

Pre-processing pipeline



Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/
down-sample
(if necessary)

High pass filter
(~.5 – 1 Hz)

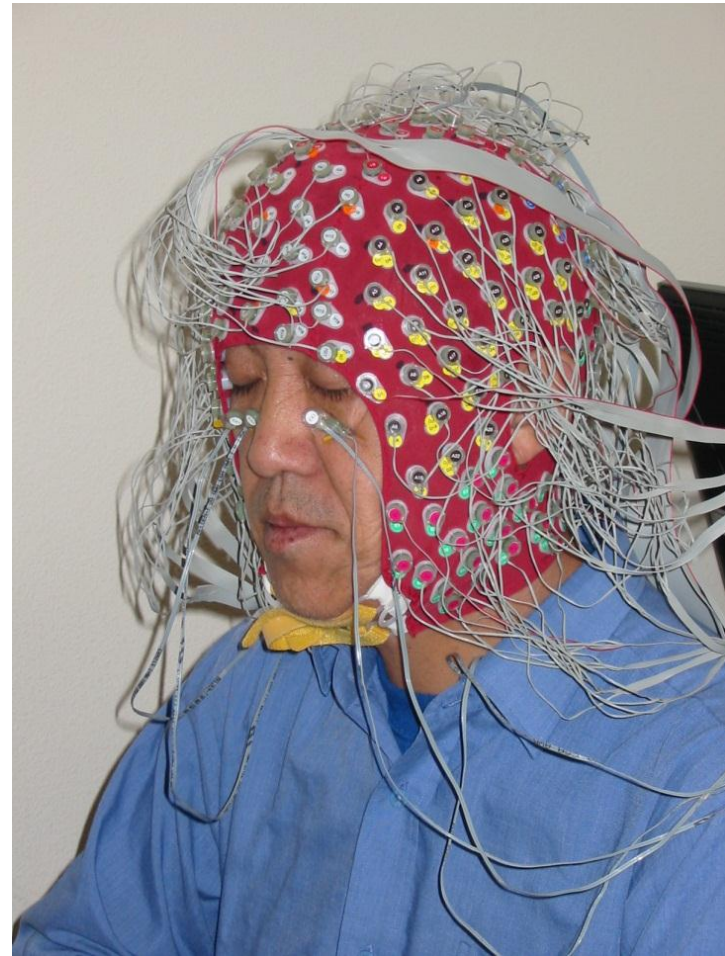
Examine raw data

Reject bad channels

Reject large artifact
time points

Run ICA

Dense-array EEG



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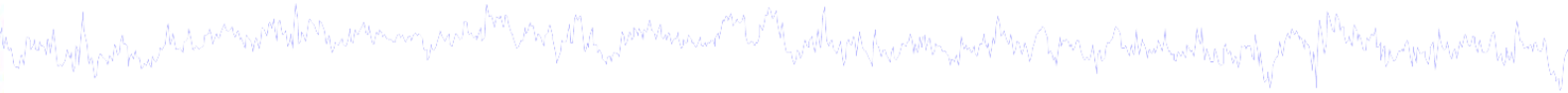
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EEGLAB Matlab toolbox



main graphic interface

EEGLAB Shell - Konsole

Session Edit View Bookmarks Settings Help

```
/home/arno> matlab -nodesktop
```

< M A T L A B >
Copyright 1984-2002 The MathWorks, Inc.
Version 6.5.0.180913a Release 13
Jun 18 2002

Using Toolbox Path Cache. Type "help toolbox_path_cache" for

To get started, type one of these: helpwin, helpdesk, or demo.
For product information, visit www.mathworks.com.

```
>> eeglab
```

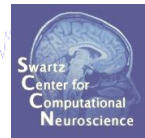
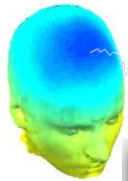
EEGLAB v5.03

File Edit Tools Plot Study Datasets Help

No current dataset

- Create a new or load an existing dataset:
Use "File > Import data" (new)
Or "File > Load existing dataset" (old)
- If new,
"File > Import epoch info" (data epochs) else
"File > Import event info" (continuous data)
"Edit > Dataset info" (add/edit dataset info)
"File > Save dataset" (save dataset)
- Prune data: "Edit > Select data"
- Reject data: "Tools > Reject continuous"
- Epoch data: "Tools > Extract epochs"
- Remove baseline: "Tools > Remove"
- Run ICA: "Tools > Run ICA"

Importing a dataset

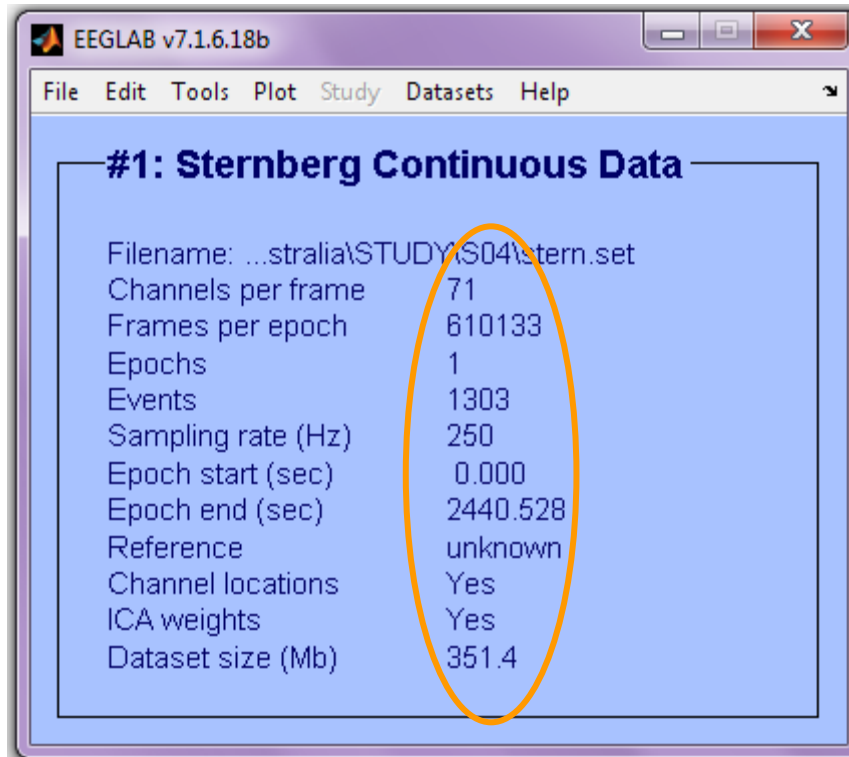
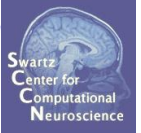
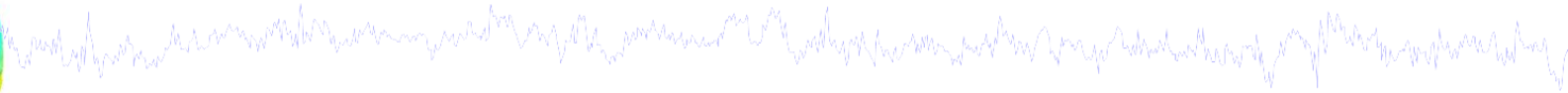
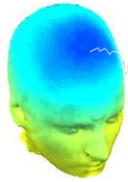


Using EEGLAB functions and plugins	Using the FILE-IO interface	Using the BIOSIG interface	Troubleshooting data formats...
From ASCII/float file or Matlab array	From Netstation .mff (FILE-IO toolbox)	From Netstation binary simple file	From Multiple seg. Netstation files
From Netstation Matlab files	From BCI2000 ASCII file	From Snapmaster .SMA file	From Neuroscan .CNT file
From Neuroscan .EEG file	From Biosemi BDF file (BIOSIG toolbox)	From Biosemi BDF and EDF files (BDF plugin)	From EDF/EDF+/GDF files (BIOSIG toolbox)
From ANT EEProbe .CNT file	From ANT EEProbe .AVR file	From BCI2000 .DAT file	From BIOPAC MATLAB files
From Brain Vis. Rec. .vhdr file	From Brain Vis. Anal. Matlab file	From CTF folder (MEG)	From ERPSS .RAW or .RDF file
From INStep .ASC file	From 4D .m4d pdf file	From Procom Infinity Text File	

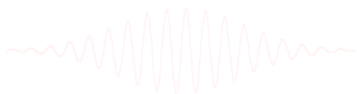
EEGLAB supports many different raw data formats



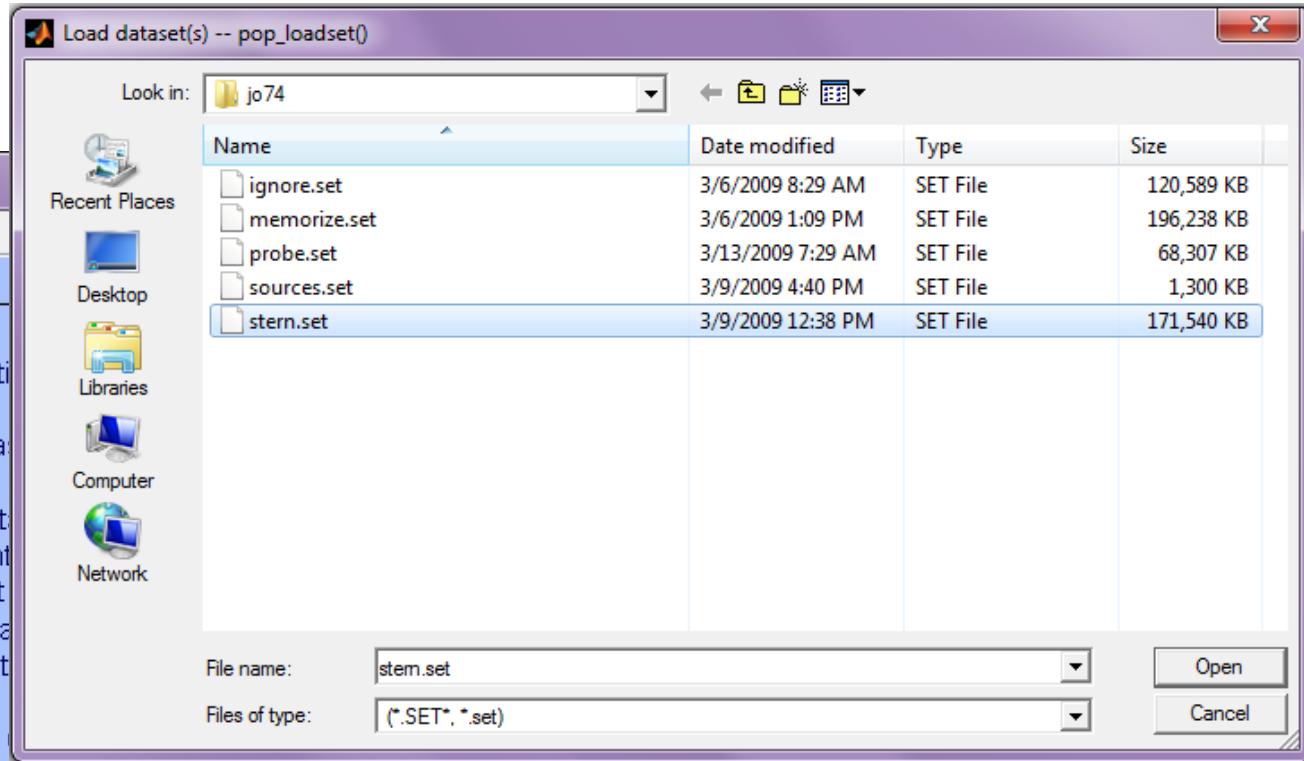
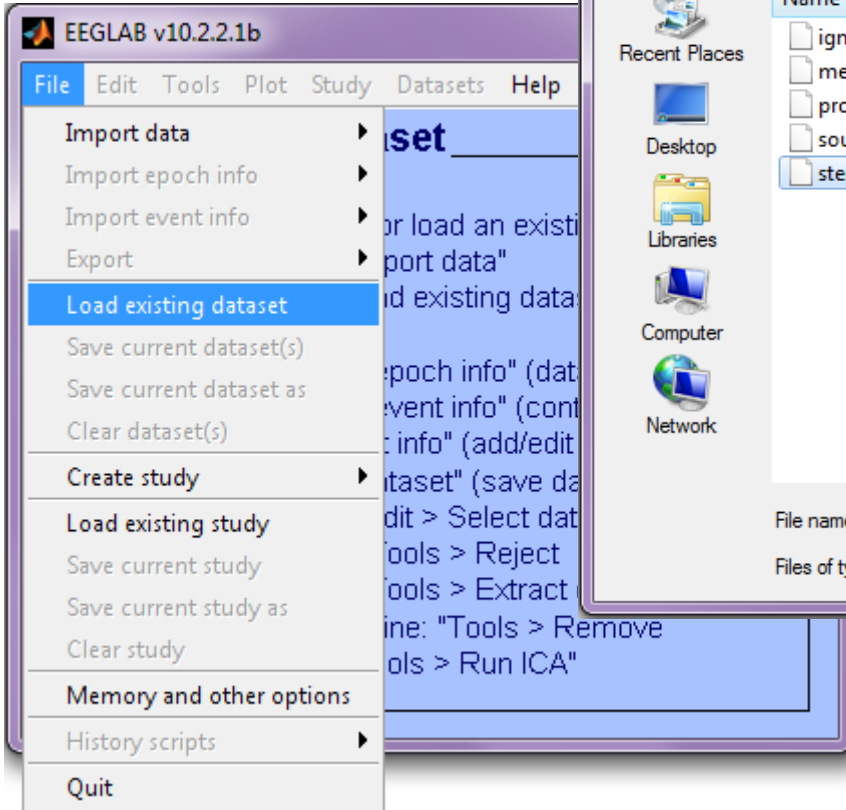
Imported EEG data



EEGLAB GUI
displays dataset
basics



Load an existing dataset



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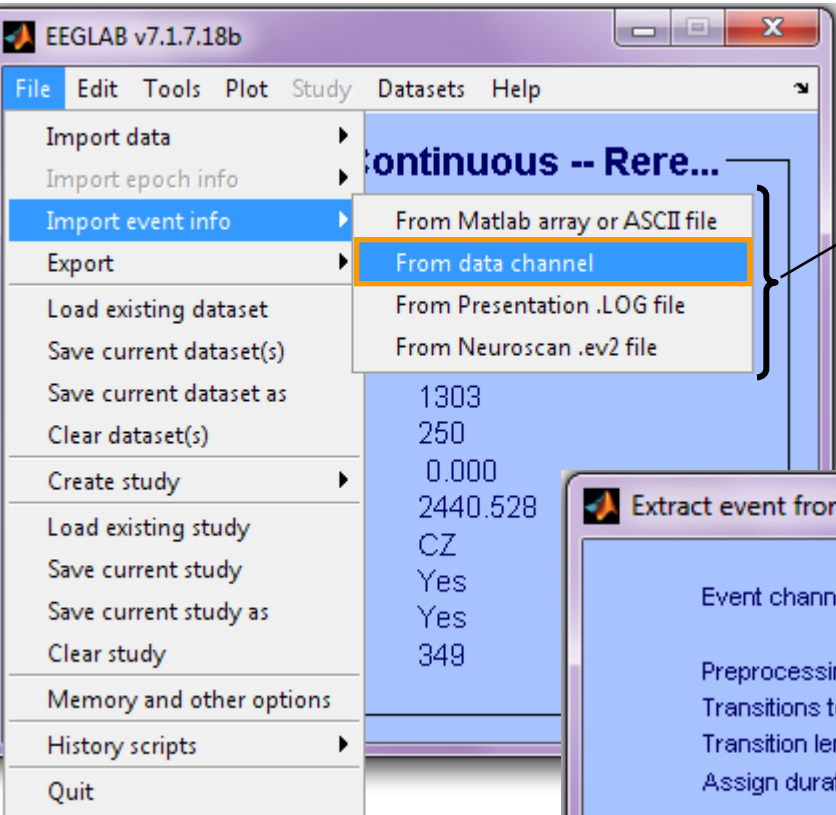
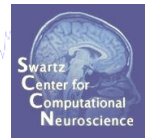
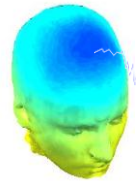
Examine raw data

Reject bad channels

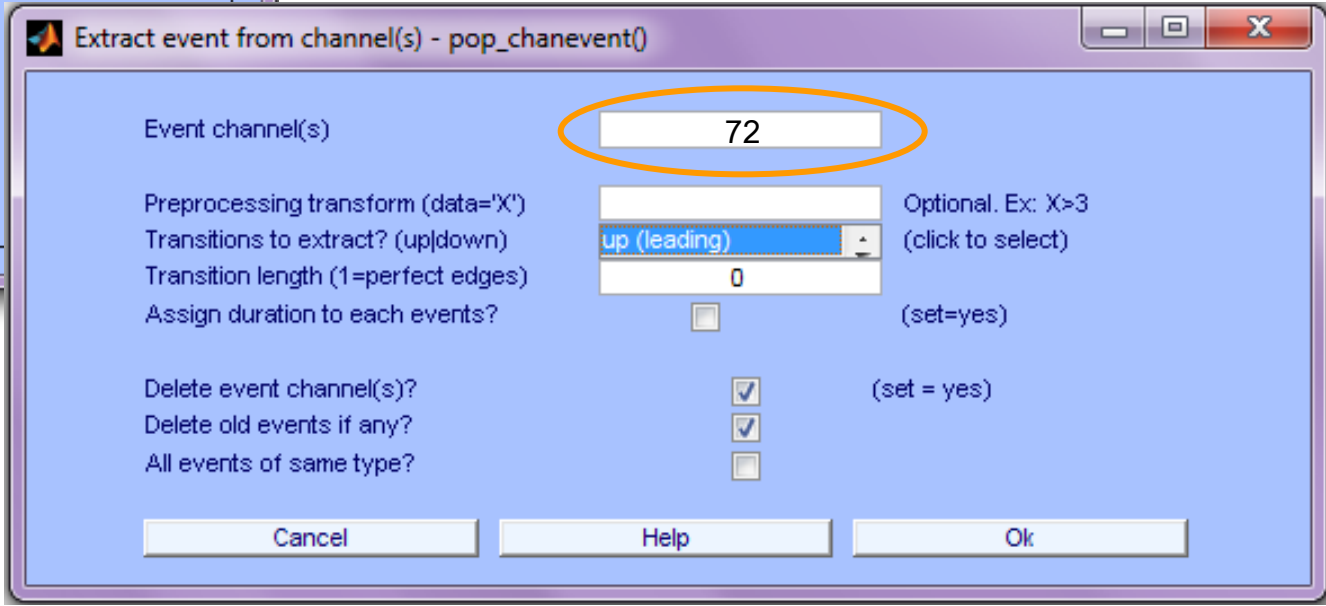
Reject large artifact
time points

Run ICA

Import data events

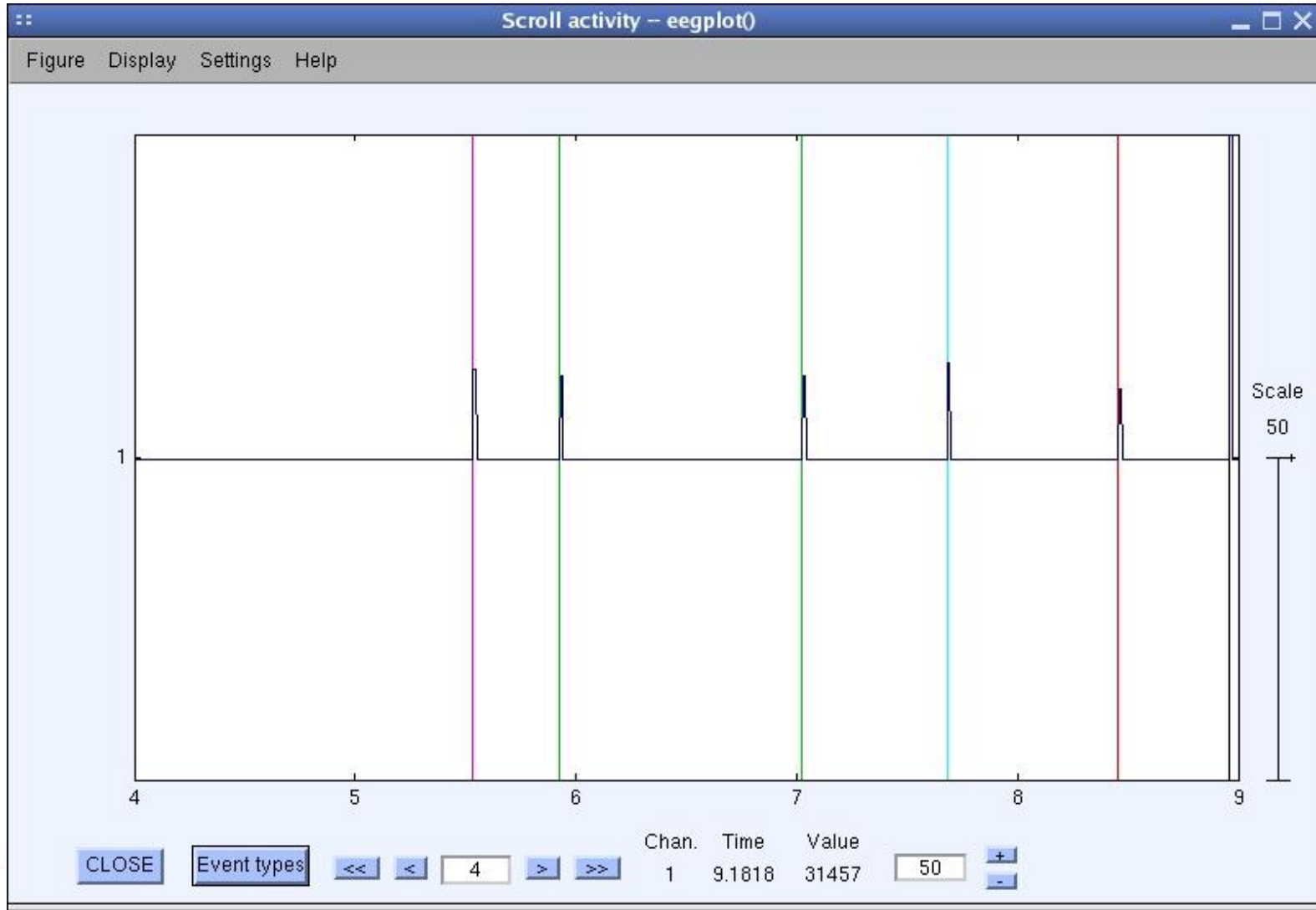
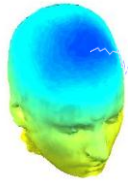


- Import events from Matlab array or ASCII file
- **Import events from data channel**
- Import from Presentation event file
- Import from Neuroscan file



Often imported automatically
during data import

Appearance of an event channel in raw data



Imported data events

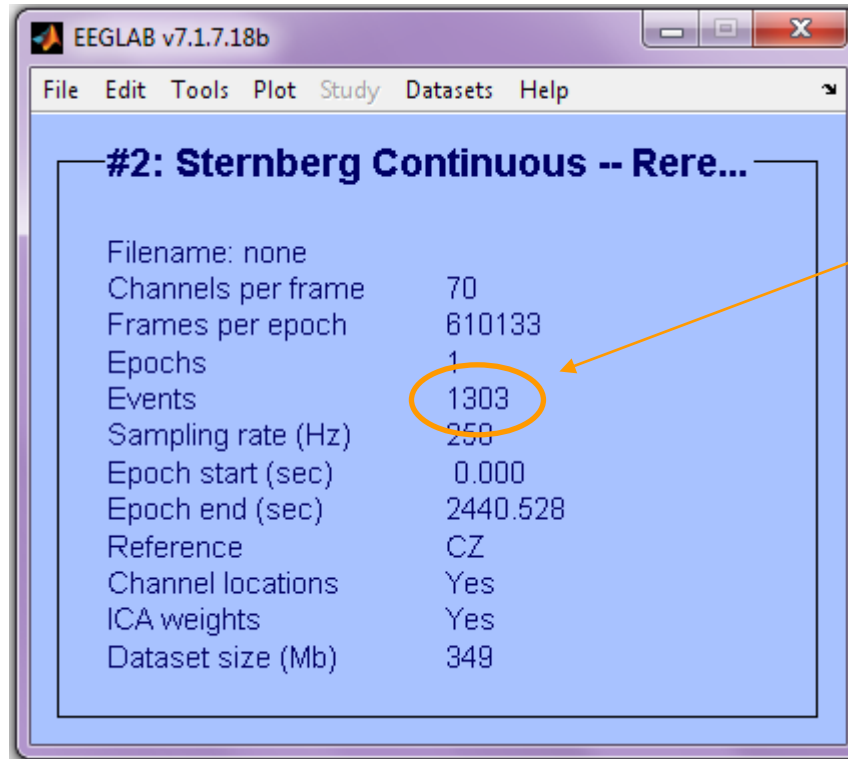


```
>> EEG.event
```

```
ans =
```

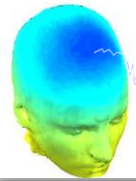
```
1x1303 struct array with fields:
```

```
Trial  
Event_Type  
type  
latency  
TTime  
Uncertainty  
Duration  
Uncertainty2  
ReqTime  
ReqDur  
init_index  
init_time  
urevent  
duration  
load  
rt
```



If event import was successful, you will see an appropriate number here

Review event values



EEGLAB v7.1.7.18b

File Edit Tools Plot Study Datasets Help

- Dataset info
- Event fields
- Event values**
- About this dataset
- Channel locations
- Select data
- Select data using events
- Select epochs or events
- Copy current dataset
- Append datasets
- Delete dataset(s)
- ICA weights
- Dataset size (Mb)

Continuous -- Rere...

