



ZA zander labs



Group Level Analysis

Clustering and statistical analysis of ICA components

EEGLAB

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Scott Makeig



Plan

Part 1

1. **Select ICA components for clustering**
2. **Precompute measures of interest**
3. **Cluster measures**
4. **Statistical analysis using clusters**

Part 2: Practicum



Edit dataset info

pop_study(): Pre-select components

Enter maximum residual (topo map - dipole proj.) var. (in %)
NOTE: This will delete any existing component clusters!

15

Keep only in-brain dipoles (requires Fieldtrip extension).

Help Cancel Ok

Create a new STUDY set -- pop_study()

Edit STUDY set information - remember to save changes

STUDY set name: henson_study

STUDY set task name: ScrambledVsNormalFace

STUDY set notes:

	dataset filename	browse	subject	session	run	condition	group	Select by r.v.	
1	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-002	1			1	Comp.: 1 2 ...	Clear
2	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-003	1			1	Comp.: 1 2 ...	Clear
3	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-004	1			1	Comp.: 1 2 ...	Clear
4	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-005	1			1	Comp.: 1 2 ...	Clear
5	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-006	1			1	Comp.: 1 2 ...	Clear
6	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-007	1			1	Comp.: 1 2 ...	Clear
7	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-008	1			1	Comp.: 1 2 ...	Clear
8	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-009	1			1	Comp.: 1 2 ...	Clear
9	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-010	1			1	Comp.: 2 3 ...	Clear
10	/Users/amon-ra/program_files/PracticalMEEG_2022/Data/ds0...	...	sub-011	1			1	Comp.: 1 2 ...	Clear

Important note: Removed datasets will not be saved before being deleted from EEGLAB memory

< Page 1 >

Dataset info (condition, group, ...) differs from study info. [set] = Overwrite dataset info for each dataset on disk.

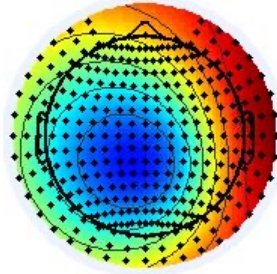
Delete cluster information (to allow loading new datasets, set new components for clustering, etc.)

Help Cancel Ok

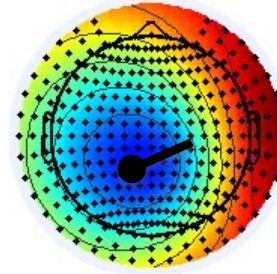


Computing residual variance (%)

Actual IC map (x_i)



Dipole projection (\tilde{x}_i)



$$rv = \frac{\sum_i (x_i - \tilde{x}_i)^2}{\sum_i x_i^2}$$



ICs to cluster

Create a new STUDY set -- pop_study()

Edit STUDY set information - remember to save changes

STUDY set name: henson_study

STUDY set task name: ScrambledVsNormalFace

STUDY set notes:

dataset filename	run	condition	group	Select by r.v.	
1 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 1 2 ...	Clear
2 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 1 2 ...	Clear
3 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 1 2 ...	Clear
4 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 1 2 ...	Clear
5 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 1 2 ...	Clear
6 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 1 2 ...	Clear
7 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 1 2 ...	Clear
8 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 1 2 ...	Clear
9 /Users/amon-ra/prog... Practica1MEEG_2022			1	Comp.: 2 3 ...	Clear
10 /Users/amon-ra/prog... Practica1MEEG_2022(Data/d...			1	Comp.: 1 2 ...	Clear

Important note: Removed datasets will not be saved before being deleted from EEGLAB memory

< Page 1 >

- Dataset info (condition, group, ...) differs from study info. [set] = Overwrite dataset info for each dataset on disk.
- Delete cluster information (to allow loading new datasets, set new components for clustering, etc.)

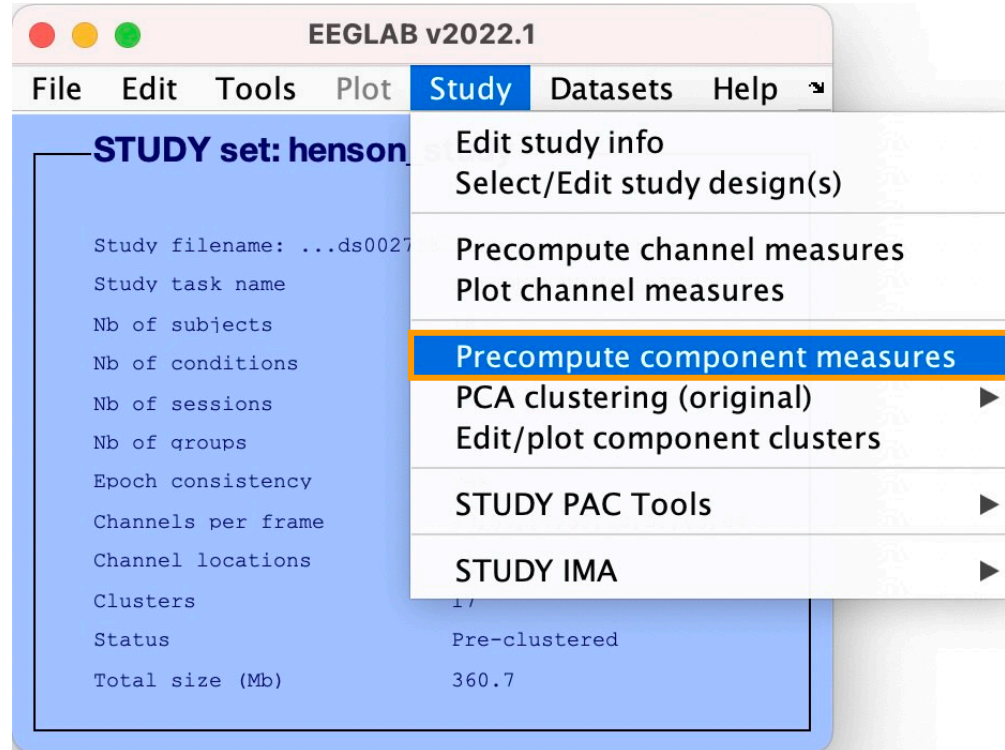
Help Cancel Ok

select components

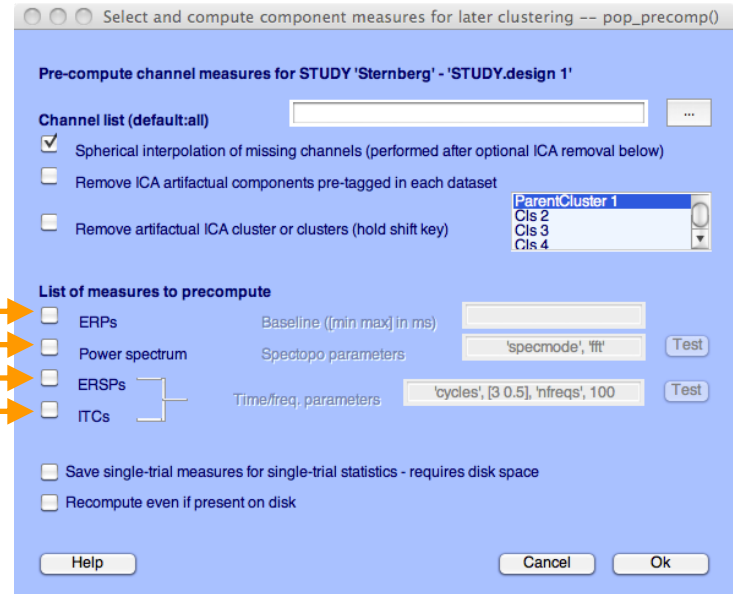
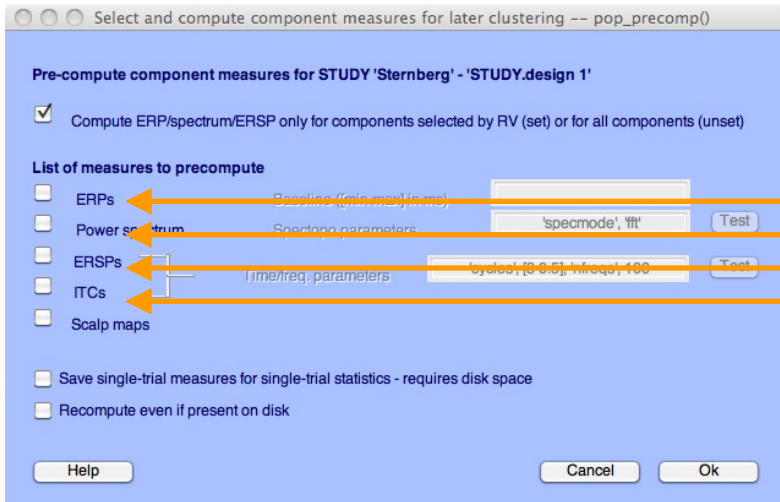
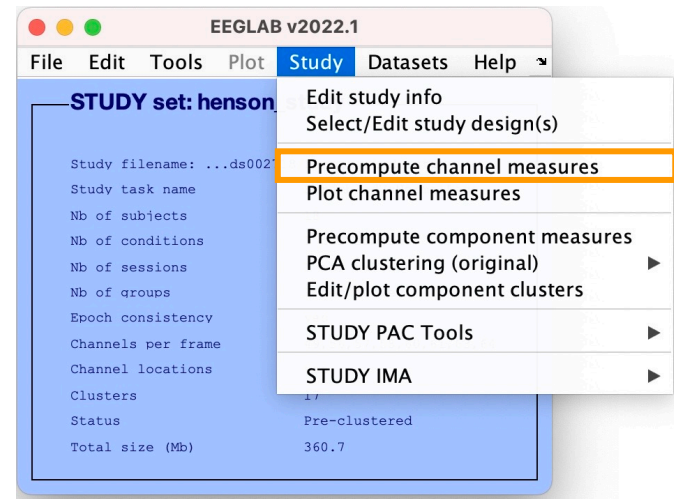
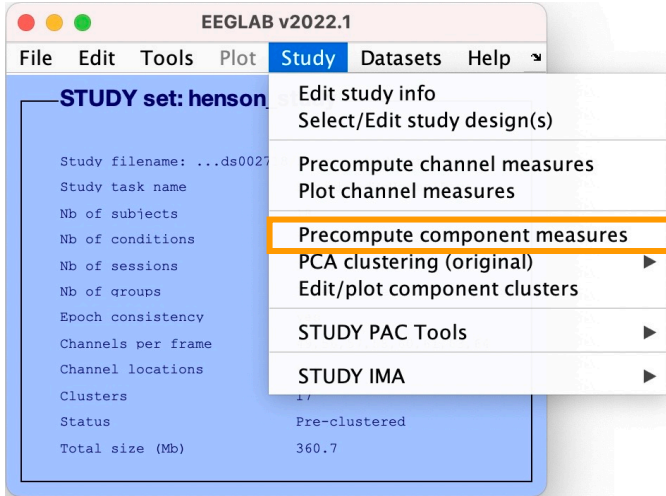
- ic 19
- ic 20
- ic 21
- ic 22
- ic 23
- ic 24
- ic 25
- ic 26
- ic 27
- ic 28
- ic 29
- ic 30
- ic 31
- ic 32

