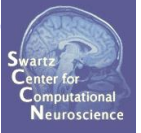
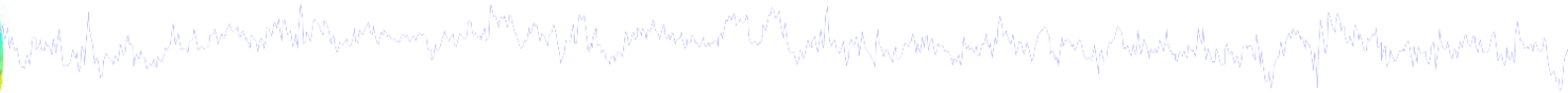
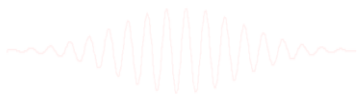


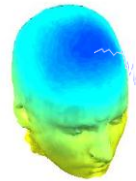
Evaluating ICA components



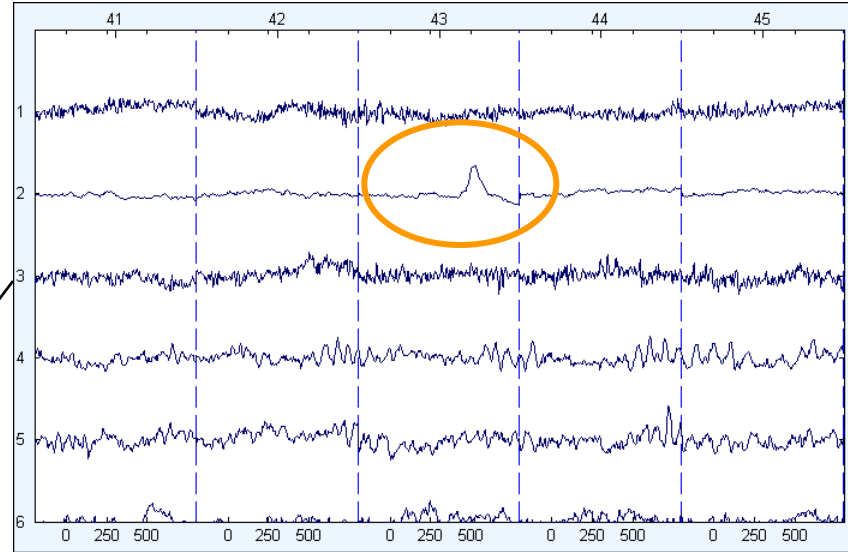
- 1. Remove an IC (back-projection)**
- 2. IC ERP envelope**
- 3. IC ERP images - advanced**
- 4. Time-frequency analysis**
- 5. IC ERSPs**
- 6. IC cross coherence**



Eye blink correction (remove IC)



Identify eye-blink components:



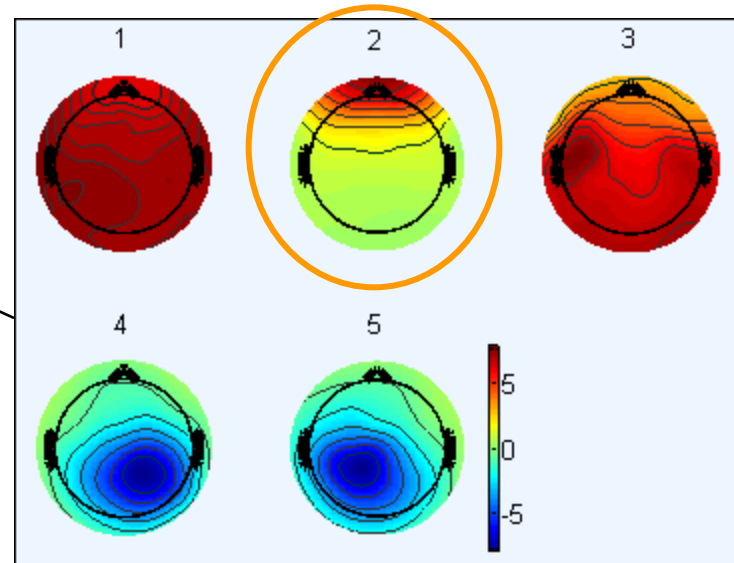
EEGLAB v4.512

File Edit Tools Plot Datasets Help

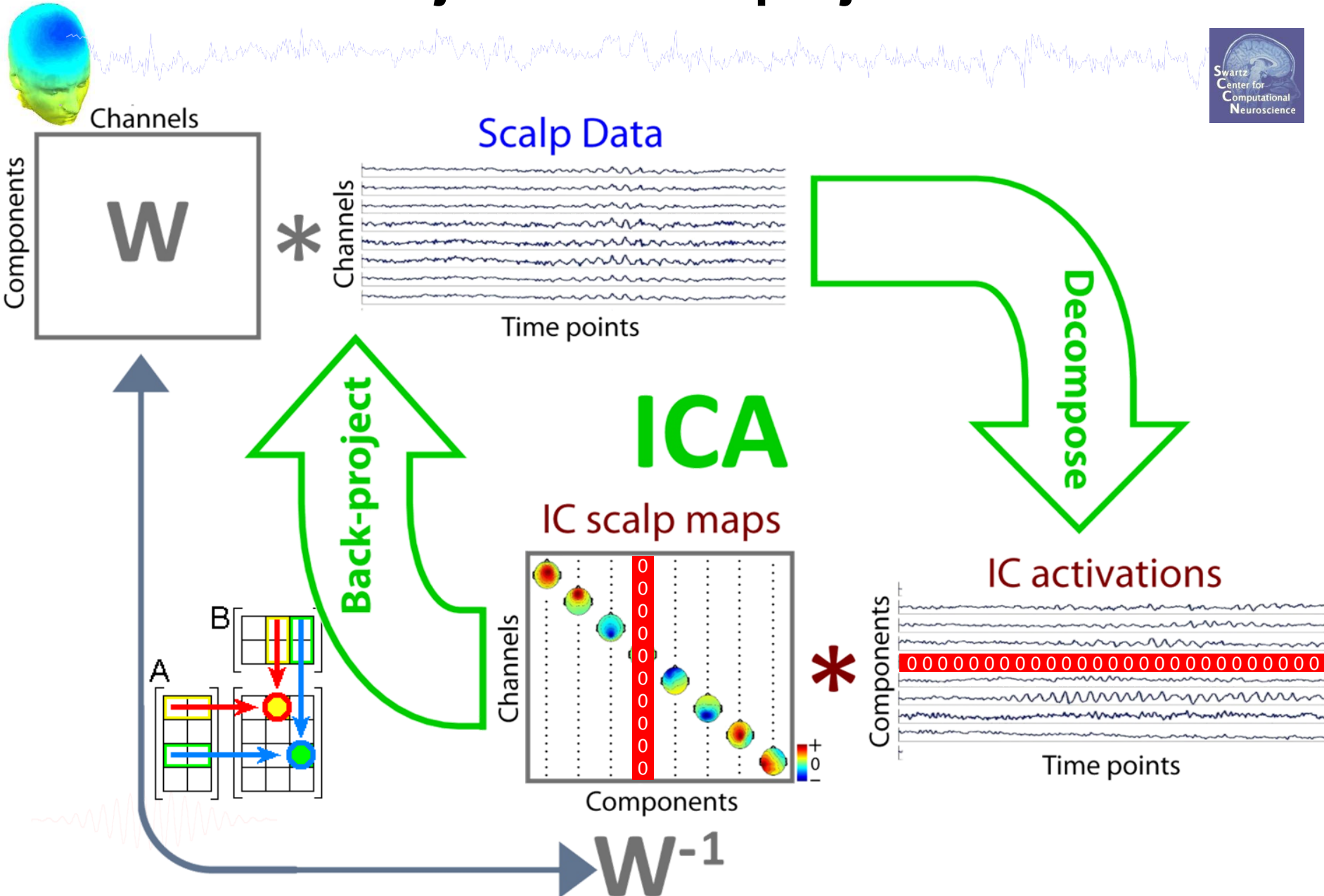
#1: (no)

Filename: Channels p Frames pe Epochs Events Sampling r Epoch star Epoch end Average re Channel lo ICA weight Dataset siz

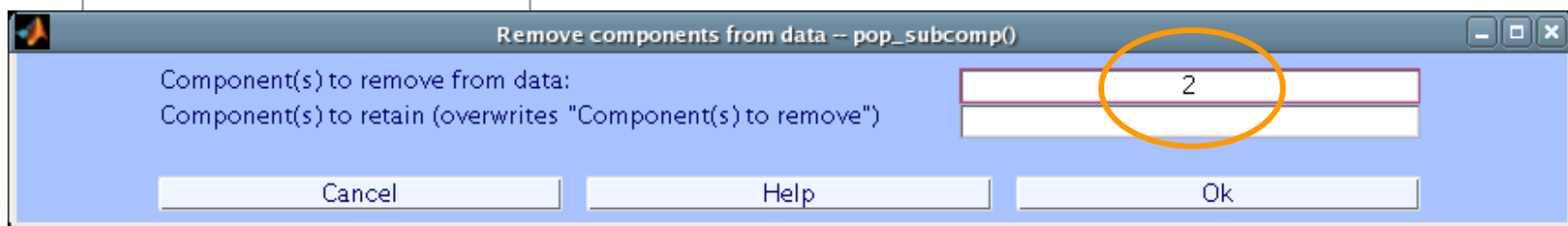
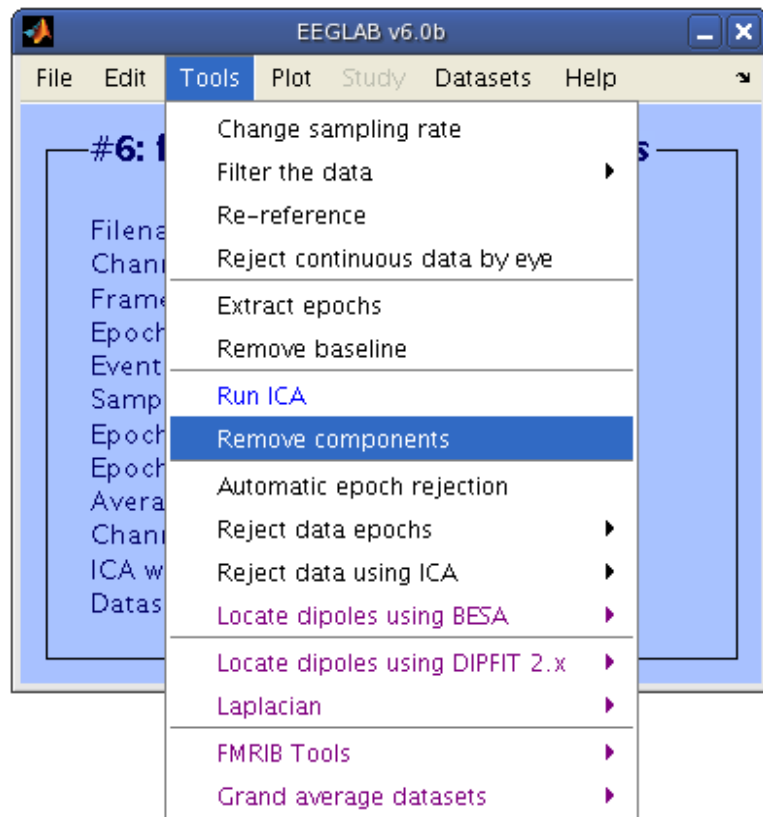
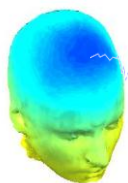
- Channel locations
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Sum/Compare ERPs
- Component activations (scroll)**
- Component spectra and maps
- Component maps**
- Component properties
- Component ERP image
- Component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



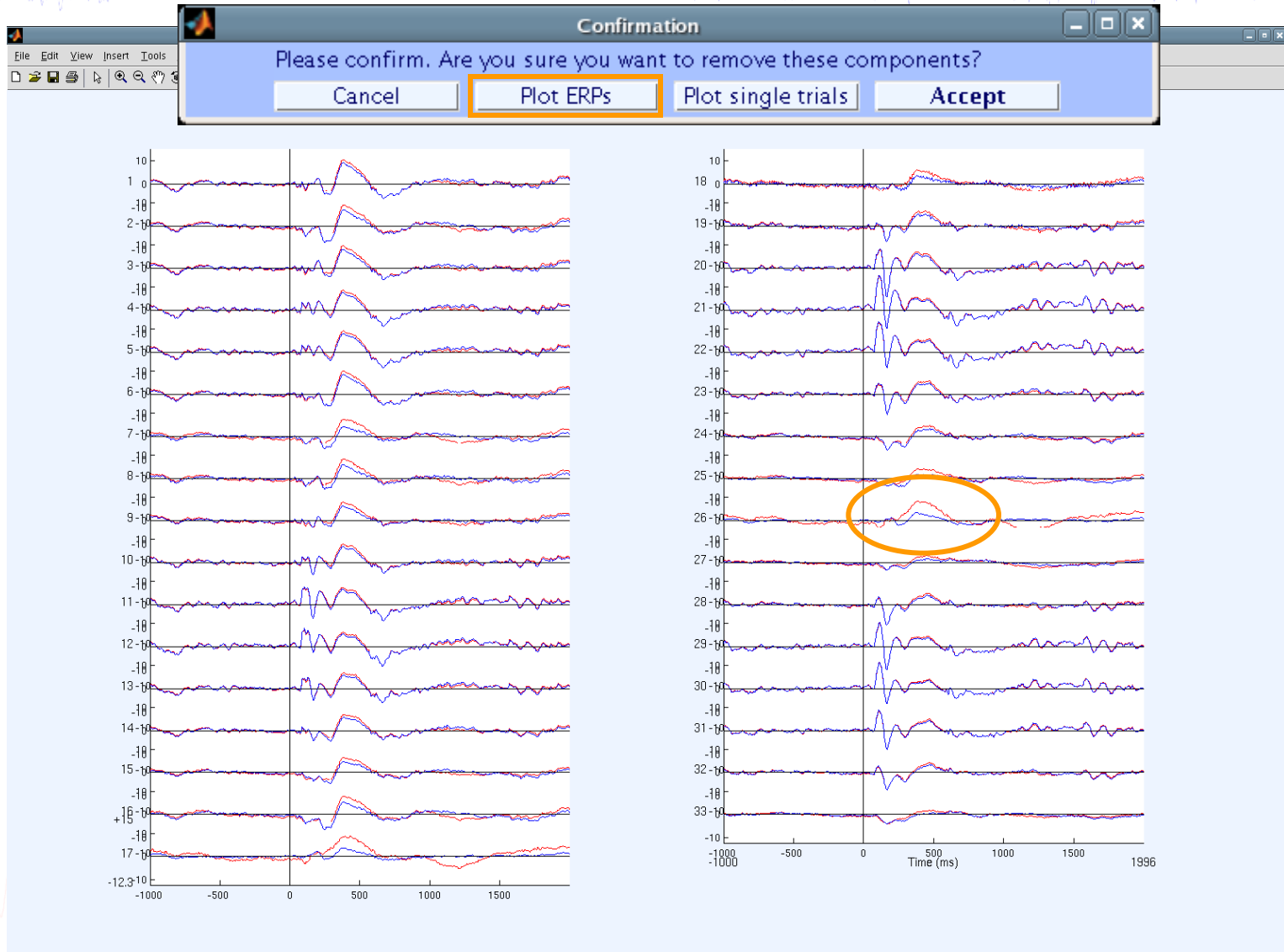
IC rejection/back-projection



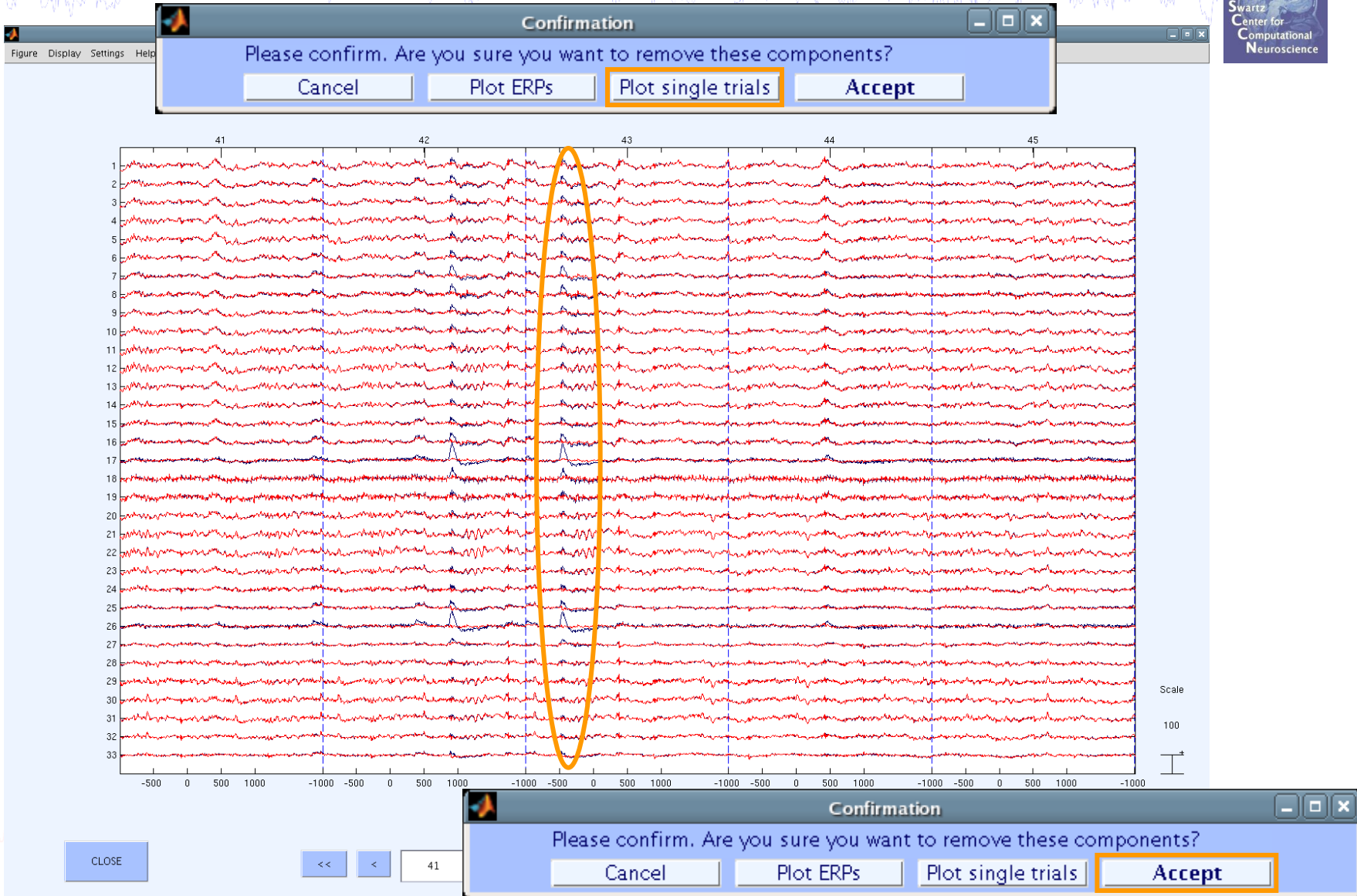
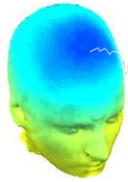
Eye blink correction (remove IC)