70
610133
1
1303
250
0.000
2440.528
CZ
Yes
Yes
349

Edit event values -- pop_editeventvals()

Edit event field values (currently 1303 events)

Trial	1
Event_Type	Picture
Type	nonVMM
Latency (sec)	3.112
Ttime	0
Uncertainty	2
Duration	50283
Uncertainty2	3
ReqTime	0
ReqDur	50000
Init_index	1
Init_time	0.0227
Duration (sec)	0
Load	

Event Num: 1

Insert event << < 1 > >> Append event

Re-order events (for review only)

Main sorting field: No field selected Click for decreasing order

Secondary sorting field: No field selected Click for decreasing order

Re-sort

Cancel Help Ok

Most relevant fields

Number of event fields is unlimited

Delete event

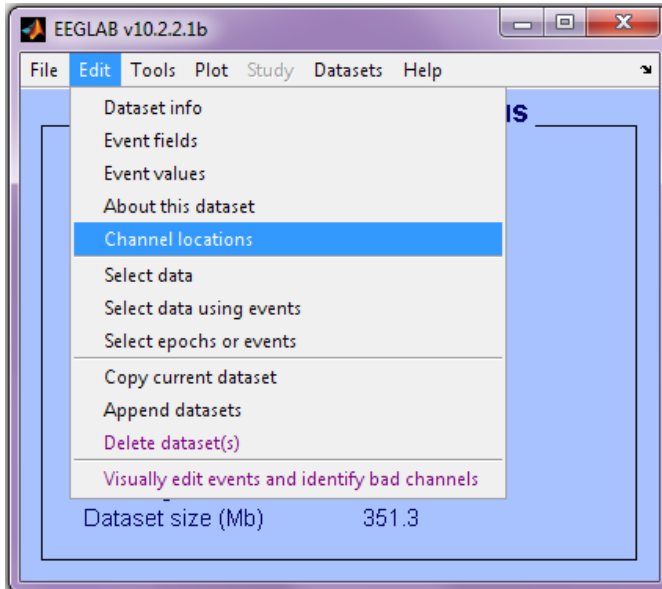
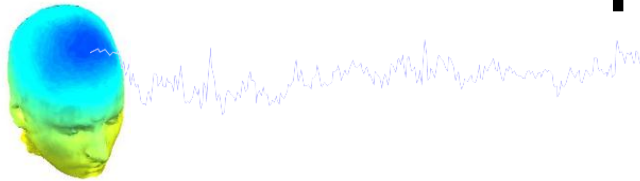
Delete CURRENT event

Append event AFTER current event

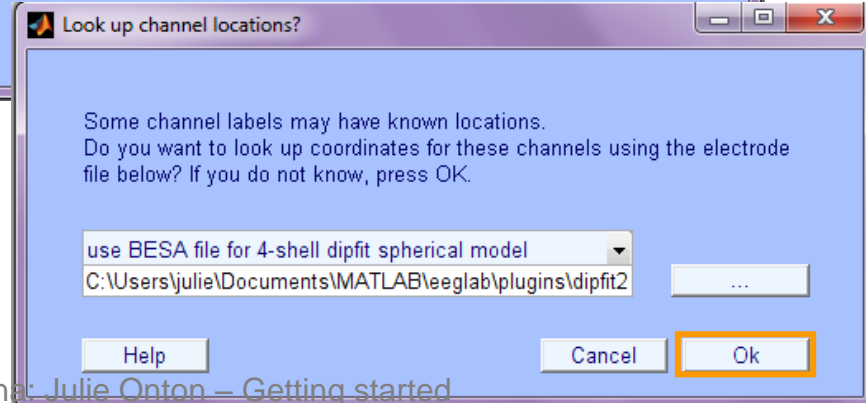
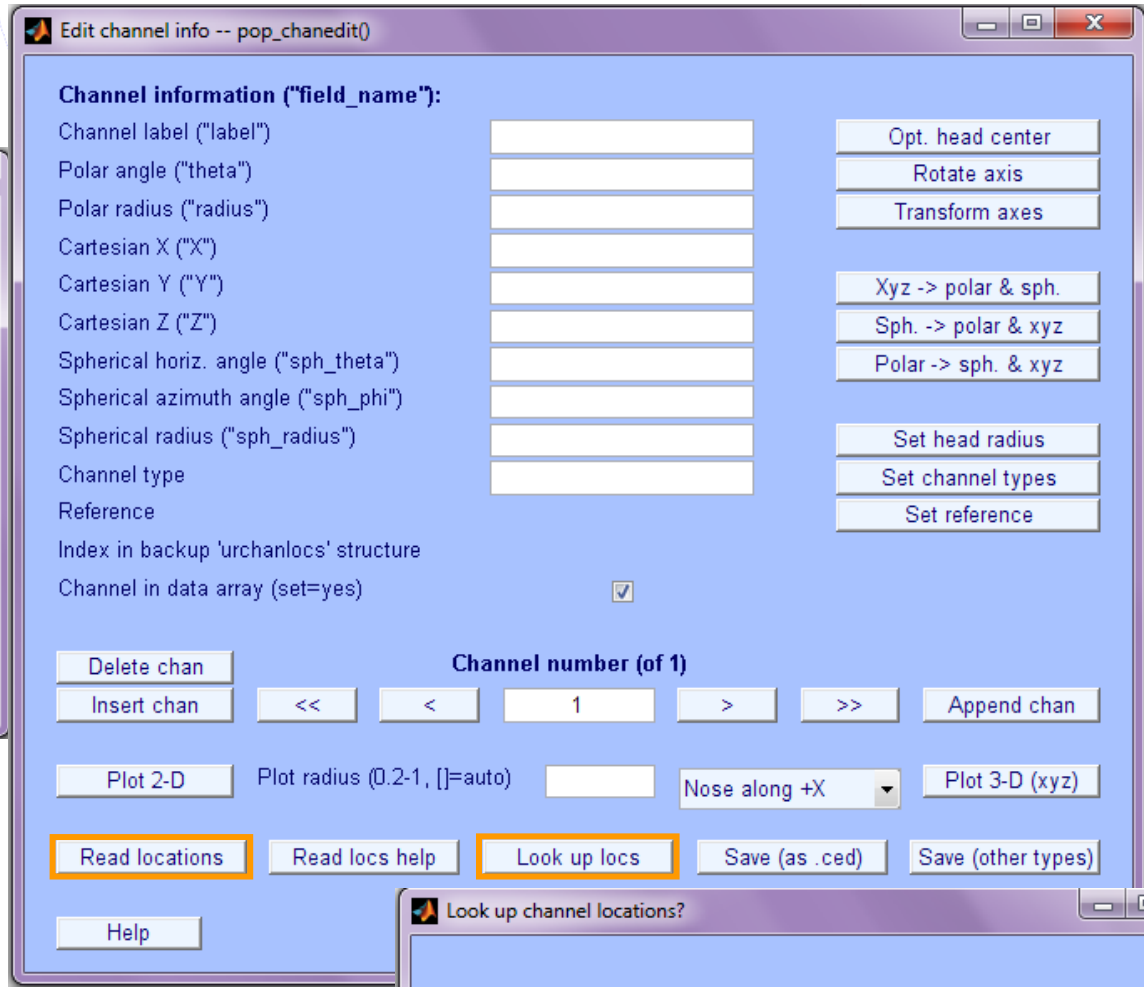
Insert event BEFORE current event

To resort: first select Main sorting field

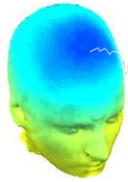
Import channel locations



Several file formats supported (Polhemus, BESA, EI Guide ...)



Import channel locations



Edit channel info -- pop_chanedit()

Channel information ("field_name"):

Channel label ("label")	LEYE
Polar angle ("theta")	-45.1543
Polar radius ("radius")	0.54374
Cartesian X ("X")	0.79487
Cartesian Y ("Y")	0.79917
Cartesian Z ("Z")	-0.15585
Spherical horiz. angle ("sph_theta")	45.1543
Spherical azimuth angle ("sph_phi")	-7.8725
Spherical radius ("sph_radius")	1.1379
Channel type	EEG
Reference	
Index in backup 'urchanlocs' structure	
Channel in data array (set=yes)	<input checked="" type="checkbox"/>

Buttons: Delete chan, Insert chan, Plot 2-D, Read locations, Help

Channel number (of 71)

Buttons: <<, <, 1, >, >>, Append chan

Buttons: Plot radius (0.2-1, [=auto]), Nose along +X, Plot 3-D (xyz)

Buttons: Read locs help, Look up locs, Save (as .ced), Save (other types)

Buttons: Cancel, Ok

Buttons: Opt. head center, Rotate axis, Transform axes, Set head radius, Set channel types, Set reference

Buttons: Xyz -> polar & sph., Sph. -> polar & xyz, Polar -> sph. & xyz

Convert channel locations -- pop_chancenter()

Optimize center location or specify center

Channel indices to ignore for best-sphere matching

Browse

Buttons: Help, Cancel, Ok

Force electrode location -- forclocs()

XY value	Coordinate	Electrode list
<input type="text" value="0"/>	X (rotate X-Z plane)	<input type="text" value="Cz"/> Pick

Buttons: Help, Cancel, Ok

Set channel ...

Channel indices

Type (e.g. EEG)

Buttons: Help, Cancel, Ok

Edit channel info -- pop_chanedit()

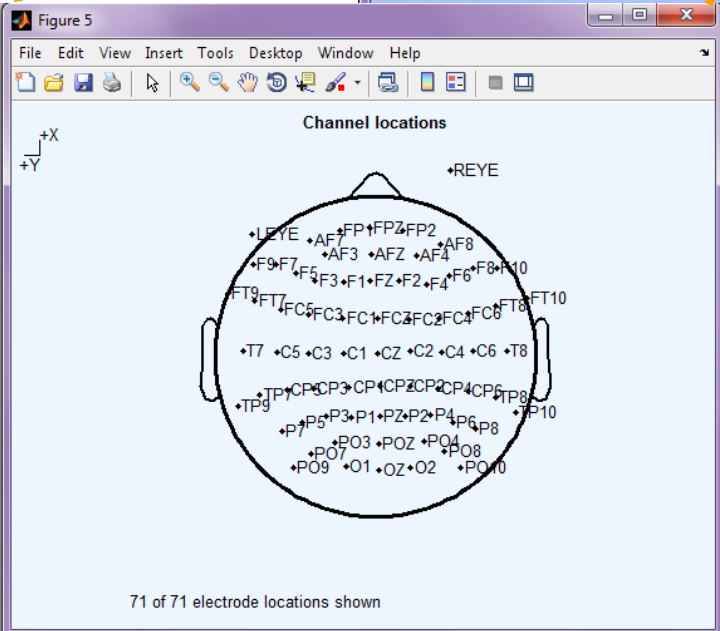
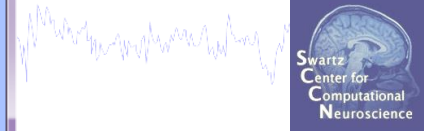
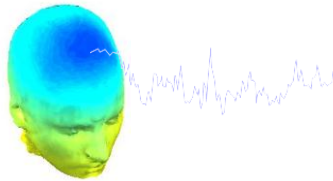
Channel information ("field_name"):

Channel label ("label")	LEYE	Opt. head center
Polar angle ("theta")	-45.1543	Rotate axis
Polar radius ("radius")	0.54374	Transform axes
Cartesian X ("X")	0.79487	XYZ -> polar & sph.
Cartesian Y ("Y")	0.79917	Sph. -> polar & xyz
Cartesian Z ("Z")	-0.15585	Polar -> sph. & xyz
Spherical horiz. angle ("sph_theta")	45.1543	Set head radius
Spherical azimuth angle ("sph_phi")	-7.8725	Set channel types
Spherical radius ("sph_radius")	1.1379	Set reference
Channel type		
Reference		
Index in backup 'urchanlocs' structure		
Channel in data array (set=yes)	<input checked="" type="checkbox"/>	

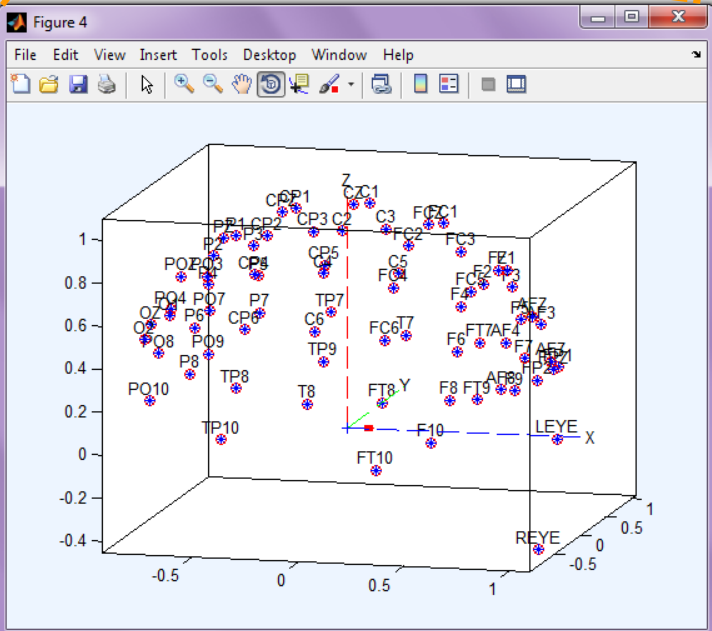
Channel number (of 71): 1

Buttons: Delete chan, Insert chan, <<, <, >, >>, Append chan

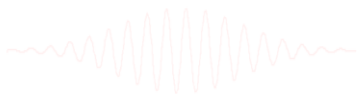
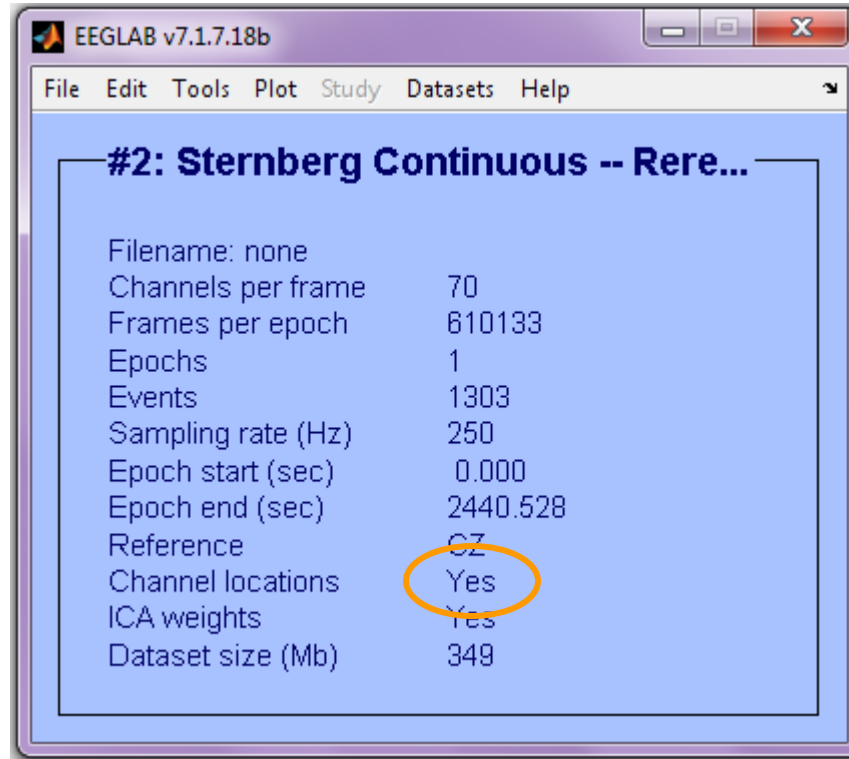
Plot 2-D, Plot radius (0.2-1, [=auto]), Nose along +X, Plot 3-D (xyz)



help Look up locs Save (as .ced) Can



Imported channel locations



Pre-processing pipeline



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(if necessary)

High pass filter
(~.5 – 1 Hz)

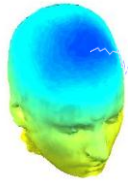
Examine raw data

Reject bad channels

Reject large artifact
time points

Run ICA

Re-reference data (if necessary/desired)



For example,
average reference

EEGLAB v10.2.2.1b

File Edit **Tools** Plot Study Datasets Help

#1

Change sampling rate

Filter the data

Re-reference

Interpolate electrodes

Reject continuous data

Extract epochs

Remove baseline

Run ICA

Remove components

Automatic channel selection

Automatic epoch rejection

Reject data epochs

Reject data using ICA

NFT plugin

SIFT

Locate dipoles using MNE

Peak detection using EEG toolbox

FMRIB Tools

Locate dipoles using LORETA

pop_reref - average reference or re-reference data

Current data reference state is: unknown

Compute average reference

Re-reference data to channel(s):

Retain old reference channels in data

Exclude channel indices (EMG, EOG) optional **LEYE REYE**

Add current reference channel back to the data

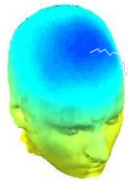
Help Cancel Ok

(use shift|ctrl to select several)

- 1 - LEYE
- 2 - REYE
- 3 - OZ
- 4 - O2
- 5 - FP1
- 6 - FPZ
- 7 - FP2
- 8 - AF7
- 9 - AF3
- 10 - AFZ
- 11 - AF4
- 12 - AF8
- 13 - F9
- 14 - F7
- 15 - F5
- 16 - F3
- 17 - F1
- 18 - FZ
- 19 - F2
- 20 - F4
- 21 - F6
- 22 - F8
- 23 - F10
- 24 - FT9
- 25 - FT7
- 26 - FC5

Cancel Ok

Re-reference data (if necessary/desired)



OR, re-reference to
(i.e.) 'linked mastoids'

EEGLAB v10.2.2.1b

File Edit **Tools** Plot Study Datasets Help

- Change sampling rate
- Filter the data
- Re-reference**
- Interpolate electrodes
- Reject continuous data
- Extract epochs
- Remove baseline
- Run ICA
- Remove components
- Automatic channel selection
- Automatic epoch rejection
- Reject data epochs
- Reject data using ICA
- NFT plugin
- SIFT
- Locate dipoles using...
- Peak detection using...
- FMRIB Tools
- Locate dipoles using LORETA

pop_reref - average reference or re-reference data

Current data reference state is: unknown

- Compute average reference
- Re-reference data to channel(s): TP9 TP10
- Retain old reference channels in data

Exclude channel indices (EMG, EOG)