Cancel Ok

Precompute data measures

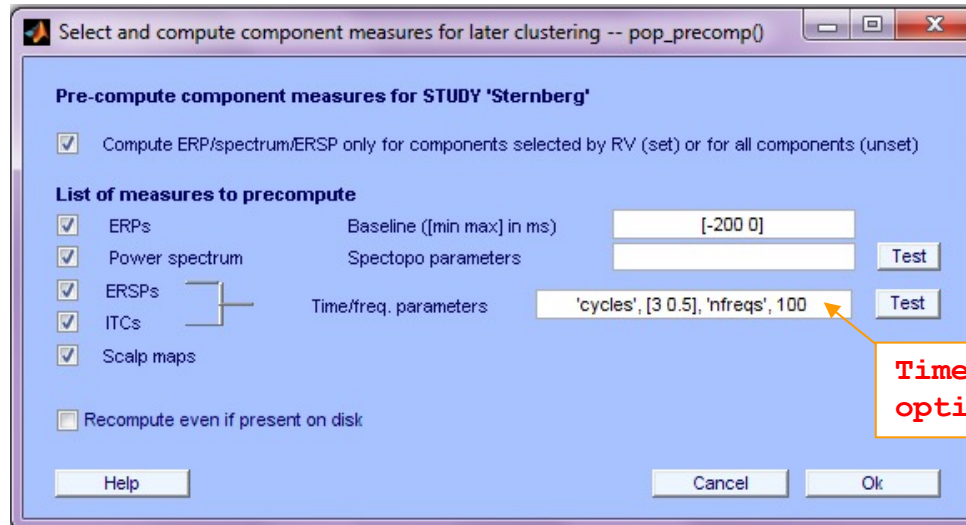


Pre-compute measures



Precompute data measures

TIP: Compute all measures so you can test different combinations for clustering



Time-frequency options



Cluster components

EEGLAB v15.x (dev)

File Edit Tools Plot **Study** Datasets Help

STUDY set: Sternberg

Study filename:
Study task name
Nb of subjects
Nb of conditions
Nb of sessions
Nb of groups
Epoch consistency: ves
Channels per frame: 69,70,71
Channel locations: ves
Clusters: 1
Status: Ready to precluster
Total size (Mb): 229.3

Study menu options:

- Edit study info
- Select/Edit study design(s)
- Precompute channel measures
- Plot channel measures
- Precompute component measures
 - PCA clustering (original)** ▶ Build preclustering array
- Edit/plot clusters
- Cluster components

Select and compute component measures for later clustering -- pop_preclust()

Build pre-clustering matrix for STUDY set: Sternberg

Only measures that have been precomputed may be used for clustering

Mixing time-based and location-based measures to cluster might result in Help

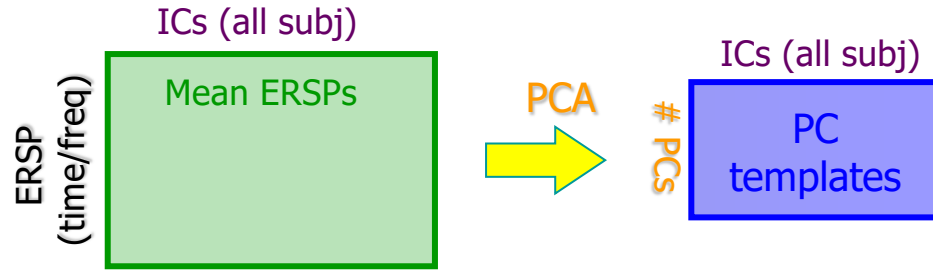
Time-based info	PCA	Weight		
<input type="checkbox"/> spectra	10	1	Freq.range [Hz]	3 25
<input type="checkbox"/> ERPs	10	1	Time range [ms]	
<input type="checkbox"/> ERSPs	10	1	Time range [ms]	Freq. range [Hz]
<input type="checkbox"/> ITCs	10	1	Time range [ms]	Freq. range [Hz]

Location-based info	PCA	Weight	
<input checked="" type="checkbox"/> dipole locations	3	1	
<input checked="" type="checkbox"/> dipole orient.	3	1	Amplitude & polarity is ignored
<input type="checkbox"/> scalp maps	10	1	Use channel v... <input type="checkbox"/> Absolute values

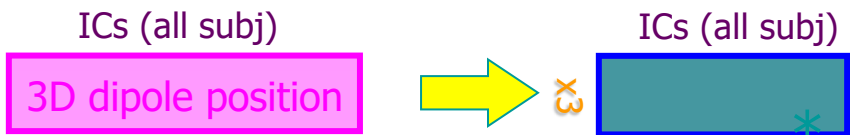
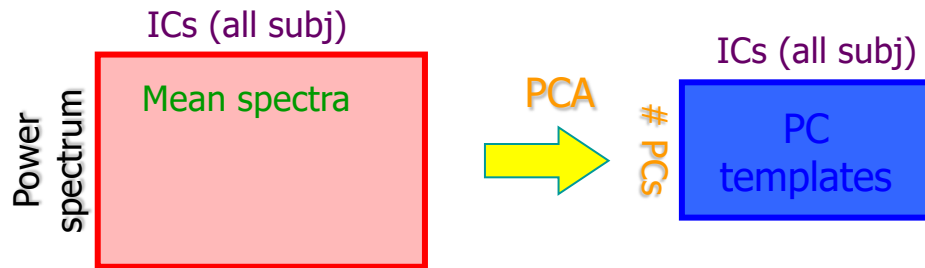
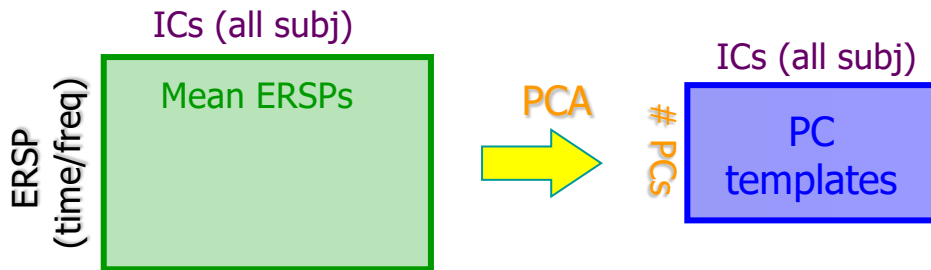
Help Cancel Ok