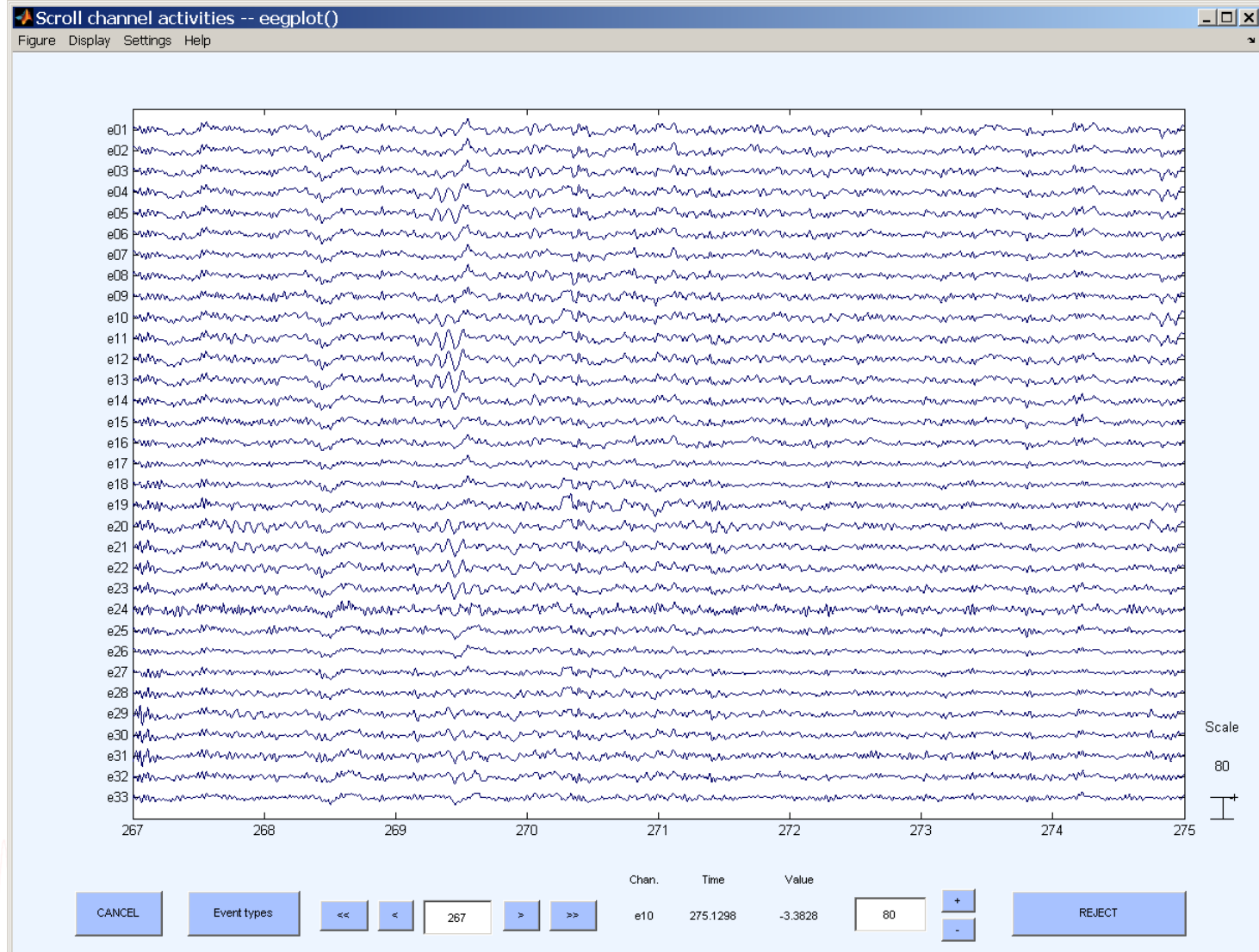
Eye blink correction (remove IC)



Eye blink correction (remove IC)



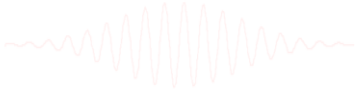
Eye blink correction (remove IC)



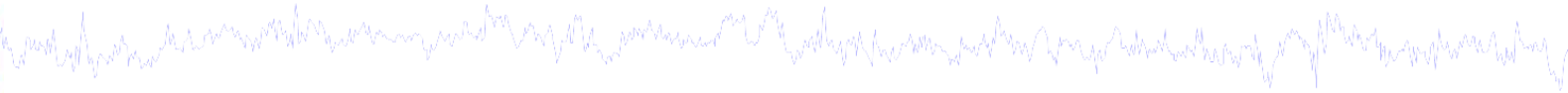
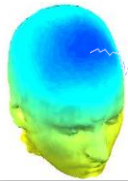
Evaluating ICA components



- 1. Remove an IC (back-projection)**
- 2. IC ERP envelope**
- 3. IC ERP images - advanced**
- 4. Time-frequency analysis**
- 5. IC ERSP**
- 6. IC cross coherence**



Extract epochs



EEGLAB v7.1.7.18b

File Edit **Tools** Plot Study Datasets Help

#2:

- 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

Extract data epochs - pop_epoch()

Time-locking event type(s) ([])=all

Epoch limits [start, end] in seconds
-1 2

Name for the new dataset
Sternberg Continuous -- Reref'd epx

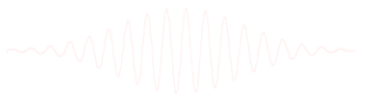
Out-of-bounds EEG limits if any [min max]

Cancel Help Ok

(use shift|ctrl to select several)

B
C
D
F
G
H
J
K
L
M
N
P
Q
R
S
T
V
W
WM
X
Y
Z
advance
boundary
gB
gC

Cancel Ok



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)

Epoch baseline removal -- pop_rmbase()

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

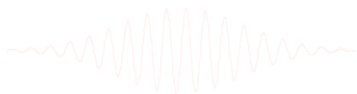
Else, baseline points vector (ex:1:56)
(overwritten by latency range above):

EEGLAB v10.2.4.4b

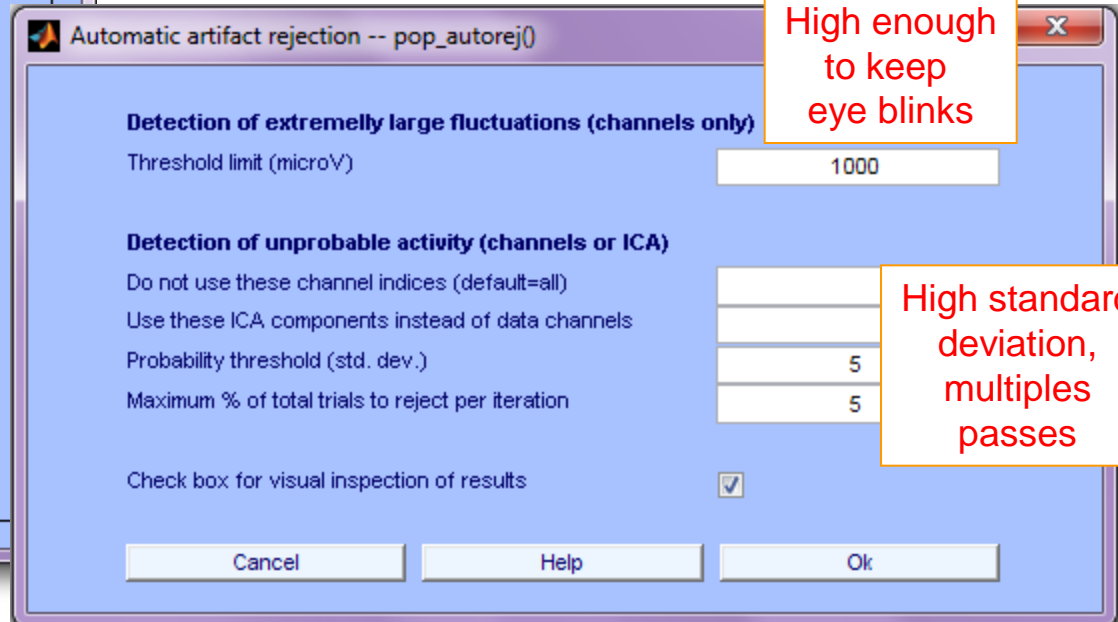
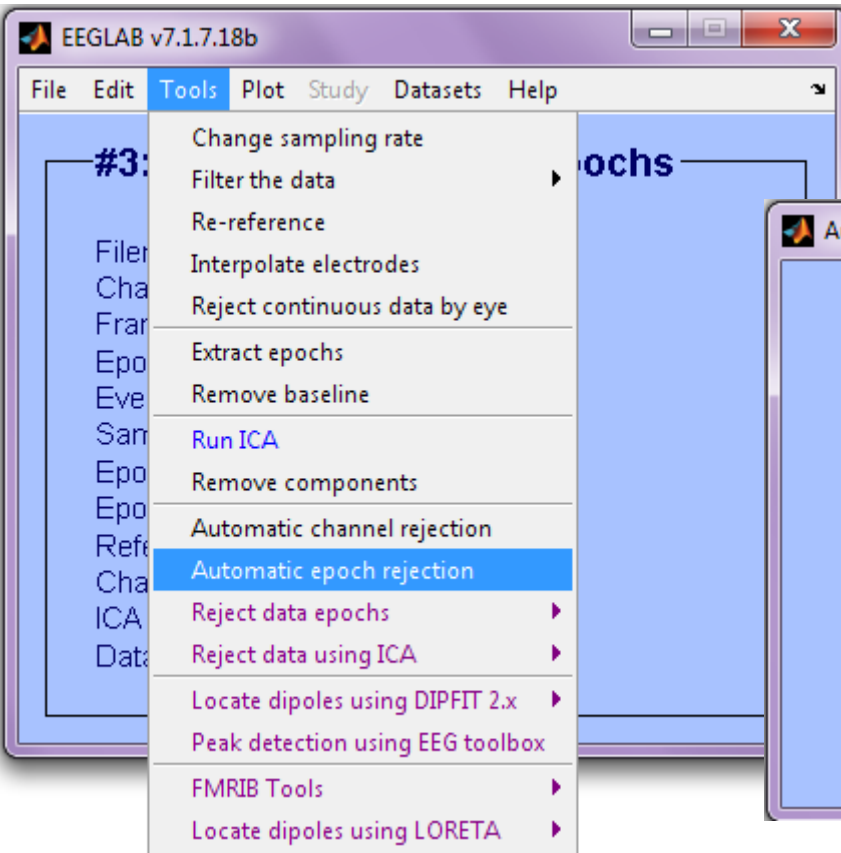
File Edit Tools Plot Study Datasets Help

#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

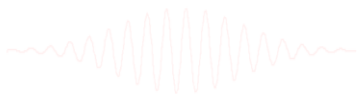
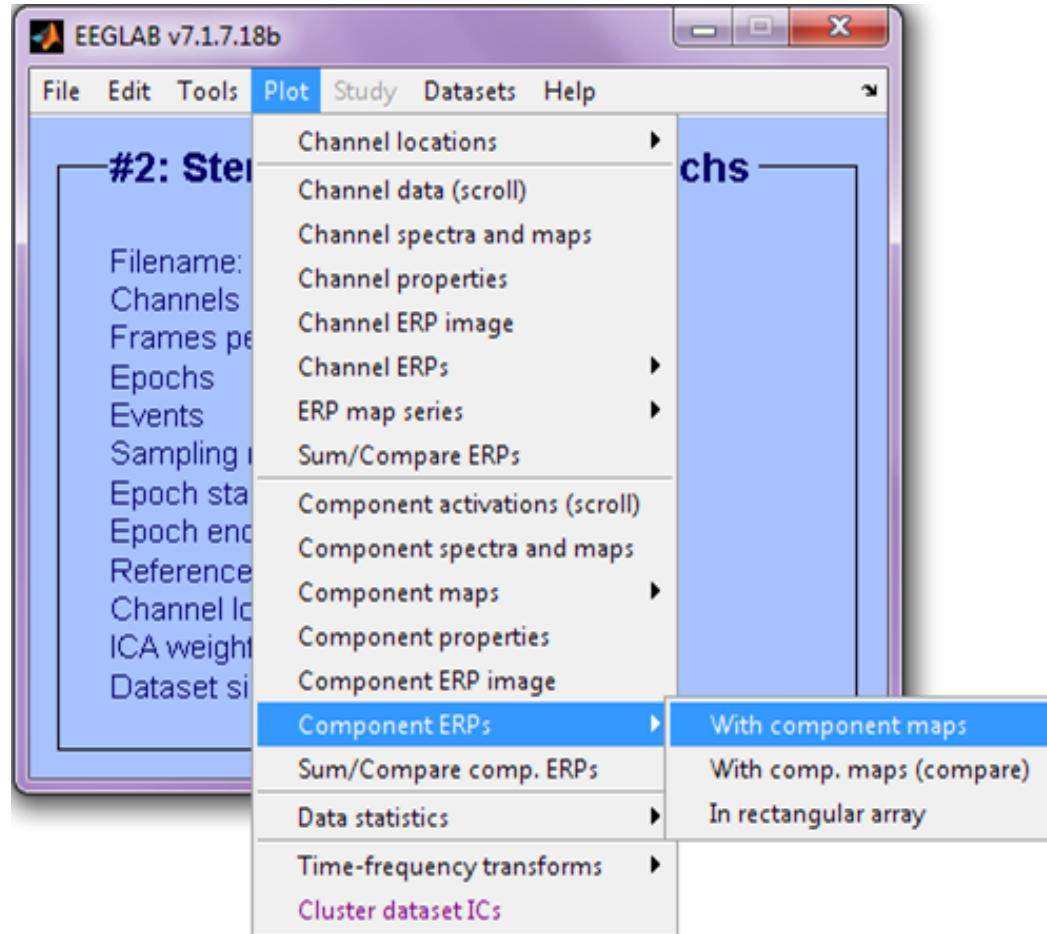
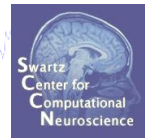


Reject data epochs (automatic)

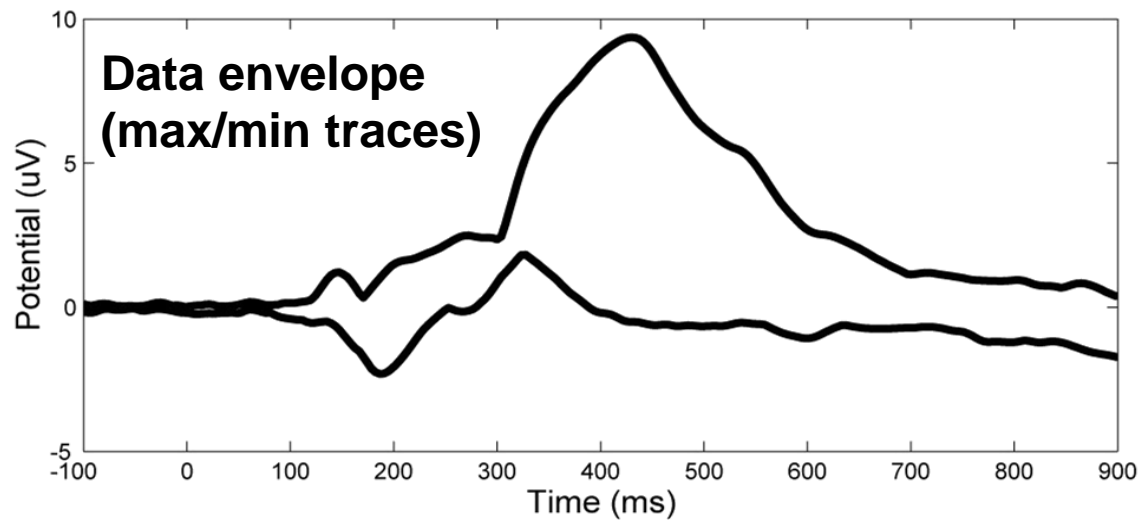
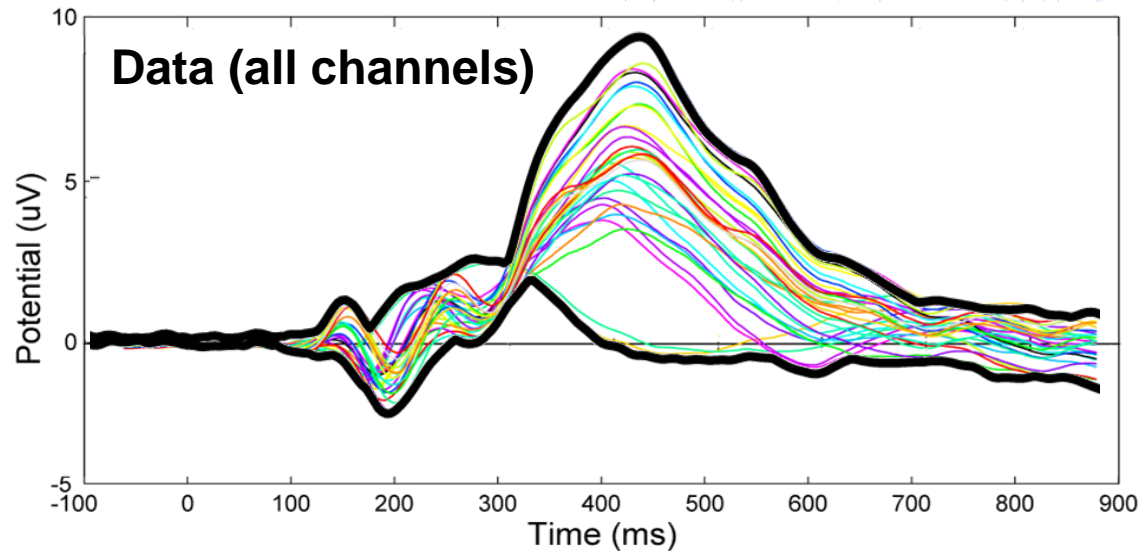


```
>> EEG = pop_autorej(EEG, 'nogui', 'on', 'eegplot', 'on');
```