Add current reference channel back to the data

Help Cancel Ok

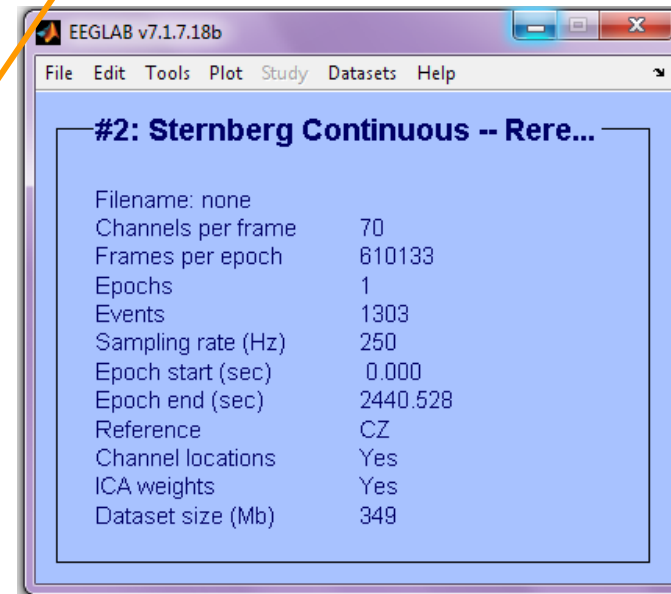
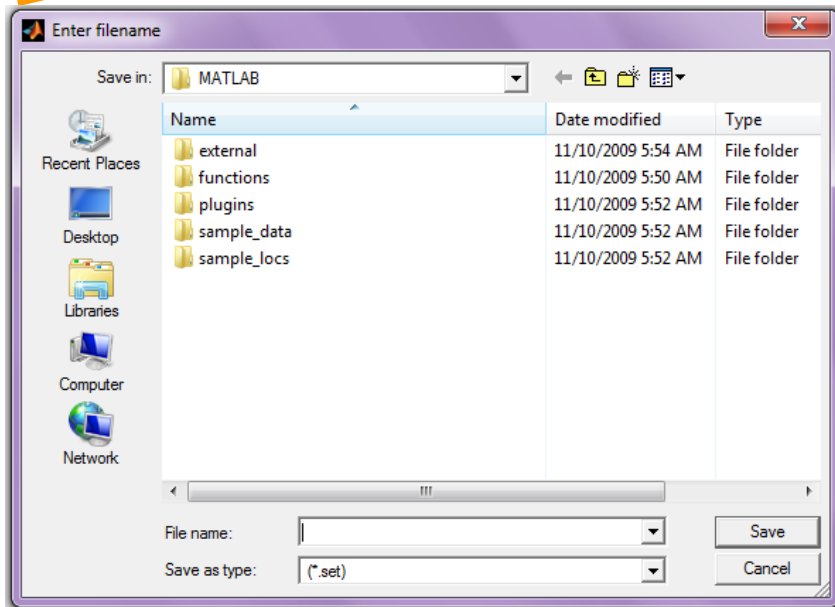
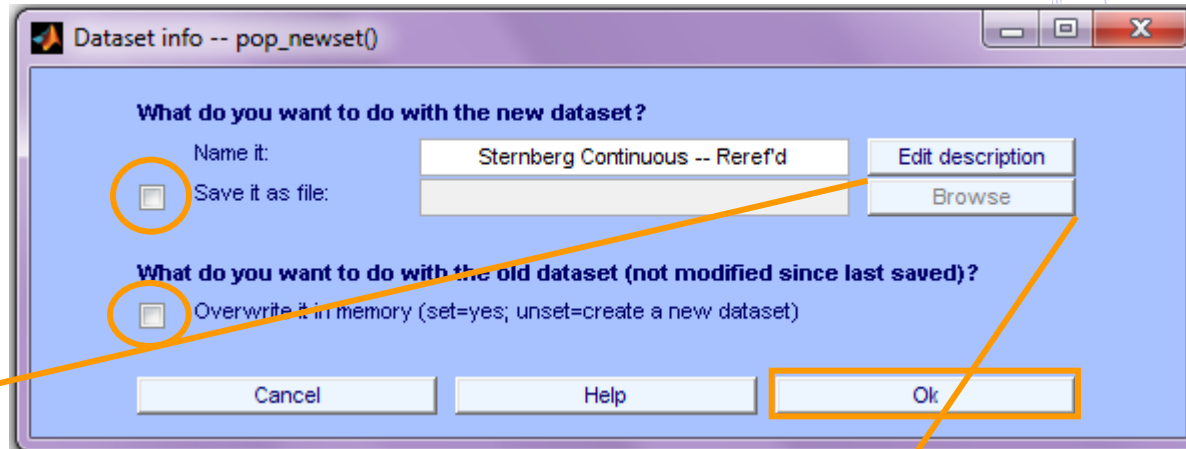
(use shift|ctrl to select several)

- 36 - C5
- 37 - C3
- 38 - C1
- 39 - CZ
- 40 - C2
- 41 - C4
- 42 - C6
- 43 - T8
- 44 - TP9**
- 45 - TP7
- 46 - CP5
- 47 - CP3
- 48 - CP1
- 49 - CPZ
- 50 - CP2
- 51 - CP4
- 52 - CP6
- 53 - TP8
- 54 - TP10**
- 55 - P7
- 56 - P5
- 57 - P3
- 58 - P1
- 59 - PZ
- 60 - P2
- 61 - P4

Cancel Ok

```
EEG = pop_reref( EEG, 39 );
```

Save new dataset, keep old one



```
[ALLEEG EEG CURRENTSET] = pop_newset(ALLEEG, EEG, 1, 'setname', ...  
'Sternberg Continuous -- Reref''d');
```

Multiple active datasets (ALLEEG)



EEGLAB v7.1.6.18b

File Edit Tools Plot Study Datasets Help

#1: Sternberg Continuous Data

Filename:	...ustralia\STUDYS04stern.set
Channels per frame	71
Frames per epoch	610133
Epochs	1
Events	1303
Sampling rate (Hz)	250
Epoch start (sec)	0.000
Epoch end (sec)	2440.520
Reference	unknown
Channel locations	Yes
ICA weights	Yes
Dataset size (Mb)	698

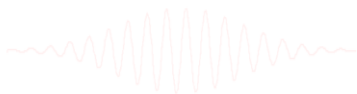
EEGLAB v10.2.4.4b

File Edit Tools Plot Study Datasets Help

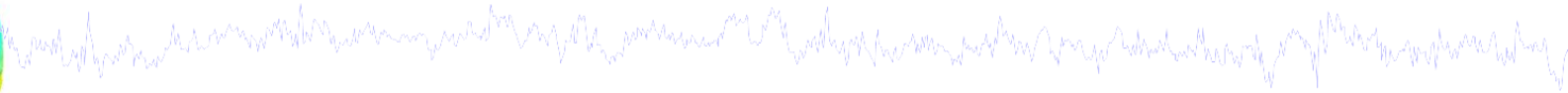
#2: Sternberg C

Filename:	none
Channels per frame	71
Frames per epoch	610133
Epochs	1
Events	1303
Sampling rate (Hz)	250
Epoch start (sec)	0.000
Epoch end (sec)	2440.520
Reference	average
Channel locations	Yes
ICA weights	No
Dataset size (Mb)	351.3

Dataset 1:Sternberg Continuous Data
✓ Dataset 2:Sternberg Continuous -- Reref'd
Select multiple datasets



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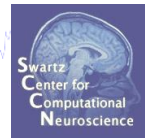
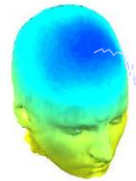
Examine raw data

Reject bad channels

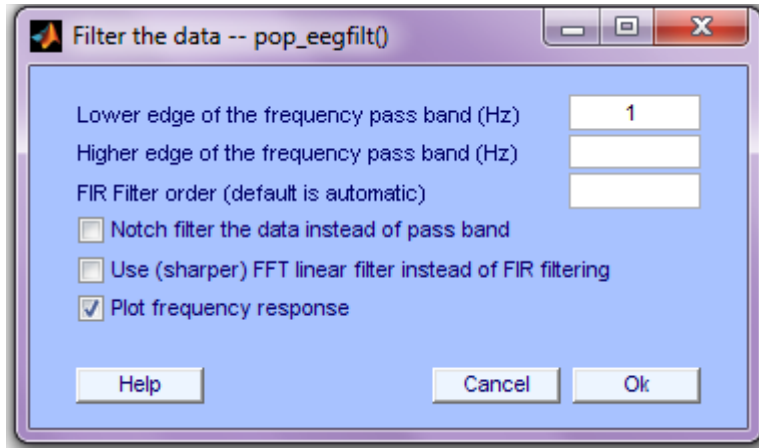
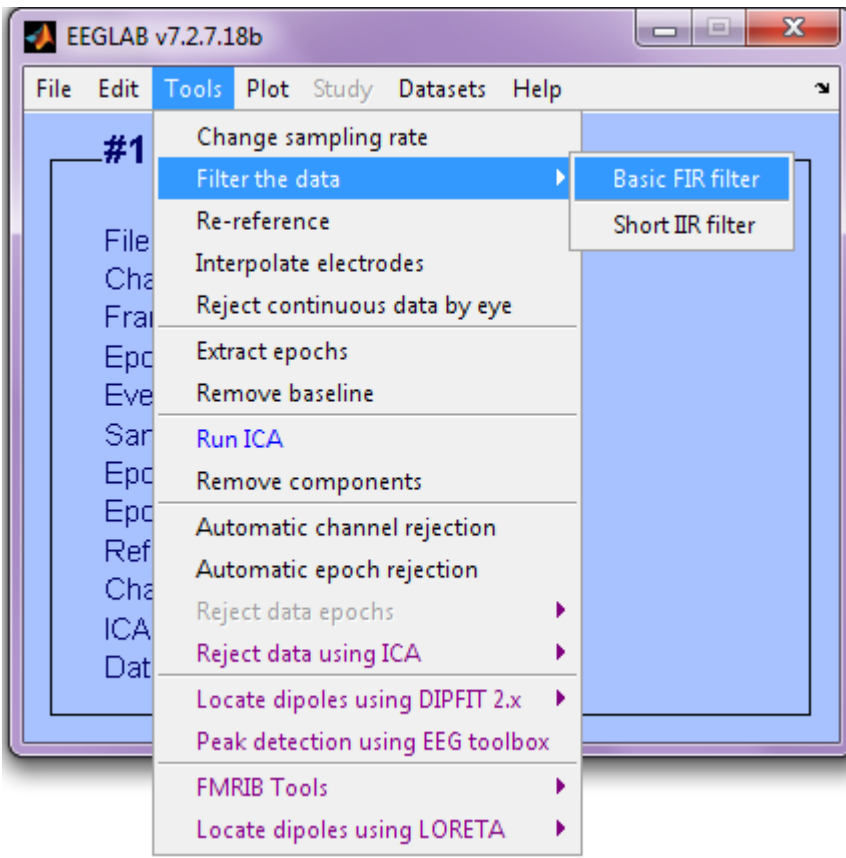
Reject large artifact
time points

Run ICA

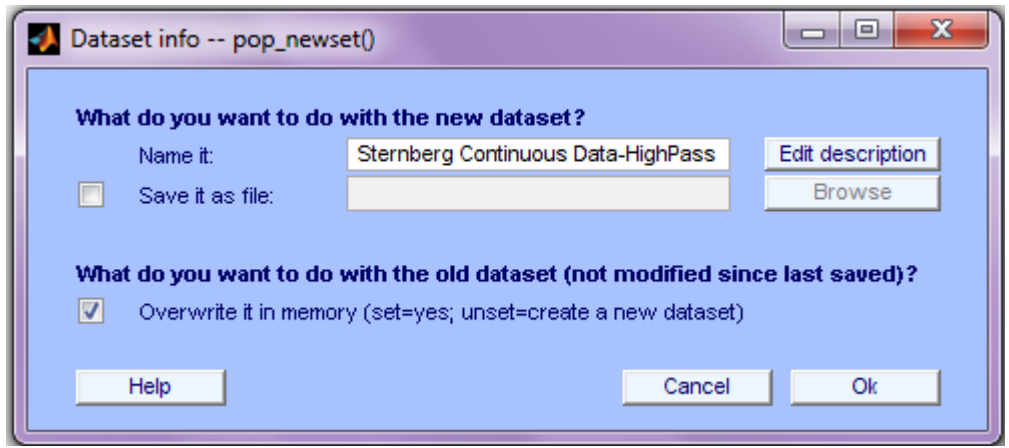
Filter the data (if necessary/desired)



Lower cut off frequencies require longer stretches of continuous data



High-pass needed for ICA



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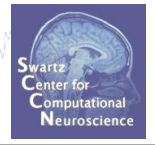
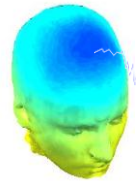
Examine raw data

Reject bad channels

Reject large artifact
time points

Run ICA

Scroll channel data



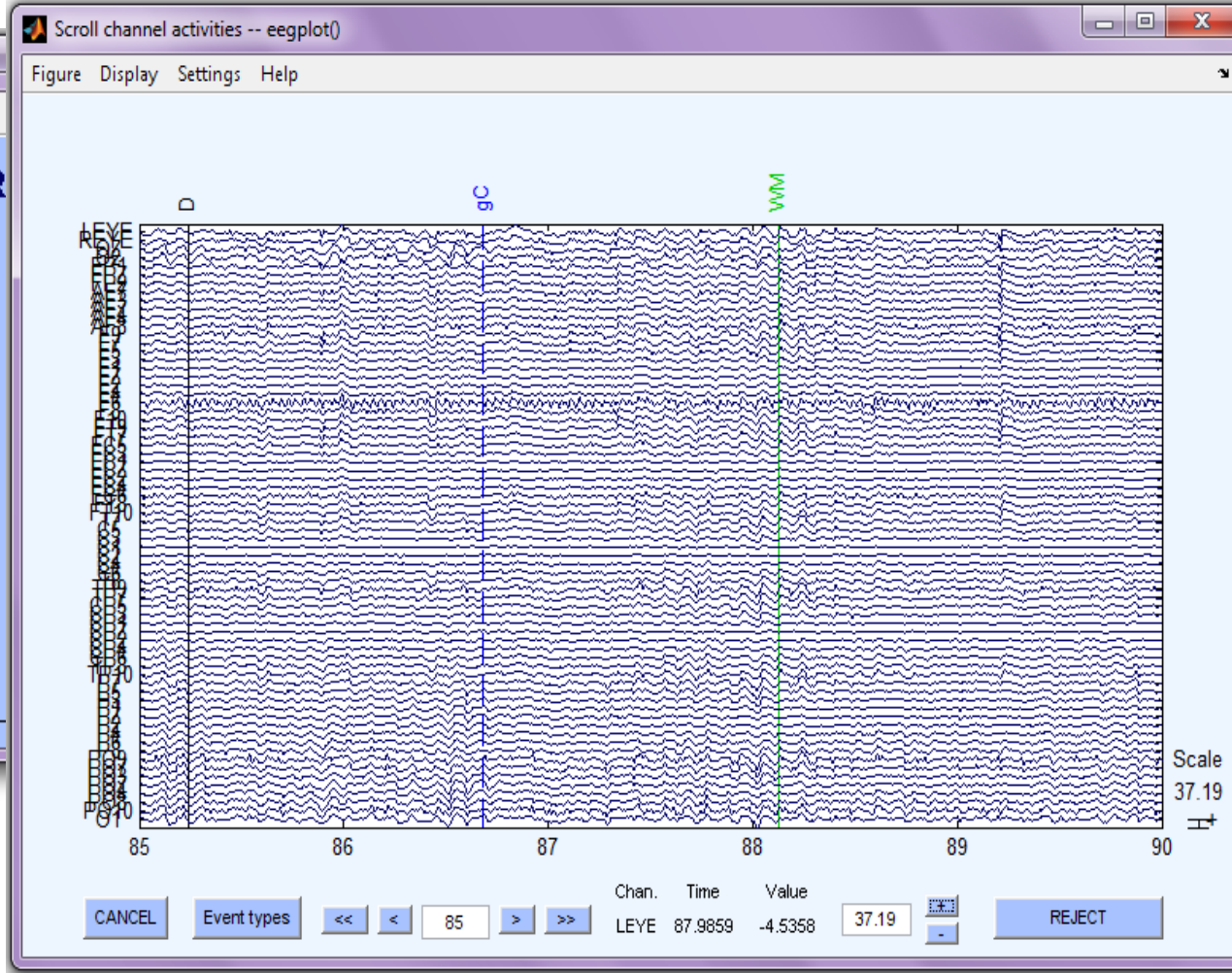
EEGLAB v7.1.7.18b

File Edit Tools **Plot** Study Datasets Help

#2: Step

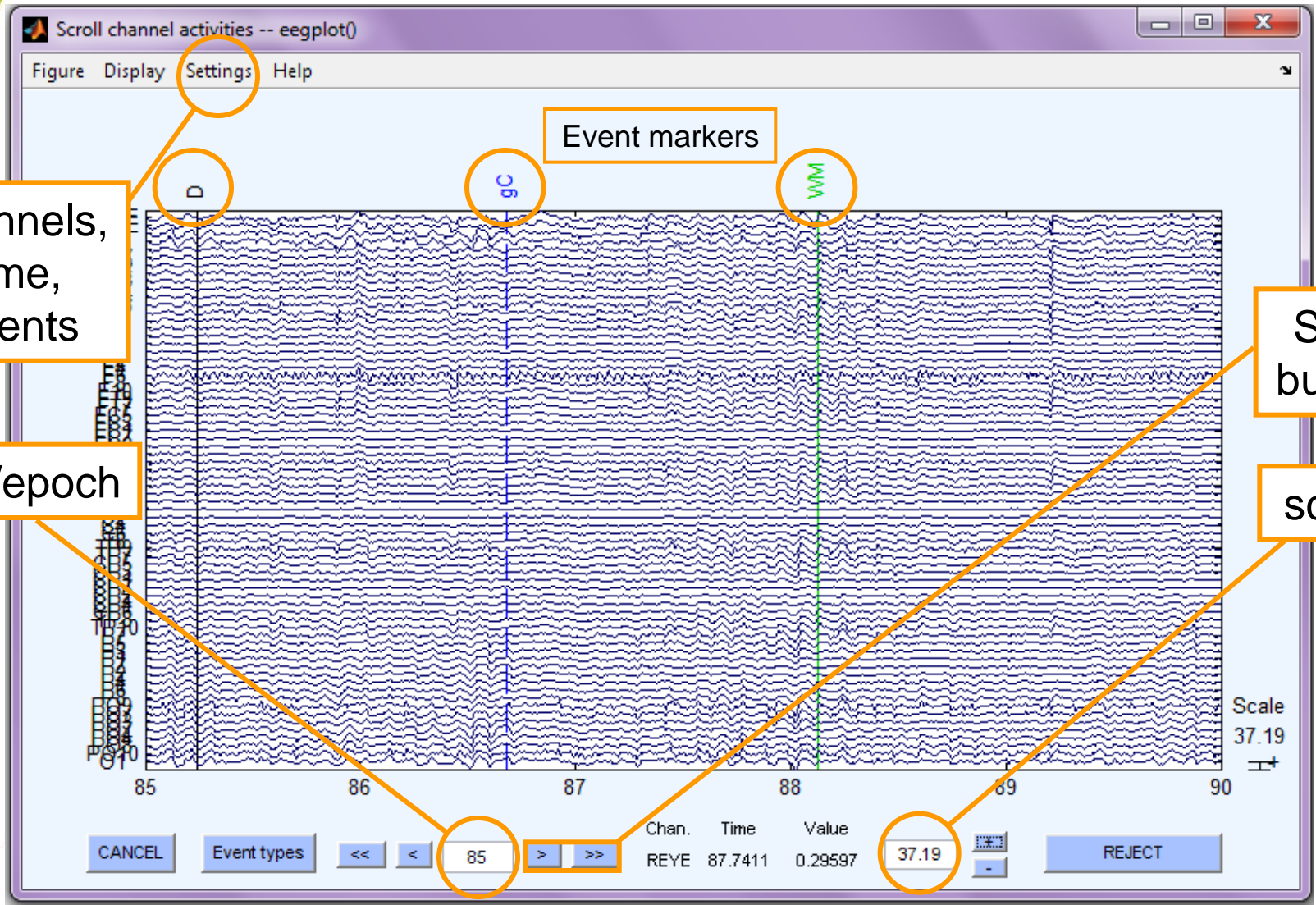
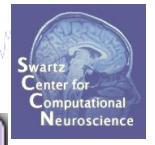
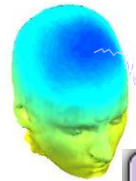
- Channel locations
- Channel data (scroll)**
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Sum/Compare ERPs
- Component activations (scroll)
- Component spectra and maps
- Component maps
- Component properties
- Component ERP image
- Component ERPs
- Sum/Compare comp. ERPs
- Data statistics
- Time-frequency transforms
- Cluster dataset ICs

Filename:
Channels
Frames per
Epochs
Events
Sampling r
Epoch sta
Epoch end
Reference
Channel lo
ICA weight
Dataset si



```
>> pop_eegplot(EEG,1,1,1);
```

Scroll channel data



Pre-processing pipeline



Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/
down-sample
(if necessary)

High pass filter
(~.5 – 1 Hz)

Examine raw data

Reject bad channels

Reject large artifact
time points

Run ICA

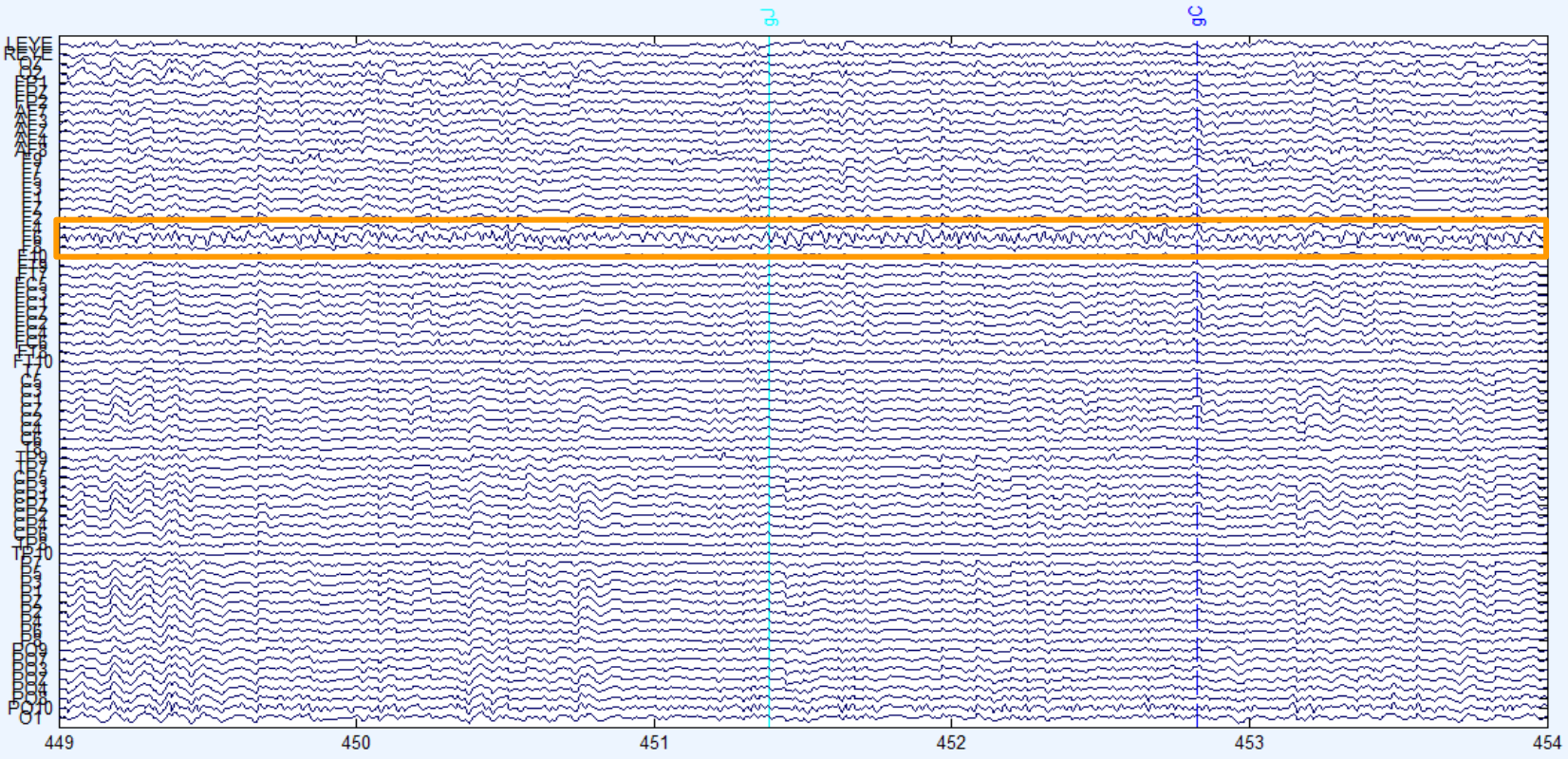
Remove channel



Scroll channel activities -- eegplot()