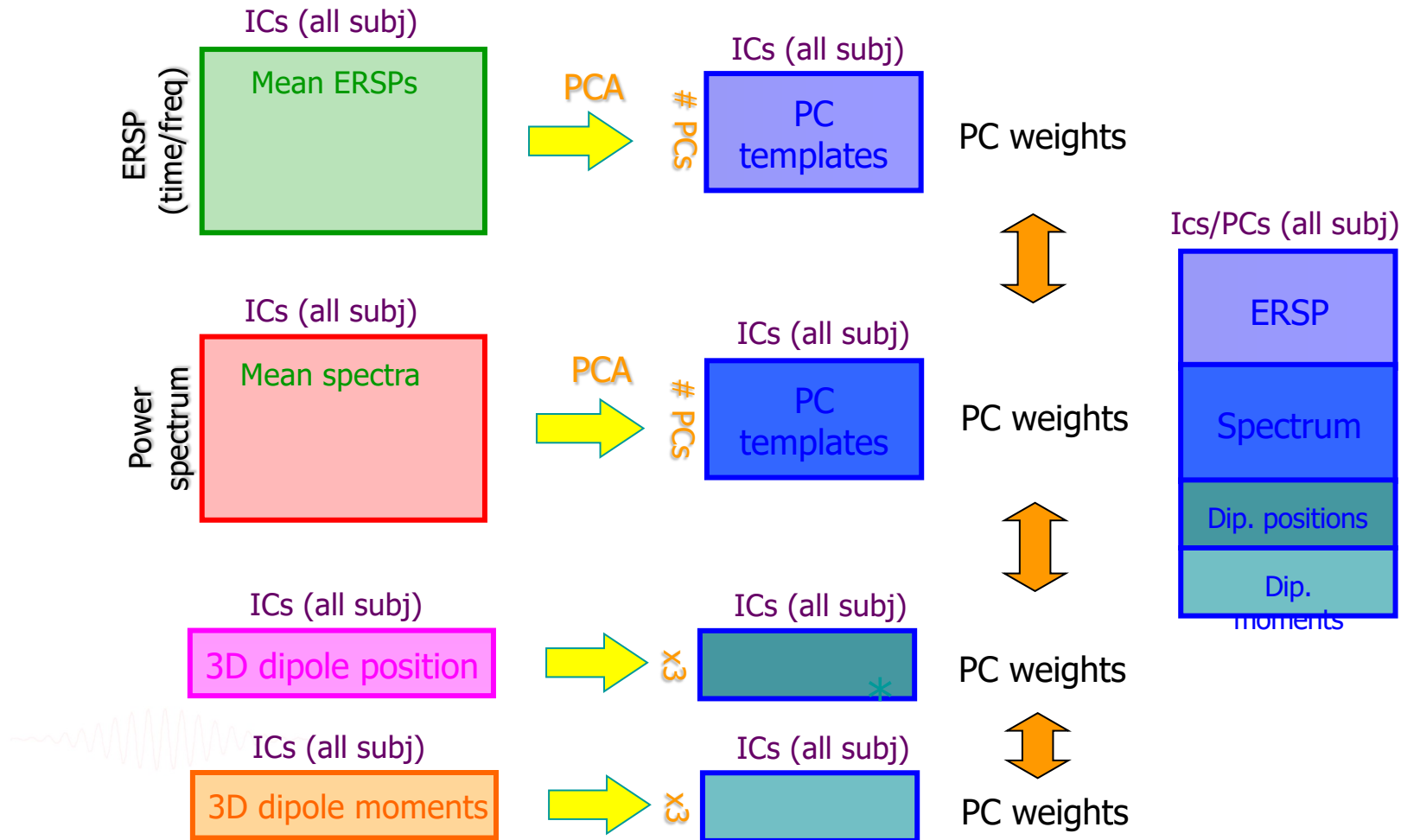
Precluster schematic



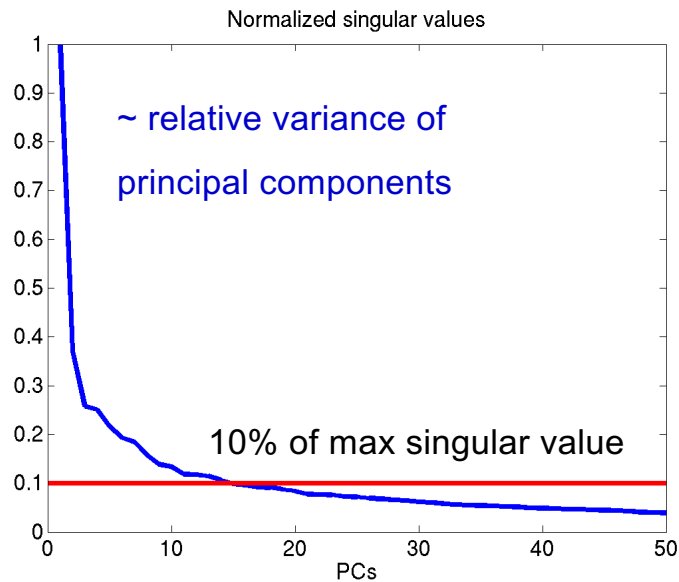
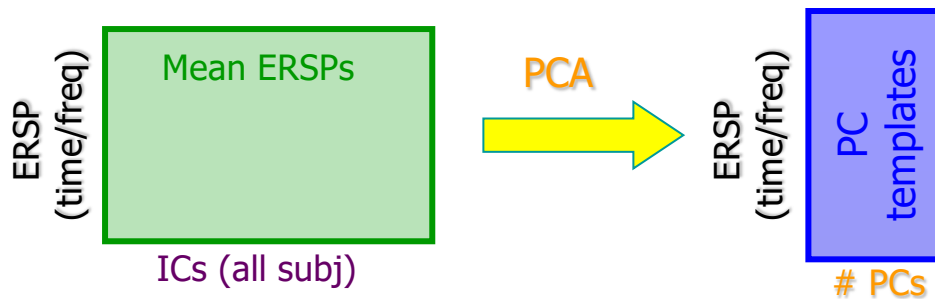
Precluster schematic



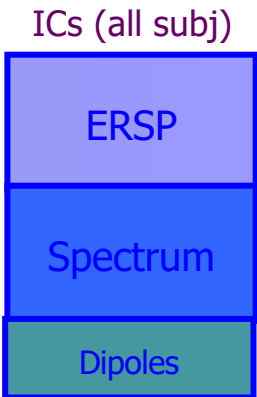
Precluster schematic



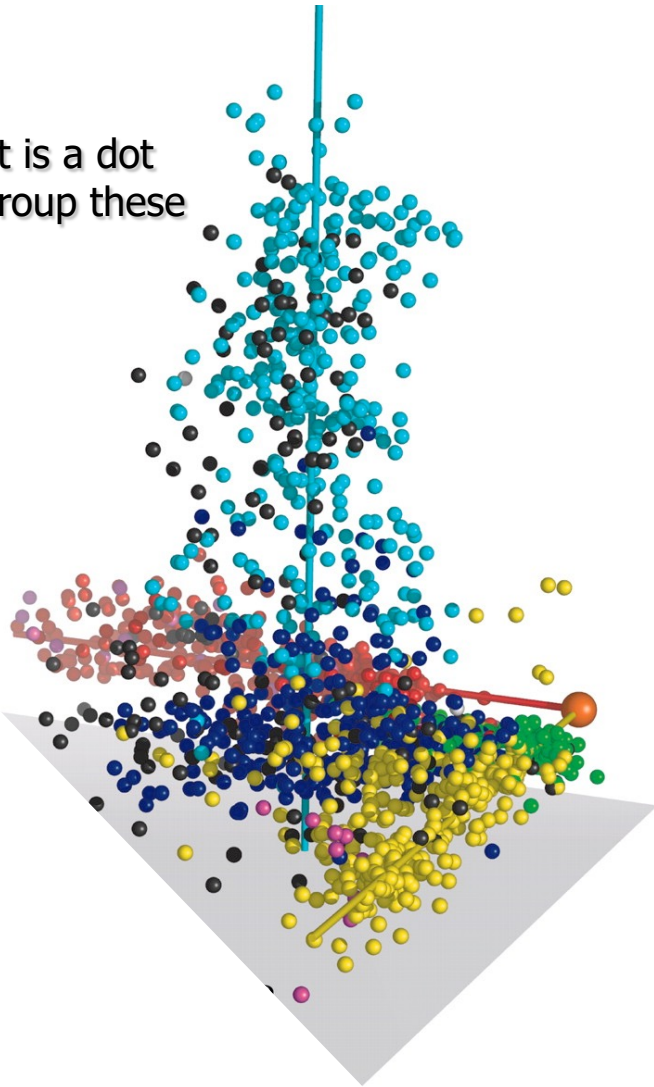
Precluster: Use singular values from PCA