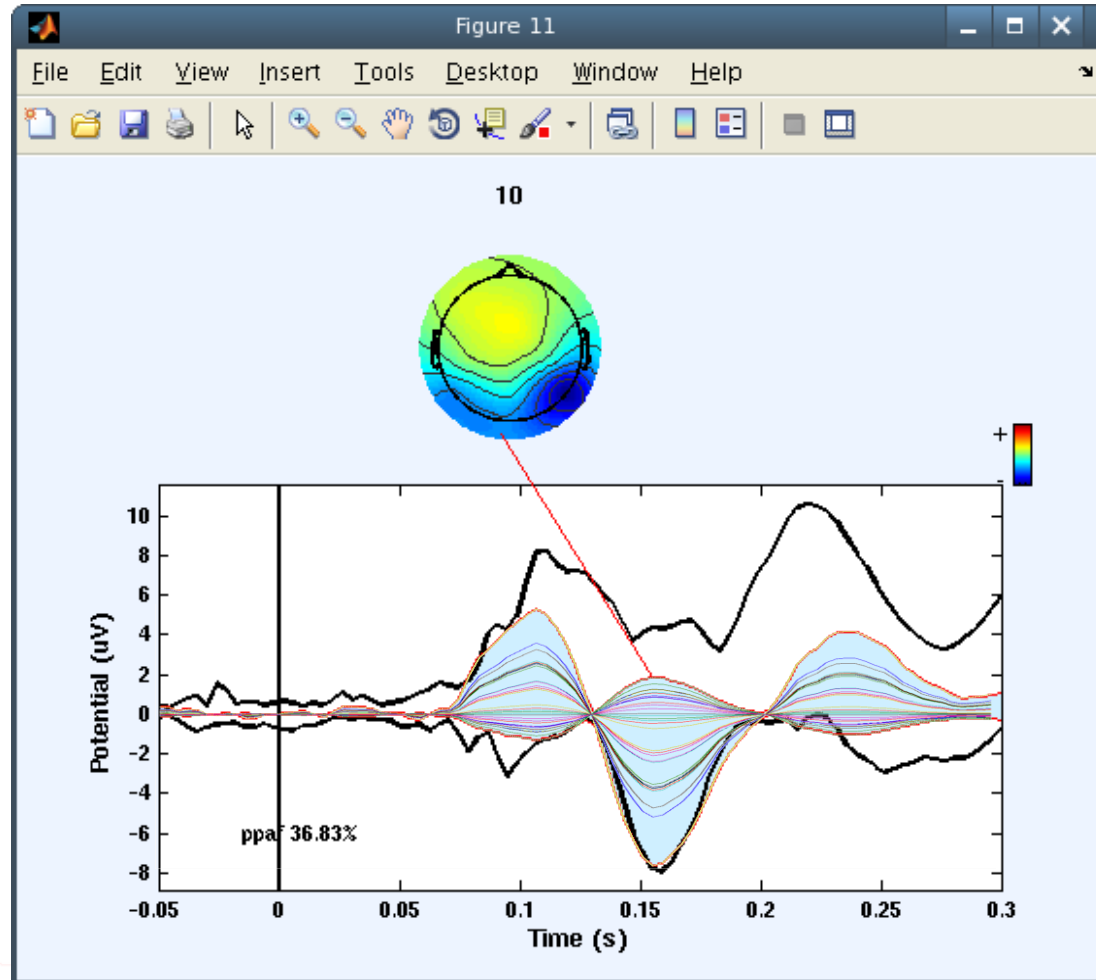
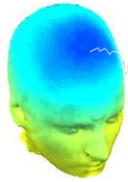
Component ERP envelope



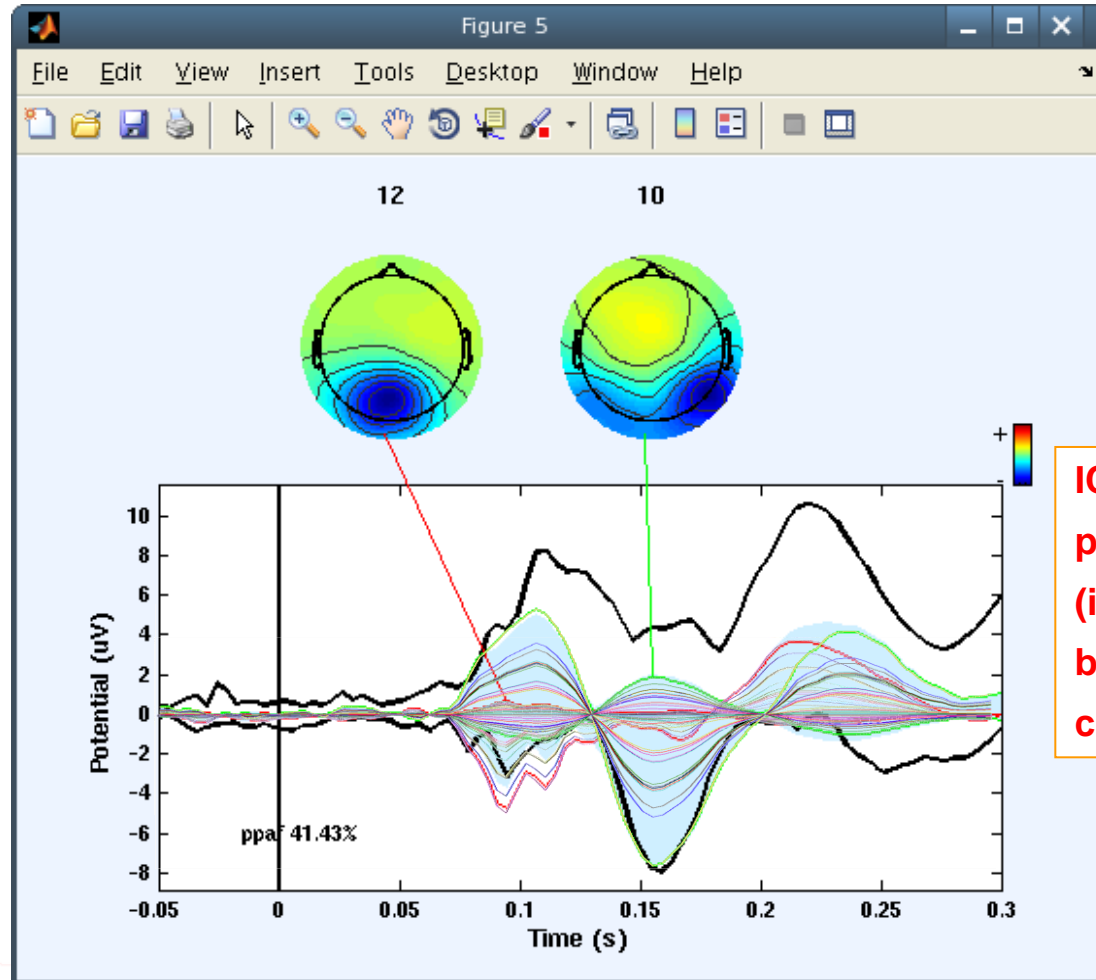
Definition: The data envelope



IC back-projection envelope

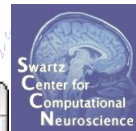
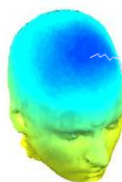


IC back-projection envelope



IC envelopes plotted for simplicity (instead of all back-projected channels)

IC contributions to ERP envelope



Plot component and ERP envelopes – pop_envtopo()

Enter time range (in ms) to plot: -100 1000

Enter time range (in ms) to rank component contributions: 0 600

Number of largest contributing components to plot (1-20): 6

Else plot these component numbers only (<21) (Ex: 2;4,7):

Component numbers to remove from data before plotting:

Plot title: ERP components of faces_4 epochs

Optional topoplot() and spectopo() arguments: 'electrodes','off'

Cancel

EEGLAB v1.10.0

File Edit Tools Plot Study Datasets Help

#2: Step 2: Select components

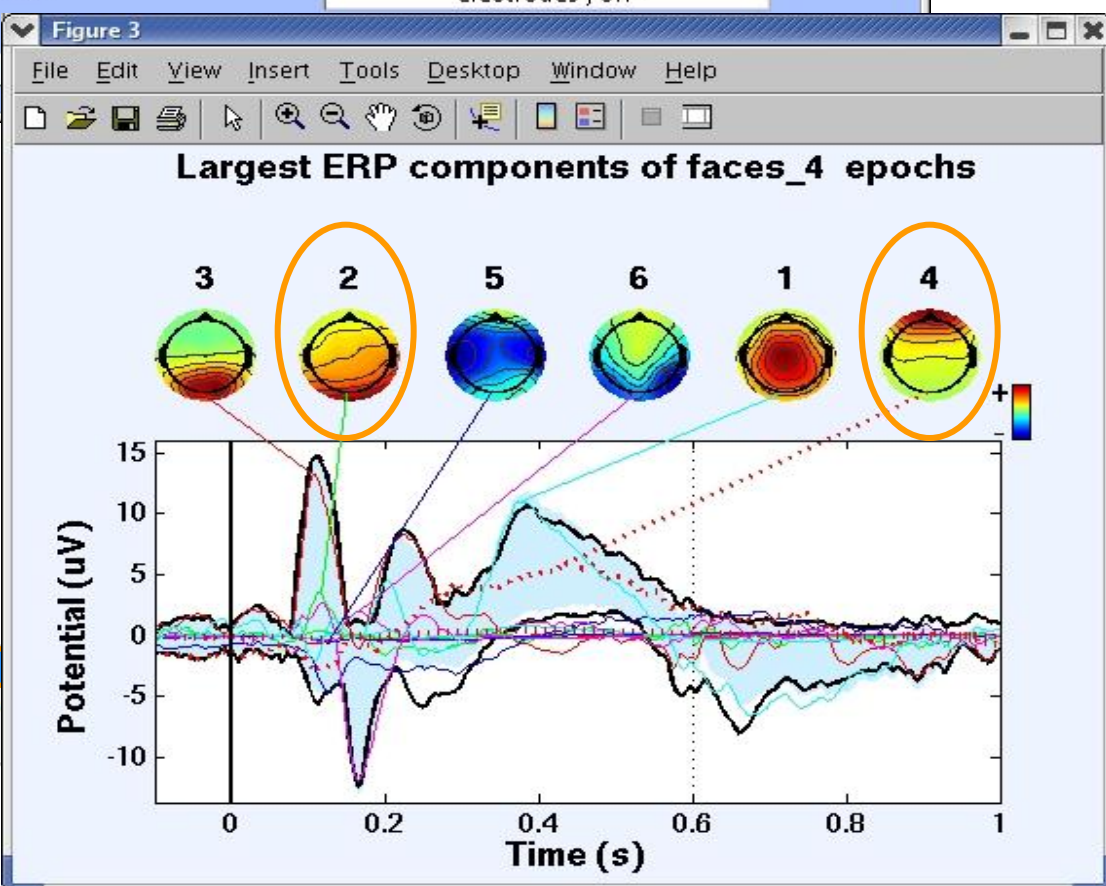
Filename: Channels Frames per Epochs Events Sampling Epoch start Epoch end Reference Channel location ICA weights Dataset size

- 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

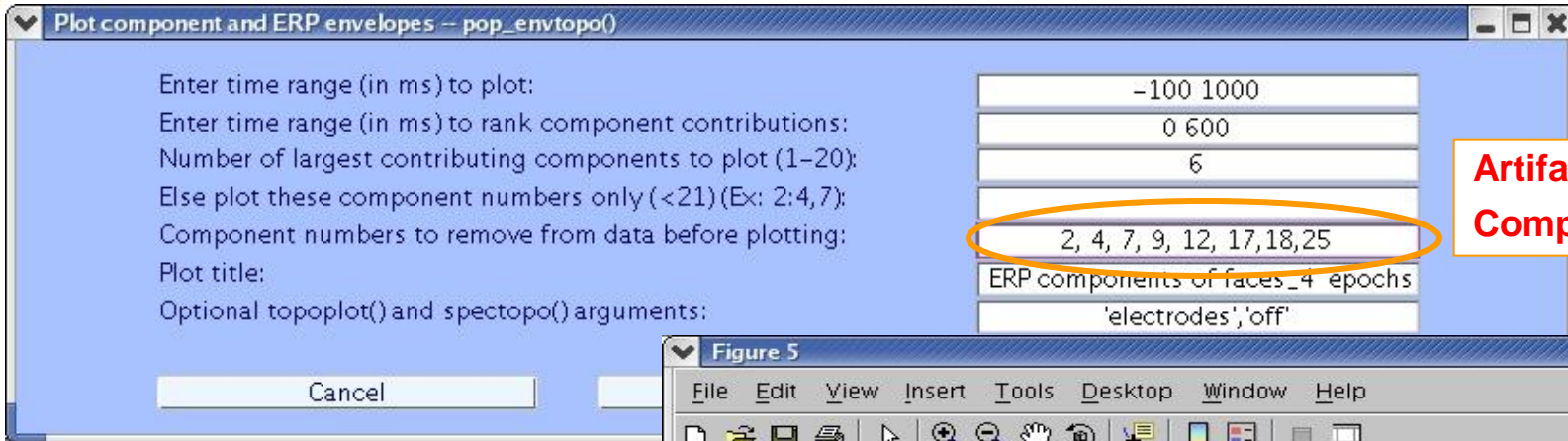
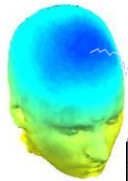
With component maps

With comp. maps (comp)

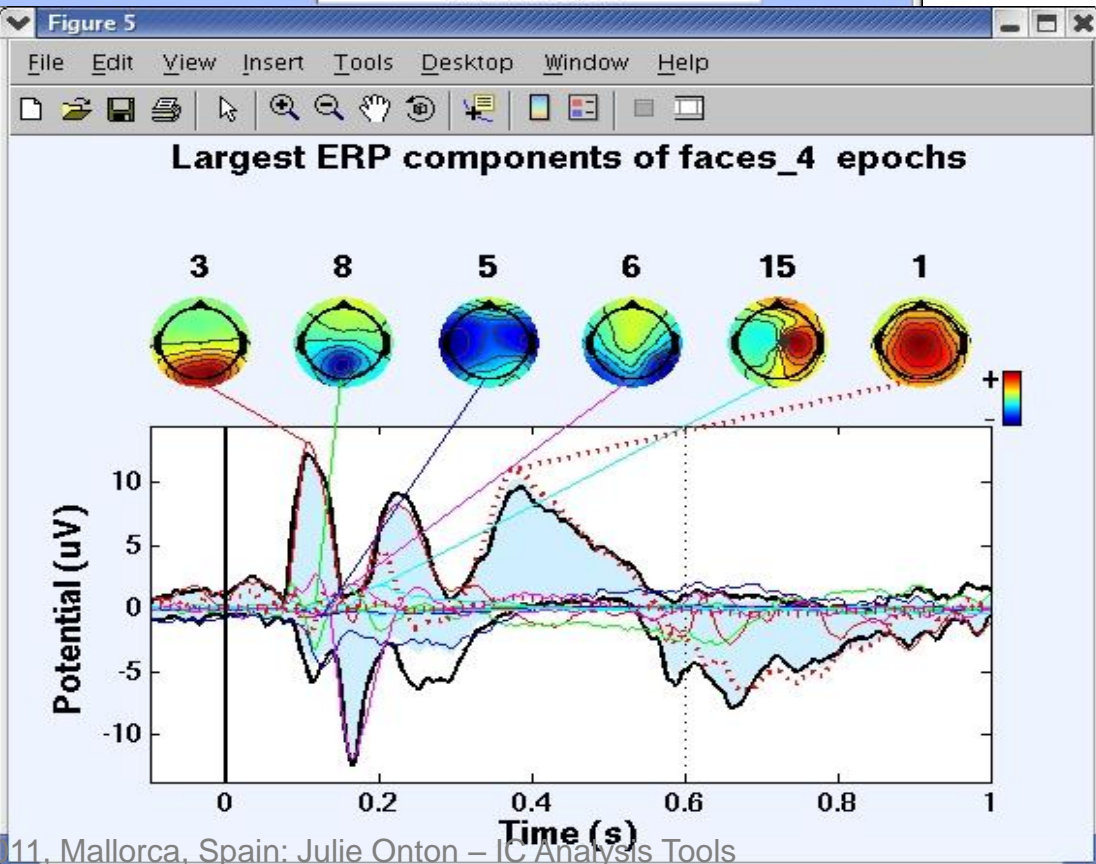
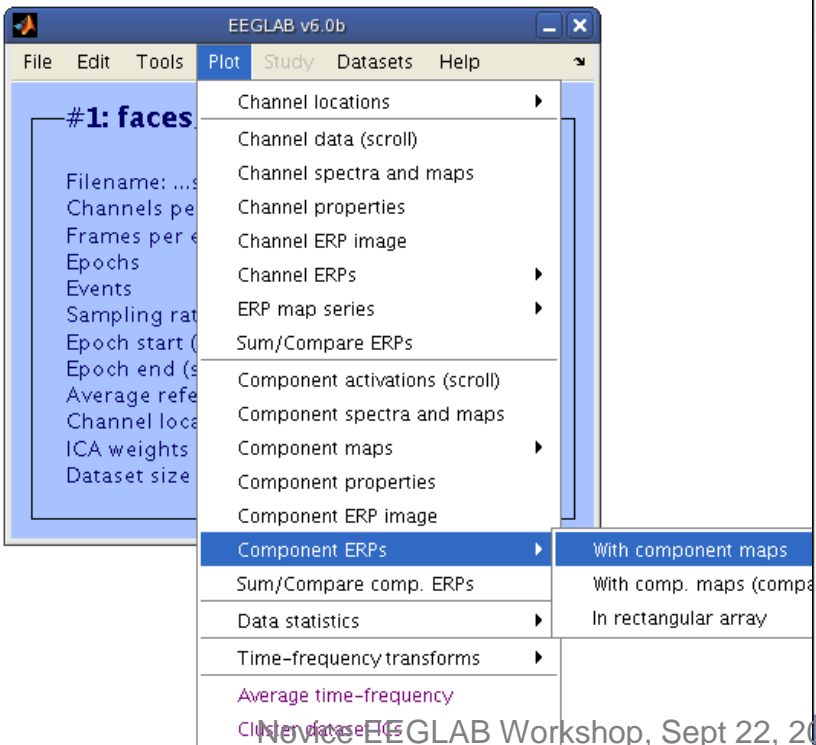
In rectangular array