Figure Display Settings Help

1) Identify bad channel

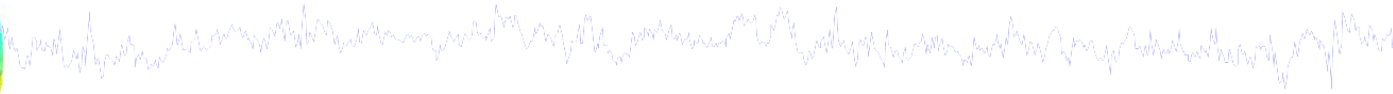


Scale
35

CANCEL Event types << < 449 > >> Chan. Time Value 35 + - REJECT

Chan.	Time	Value
01	451.0988	3.6619

Remove channel(s)



EEGLAB v7.1.7.18b

File Edit Tools Plot Study Datasets Help

Dataset info
Event fields
Event values
About this dataset
Channel locations
Select data
Select data using events
Select epochs or events
Copy current dataset
Append datasets
Delete dataset(s)

Continuous Data

Data\stern.set
71
610133
1
1303
250
0.000
2440.528
unknown
Yes
Yes
351.4

(use shift(ctrl) to select several)

- 1 - LEYE
- 2 - REYE
- 3 - OZ
- 4 - O2
- 5 - FPZ
- 6 - FPZ
- 7 - FP2
- 8 - AF7
- 9 - AF3
- 10 - AFZ
- 11 - AF4
- 12 - AF8
- 13 - F9
- 14 - F7
- 15 - F5
- 16 - F3
- 17 - F1
- 18 - FZ
- 19 - F2
- 20 - F4
- 21 - F6**
- 22 - F8
- 23 - F10
- 24 - FT9
- 25 - FT7
- 26 - FC5
- 27 - FC2

Cancel Ok

Select data -- pop_select()

Select data in: Input desired range on

Time range [min max] (s)

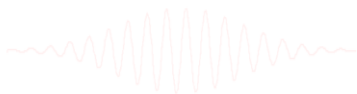
Point range (ex: [1 10])

Epoch range (ex: 3:2:10)

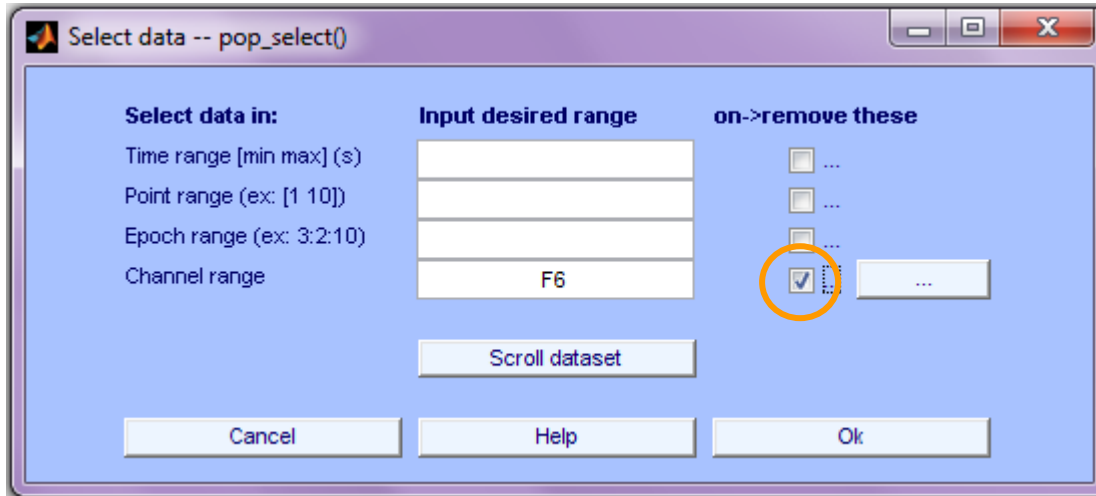
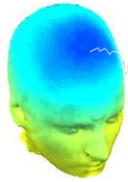
Channel range

Scroll dataset

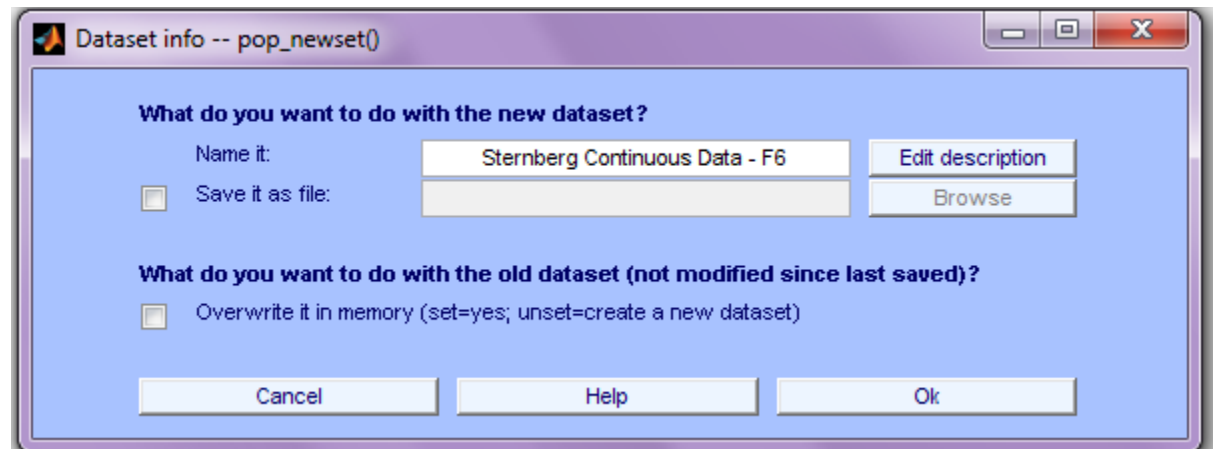
Cancel Help Ok



Removing channel(s)



If not checked, will result in dataset with one channel

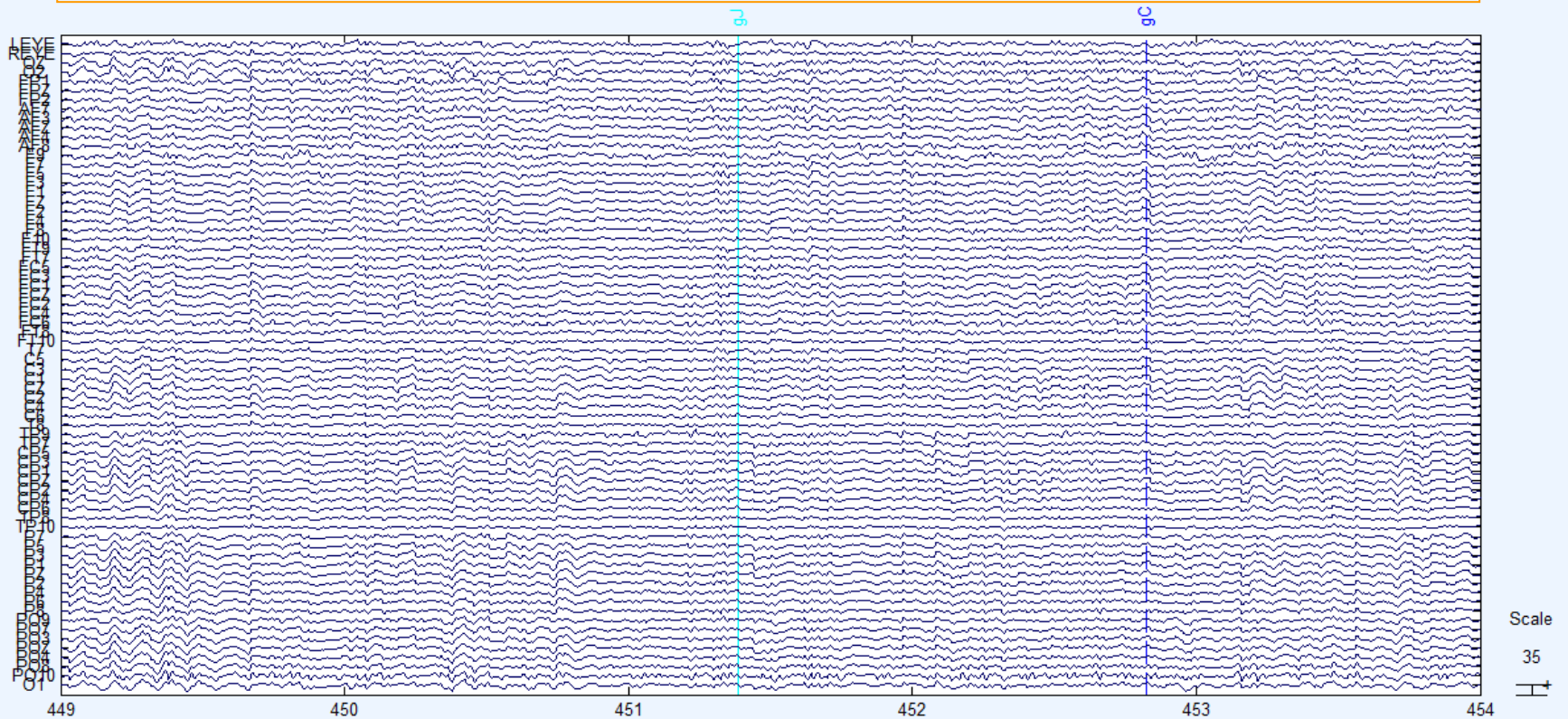


Channel removed



Scroll channel activities -- eegplot() Figure Display Settings Help

Channel data without 'F6' (see supplementary material for interpolation)



CANCEL Event types << < 449 > >> Chan. Time Value 35 + - REJECT

Chan.	Time	Value
P8	453.5014	4.1308

Pre-processing pipeline



Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/
down-sample
(if necessary)

High pass filter
(~.5 – 1 Hz)

Examine raw data

Reject bad channels

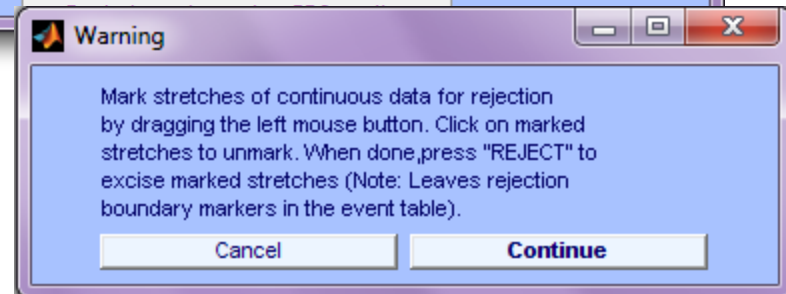
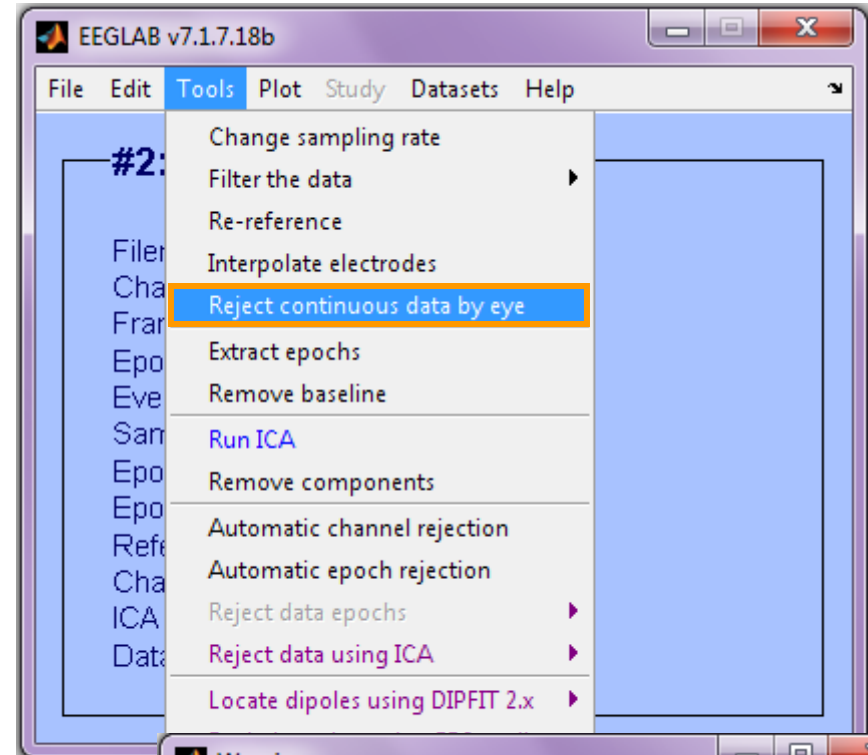
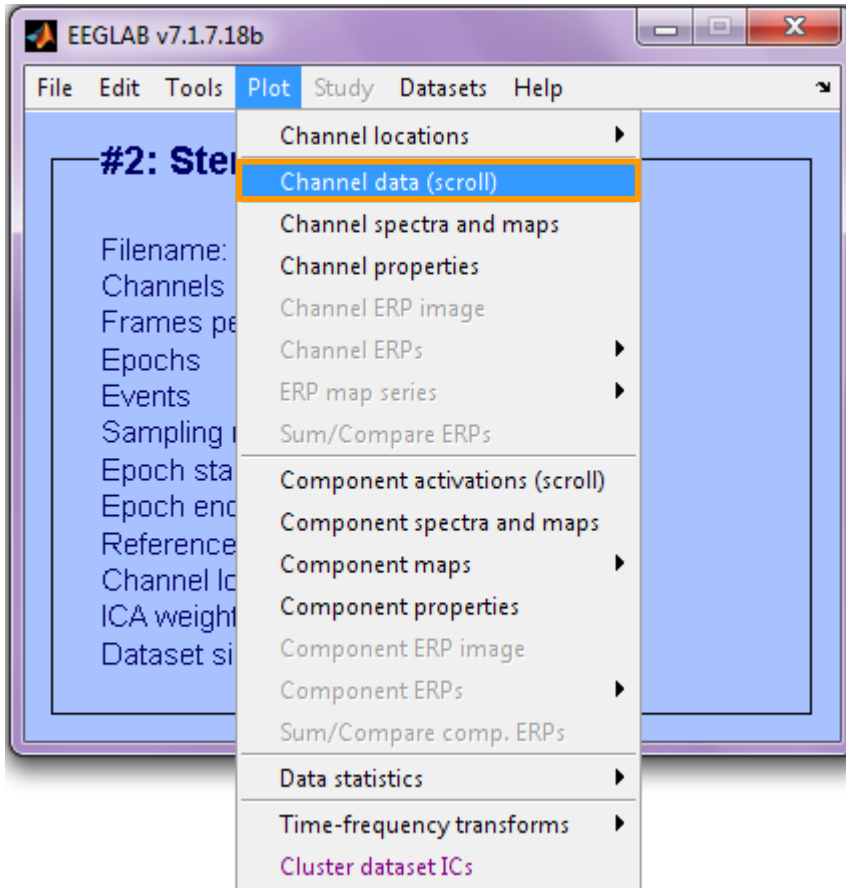
Reject large artifact
time points

Run ICA

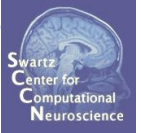
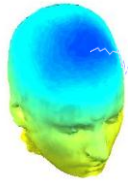
Reject continuous data



Equivalent

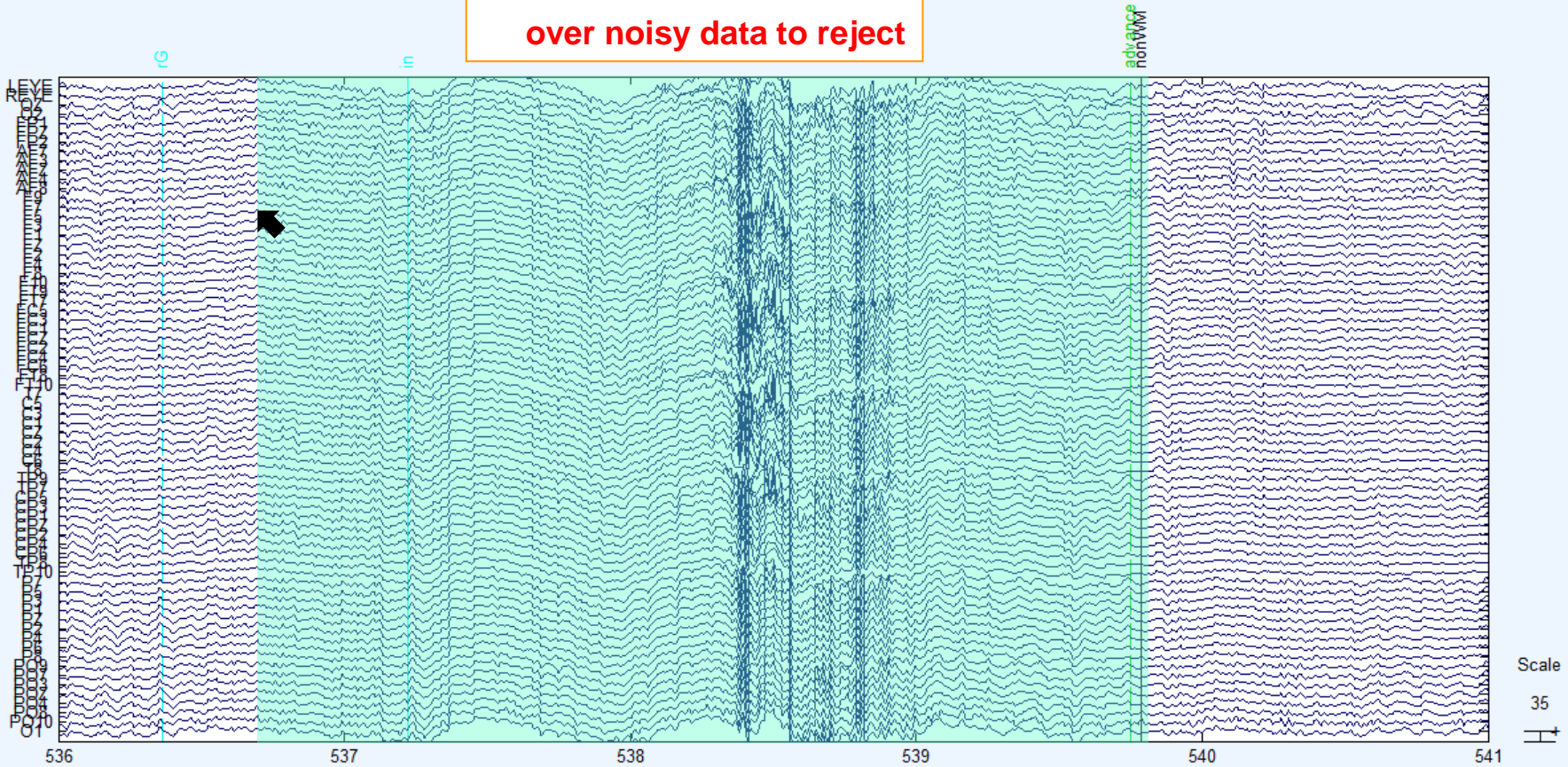


Reject continuous data



Scroll channel activities -- eegplot() - [] X
Figure Display Settings Help

**Click and drag with mouse
over noisy data to reject**



CANCEL

Event types

<<

<

536

>

>>

Chan.

Time

Value

FC6

539.9355

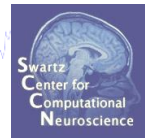
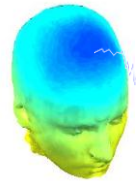
4.8773

35

+

REJECT

Rejecting data for ICA



To prepare data for ICA:

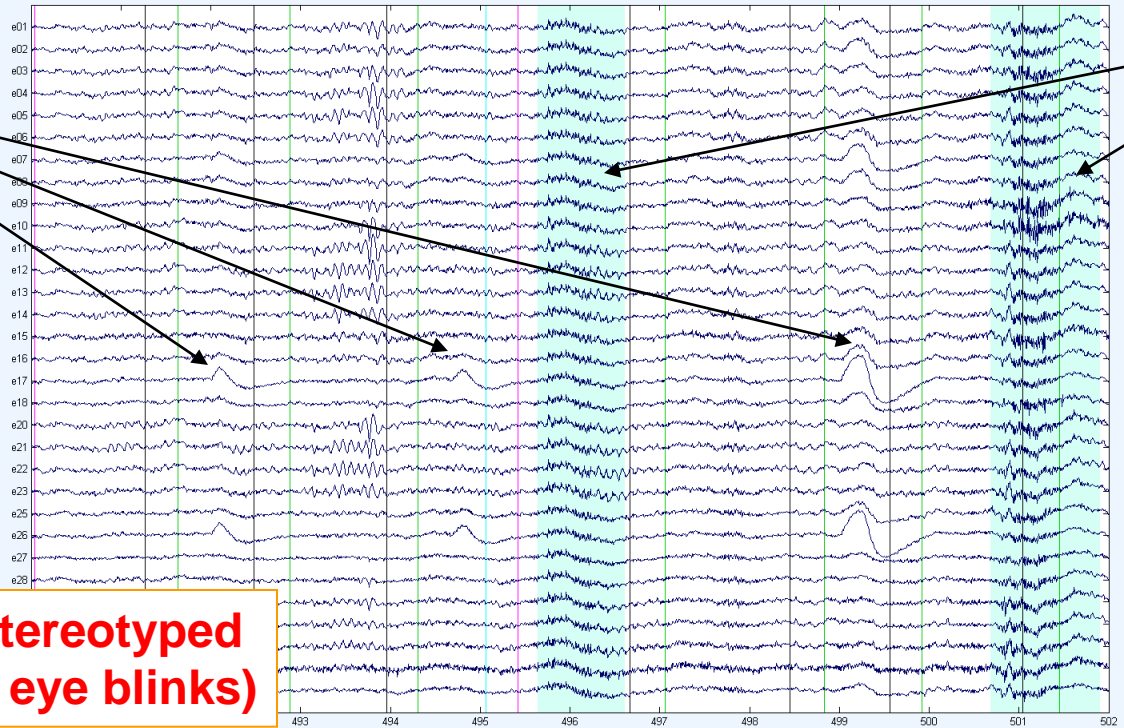
Reject large muscle or otherwise strange events...