Precluster schematic



Each component is a dot
Clustering will group these dots



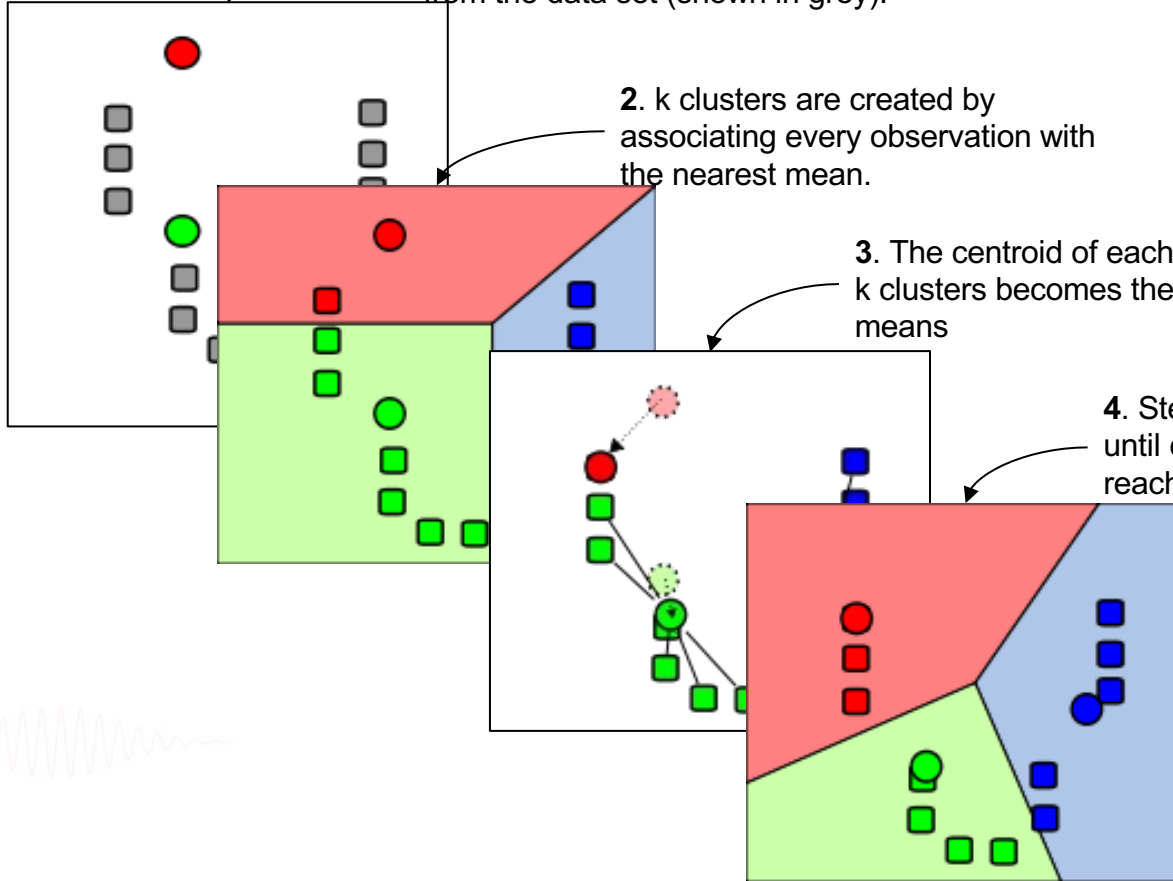
Standard Kmean Clustering

1. k initial "means" (in this case $k=3$, (shown in color)) are randomly selected from the data set (shown in grey).

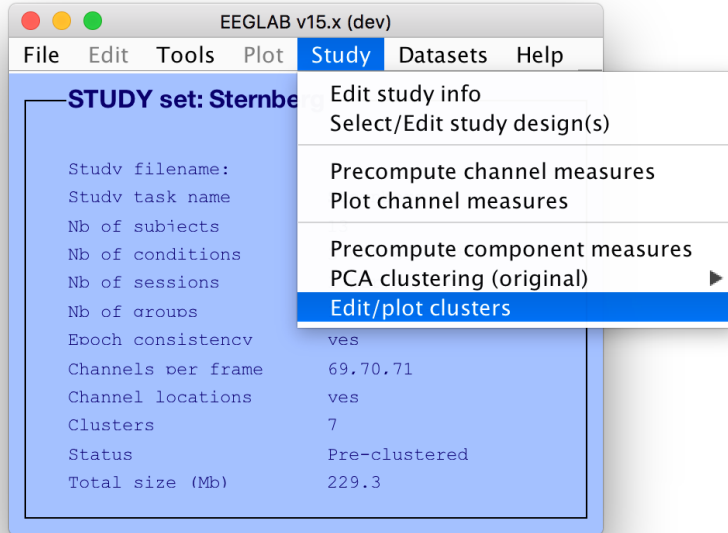
2. k clusters are created by associating every observation with the nearest mean.

3. The centroid of each of the k clusters becomes the new means

4. Steps 2 and 3 are repeated until convergence has been reached.



Cluster components



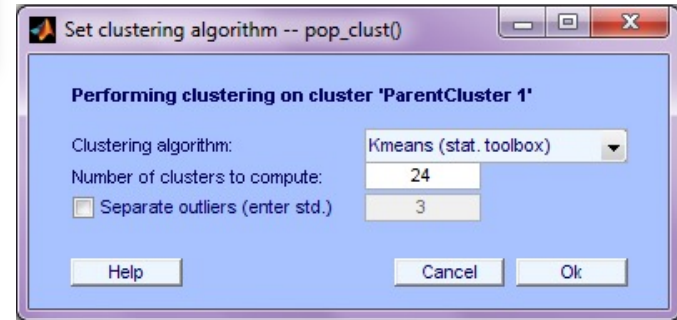
EEGLAB v15.x (dev)

File Edit Tools Plot **Study** Datasets Help

STUDY set: Sternbe

- Edit study info
- Select/Edit study design(s)
- Precompute channel measures
- Plot channel measures
- Precompute component measures
- PCA clustering (original)
- Edit/plot clusters**

Study filename:
Study task name
Nb of subjects
Nb of conditions
Nb of sessions
Nb of groups
Epoch consistency ves
Channels per frame 69.70.71
Channel locations ves
Clusters 7
Status Pre-clustered
Total size (Mb) 229.3



Set clustering algorithm -- pop_clust()

Performing clustering on cluster 'ParentCluster 1'

Clustering algorithm: Kmeans (stat. toolbox)

Number of clusters to compute: 24

Separate outliers (enter std.) 3

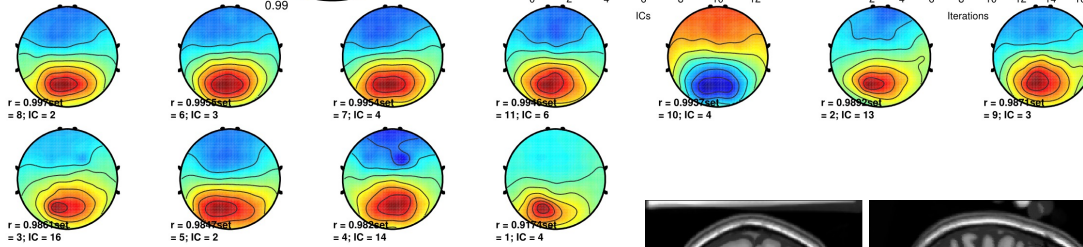
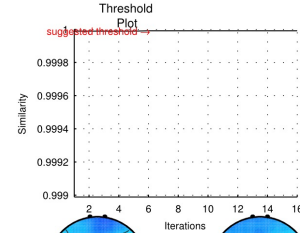
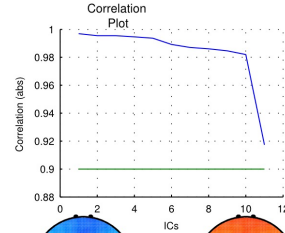
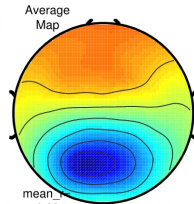
Help Cancel Ok



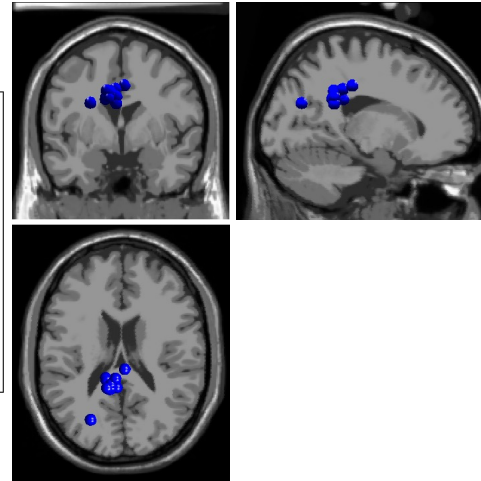
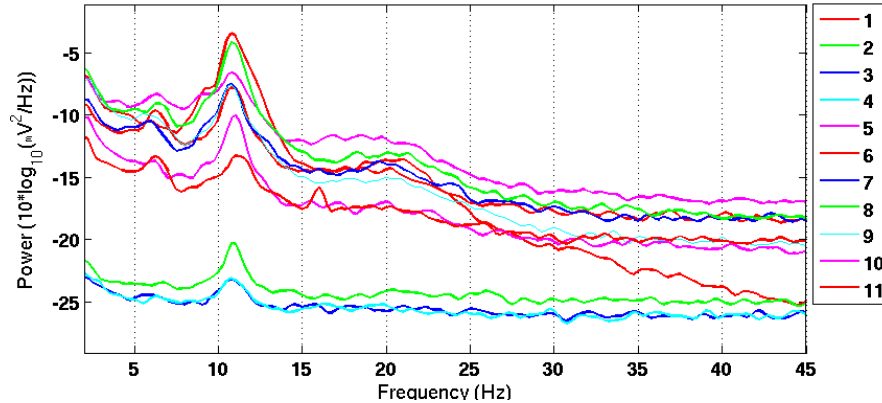
Results (Cluster 1 within subject)