IC contributions to ERP envelope



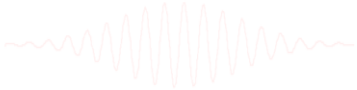
Artifact Components



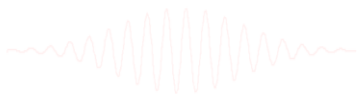
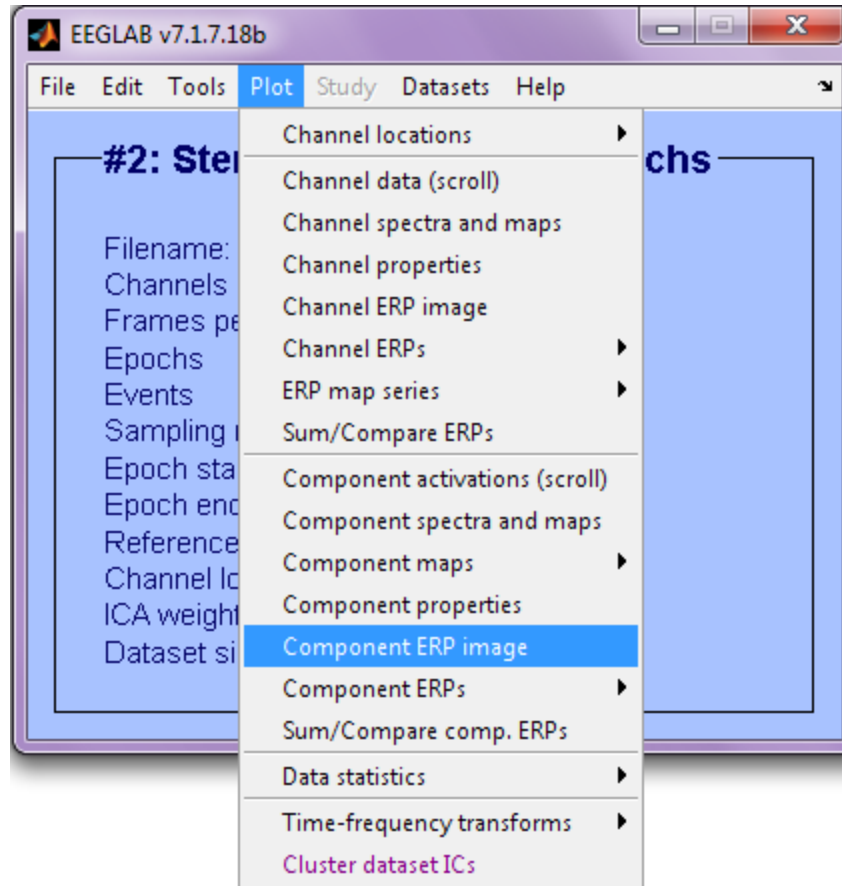
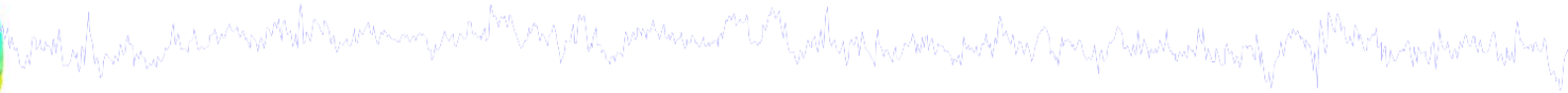
Evaluating ICA components



- 1. Remove an IC (back-projection)**
- 2. IC ERP envelope**
- 3. IC ERP images - advanced**
- 4. Time-frequency analysis**
- 5. IC ERSP**
- 6. IC cross coherence**



Component ERP image



Component ERP Images

select fields

latency
type
epoch

Cancel Ok

11
10
1
-1000 1996

Figure title

Plot scalp map
 Plot ERP
 Plot colorbar

ERP limits
Color limits (see Help)

Sort/align trials by epoch event values

Epoch-sorting field: latency
Event type(s): bp1' 'bp4
Event time range: 0 2000

Rescale: no
Align:
_Don't sort by value
_Don't plot values

Sort trials by phase

Frequency (Hz | minH
amp. trials to ig

Inter-trial coherence

Frequency (Hz | minH
(<0.20)

Other options

Plot spectrum (minHz
l. (dB)

select fields

bp1
bp4
face
object

Cancel Ok

Figure 5: erpimage()

File Edit View Insert Tools Desktop Window Help

Comp. 11

Sorted Trials

Time (ms)

0.4
-0.4

Novice EEGLAB Workshop, Sept 22, 2011 Mallorca, Spain: Julie Onton – IC Analysis Tools

Component ERP Images

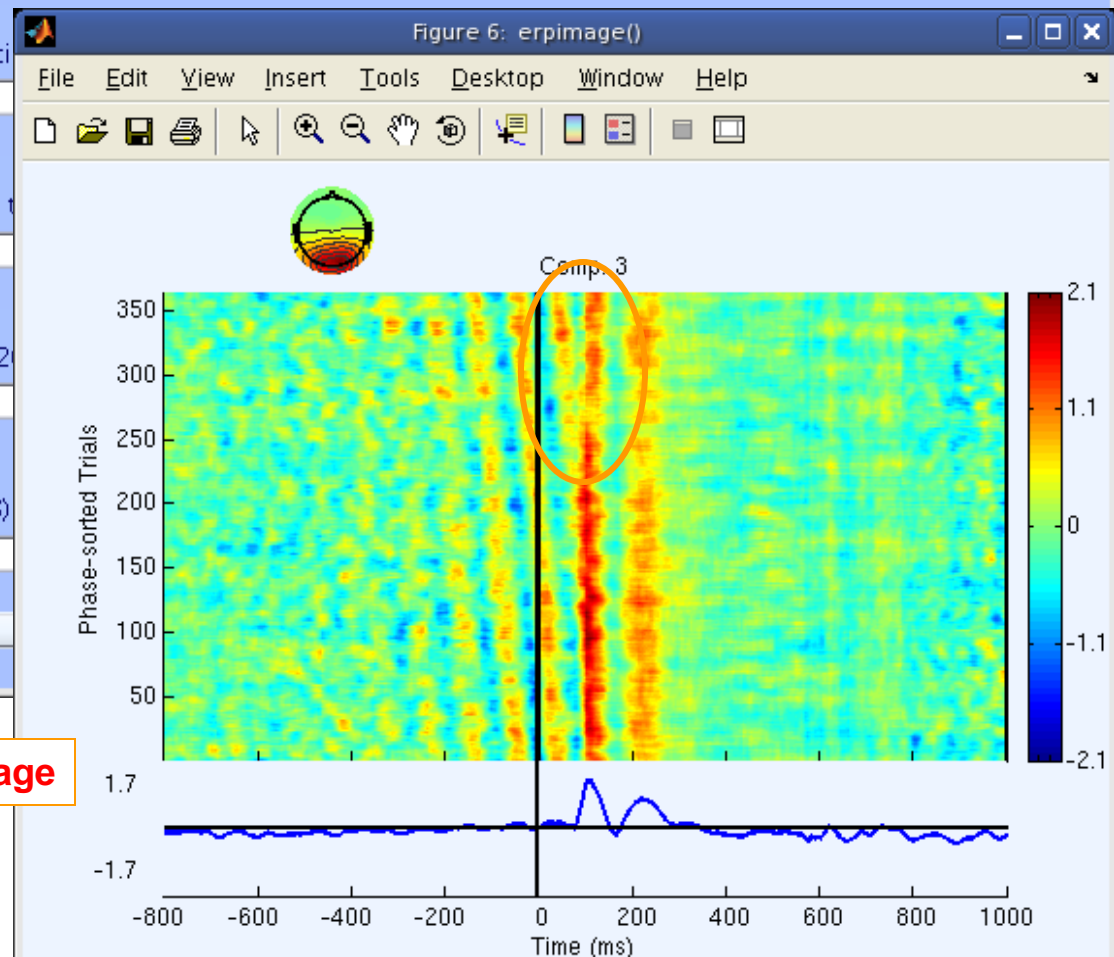
Component ERP image -- pop_erpimage()

Component(s)
Project to channel #
Smoothing
Downsampling
Time limits (ms)

Figure title
 Plot scalp map
 Plot ERP
 Plot colorbar
ERP limits
Color limits (see Help)

Sort/align trials by epoch event values
Epoch-sorting field Event type(s) Event time

Sort trials by phase
Frequency (Hz | minHz maxHz) Percent low-amp.
Inter-trial coherence options
Frequency (Hz | minHz maxHz) Signif. level (<0.2)
Other options
Plot spectrum (minHz maxHz) Baseline ampl. (dB)



Phase-sorted image

Component ERP Images

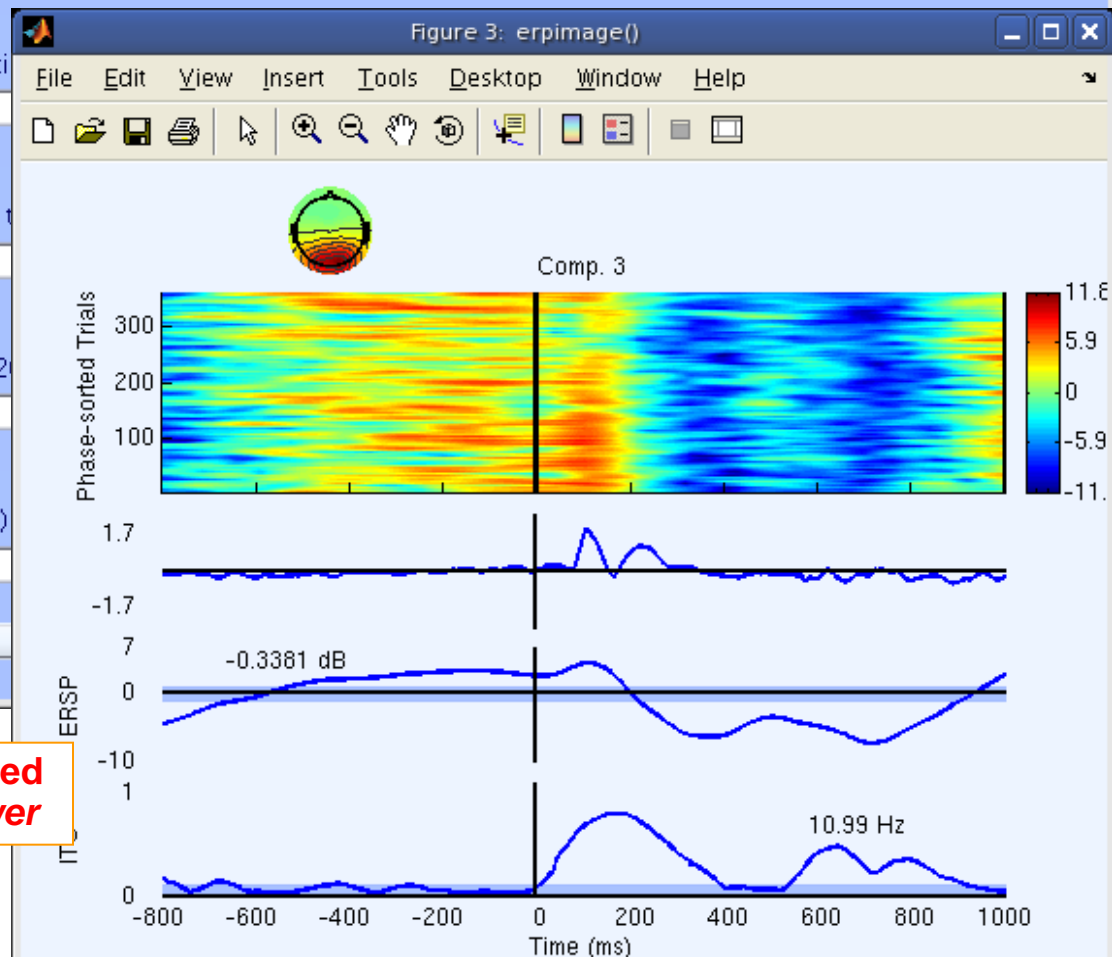
Component ERP image -- pop_erpimage()

Component(s)
Project to channel #
Smoothing
Downsampling
Time limits (ms)

Figure title
 Plot scalp map
 Plot ERP
 Plot colorbar
ERP limits
Color limits (see Help)

Sort/align trials by epoch event values
Epoch-sorting field Event type(s) Event time

Sort trials by phase
Frequency (Hz | minHz maxHz) Percent low-amp.
Inter-trial coherence options
Frequency (Hz | minHz maxHz) Signif. level (<0.2)
Other options
Plot spectrum (minHz maxHz) Baseline ampl. (dB)



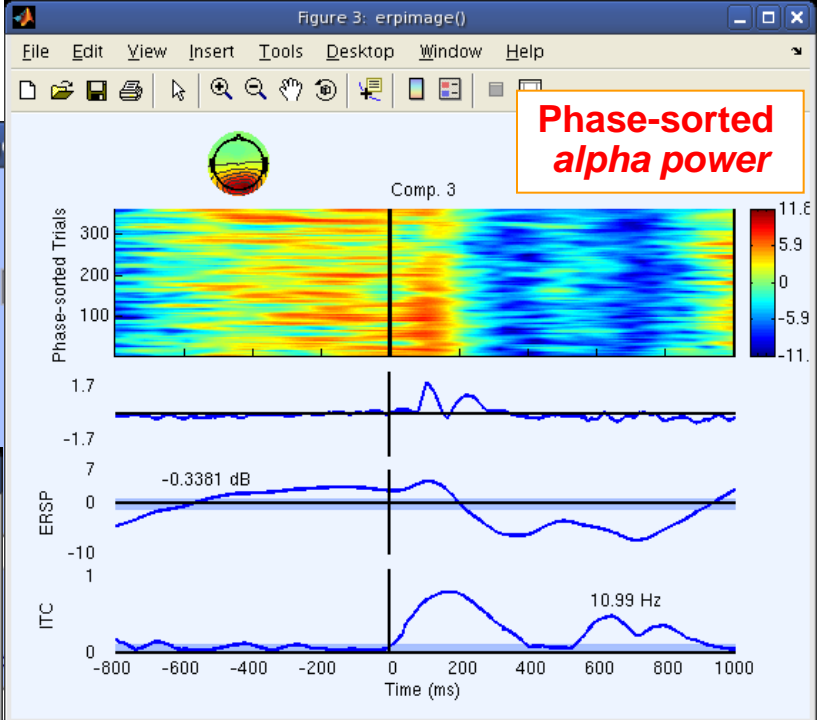
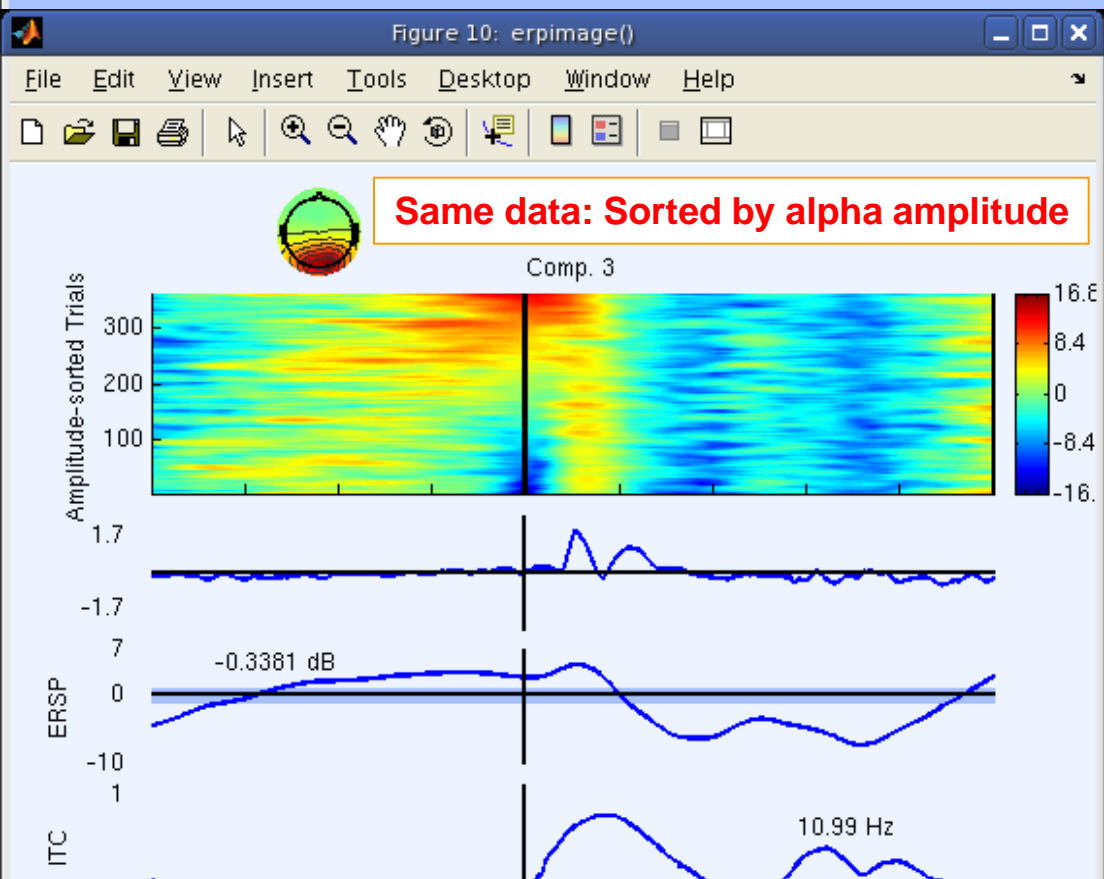
Phase-sorted
alpha power

Component ERP

Component ERP image -- pop_erpimag

Component(s)	3	Figure title
Project to channel #		
Smoothing	10	
Downsampling	1	
Time limits (ms)	-800 1000	

Plot scalp map
 Plot ERP
 Plot colorbar



Coher limits (≤ 1)

Image amps (Requires signif.)