Scroll channel activities -- eegplot()
Figure Display Settings Help

Keep

Reject

... but keep stereotyped artifacts (like eye blinks)



CANCEL Event types << < 480 > >> Chan. Time Value e01 502.3519 -9.7 100 REJECT

Pre-processing pipeline



Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/
down-sample
(if necessary)

High pass filter
(~.5 – 1 Hz)

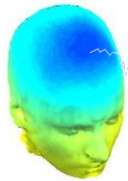
Examine raw data

Reject bad channels

Reject large artifact
time points

Run ICA

Independent Component Analysis



x = scalp EEG

W = unmixing matrix

u = sources



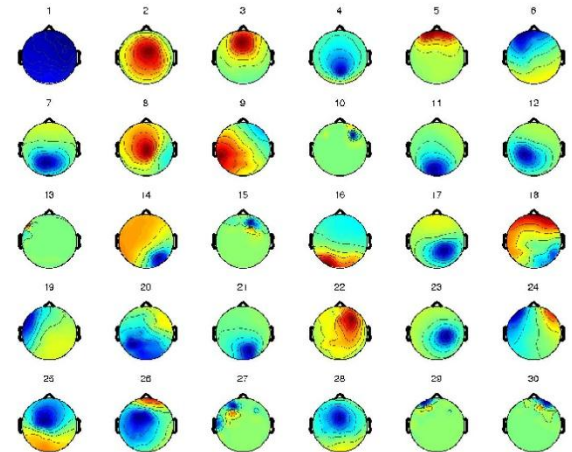
$$W^*x = u$$

ICA

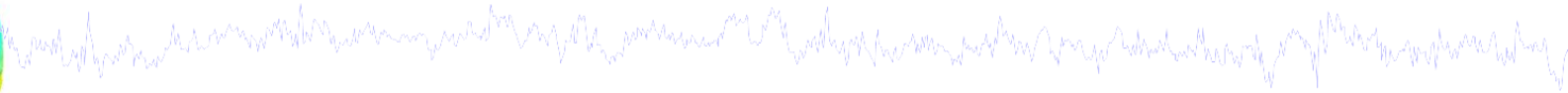
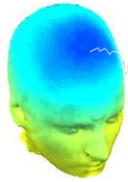
u = sources

$$x = W^{-1} * u$$

W^{-1} (scalp projections)

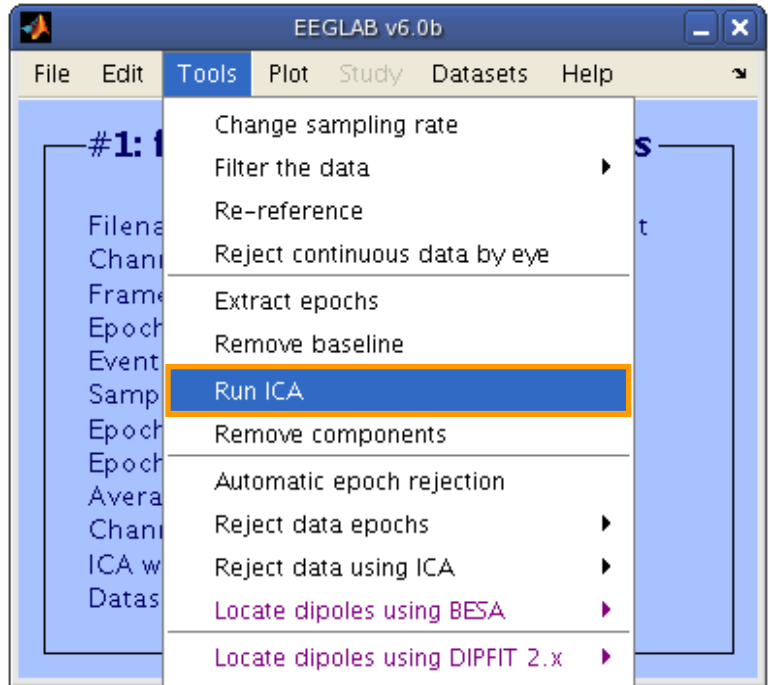
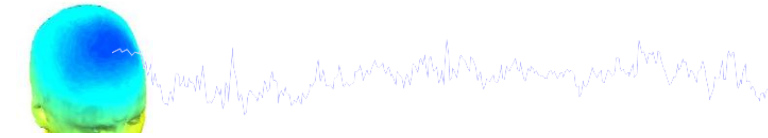


“Secrets” to a good ICA decomposition



- **Garbage in... garbage out (it's not magic)**
- **Remove large, non-stereotyped artifacts**
- **Do you have enough data? (based mostly on time, not frames)**
 - * ~30 min of data for 60-70 channels, ~60 min for > 200 channels
- **High-pass filter to remove slow drifts**
 - * low-pass/ notch filters usually unnecessary
- **Remove bad channels**
- **Data must be in double precision (not single)**

Runica options

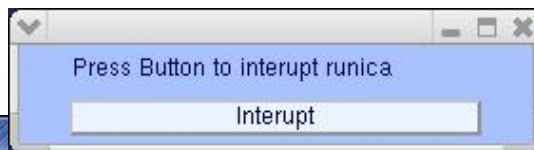
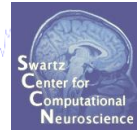
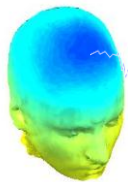


Option	Default	Comments
'extended'	0	1 is recommended to find sub-gaussians
'stop'	1e-7	final weight change → stop
'lrate'	determined from data	too small → too long... too large → wts blow up
'maxsteps'	512	more channels → more steps
'pca'	0 or EEG.nbchan	Decompose only a principal data subspace

Other algorithms:
binica, sobi, acsobi



Runica progress...



```
Input data size [33,133175] = 33 channels, 133175 frames/nFinding 33 ICA components using extended ICA.
Kurtosis will be calculated initially every 1 blocks using 6000 data points.
Decomposing 122 frames per ICA weight ((1089)^2 = 133175 weights, Initial learning rate will be 0.001, block size
Learning rate will be multiplied by 0.98 whenever angledelta >= 60 deg.
More than 32 channels; default stopping weight change 1E-7
Training will end when wchange < 1e-07 or after 512 steps.
Online bias adjustment will be used.
Removing mean of each channel ...
Final training data range: -171.806 to 179.094
Computing the sphering matrix...
Starting weights are the identity matrix ...
Sphering the data ...
Beginning ICA training ... first training step may be slow ...
step 1 - lrate 0.001000, wchange 16.85061324, angledelta 0.0 deg
step 2 - lrate 0.001000, wchange 0.26760405, angledelta 0.0 deg
step 3 - lrate 0.001000, wchange 0.79058323, angledelta 104.0 deg
step 4 - lrate 0.000980, wchange 0.66700031, angledelta 147.2 deg
step 5 - lrate 0.000960, wchange 0.62849071, angledelta 146.5 deg
step 6 - lrate 0.000941, wchange 0.73967955, angledelta 150.7 deg
step 7 - lrate 0.000922, wchange 0.73727229, angledelta 151.6 deg
step 8 - lrate 0.000904, wchange 0.74051387, angledelta 137.9 deg
step 9 - lrate 0.000886, wchange 0.74536137, angledelta 156.0 deg
step 10 - lrate 0.000868, wchange 0.72101402, angledelta 143.7 deg
step 11 - lrate 0.000851, wchange 0.14690114, angledelta 102.5 deg
step 12 - lrate 0.000834, wchange 0.11822100, angledelta 114.3 deg
step 13 - lrate 0.000817, wchange 0.75552966, angledelta 100.6 deg
step 14 - lrate 0.000801, wchange 0.26739750, angledelta 109.1 deg
step 15 - lrate 0.000785, wchange 0.12123251, angledelta 94.2 deg
step 16 - lrate 0.000769, wchange 0.10285606, angledelta 110.7 deg
step 17 - lrate 0.000754, wchange 0.09770499, angledelta 118.6 deg
step 18 - lrate 0.000739, wchange 0.09544428, angledelta 117.1 deg
```

```
step 241 - lrate 0.000002, wchange 0.00000082, angledelta 101.5 deg
step 242 - lrate 0.000001, wchange 0.00000061, angledelta 96.1 deg
step 243 - lrate 0.000001, wchange 0.00000057, angledelta 97.5 deg
step 244 - lrate 0.000001, wchange 0.00000054, angledelta 93.7 deg
step 245 - lrate 0.000001, wchange 0.00000055, angledelta 100.3 deg
step 246 - lrate 0.000001, wchange 0.00000047, angledelta 96.9 deg
step 247 - lrate 0.000001, wchange 0.00000046, angledelta 91.3 deg
step 248 - lrate 0.000001, wchange 0.00000045, angledelta 101.5 deg
step 249 - lrate 0.000001, wchange 0.00000041, angledelta 103.1 deg
step 250 - lrate 0.000001, wchange 0.00000036, angledelta 95.5 deg
step 251 - lrate 0.000001, wchange 0.00000033, angledelta 92.1 deg
step 252 - lrate 0.000001, wchange 0.00000029, angledelta 97.4 deg
step 253 - lrate 0.000001, wchange 0.00000030, angledelta 95.8 deg
step 254 - lrate 0.000001, wchange 0.00000023, angledelta 94.2 deg
step 255 - lrate 0.000001, wchange 0.00000023, angledelta 97.6 deg
step 256 - lrate 0.000001, wchange 0.00000023, angledelta 97.1 deg
step 257 - lrate 0.000001, wchange 0.00000021, angledelta 92.0 deg
step 258 - lrate 0.000001, wchange 0.00000020, angledelta 99.1 deg
step 259 - lrate 0.000001, wchange 0.00000019, angledelta 95.0 deg
step 260 - lrate 0.000001, wchange 0.00000015, angledelta 98.3 deg
step 261 - lrate 0.000001, wchange 0.00000014, angledelta 99.0 deg
step 262 - lrate 0.000001, wchange 0.00000014, angledelta 94.3 deg
step 263 - lrate 0.000001, wchange 0.00000013, angledelta 95.4 deg
step 264 - lrate 0.000001, wchange 0.00000012, angledelta 94.1 deg
step 265 - lrate 0.000001, wchange 0.00000011, angledelta 96.1 deg
step 266 - lrate 0.000001, wchange 0.00000010, angledelta 94.8 deg
step 267 - lrate 0.000001, wchange 0.00000010, angledelta 94.5 deg
step 268 - lrate 0.000001, wchange 0.00000010, angledelta 97.7 deg
step 269 - lrate 0.000001, wchange 0.00000008, angledelta 95.1 deg
Sorting components in descending order of mean projected variance ...
Permuting the activation wave forms ...
>>
>>
```

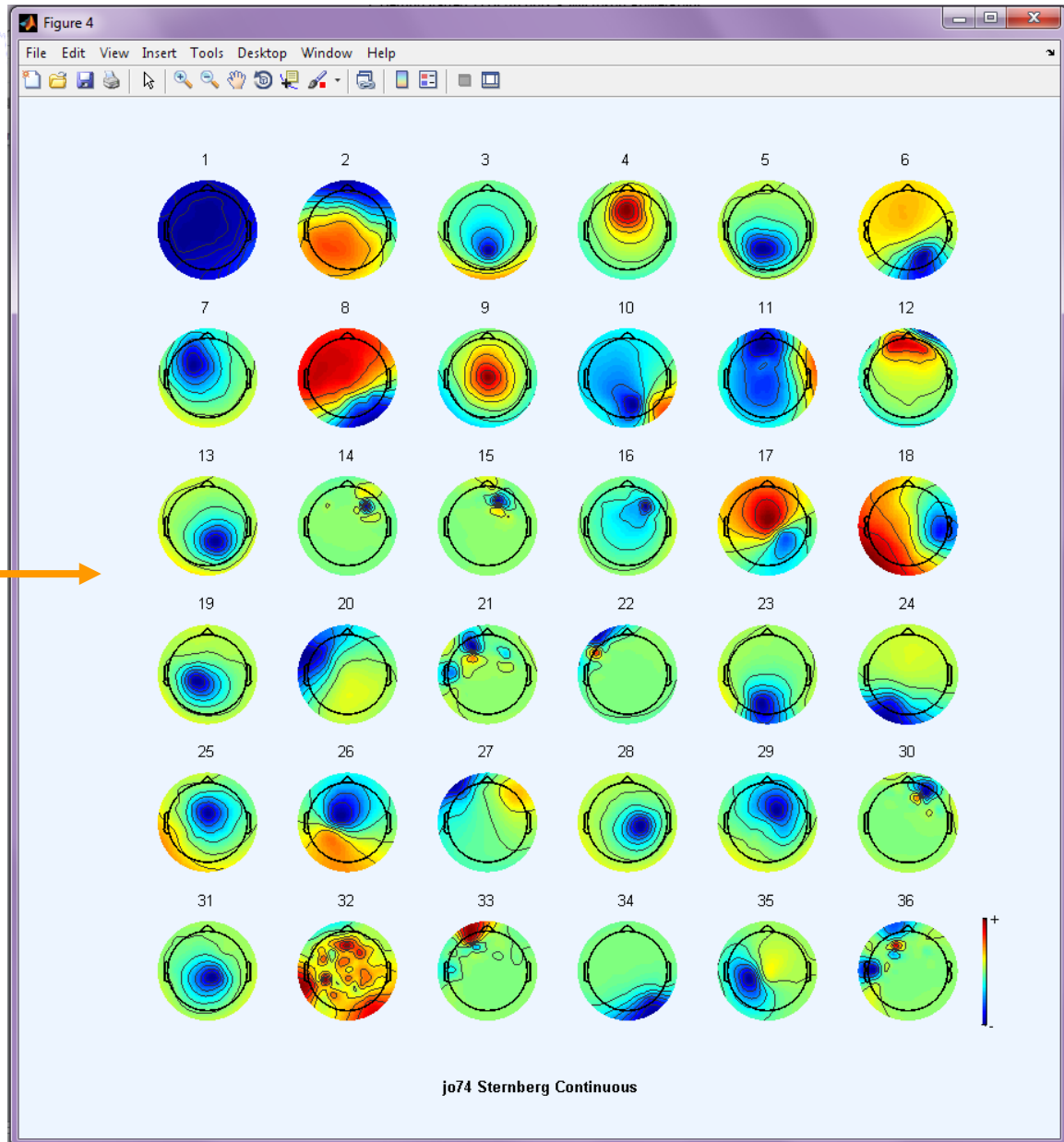

ICA weights in EEG structure

```
Terminal
File Edit View Terminal Tabs Help
>> EEG

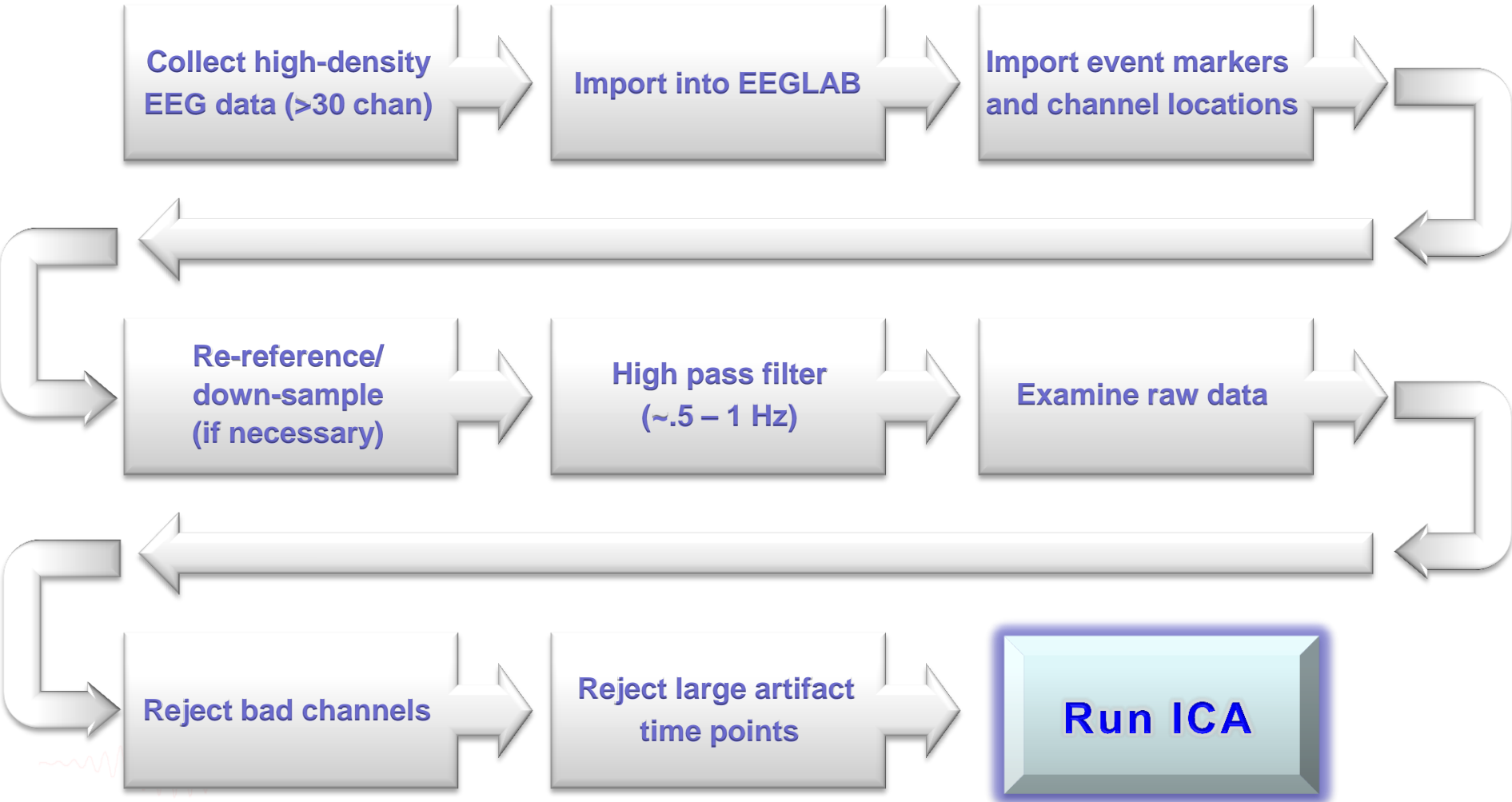
EEG =

    setname: 'faces_4 continuous'
    filename: 'faces_4.set'
    filepath: '/home/julie/workshop06/'
    subject: ''
    group: ''
    condition: ''
    session: []
    comments: [15x48 char]
    nbchan: 33
    trials: 1
    pnts: 133175
    srate: 250
    xmin: 0
    xmax: 532.6960
    times: []
    data: [33x133175 single]
    icaact: [33x133175 single]
    icawinv: [33x33 double]
    icasphere: [33x33 double]
    icaweights: [33x33 double]
    ica chansind: [1x33 double]
    chanlocs: [1x33 struct]
    urchanlocs: []
    chaninfo: [1x1 struct]
    ref: 'common'
    event: [1x731 struct]
    urevent: [1x731 struct]
    eventdescription: {[] []}
    epoch: []
    epochdescription: {}
    reject: [1x1 struct]
    stats: [1x1 struct]
    specdata: []
    specicaact: []
    splinefile: ''
    icasplinefile: ''
    dipfit: [1x1 struct]
    history: [1x1633 char]
    saved: 'no'
    etc: []

>>
```



Pre-processing pipeline (review)



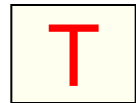
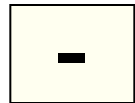
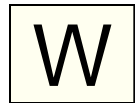
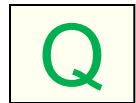
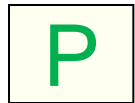
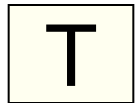
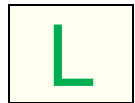
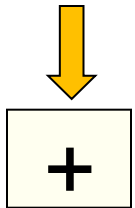
The example data: Sternberg working memory



File .../SampleData/**stern.set**
Data Continuous data (not epoched), ref'd to right mastoid
Task between **3** and **7** letters to **memorize (colored black)**,
between **1** and **5** letters to **ignore (colored green)**,
8 letters presented during each trial
50% chance of **probe** letter being 'in-set'

Fixation

(5 sec)



SOA

(1.4 sec)



Maintenance

(2-4 sec) **Probe**



Memorize

Ignore

*See 'SternbergTaskExplanation.pdf' on wiki
for more task details.*

Was this letter in the memorized set?

(RT)

RESPONSE

Epoch on EEG.event type



Memorize letters: capital letters
Ignore letters: 'g' preceding capital letter (e.g., 'gB')
Probe letters: 'r' preceding capital letter (e.g., 'rB')

```
>> EEG = pop_epoch( EEG, {'B','C','D',...  
'F','G','H','J','K','L','M','N','P'...  
'Q' 'R' 'S' 'T' 'V' 'W'...  
'X' 'Y' 'Z' }, [-1 2], 'newname',...  
'Sternberg Memorize letter epochs',...  
'epochinfo', 'yes');
```

Extract epochs



Dataset info -- pop_newset()

What do you want to do with the new dataset?

Name it:

Save it as file:

What do you want to do with the old data?