100 % Sessions contribute

INFO:
 Template: CB Session 7 PREPROC:STEP 2; Set 7; IC 3;
 Number of datasets: 11
 Correlation threshold: 0.9 (green line)
 Max ICs from each dataset: 1
 Cluster: 11 ICs from 11 sets
 All datasets contribute.
 Similarity = 1.0000



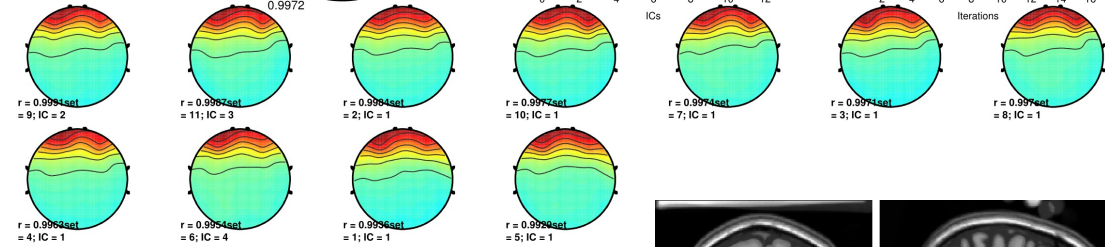
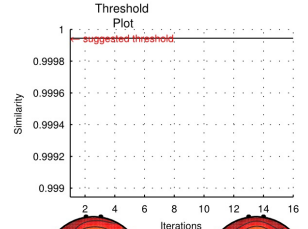
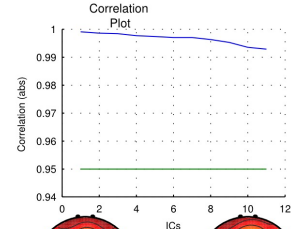
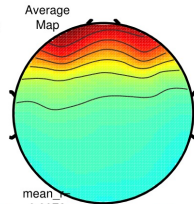
Cls 3 Spectrum



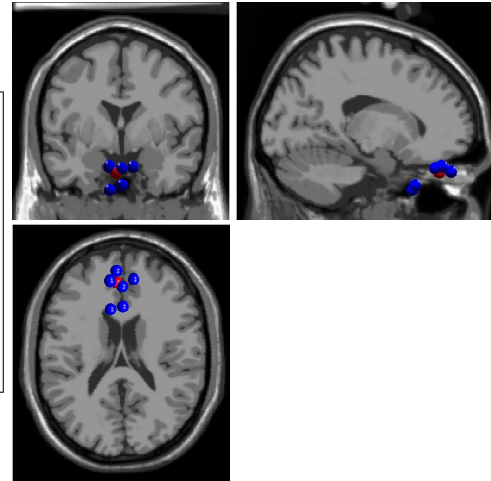
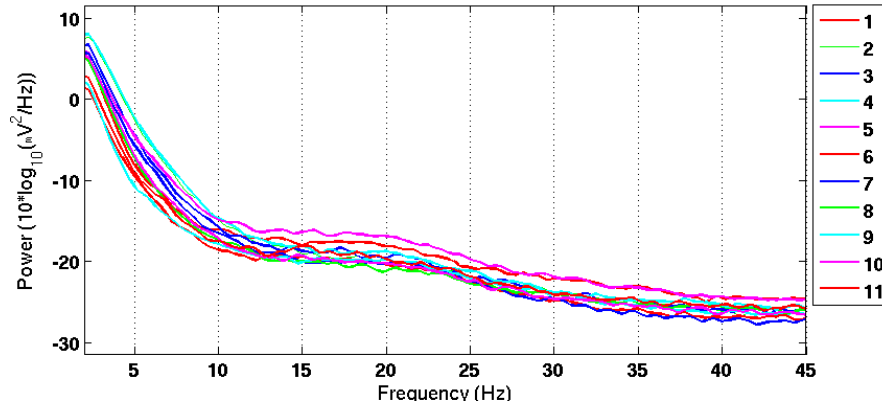
Results (Cluster 2 within subject)

100 % Sessions contribute

INFO:
 Template: CB Session 5 PREPROC:STEP 2; Set 5; IC 1;
 Number of datasets: 11
 Correlation threshold: 0.95 (green line)
 Max ICs from each dataset: 1
 Cluster: 11 ICs from 11 sets
 All datasets contribute.
 Similarity = 0.9999



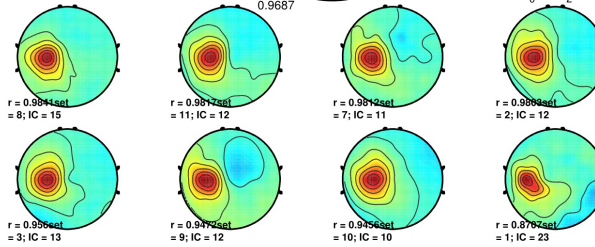
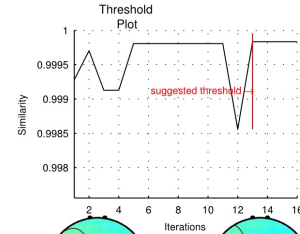
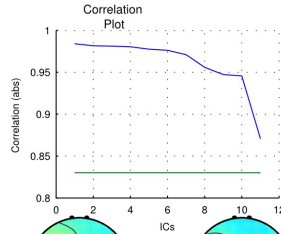
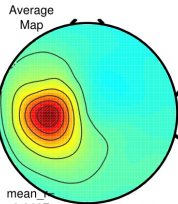
Cls 4 Spectrum



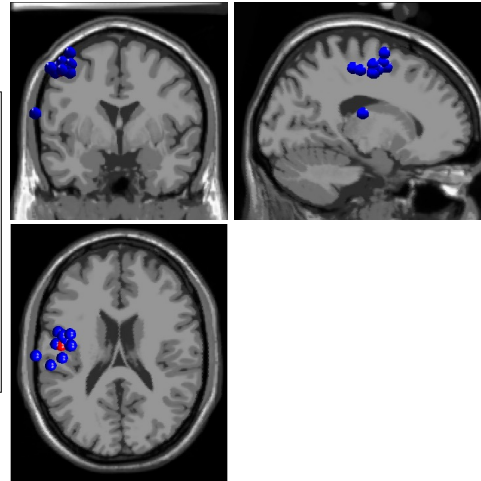
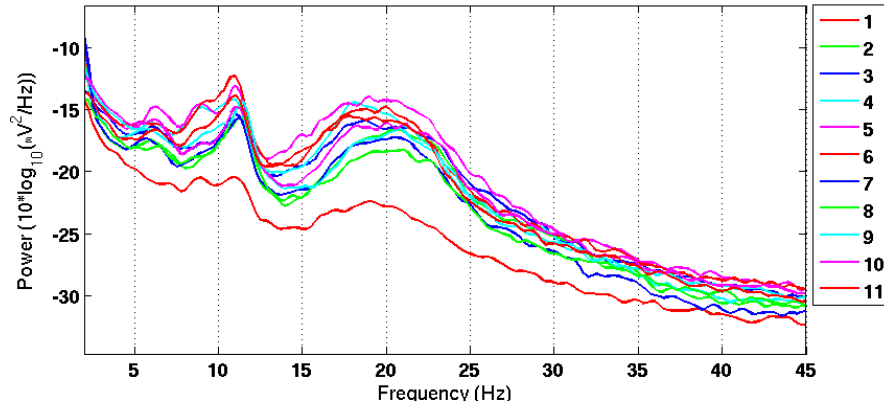
Results (Cluster 8 within subject)

100 % Sessions contribute

INFO:
 Template: CB Session 7 PREPROC:STEP 2; Set 7; IC 11;
 Number of datasets: 11
 Correlation threshold: 0.83 (green line)
 Max ICs from each dataset: 1
 Cluster: 11 ICs from 11 sets
 All datasets contribute.
 Similarity = 0.9998



Cls 8 Spectrum



Results (Cluster 13 within subject)

63.64% Sessions contribute

INFO:

Template: CB Session 2 PREPROC:STEP 2; Set 2; IC 24;

Number of datasets: 11

Correlation threshold: 0.8 (green line)