More options (see >> help erpimage)

>> help erpimage
 'ampsort' = [center_ms, prcnt, freq, maxfreq] Sort epochs by amplitude.

Component ERP Images

Component ERP image -- pop_erpimage()

Component(s)	3
Project to channel #	
Smoothing	10
Downsampling	1
Time limits (ms)	-800 1000

Figure title

Plot scalp map

Plot ERP

Plot colorbar

ERP limits

Color limits (see Help)

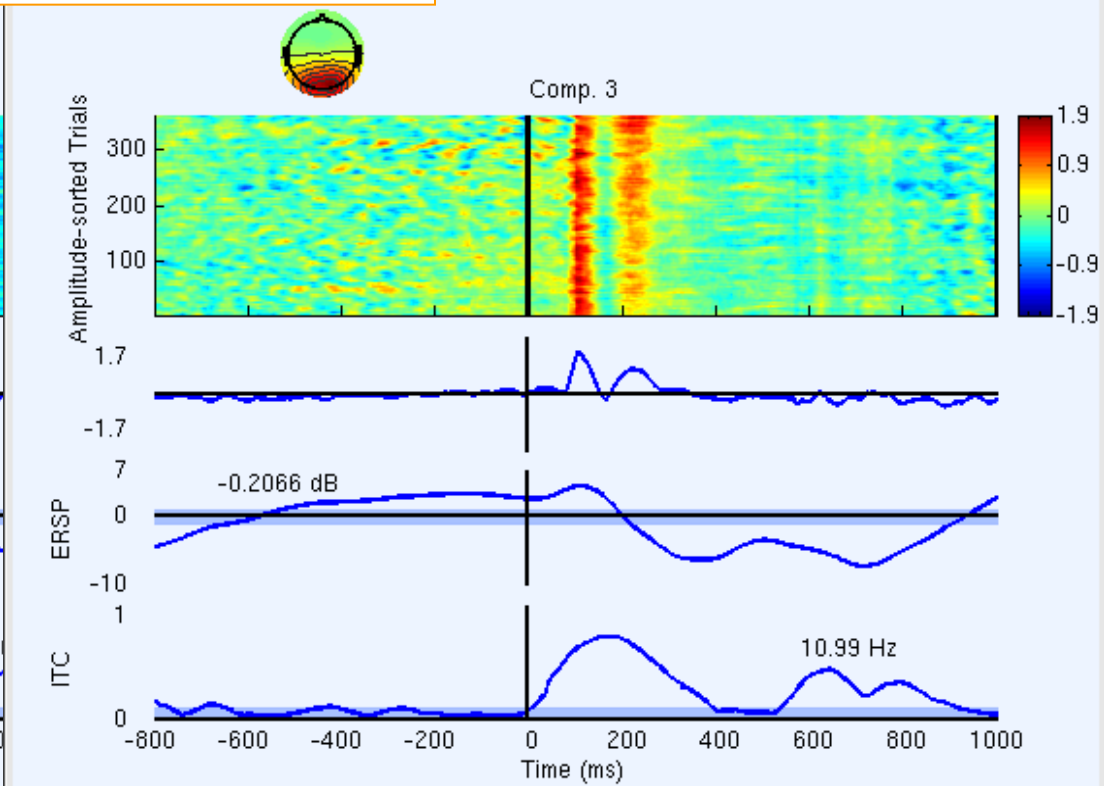
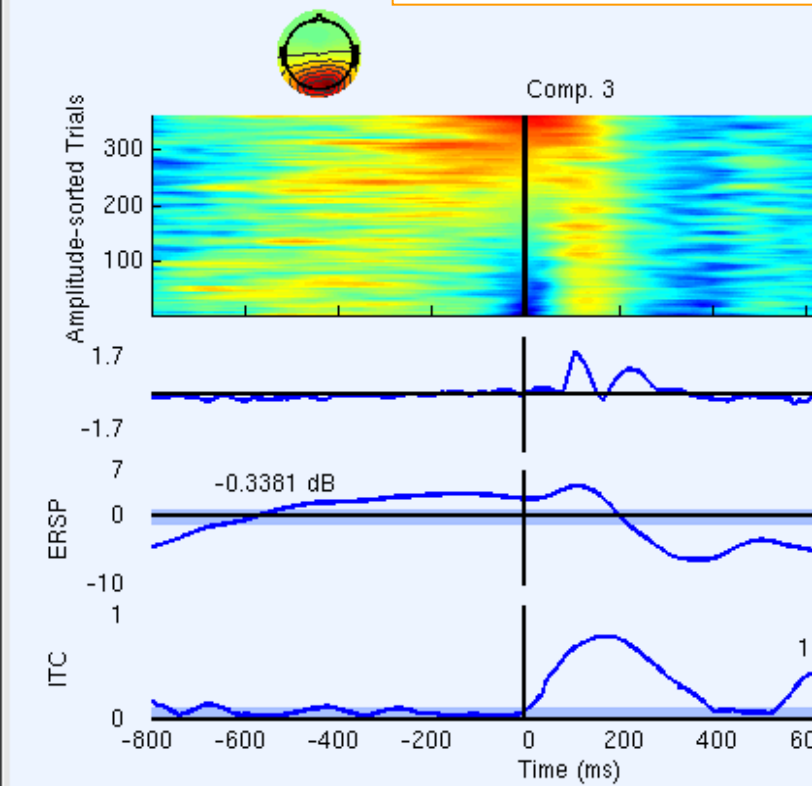
Figure 10: erpimage()

File Edit View Insert Tools Desktop Window Help

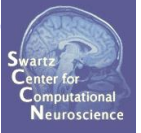
Figure 11: erpimage()

File Edit View Insert Tools Desktop Window Help

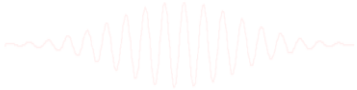
Same sorting order: Amplitude vs. activations



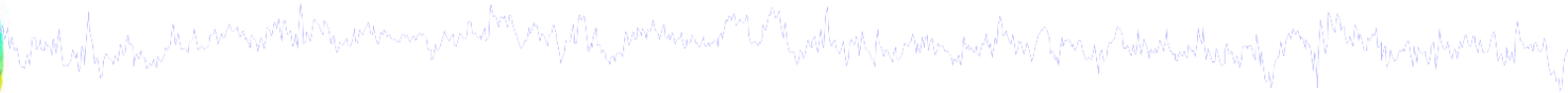
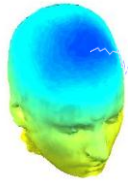
Evaluating ICA components



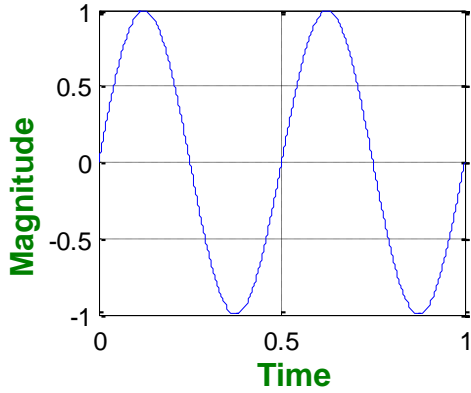
- 1. Remove an IC (back-projection)**
- 2. IC ERP envelope**
- 3. IC ERP images - advanced**
- 4. Time-frequency analysis**
- 5. IC ERSP**
- 6. IC cross coherence**



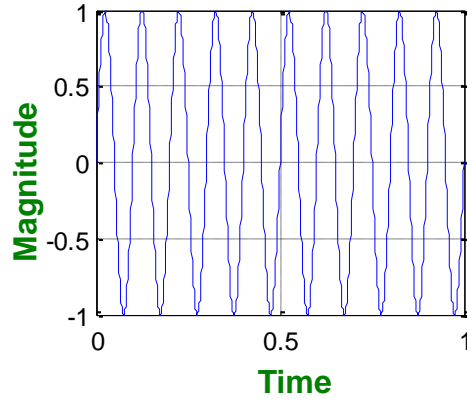
Stationary signals



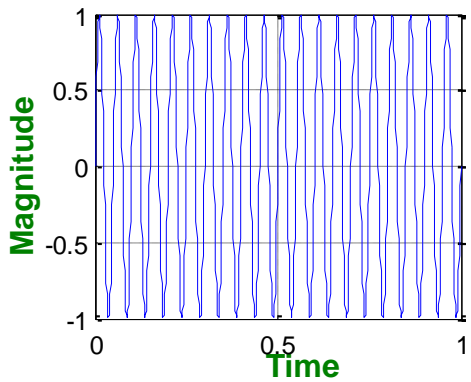
2 Hz



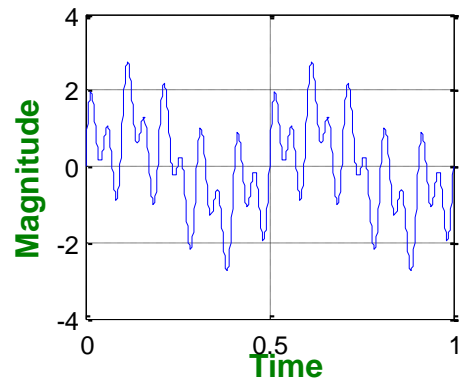
10 Hz



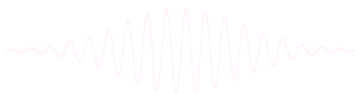
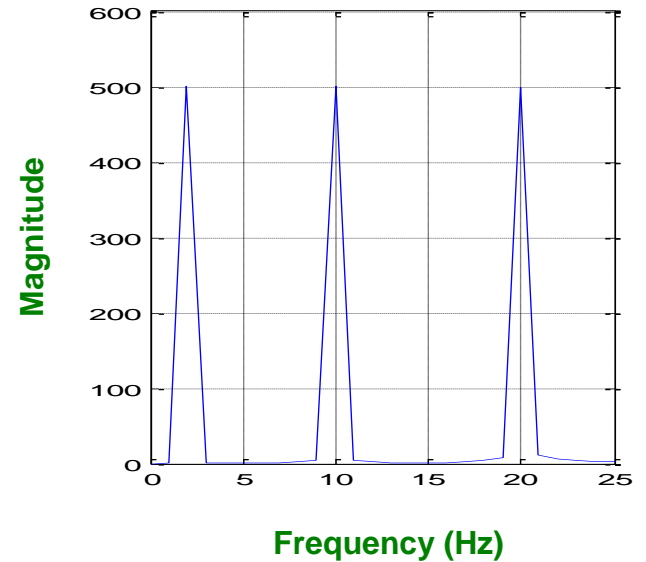
20 Hz



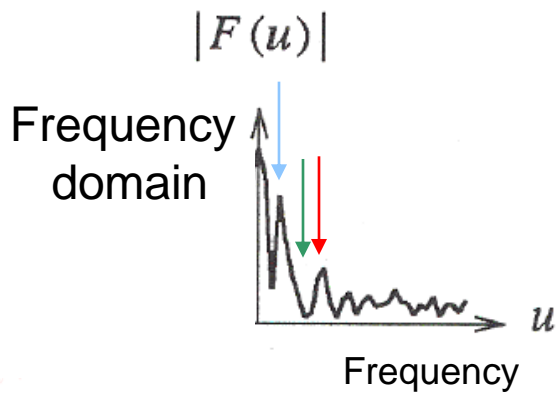
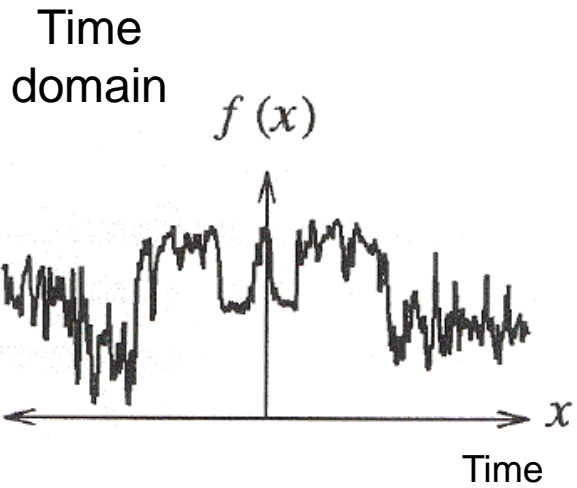
2+10+20 Hz



Power spectrum

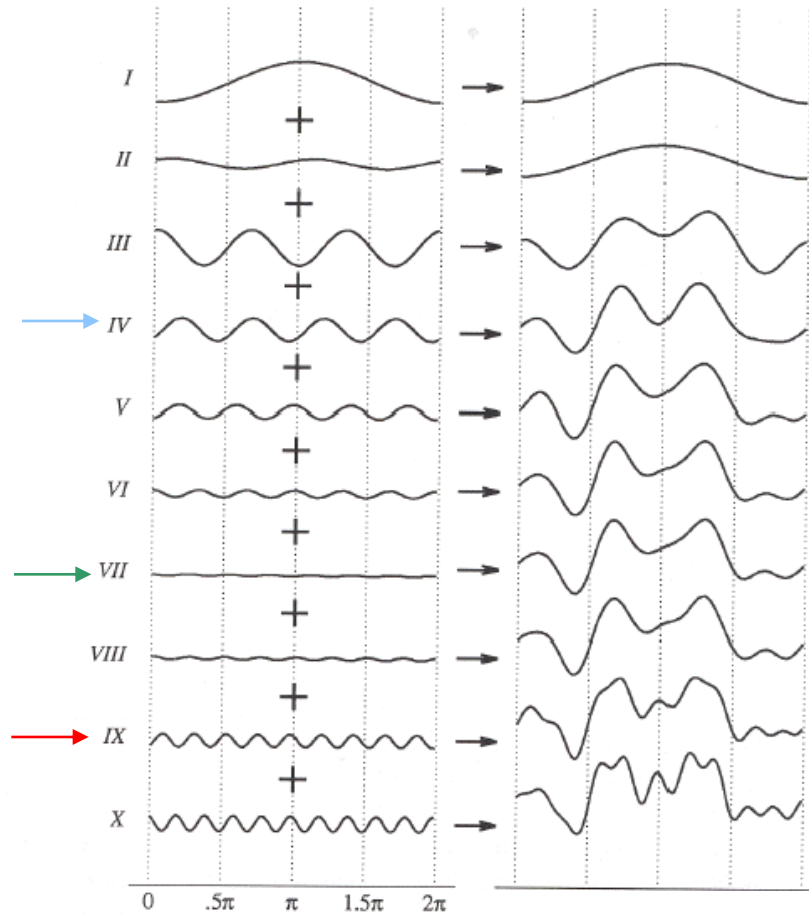


Summing stationary signals and decomposing

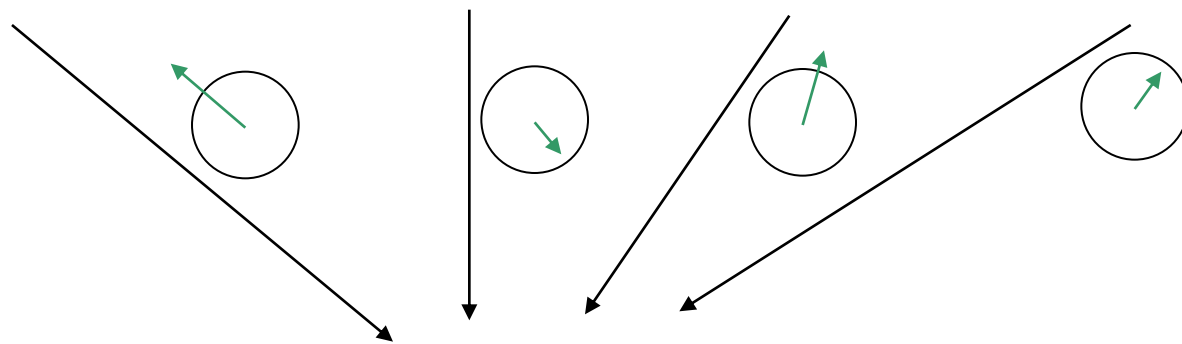
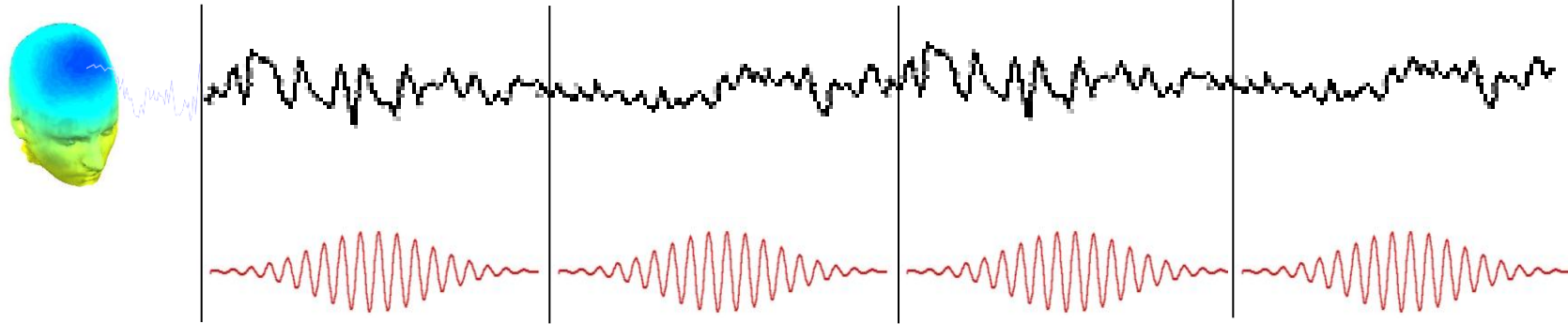


Freq. decomp.