Overwrite it in memory (set=yes; unset=no)

Epoch baseline removal -- pop_rmbase()

Baseline latency range (min_ms max_ms) (0 = whole epoch):

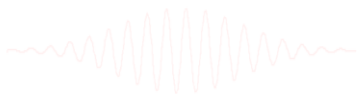
Else, baseline points vector (ex:1:56)
(overwritten by latency range above):

EEGLAB v10.2.4.4b

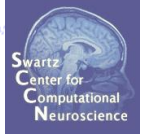
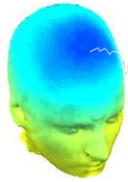
File Edit Tools Plot Study Datasets Help

#2: Sternberg Memorize epochs

Filename:	none
Channels per frame	71
Frames per epoch	750
Epochs	500
Events	1000
Sampling rate (Hz)	250
Epoch start (sec)	-1.000
Epoch end (sec)	1.996
Reference	unknown
Channel locations	No
ICA weights	Yes
Dataset size (Mb)	433.1

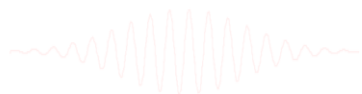
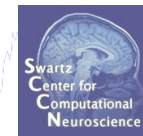
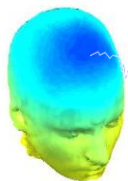


Exercise

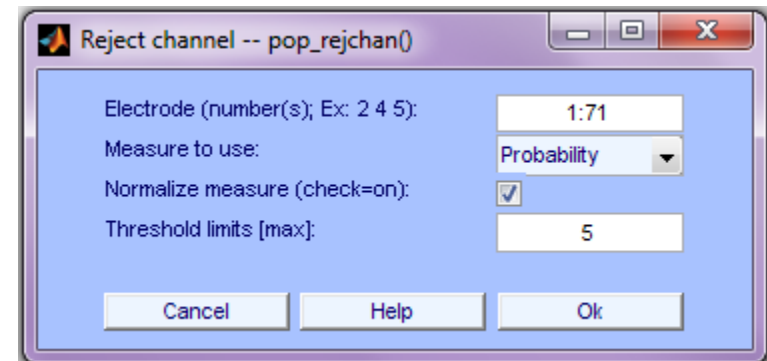
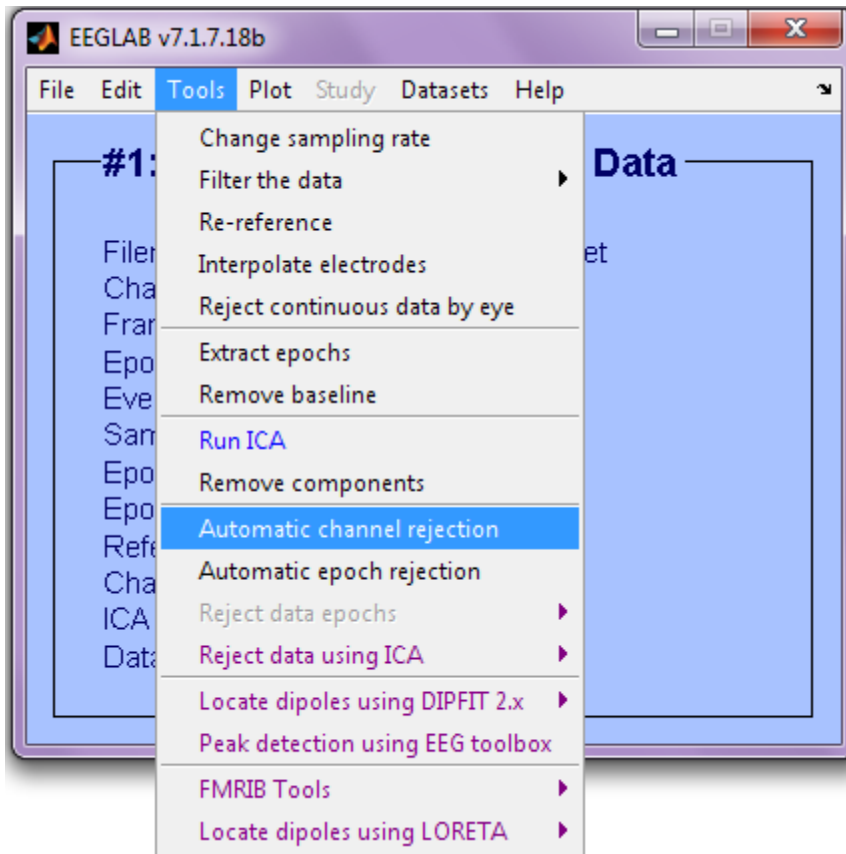


- **ALL**
 - Load stern.set (continuous data)
 - Do not save your changes under the same filename!
- **Novice**
 - Scroll channel data and explore plotting options under 'Settings'.
 - Reject noisy time points by visual inspection
 - Import standard channel locations
 - Practice preprocessing steps described in this lecture
- **Intermediate / Advanced** (requires supplementary material)
 - Remove a channel and then replace it by interpolation
 - Compare this signal with the original when you do this with a 'clean' channel
 - Epoch data even of interest, plot Channel ERPs from Plot menu
 - Try different filter methods and cut-offs, compare results

Supplementary lessons

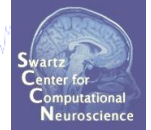


Auto-detection of noisy channels



```
>> EEG = pop_rejchan(EEG, 'elec', [1:71], 'threshold', 5, ...  
'norm', 'on', 'measure', 'prob');
```

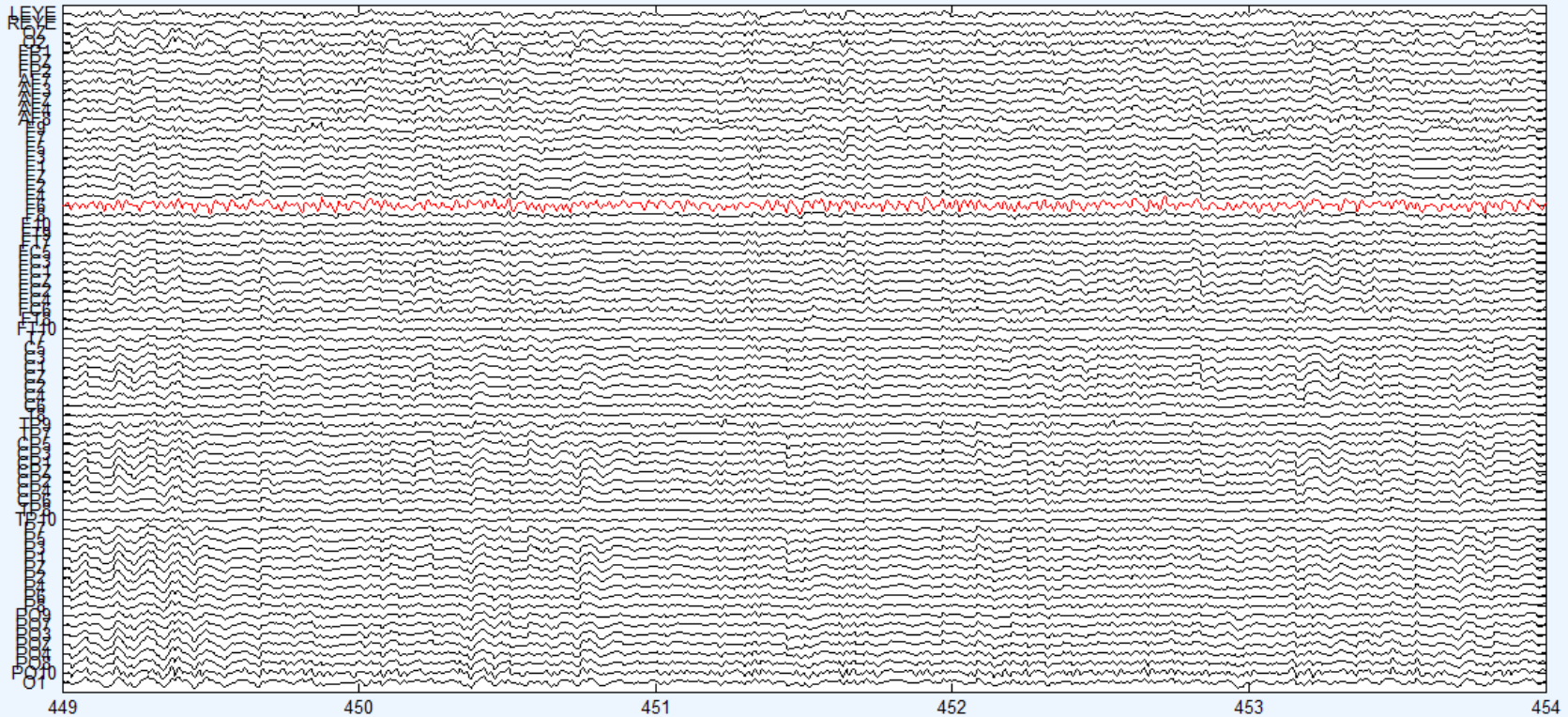

Auto-detected noisy channel



Scroll component activities -- eegplot()



Figure Display Settings Help



Scale
35
↑

CANCEL

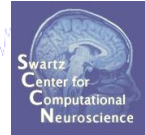
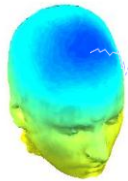
<< < 449 > >>

Chan.	Time	Value
TP8	452.1146	-2.6647

35
+
-

REJECT

Interpolate bad channel



EEGLAB v7.1.7.18b

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

Interpolate channel(s) --...

What channel(s) to interpolate

none

Select from non-data channels

Select from other dataset

Use list of other dataset

Interpolation method: Spherical

Cancel Help Ok

Choose a channel from other dataset

Auto-select deleted channel from other dataset

Choose...

Dataset index

1

Cancel Help Ok

Interpolate channel(s) --...

What channel(s) to interpolate

F6

Select from non-data channels

Select from other dataset

Use list of other dataset

Interpolation method: Spherical

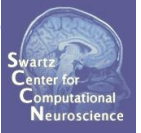
Cancel Help Ok

(use shift|ctrl to select several)

- LEYE
- REYE
- OZ
- O2
- FP1
- FPZ
- FP2
- AF7
- AF3
- AFZ
- AF4
- AF8
- F9
- F7
- F5
- F3
- F1
- FZ
- F2
- F4
- F6**
- F8
- F10
- FT9
- FT7
- EC5

Cancel Ok

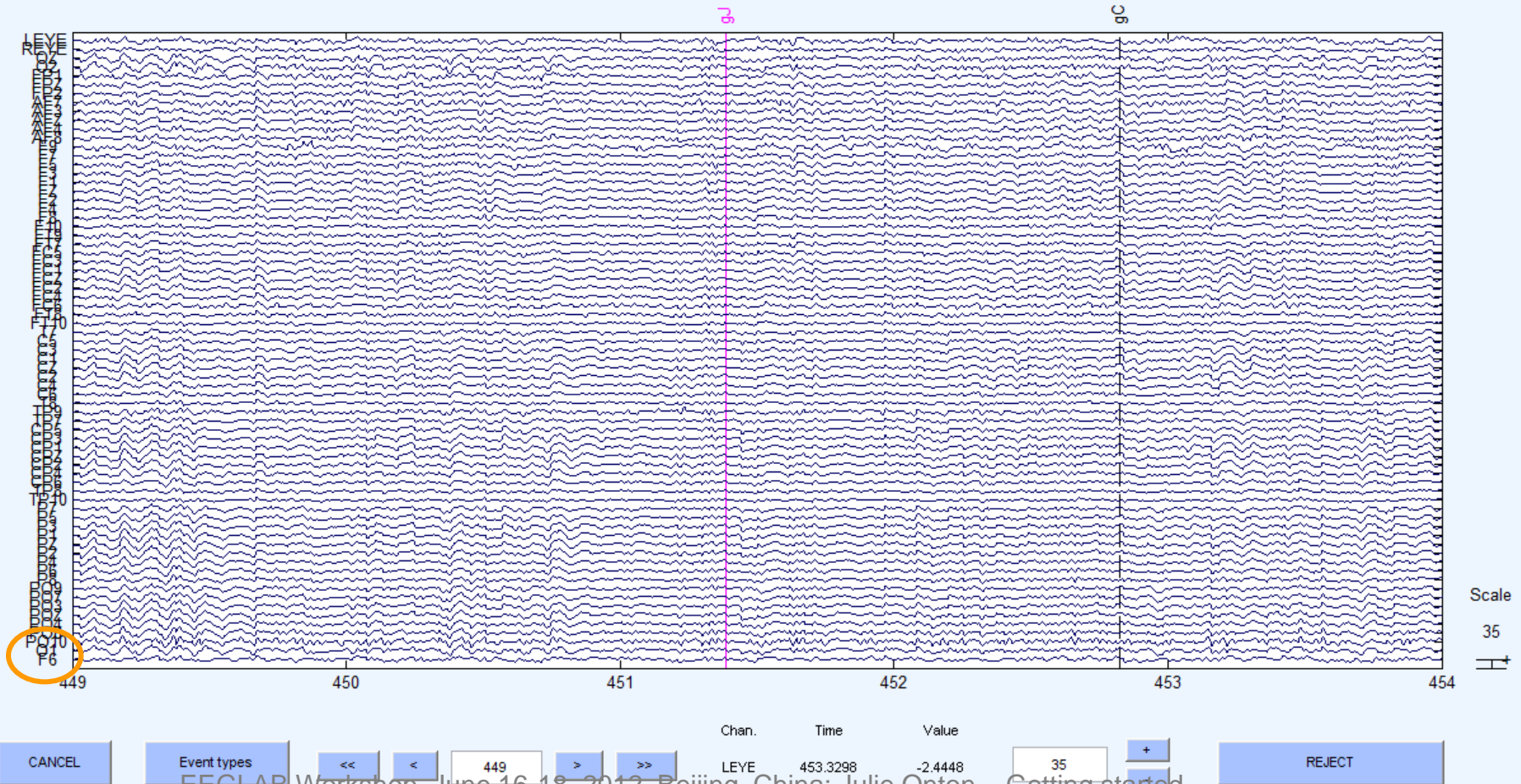
Interpolated channel



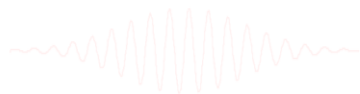
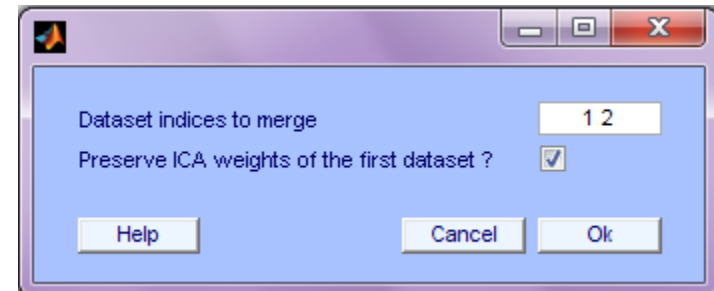
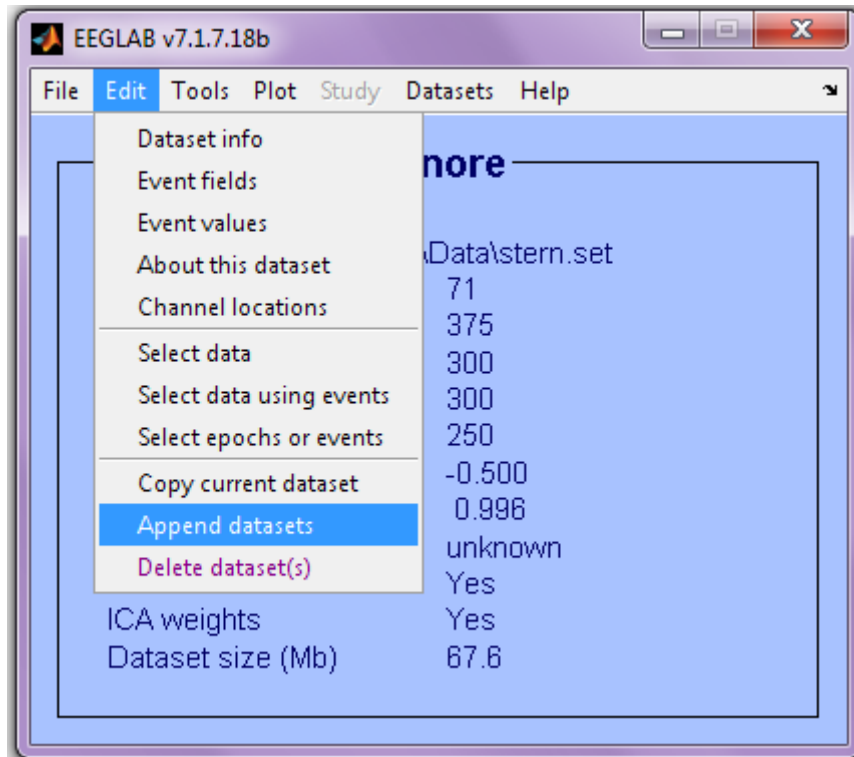
Scroll channel activities -- eegplot()

Figure Display Settings Help

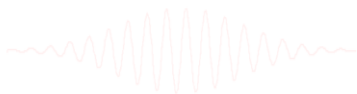
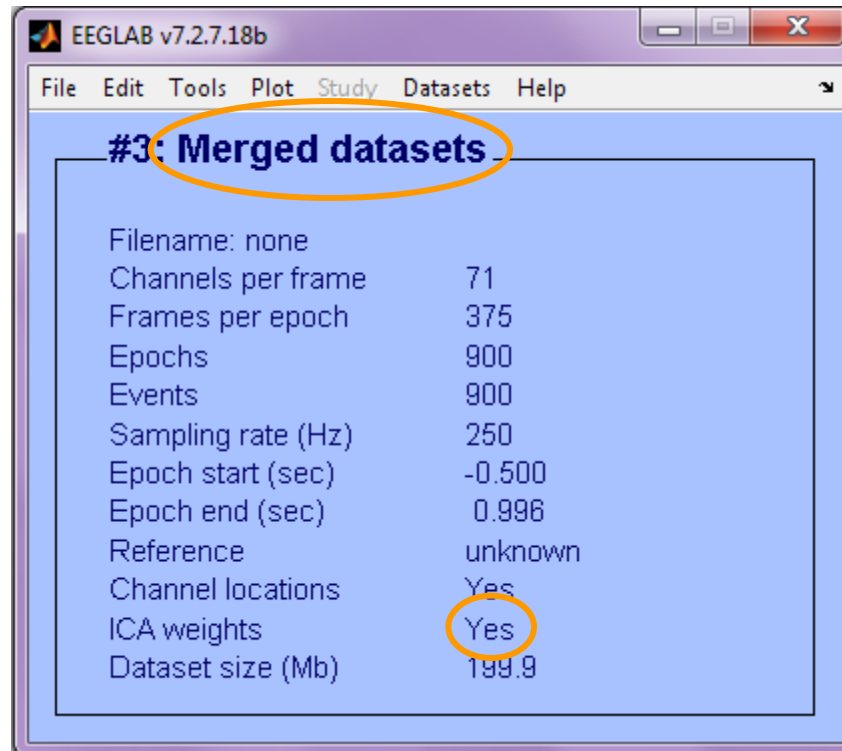
Channel order changes, but scalp location is correct



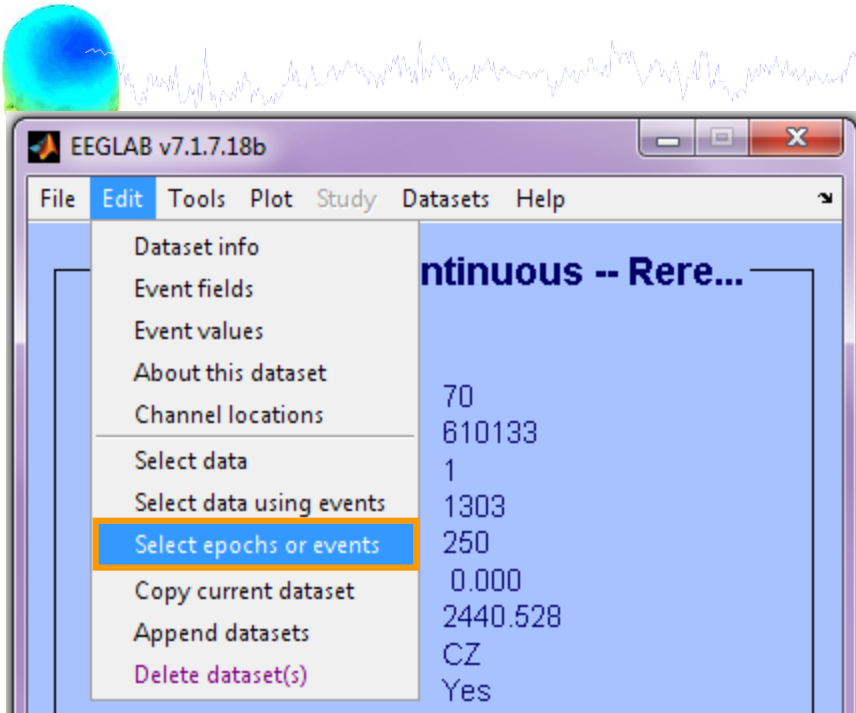
Merge (append) datasets



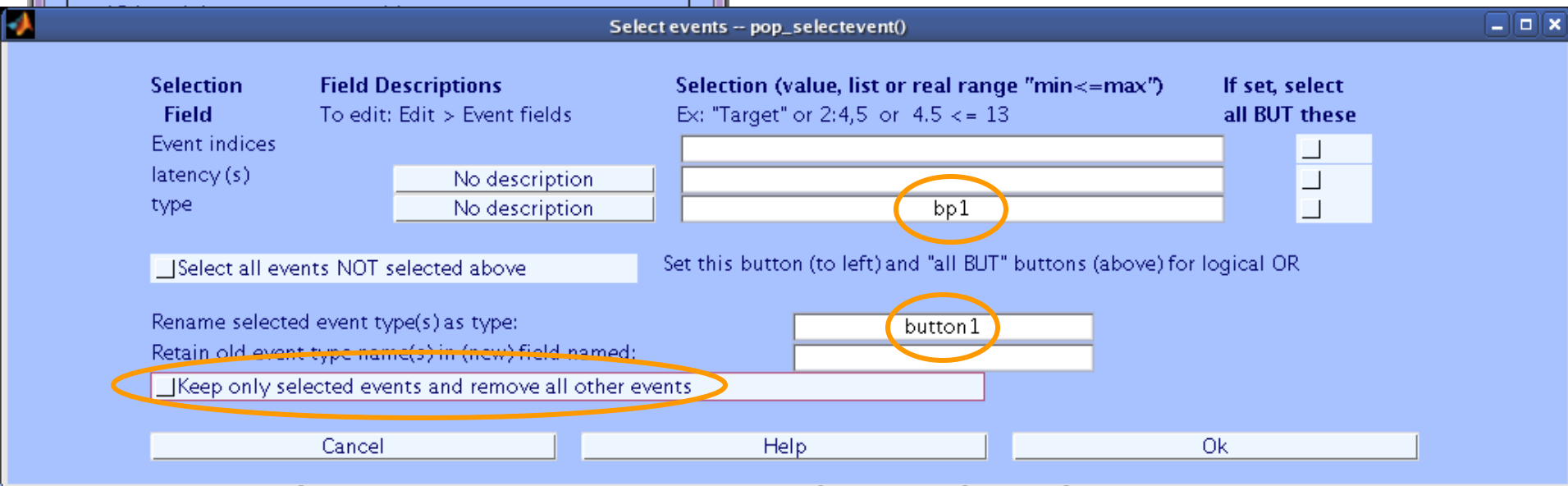
Merged datasets



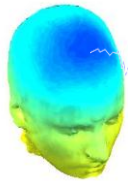
Renaming events



- 1) input original 'type' code
- 2) input new 'type' code
- 3) Keep/delete all other events



Renaming events



EEGLAB v7.1.7.18b

File Edit Tools Plot Study Datasets Help

Dataset info
Event fields
Event values
About this dataset
Channel locations
Select data
Select data using events
Select epochs or events
Copy current dataset
Append datasets
Delete dataset(s)

70
610133
1
1303
250
0.000
2440.528
CZ
Yes
Yes
349

Edit event values -- pop_editeventvals()

Edit event field values (currently 732 events) Delete event

Latency (sec) 5.724
Type button1

Event Num
Insert event << < 3 > >> Append event

Re-order events (for review only)
Main sorting field: No field selected Click for decreasing order
Secondary sorting field: No field selected Click for decreasing order

Re-sort

Cancel Help Ok

Analysis of channel ERPs



EEGLAB v7.1.7.18b

File Edit Tools **Plot** Study Datasets Help

#3: Step

Filename:
Channels
Frames per
Epochs
Events
Sampling
Epoch start
Epoch end
Reference
Channel loc
ICA weight
Dataset si