Max ICs from each dataset: 1

Cluster: 7 ICs from 7 sets

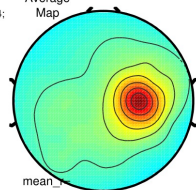
Sets not contributing:

#3; #4; #7; #11;

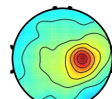
Similarity = 0.9993

Average

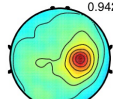
Map



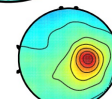
rmean = 0.9425



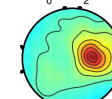
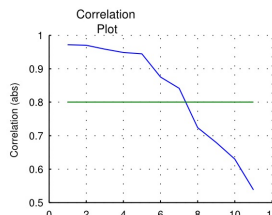
r = 0.9776
= 1; IC = 21



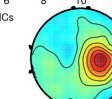
r = 0.9690
= 2; IC = 24



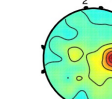
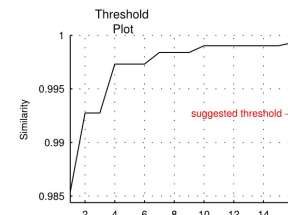
r = 0.9584
= 6; IC = 16



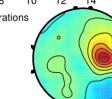
r = 0.9494
= 5; IC = 17



r = 0.9447
= 6; IC = 12

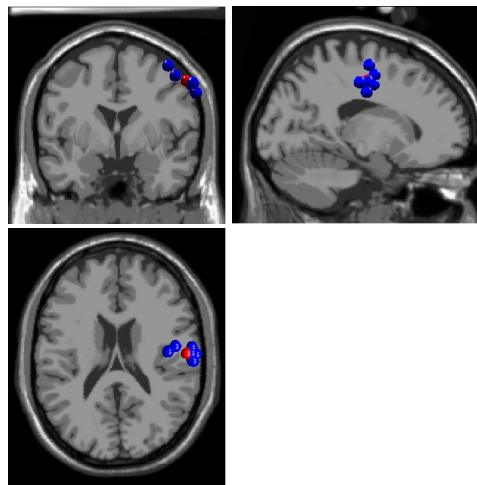
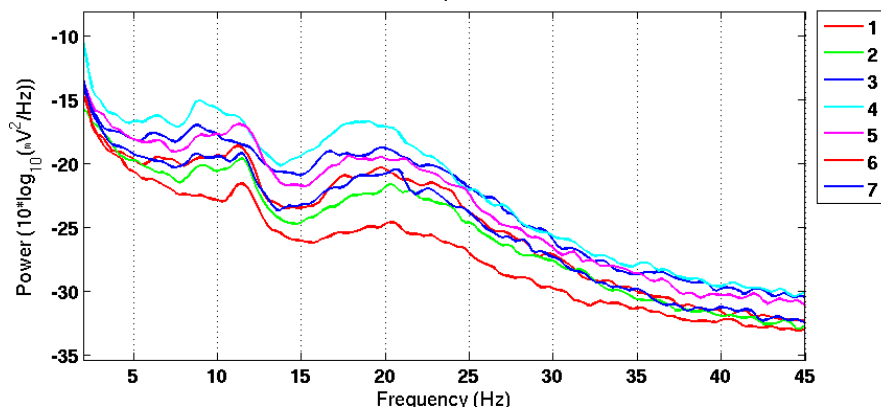


r = 0.8754
= 9; IC = 18



r = 0.8472
= 10; IC = 15

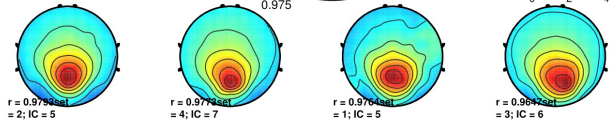
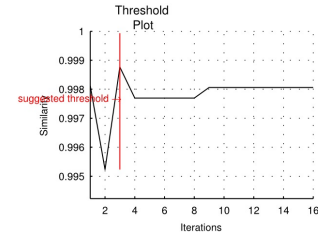
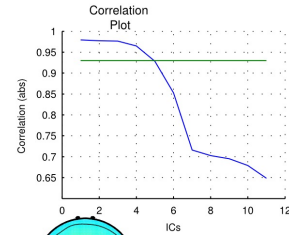
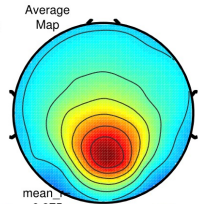
CIs 13 Spectrum



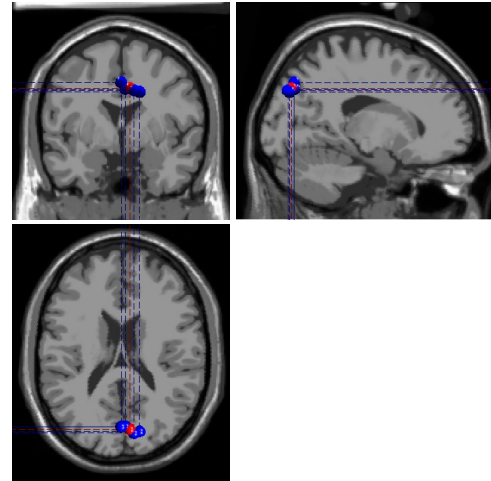
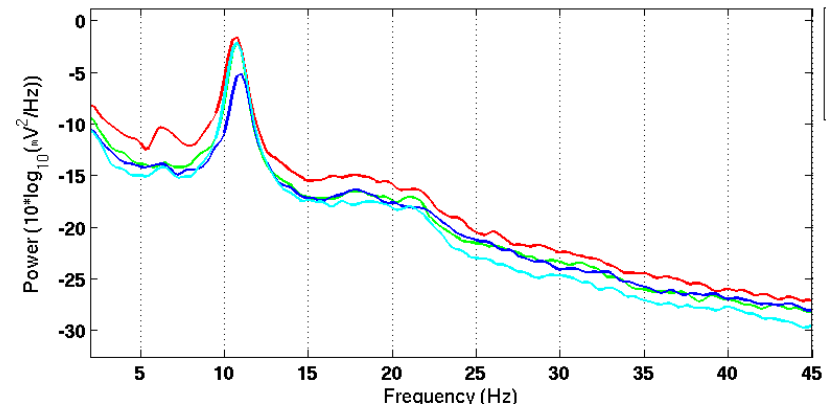
Results (Cluster 14 within subject)

36.36% Sessions contribute

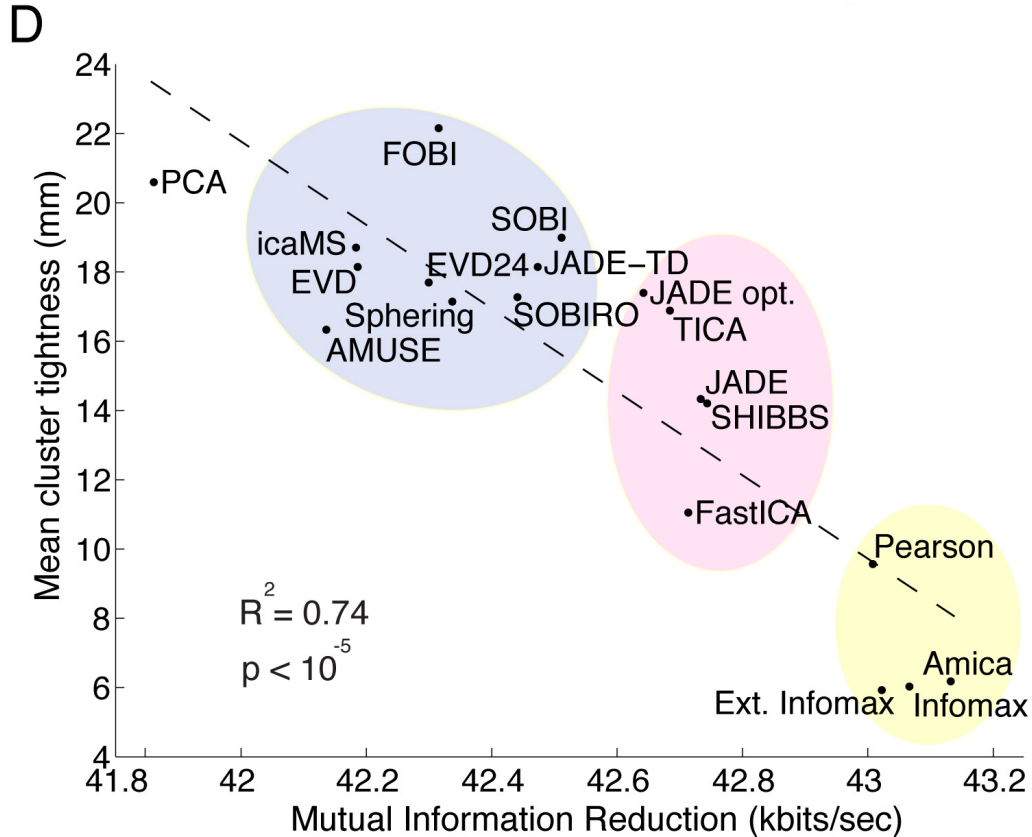
INFO:
Template: CB Session 1 PREPROC:STEP 2; Set 1; IC 5;
Number of datasets: 11
Correlation threshold: 0.93 (green line)
Max ICs from each dataset: 1
Cluster: 4 ICs from 4 sets
Sets not contributing:
#5; #6; #7; #8; #9; #10#11;
Similarity = 0.9988