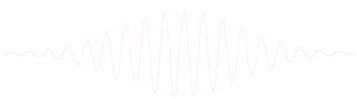
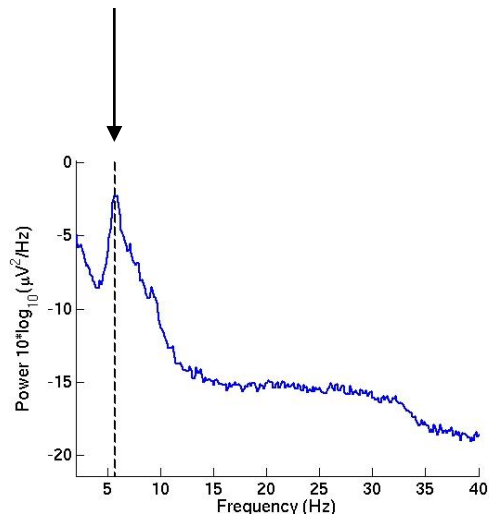
Sum of freq.

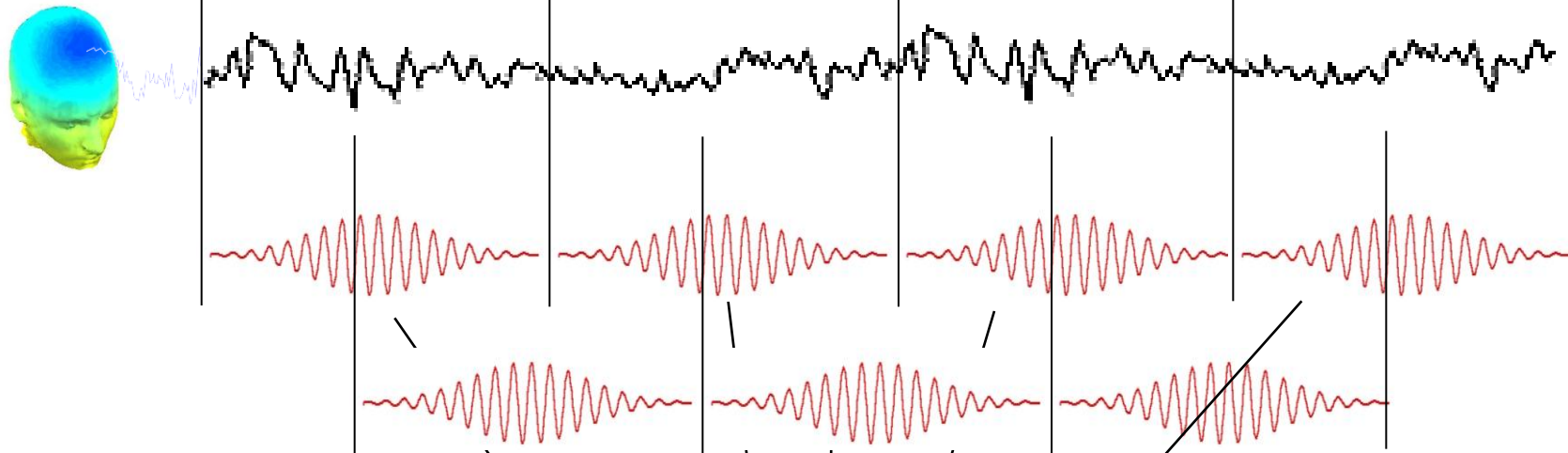


Figure, courtesy of Ravi Ramamoorthi & Wolberg



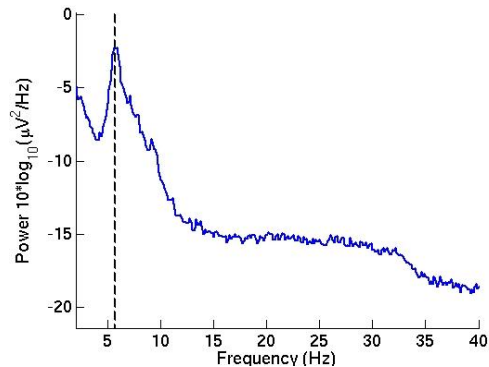
Average of squared absolute values



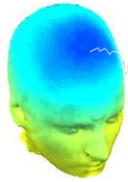


Overlap 50%

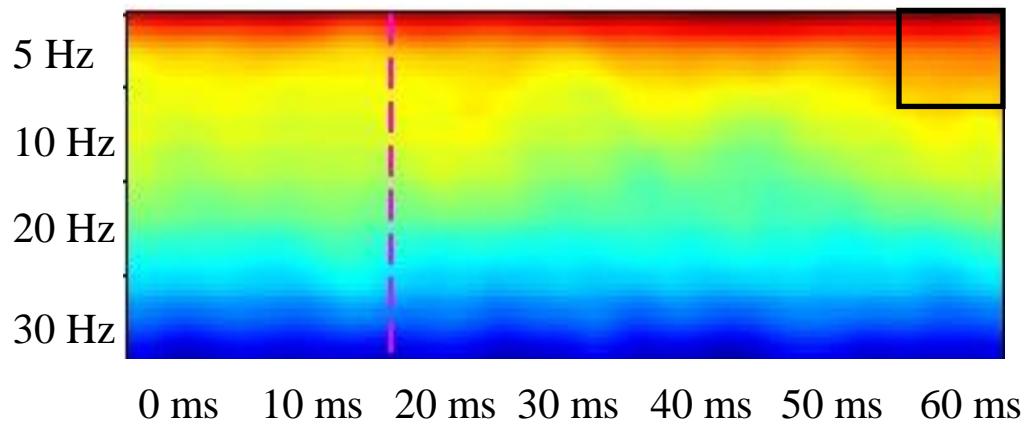
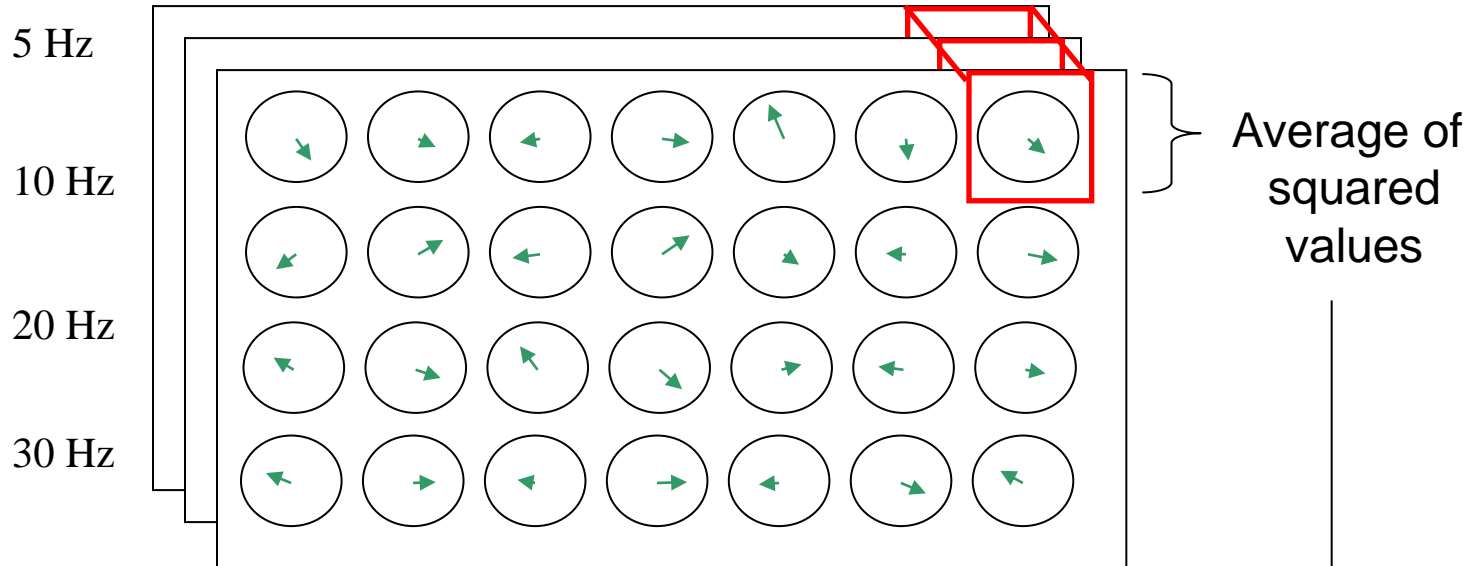
Average of squared amplitudes



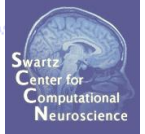
Spectrogram or ERSP



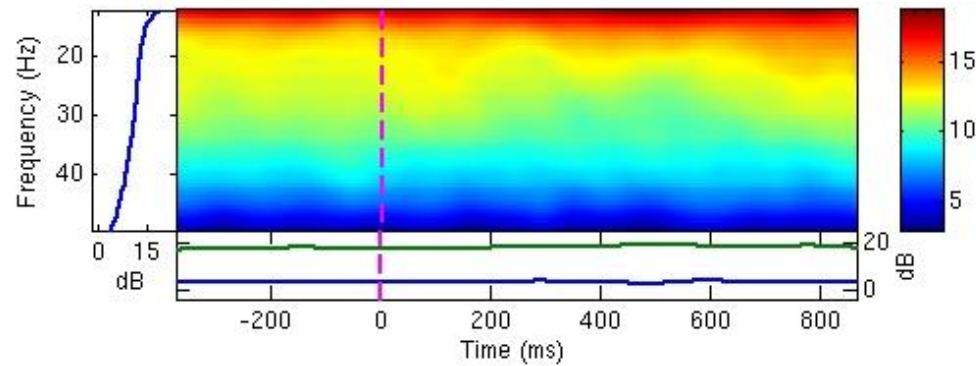
0 ms 10 ms 20 ms 30 ms 40 ms 50 ms 60 ms



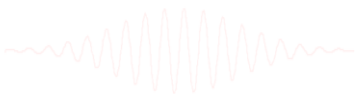
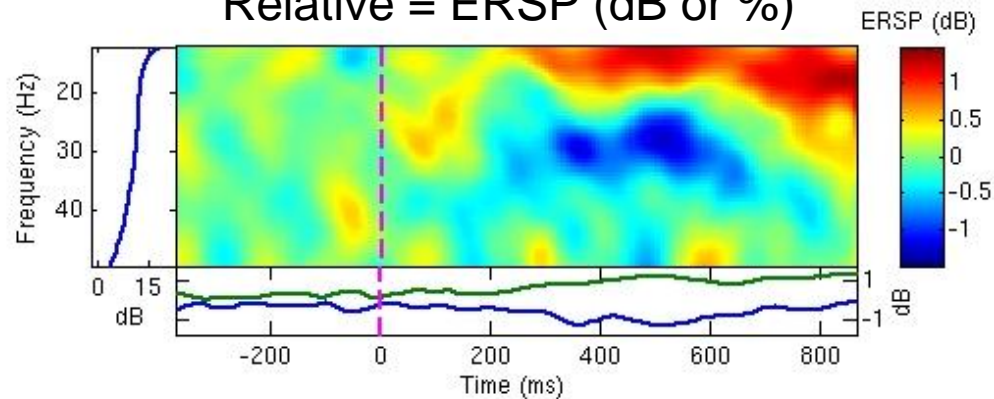
Absolute versus relative power



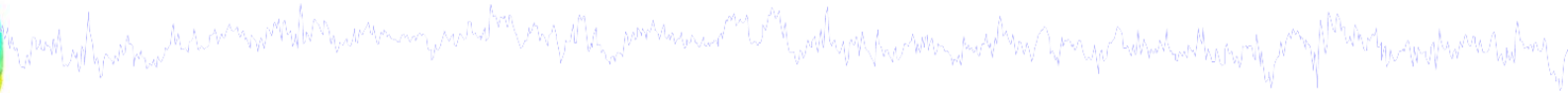
Absolute = ERS



Relative = ERSP (dB or %)



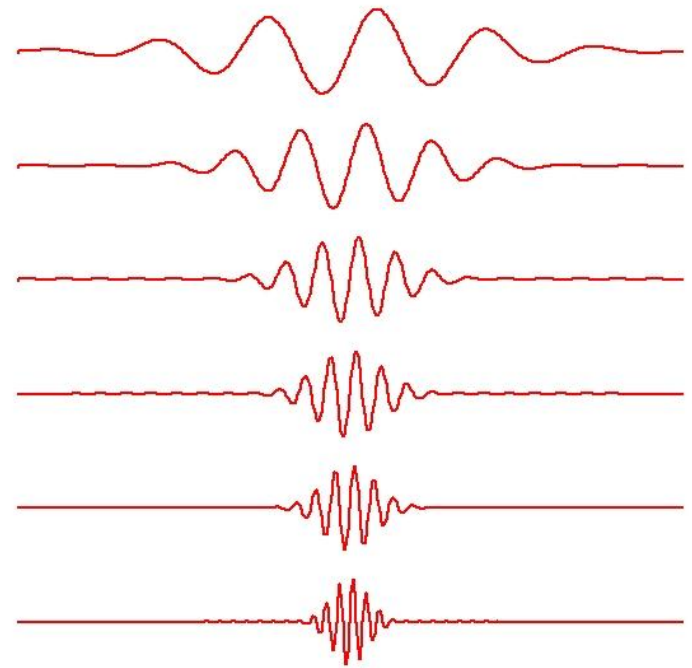
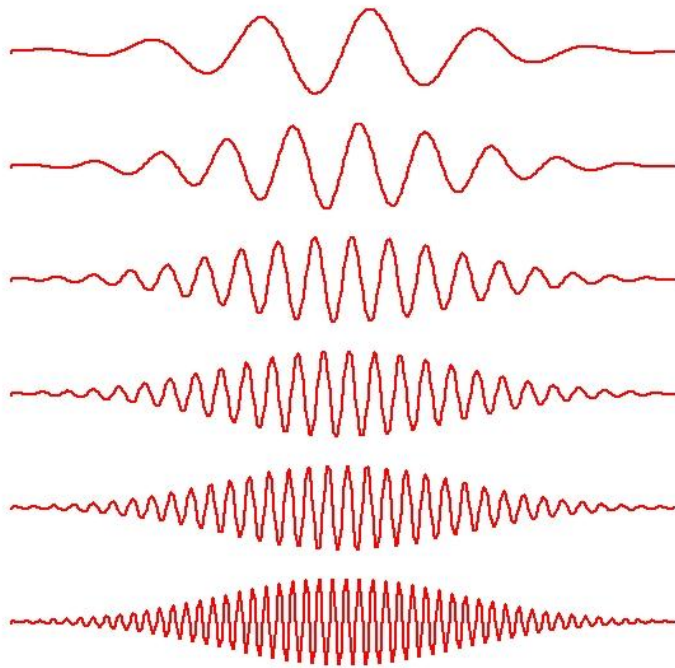
Difference between FFT and wavelets



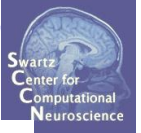
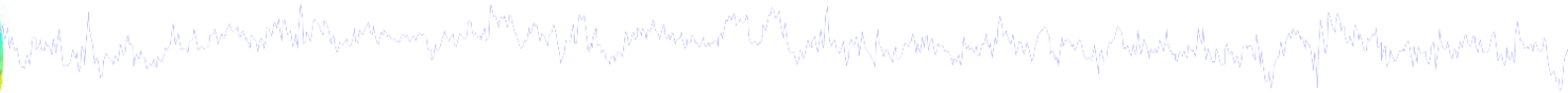
FFT