Channel locations
Channel data (scroll)
Channel spectra and maps
Channel properties
Channel ERP image
Channel ERPs
ERP map series
Sum/Compare ERPs
Component activations (scroll)
Component spectra and maps
Component maps
Component properties
Component ERP image
Component ERPs
Sum/Compare comp. ERPs
Data statistics
Time-frequency transforms
Cluster dataset ICs

hs

With scalp maps
In scalp/rect. array

ERP data and scalp maps -- pop_timtopo()

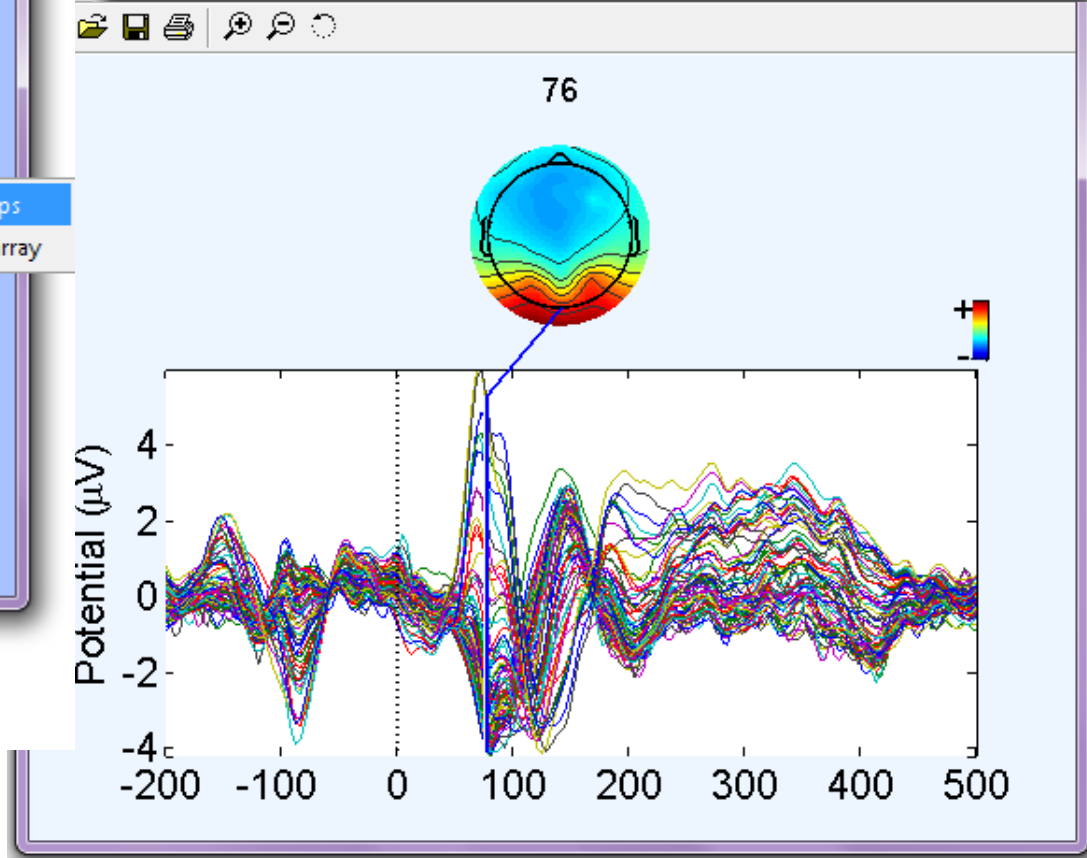
Plotting time range (ms): -200 500

Scalp map latencies (ms, NaN -> max-RMS): NaN

Plot title: ERP data and scalp maps of:

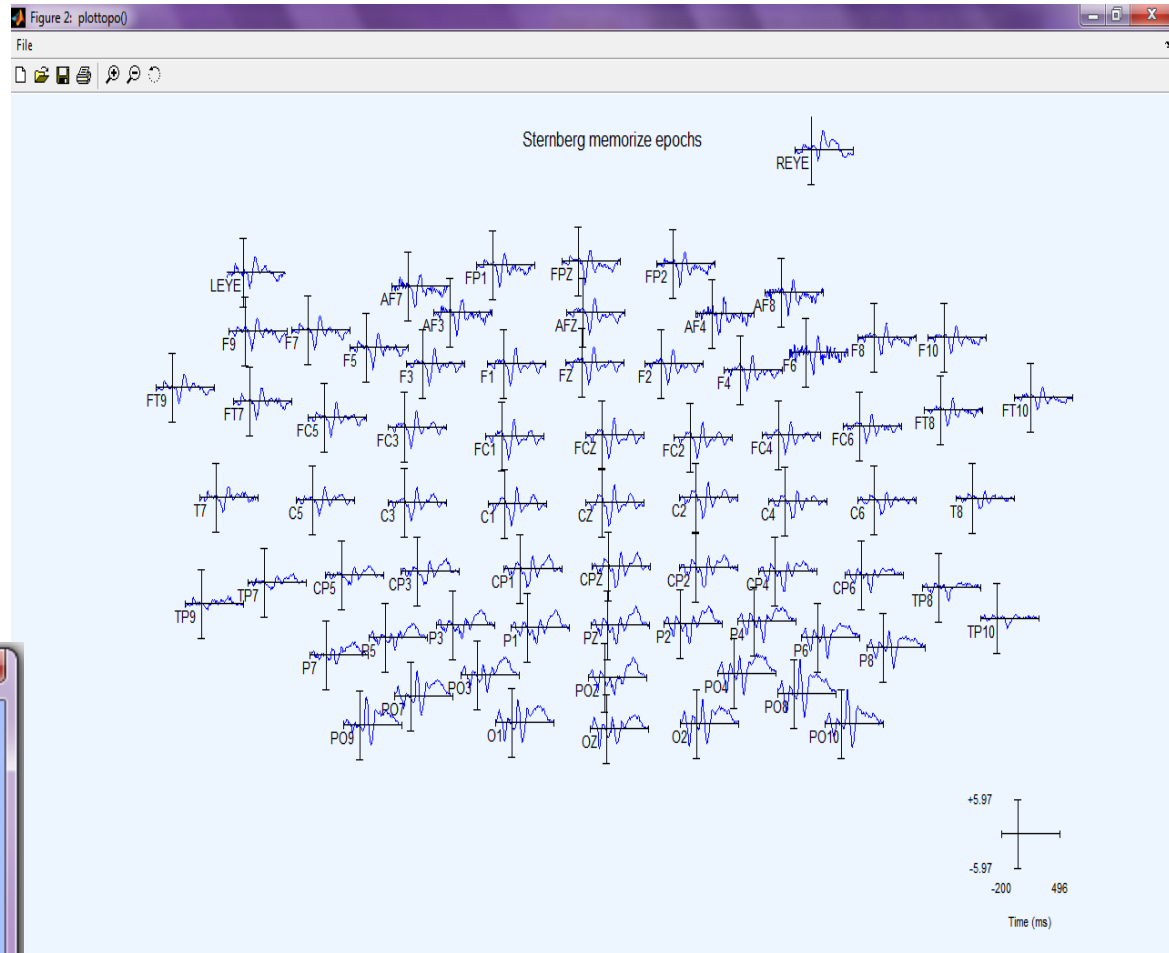
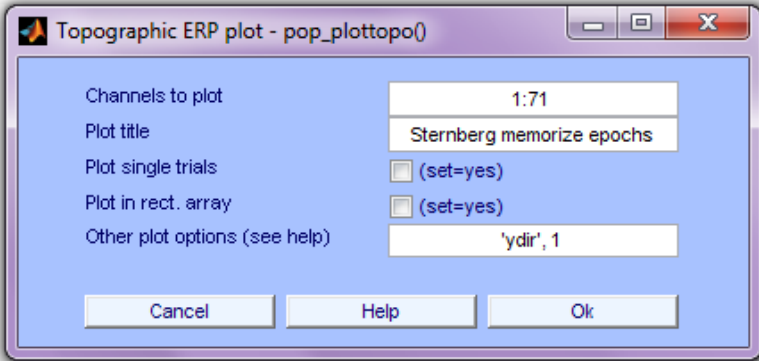
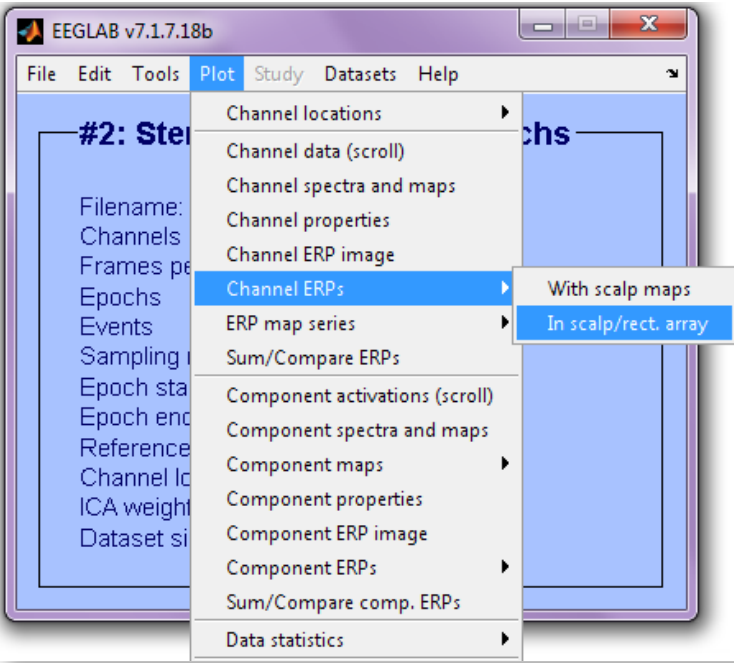
Scalp map options (see >> help topoplot):

Cancel Help Ok

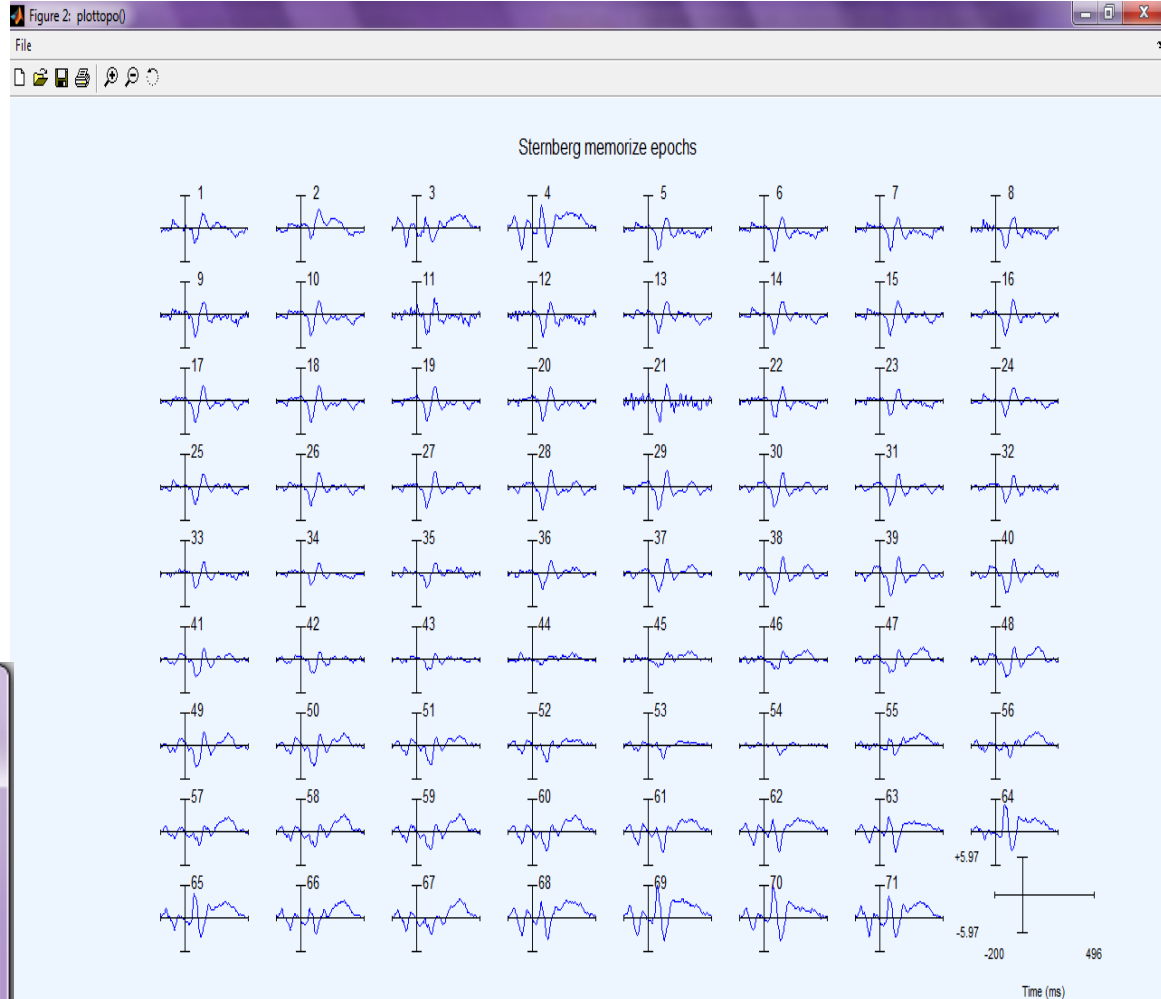
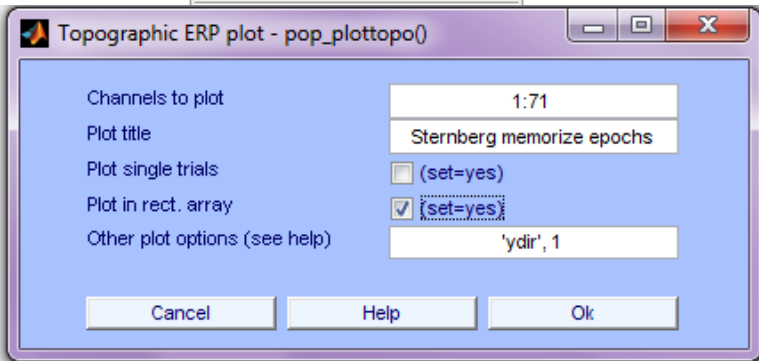
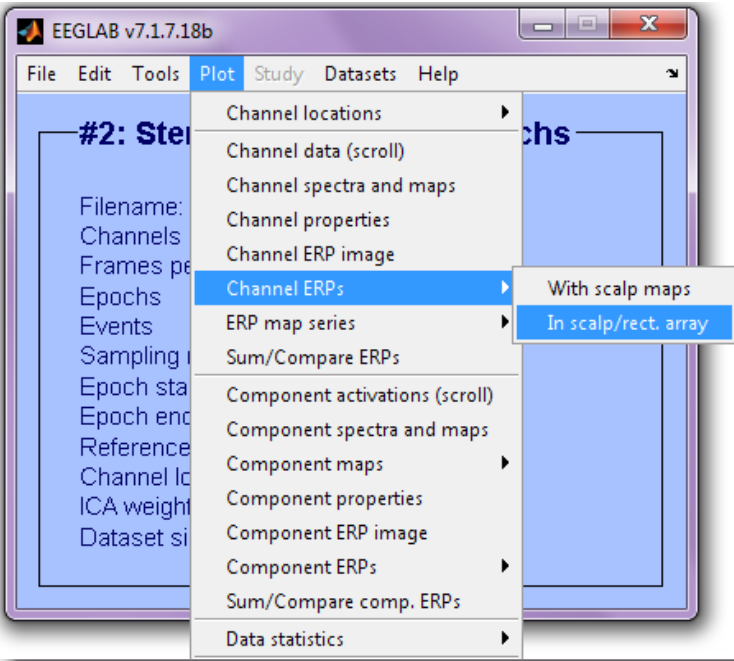
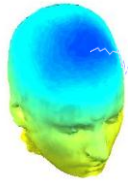


```
>> pop_timtopo(EEG, [-200 500], [NaN], 'ERP data and scalp maps');
```

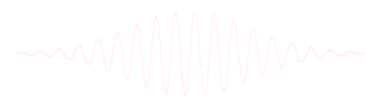
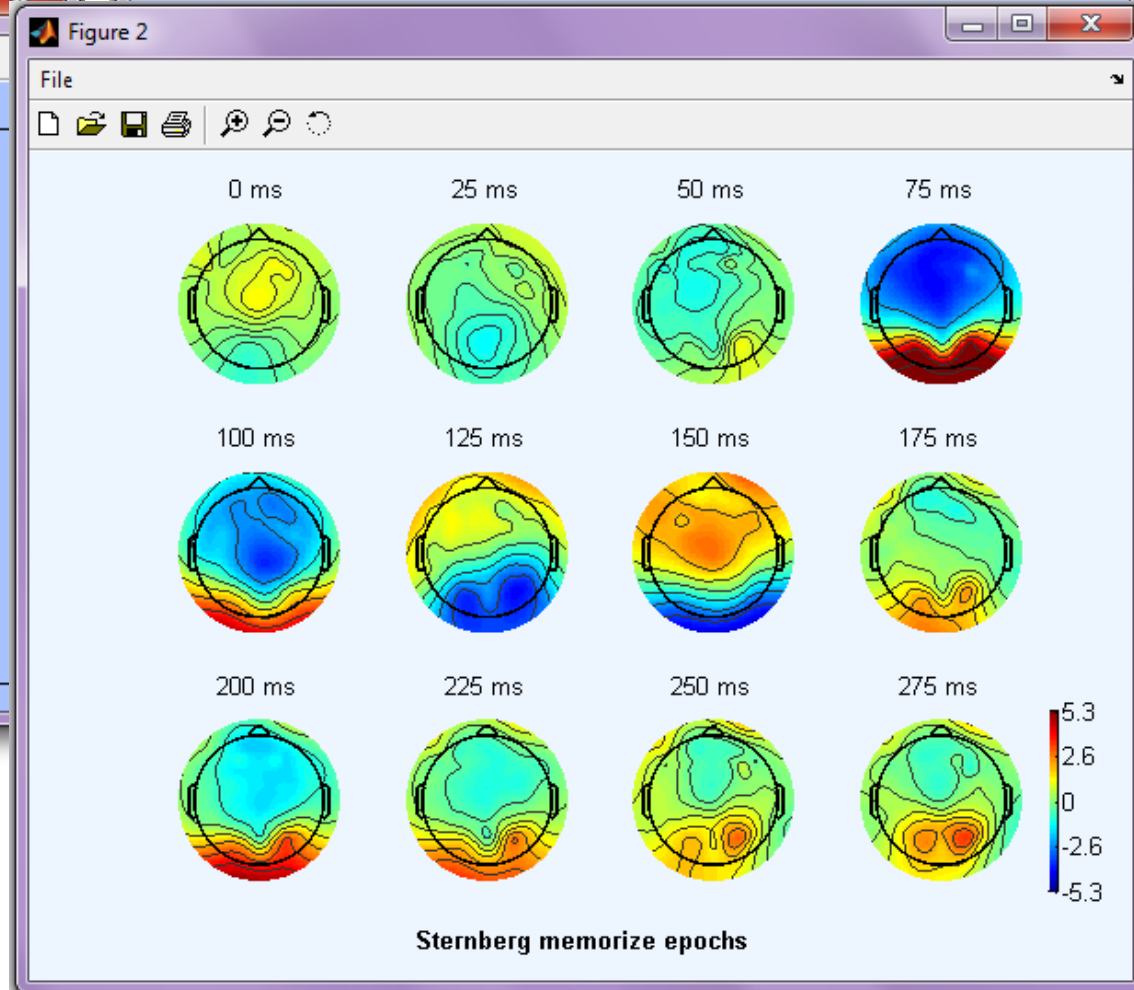
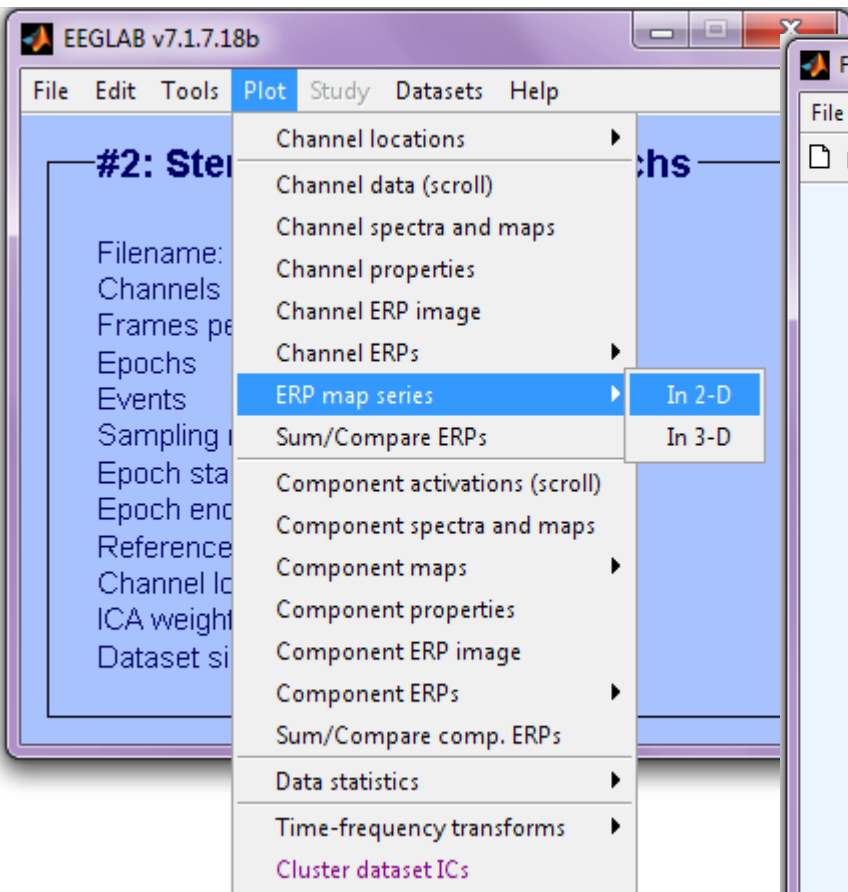
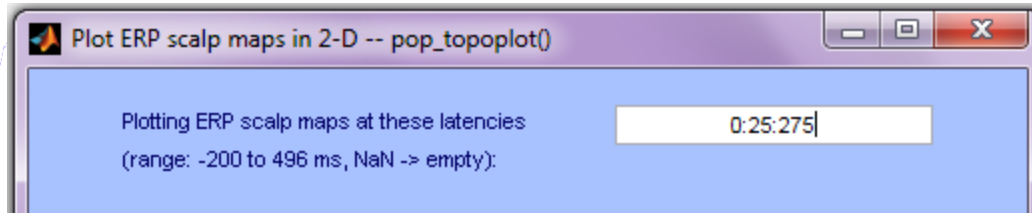
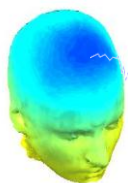

Analysis of channel ERPs



Channel ERP in rectangular array



Analysis of channel ERPs



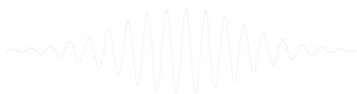
```
pop_topoplot(EEG,1,[0:25:275],'Memorize',[3 4],0,'electrodes','off');
```

Compare ERPs across conditions



Filename:	none
Channels per frame	
Frames per epoch	175
Epochs	600
Events	600
Sampling rate (Hz)	250
Epoch start (sec)	-0.200
Epoch end (sec)	0.496
Reference	unknown
Channel locations	Yes
ICA weights	Yes
Dataset size (Mb)	64.5

How do 'Memorize' and 'Ignore' ERPs differ?