CIs 14 Spectrum



More independence -> more biological components



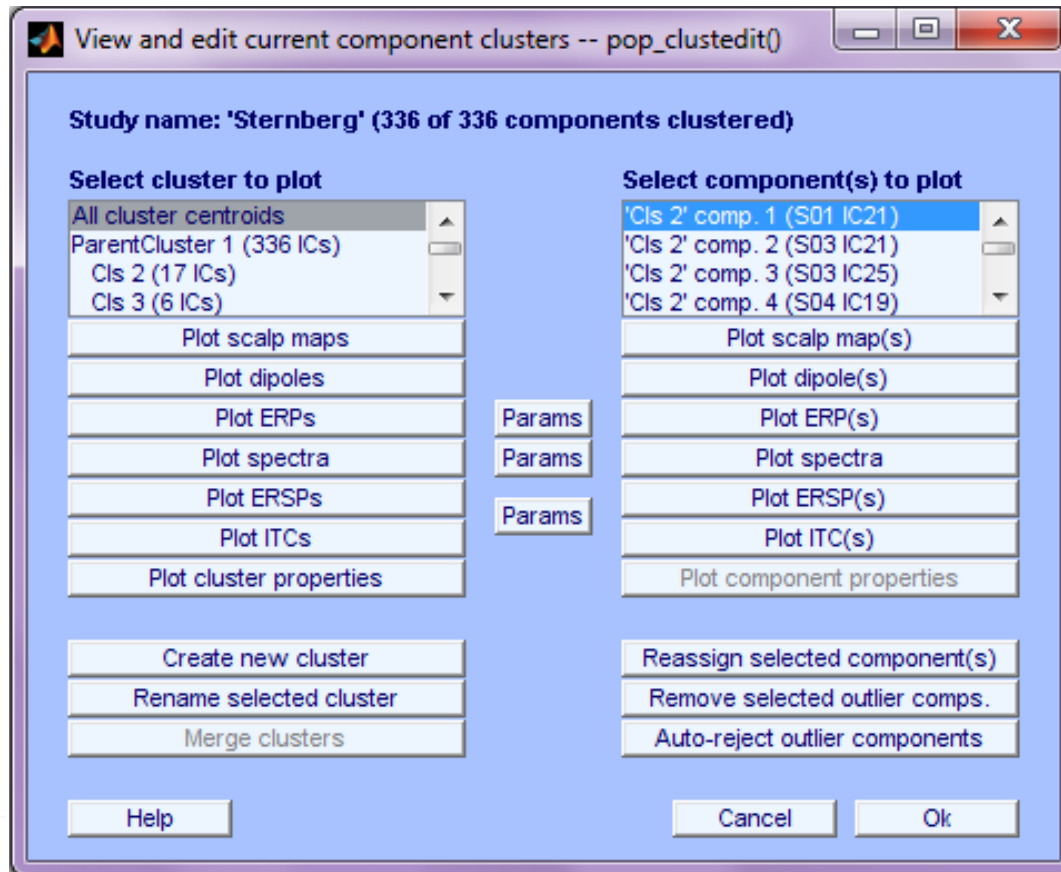
View and edit clusters

The screenshot shows the EEGLAB v15.x (dev) interface. The 'Study' menu is open, displaying options for editing study information, precomputing channel and component measures, and editing/plotting clusters. The 'Edit/plot clusters' option is highlighted. In the background, a window titled 'STUDY set: Sternberg' displays a list of study parameters and their values.

Parameter	Value
Study filename:	
Study task name	
Nb of subjects	
Nb of conditions	
Nb of sessions	
Nb of groups	
Epoch consistency	yes
Channels per frame	69.70.71
Channel locations	yes
Clusters	7
Status	Pre-clustered
Total size (Mb)	229.3



Plot/edit clusters



Plot cluster data

The screenshot shows a software window titled "View and edit current component clusters -- pop_clustedit()". The main area displays "Study 'Attention': 181 of 181 components clustered".

Select cluster to plot:

- All cluster centroids
- ParentCluster 1 (181 ICs)
- outlier 2 (1 ICs)
- Cls 3 (5 ICs)

Select component(s) to plot:

- 'outlier 2' comp. 1 (S12 IC12)
- 'Cls 3' comp. 1 (S01 IC1)
- 'Cls 3' comp. 2 (S05 IC11)
- 'Cls 3' comp. 3 (S06 IC15)

Plotting options:

- Plot scalp maps
- Plot dipoles
- Plot ERPs
- Plot spectra
- Plot ERSPs
- Plot ITCs
- Plot cluster properties

Buttons: Params, Create new cluster, Rename selected cluster, Merge clusters, Save STUDY set to disk (checkbox), Cancel, Help.

Figure 3: Average scalp map for all clusters

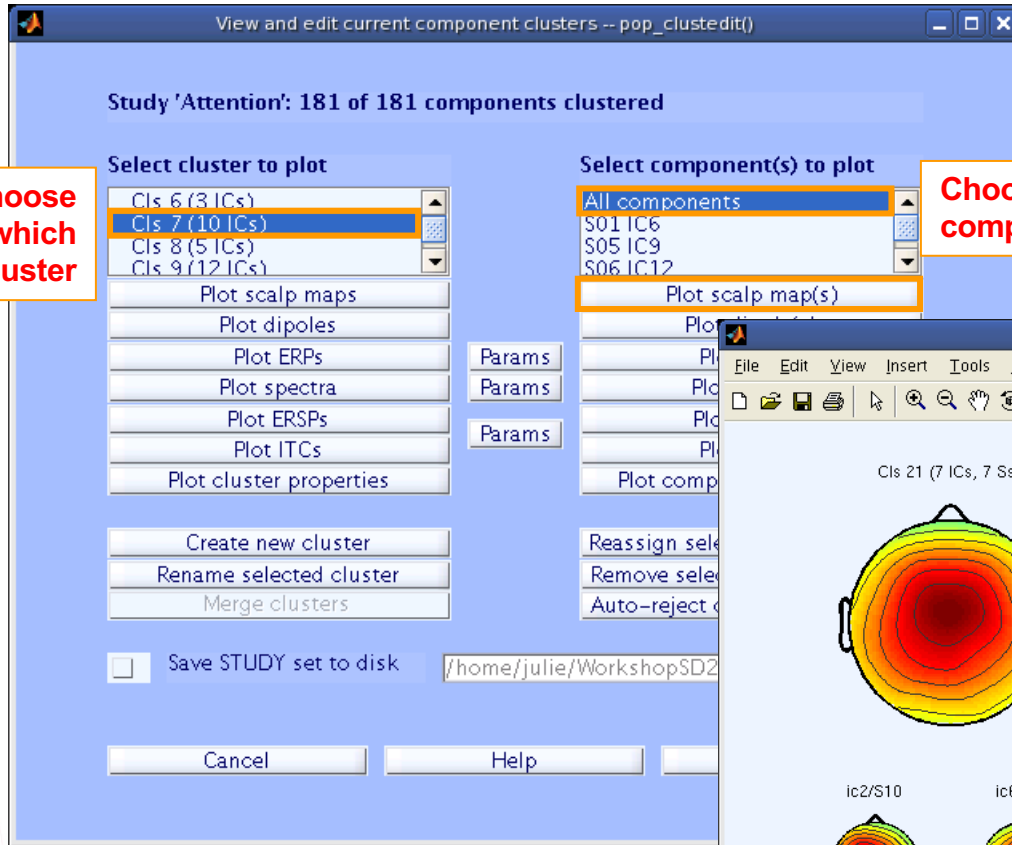
This figure displays a grid of 27 topographic scalp maps, each representing a different cluster. The maps are arranged in a grid with 5 columns and 6 rows. Each map is labeled with its cluster ID and the number of independent components (ICs) and sensors (Ss) it contains. The maps show varying patterns of activity across the scalp, with colors ranging from blue (low activity) to red (high activity).

Cluster ID	ICs	Ss
outlier 2	12	7
Cls 3	4	4
Cls 4	8	8
Cls 5	7	7
Cls 6	3	3
Cls 7	10	6
Cls 8	5	5
Cls 9	12	8
Cls 10	4	4
Cls 11	8	8
Cls 12	3	2
Cls 13	6	4
Cls 14	6	5
Cls 15	14	9
Cls 16	3	3
Cls 17	7	7
Cls 18	4	4
Cls 19	10	8
Cls 20	17	15
Cls 21	6	6
Cls 22	11	8
Cls 23	8	7
Cls 24	7	7
Cls 25	3	3
Cls 26	3	3
Cls 27	1	1

An orange arrow points from the "Plot scalp maps" button in the main window to the "Average scalp map for all clusters" window, which is titled "Figure 3: Average scalp map for all clusters".