Wavelet

Frequency



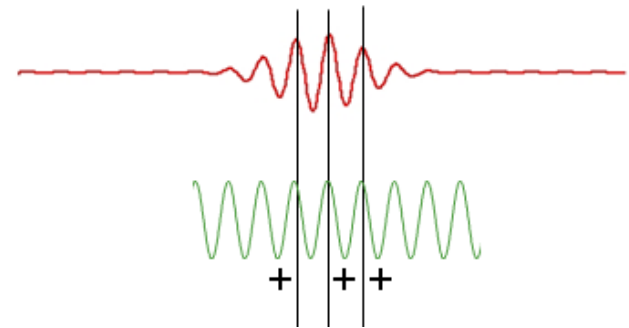
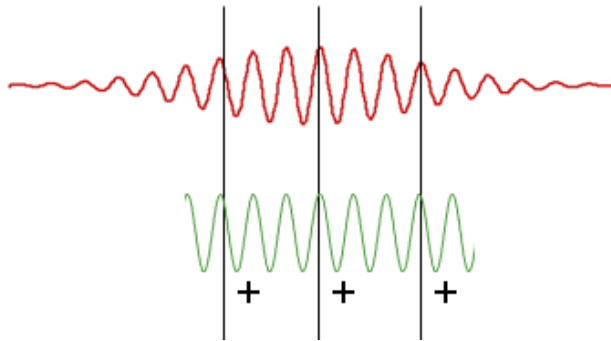
Time-frequency resolution trade off



FFT

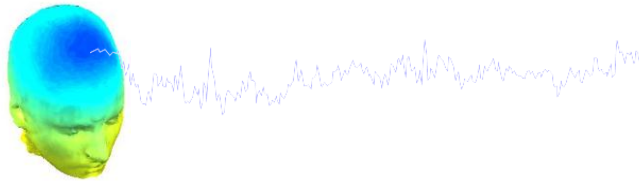
Wavelet

Exact

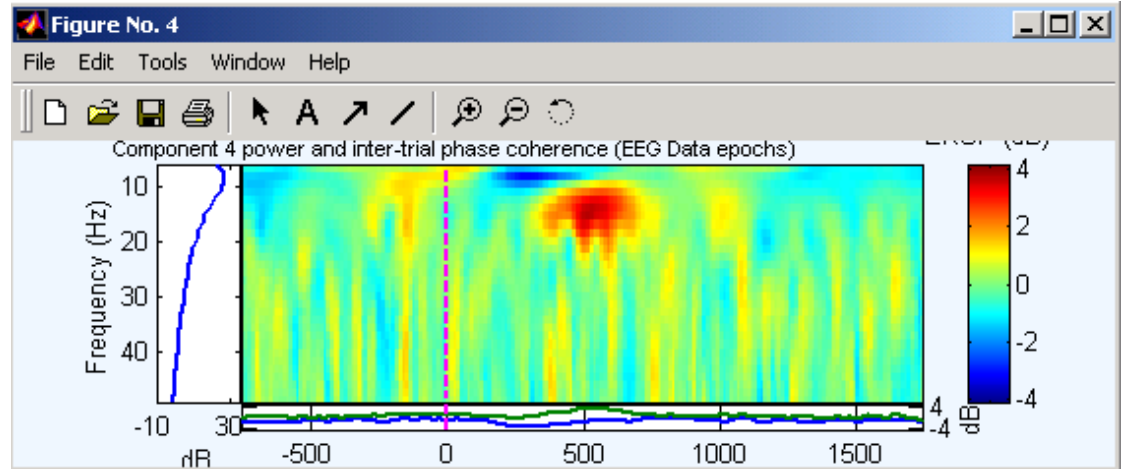
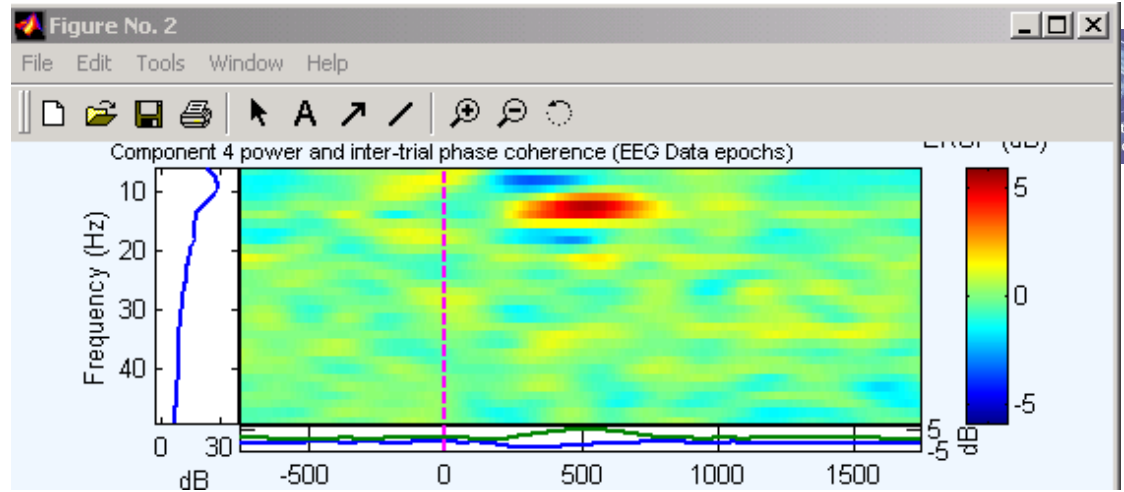


High freq. resolution
low time-resolution

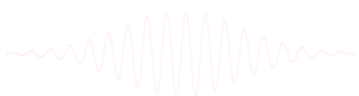
Low freq. resolution
high time-resolution



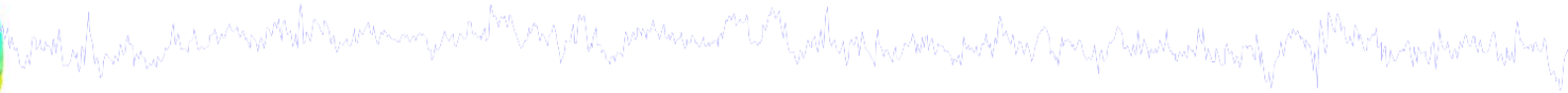
FFT



Pure wavelet

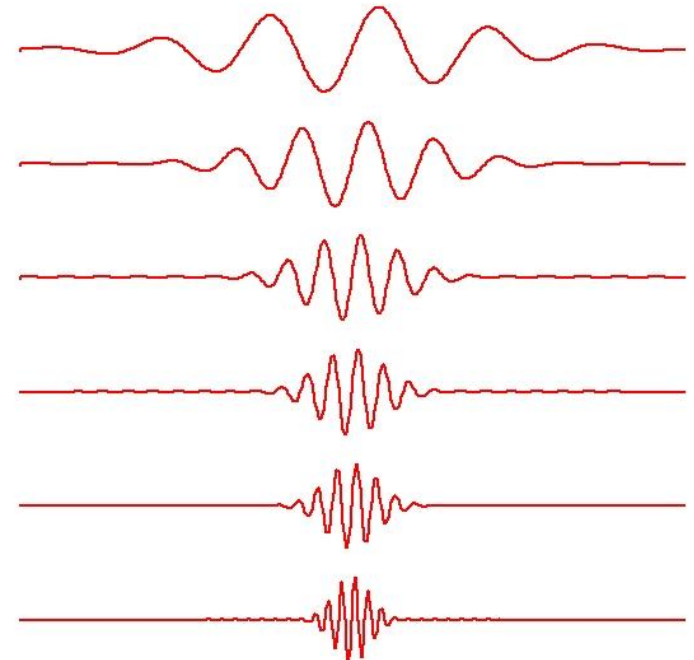
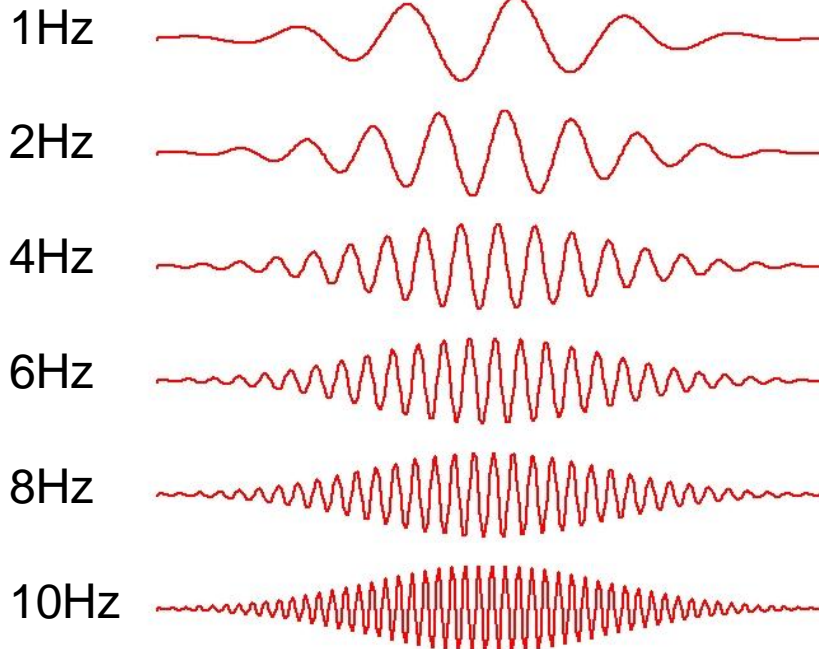


Wavelets factor

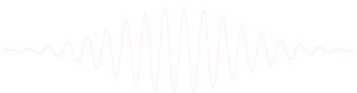


Wavelet (0)= FFT

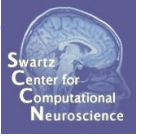
Wavelet (1)



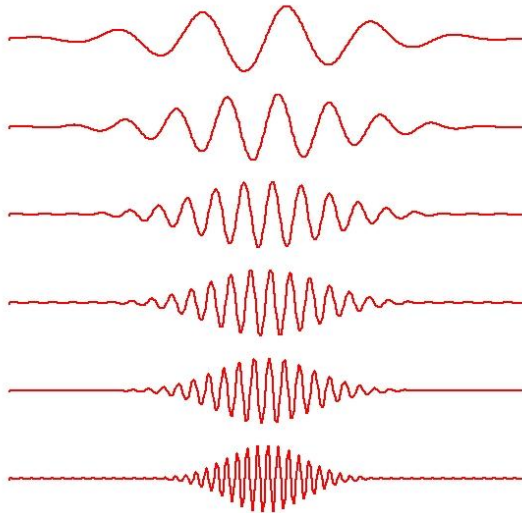
exact same number of wavelets at all freqs



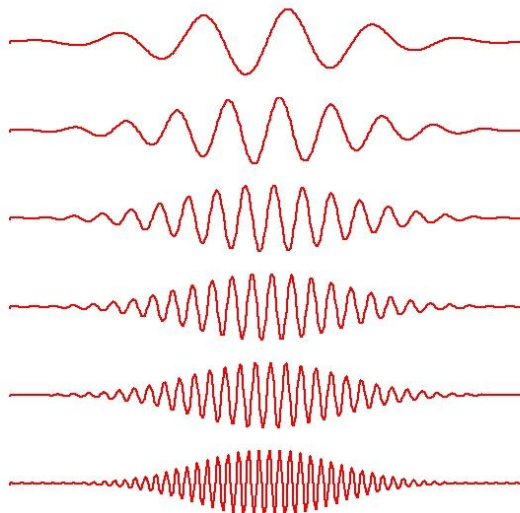
Modified wavelets



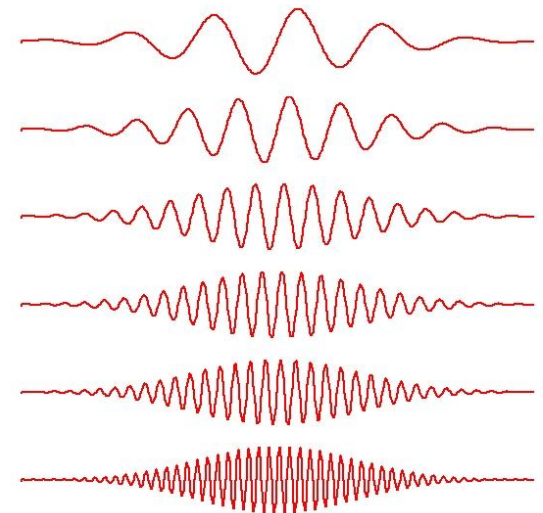
Wavelet (0.8)



Wavelet (0.5)

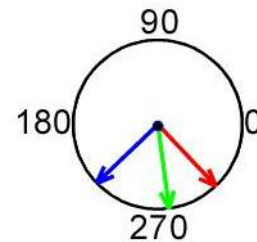
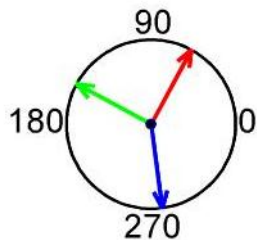
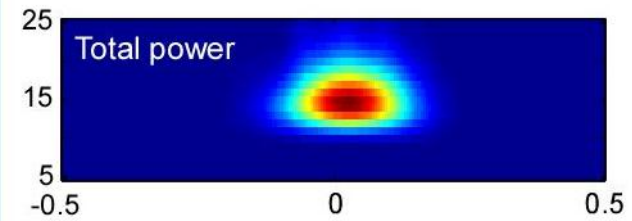
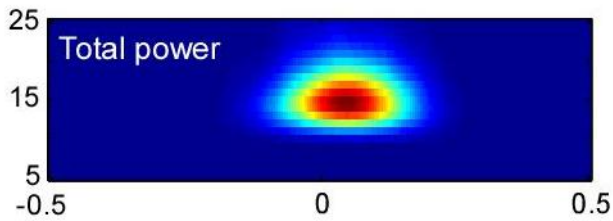
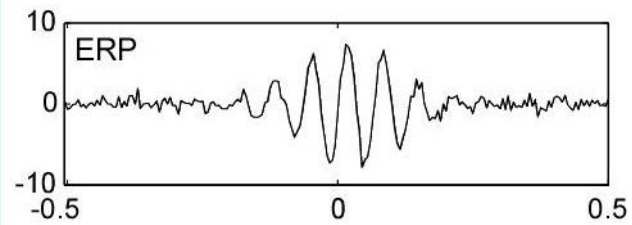
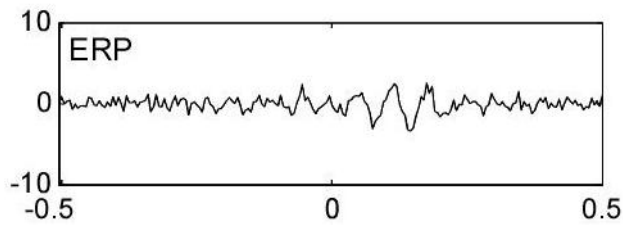
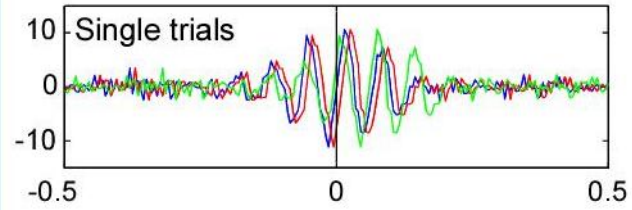
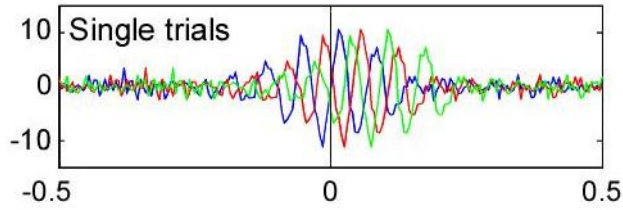
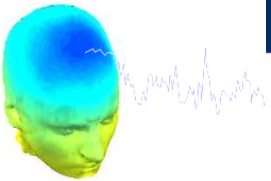


Wavelet (0.2)



Scaled to require more wavelets at higher freqs (less than FFT though)

Intertrial Coherence (ITC)



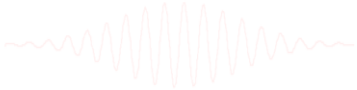
ITC: .05

ITC: .80

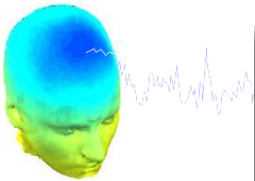
Evaluating ICA components



- 1. Remove an IC (back-projection)**
- 2. IC ERP envelope**
- 3. IC ERP images - advanced**
- 4. Time-frequency analysis**
- 5. IC ERSP**
- 6. IC cross coherence**



Plot IC ERSP



Plot component time frequency -- pop_newtimef()

Component number	3
Sub epoch time limits [min max] (msec)	-1000 1996
Frequency limits [min max] (Hz) or sequence	
Baseline limits [min max] (msec) (0->pre-stim.)	0
Wavelet cycles [min max/fact] or sequence	3 0.5
ERSP color limits [max] (min=)	
ITC color limits [max]	
Bootstrap significance level (f)	
Optional newtimef() argument	

Use 200 time points
 Use limits, padding 1
 Use divisive baseline
 Use limits
 Log spaced
 No baseline
 Use FFT