Compare ERPs across conditions



Compare ERPs from two conditions

EEGLAB v7.1.7.18b

File Edit Tools Plot Study Datasets Help

#2: Step

Channel location
Channel data (sc...
Channel spectra...
Channel properti...
Channel ERP ima...
Channel ERPs
ERP map series
Sum/Compare ERP
Component activ...
Component spec...
Component map...
Component prop...
Component ERP...
Component ERPs...
Sum/Compare co...
Data statistics
Time-frequency transforms
Cluster dataset ICs

ERP grand average/RMS - pop_comperp()

	avg.	std.	all ERPs
Datasets to average (ex: 1 3 4):	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Datasets to average and subtract (ex: 5 6 7):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Plot difference	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Datasets to average (ex: 1 3 4): 2 3

Datasets to average and subtract (ex: 5 6 7):

Plot difference

Channels subset ([]=all):

Highlight significant regions (.01 -> p=.01)

Use RMS instead of average (check):

Low pass (Hz) (for display only): 20

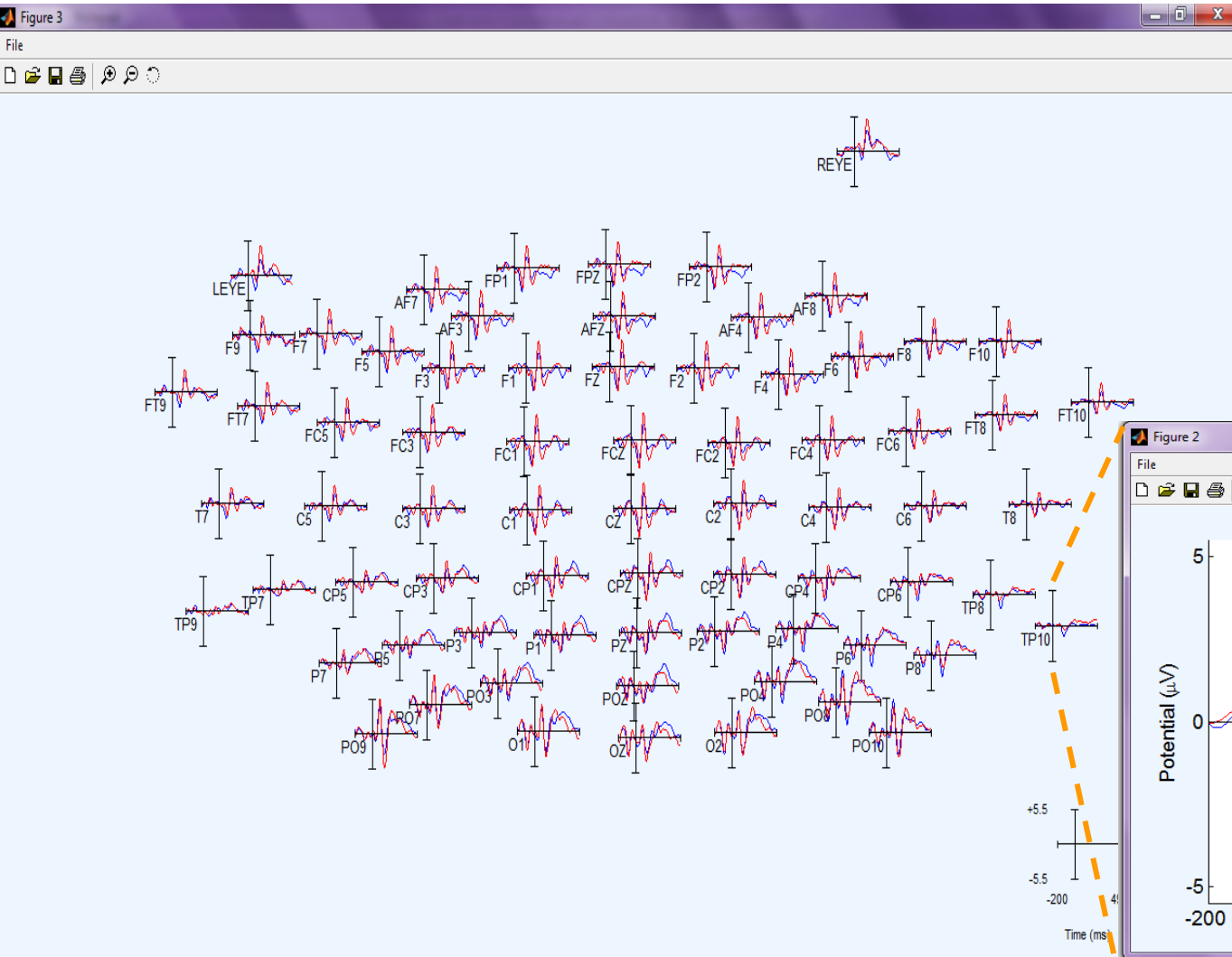
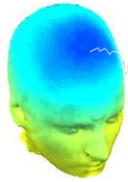
Plottopo options ('key', 'val'): 'ydir', 1

Help

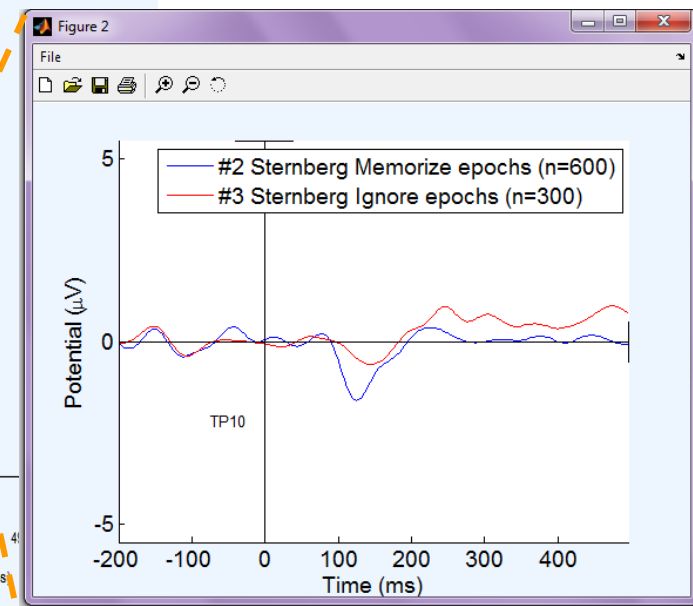
Cancel Help Ok

```
>>pop_comperp(ALLEEG,1,[2 3],[],'addavg','off','addstd','off', ...  
'addall','on','diffavg','off','diffstd','off','lowpass',20, ...  
'tplotopt',{'ydir',1});
```

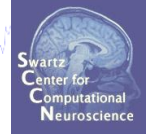
Compare ERPs across conditions



Click on an axis to see larger image



Analysis of ERP differences



Plot difference
between two conditions

ERP grand average/RMS - pop_comperp

	avg.	std.	all ERPs
Datasets to average (ex: 1 3 4):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Datasets to average and subtract (ex: 5 6 7):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Plot difference	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Channels subset ([])=all):

Highlight significant regions (.01 -> p=.01)

Use RMS instead of average (check):

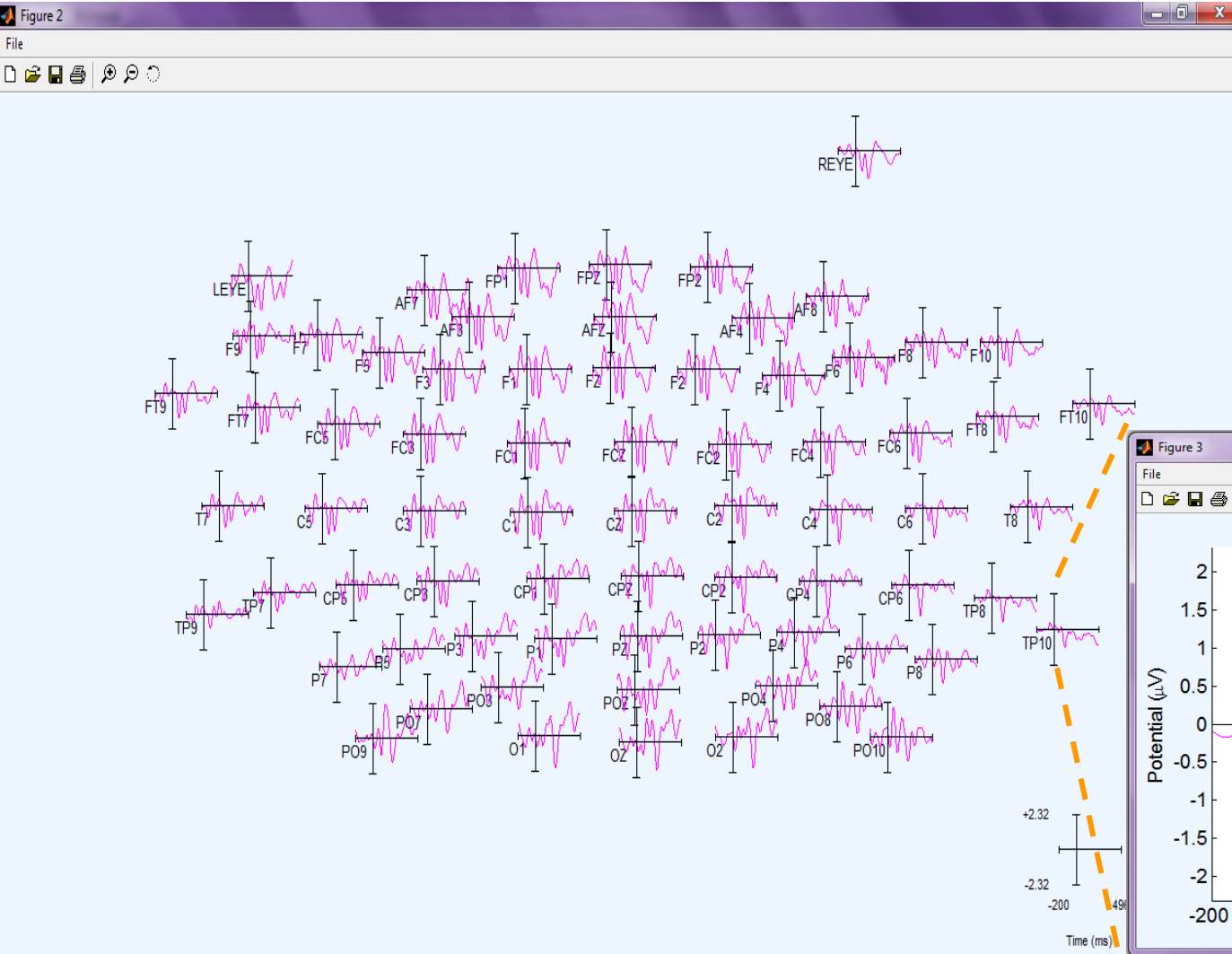
Low pass (Hz) (for display only): 20

Plottopo options ('key', 'val'): Help 'ydir', 1

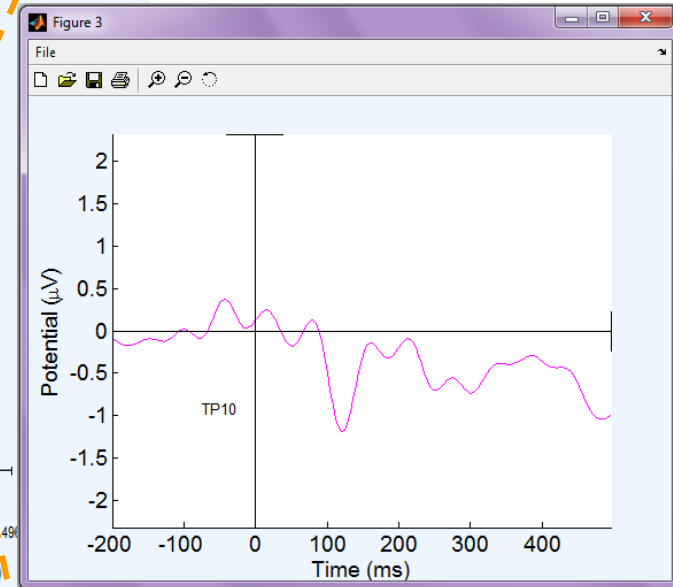
Cancel Help Ok

```
>> pop_comperp(ALLEEG, 1, 2, 3, 'addavg', 'off', ...  
'addstd', 'off', 'diffavg', 'on', 'diffstd', 'off', ...  
'lowpass', 20, 'tplotopt', {'ydir', 1});
```

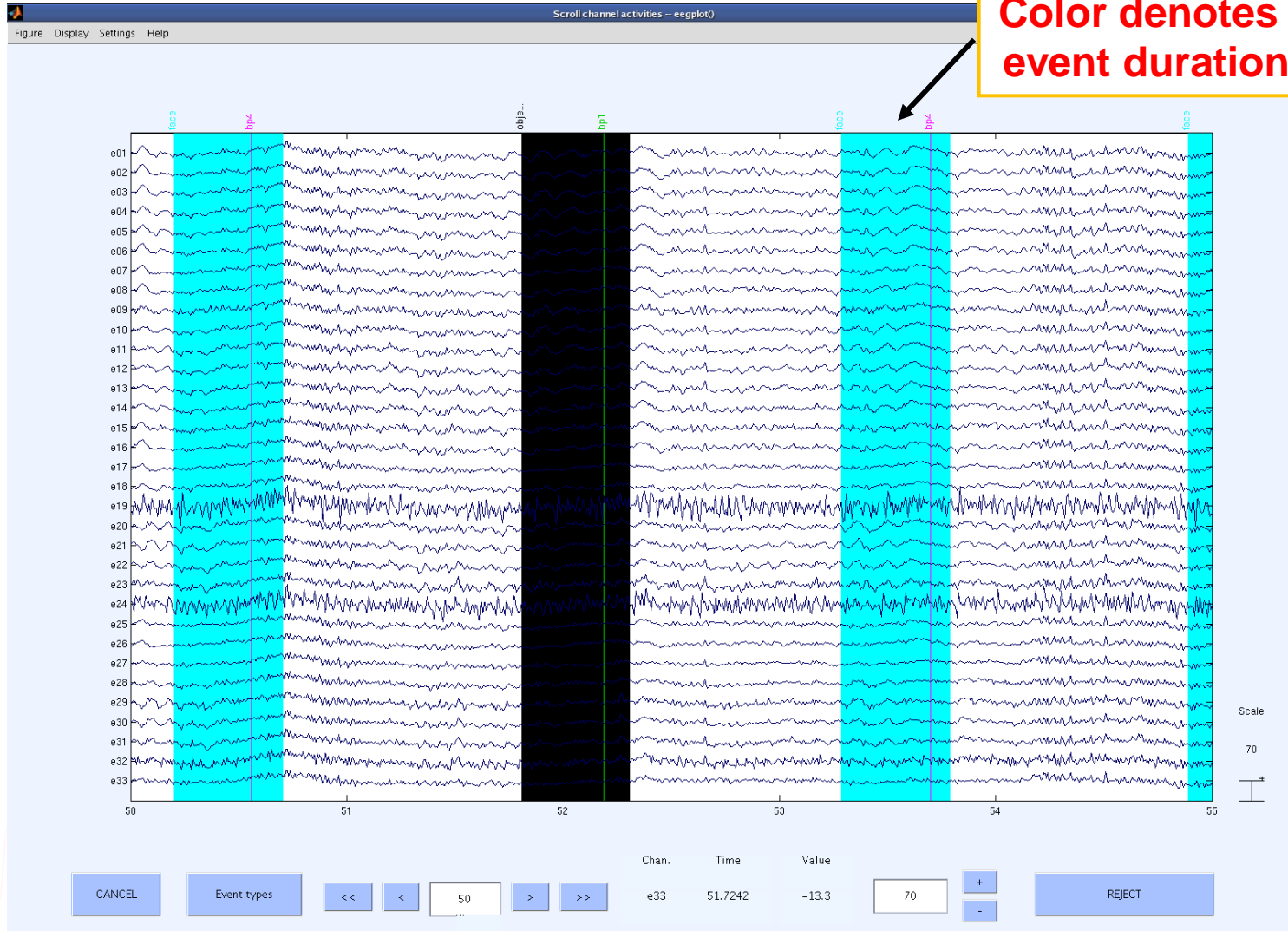
Analysis of ERP differences



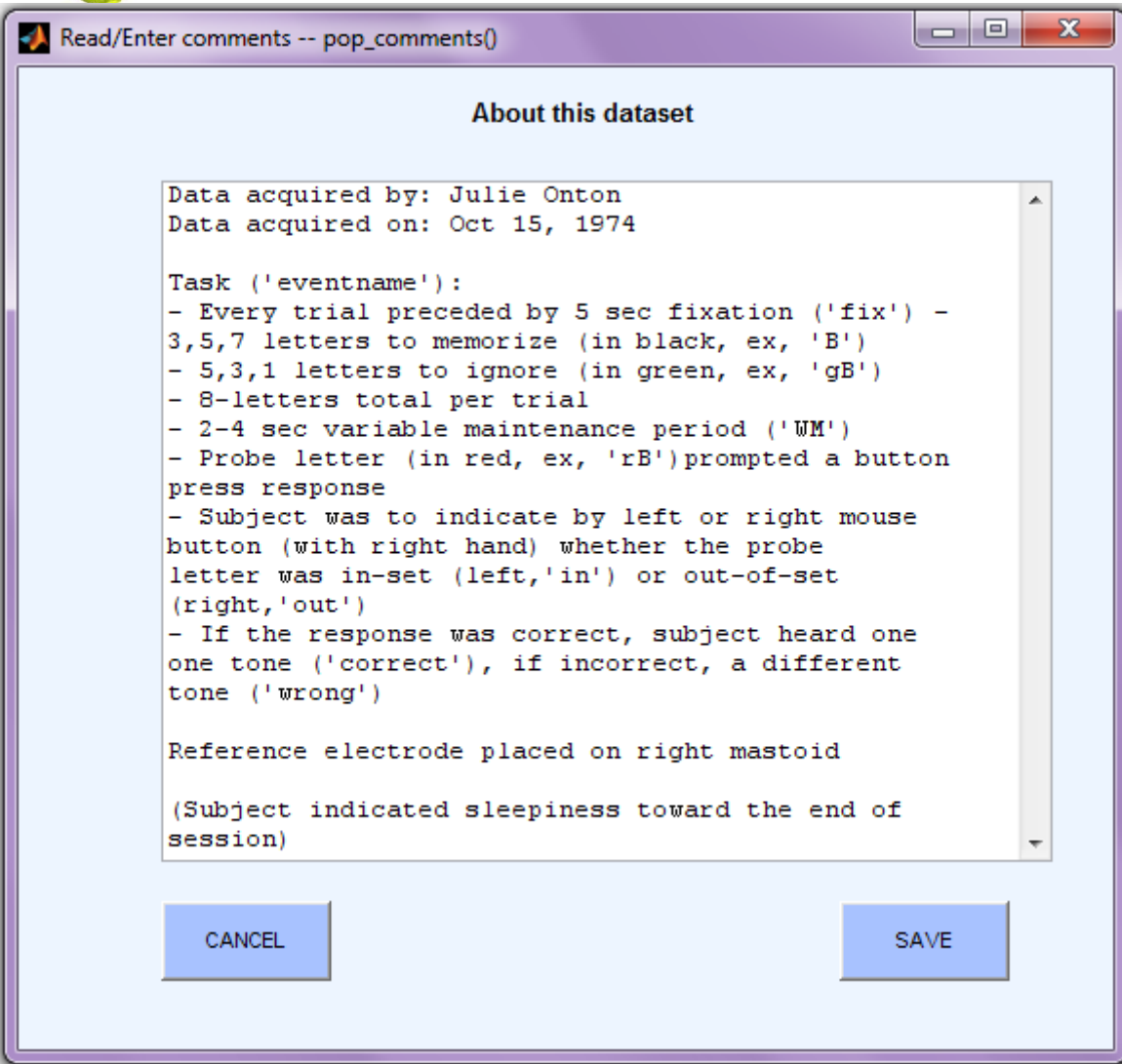
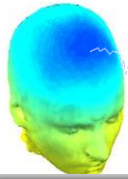
ERP
difference
between
2 conditions



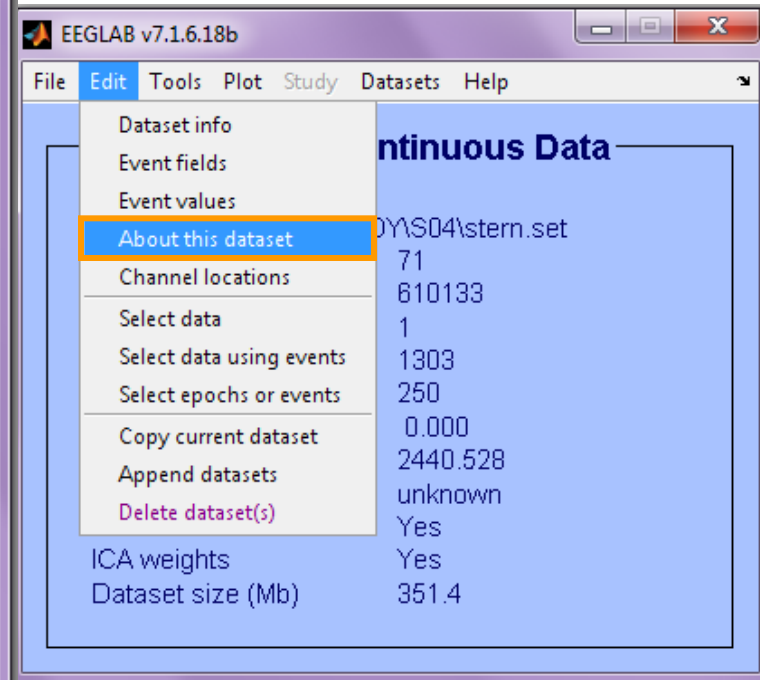
Event durations



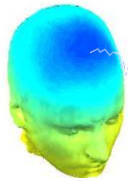
Comments in EEGLAB structure



>> EEG.comments



Memory options



Set when loading a STUDY

