average ERP for all channels. Experiment with statistics.

Build a STUDY design to compare Ignore letter grouped with Memorize letter with Probe letters. Recompute spectrum and plot spectrum for electrode Fz using statistics. Do the same for the frontal midline component cluster (cluster 19).