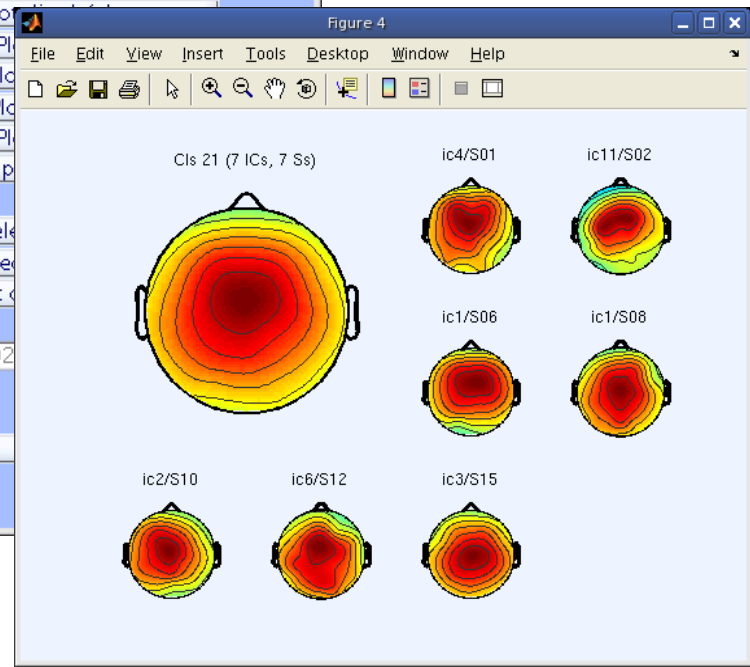
Plot mean scalp maps for easy reference

Plot cluster data



Choose which cluster

Choose which components



Plot cluster data

Cls 3 - 9 sets - 15 components (15 dipoles)

File Edit View Insert Tools Desktop Window Help

16 dipoles:

- Plot one
- Keep|Next
- Next
- Prev
- Keep|Prev
- 1
- S01, IC6
- RV: 2.92%
- X tal: -39
- Y tal: -10
- Z tal: -1

Display:

- Mesh on
- Tight view
- Sagittal view
- Coronal view
- Top view

No controls

edit current component clusters -- pop_clustedit()

memorize vs ignore

Select component to plot

- All components
- S01 IC6
- S01 IC8
- S02 IC8
- S02 IC23
- S02 IC40

STATS

Params Plot dipole(s)

Params Plot ERP(s)

Params Plot spectra

Params Plot ERPImage(s)

Params Plot ERSP(s)

Params Plot ITC(s)

Plot component properties

Create new cluster

Rename selected cluster

Merge clusters

Reassign selected component(s)

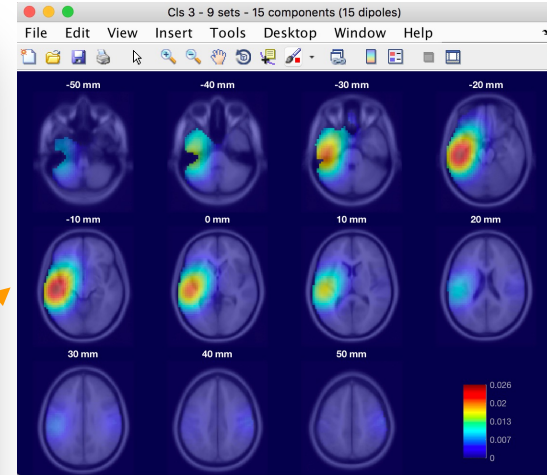
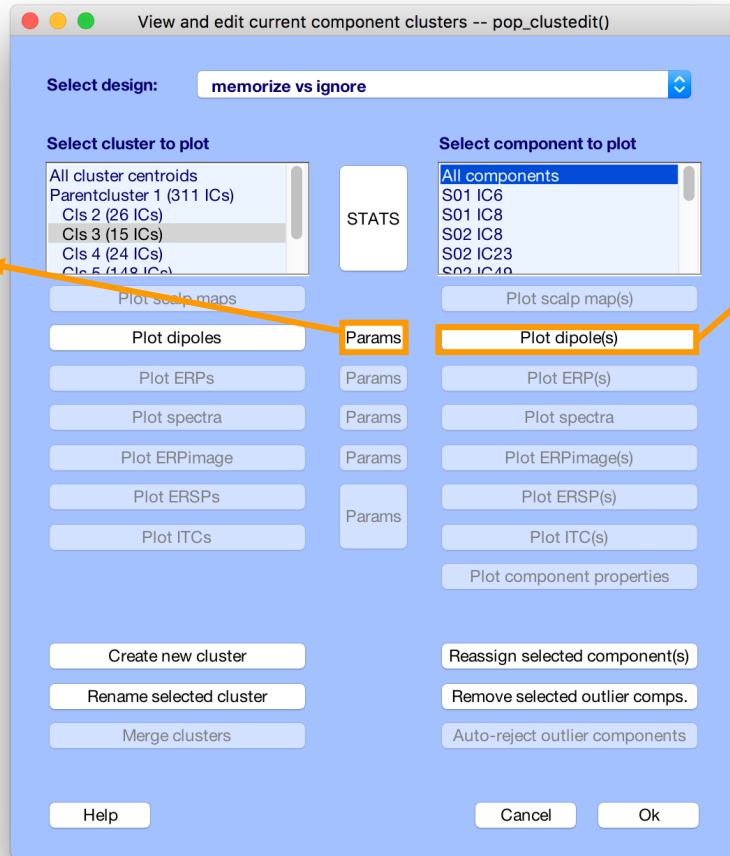
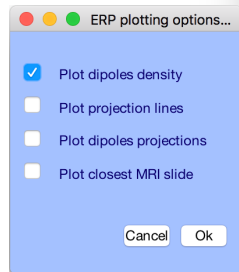
Remove selected outlier comps.

Auto-reject outlier components

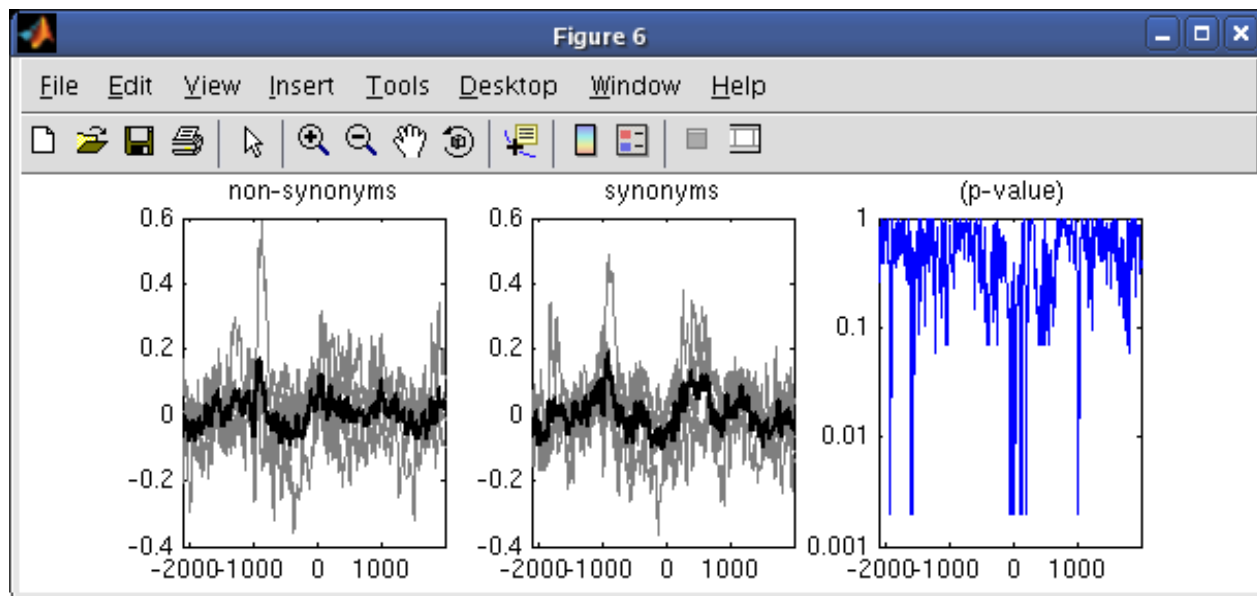
Help Cancel Ok



Plot cluster data



Plot cluster ERP



Exercise

- Load the STUDY in the file henson.study
- Precompute **ERS** for components, scalp topo.
- Precluster and cluster components using **dipole locations (weight =10), ERPs (weight = 1), topo maps (weight = 1)**
- Look at your cluster. Identify frontal midline theta cluster(s) and occipital alpha cluster(s)
- Plot significant difference (parametric statistics) for one component cluster spectrum between conditions