Plot Event Related Spectral Power

Cancel

EEGLAB v7.1.7.18b

File Edit Tools Plot

#2: Step

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

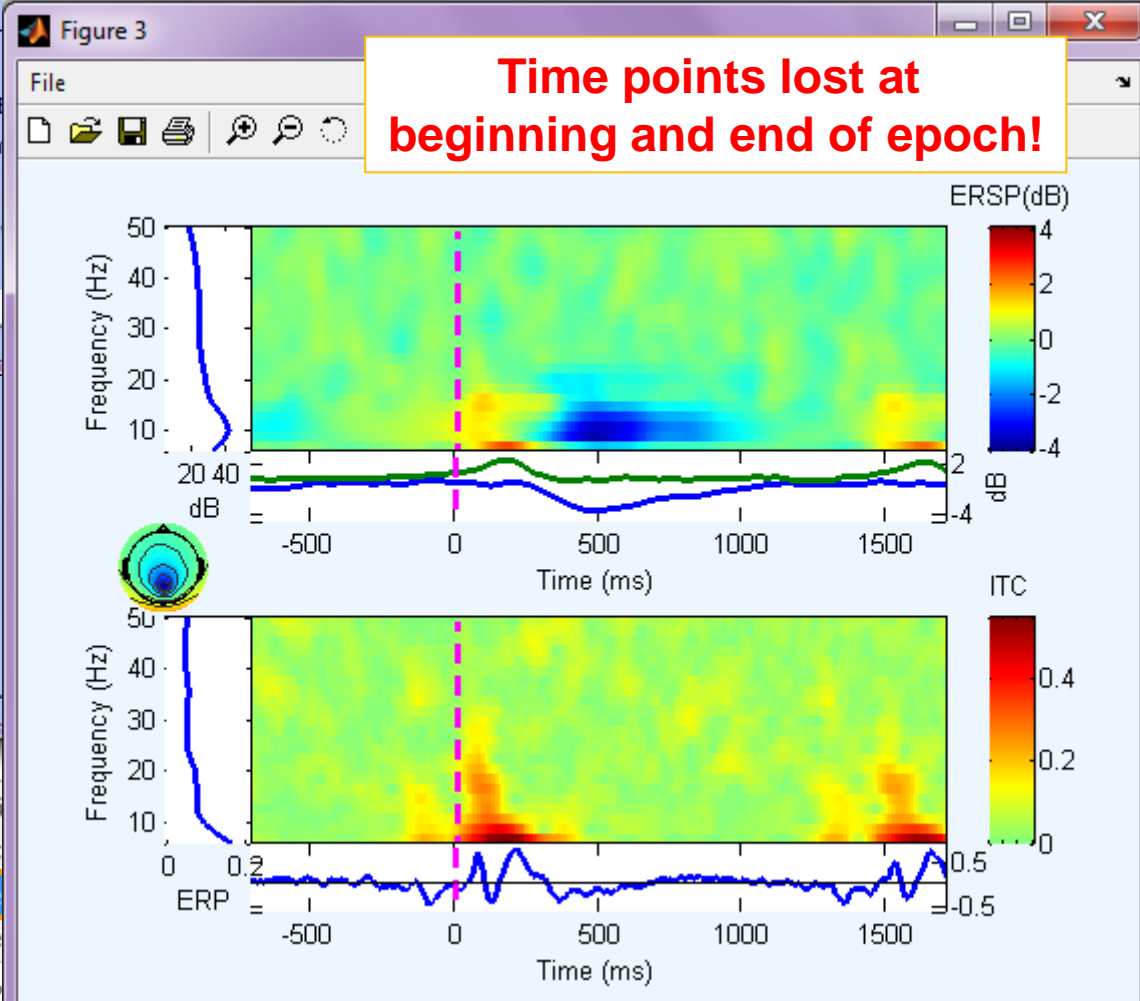
Sum/Compare ERPs

- Component activations (scroll)
- Component spectra and maps
- Component maps
- Component properties
- Component ERP image
- Component ERPs
- Sum/Compare comp. ERPs

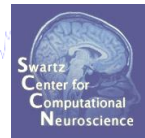
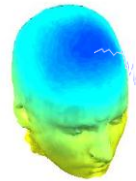
Data statistics

Time-frequency transforms

Cluster dataset ICs



Plot IC ERSP

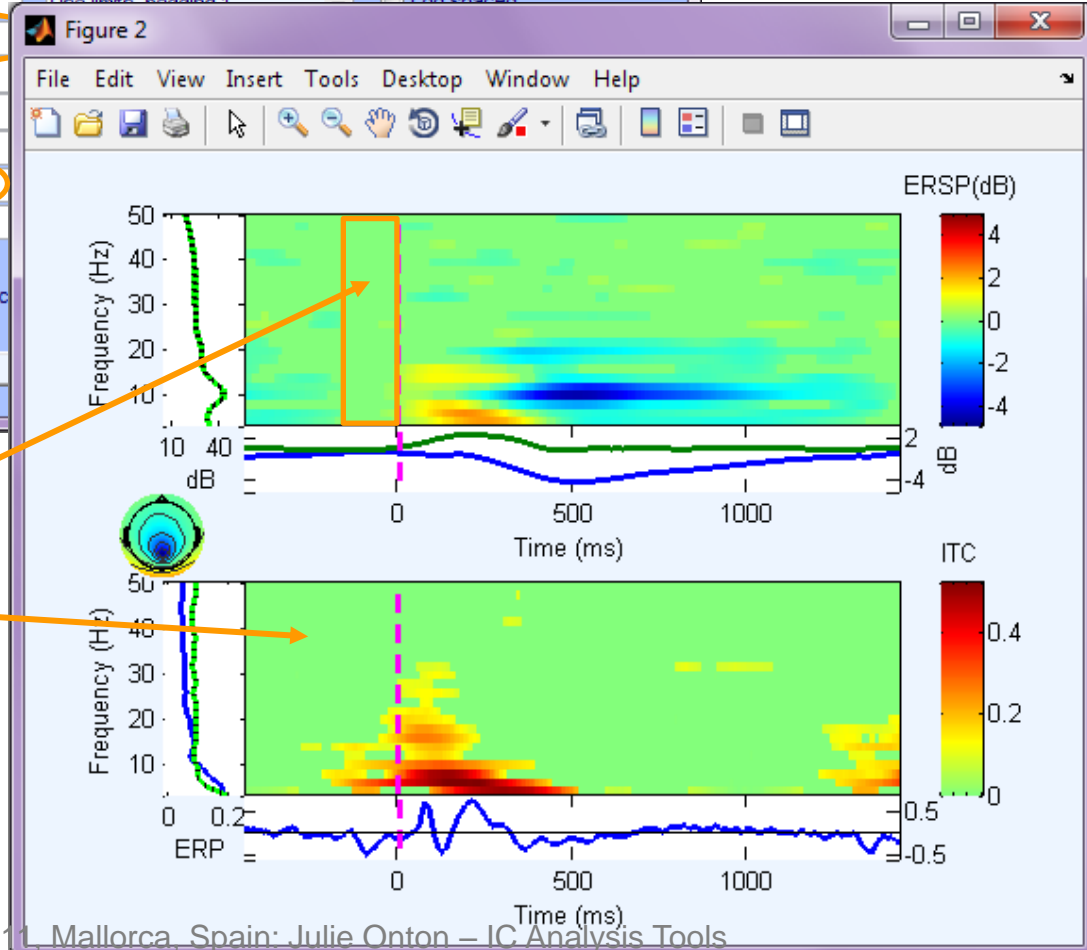


Plot component time frequency -- pop_newtimef()

Component number	3
Sub epoch time limits [min max] (msec)	-1000 1996
Frequency limits [min max] (Hz) or sequence	3 50
Baseline limits [min max] (msec) (0->pre-stim.)	-200 0
Wavelet cycles [min max/fact] or sequence	3 0.5
ERSP color limits [max] (min=-max)	
ITC color limits [max]	
Bootstrap significance level (Ex: 0.01 -> 1%)	.01
Optional newtimef() arguments (see Help)	

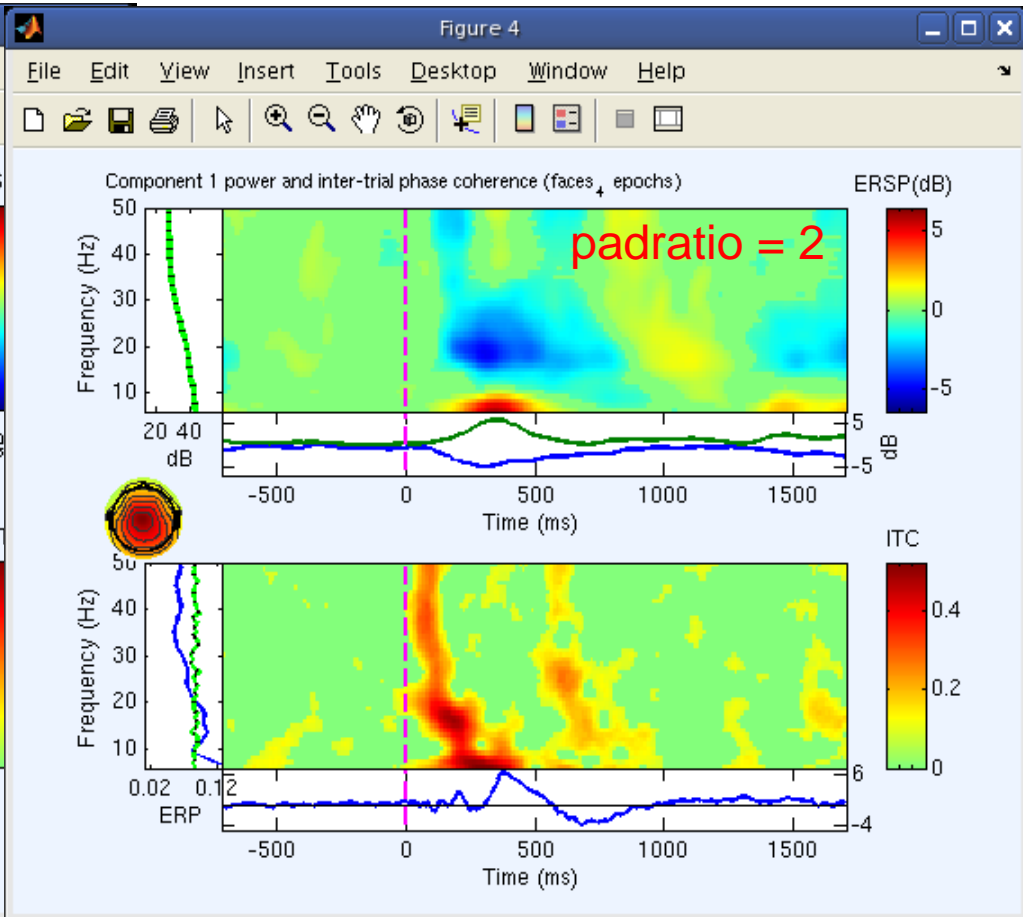
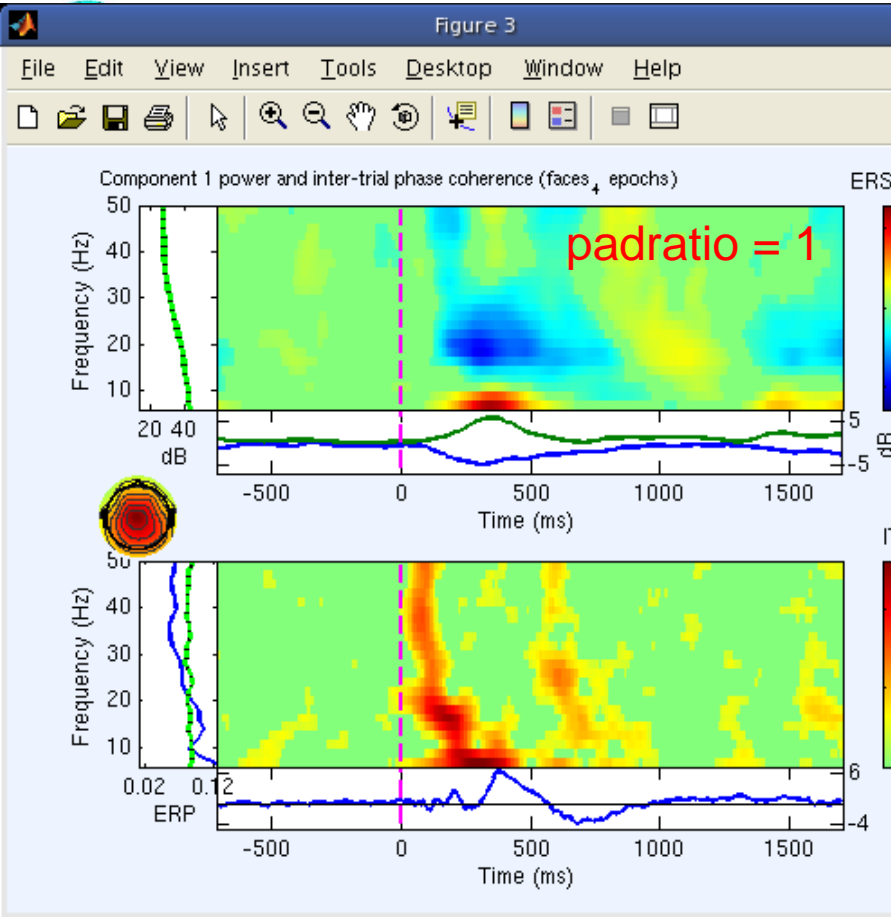
Plot Event Related Spectral Power Plot Inter Trial Coherence

Cancel Help



Pure green denotes non-significant points

Plot IC ERSP



- Component number**
- Sub epoch time limits [min max] (msec)**
- Frequency limits [min max] (Hz) or sequence**
- Baseline limits [min max] (msec) (0->pre-stim.)**
- Wavelet cycles [min max/fact] or sequence**
- ERSP color limits [max] (min=-max)**
- ITC color limits [max]**
- Bootstrap significance level (Ex: 0.01 -> 1%)**
- Optional newtimef() arguments (see Help)**

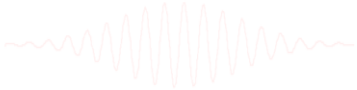
Increase # freq bins

1	Use 200 time points	<input type="checkbox"/> Log spaced
-1000 1996	Use limits, padding 1	<input type="checkbox"/> No baseline
	Use divisive baseline	<input type="checkbox"/> Use FFT
0	Use limits	
3 0.5	<input checked="" type="checkbox"/> see log power (set)	
	<input type="checkbox"/> plot ITC phase (set)	
	<input type="checkbox"/> FDR correct (set)	

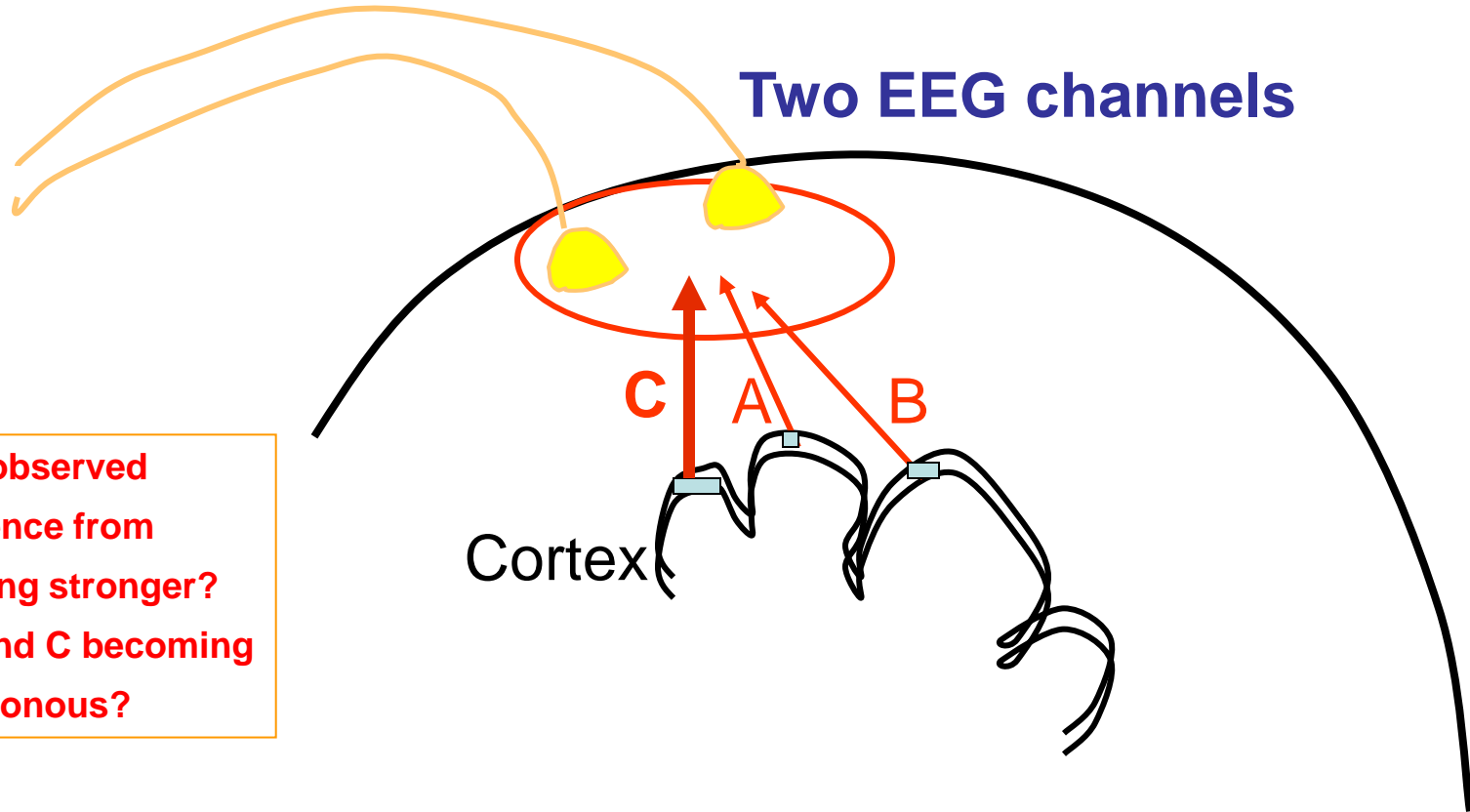
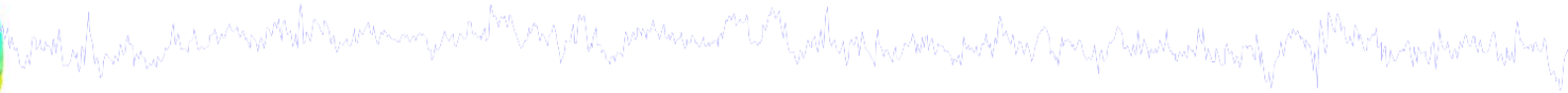
Evaluating ICA components



- 1. Remove an IC (back-projection)**
- 2. IC ERP envelope**
- 3. IC ERP images - advanced**
- 4. Time-frequency analysis**
- 5. IC ERSP**
- 6. IC cross coherence**



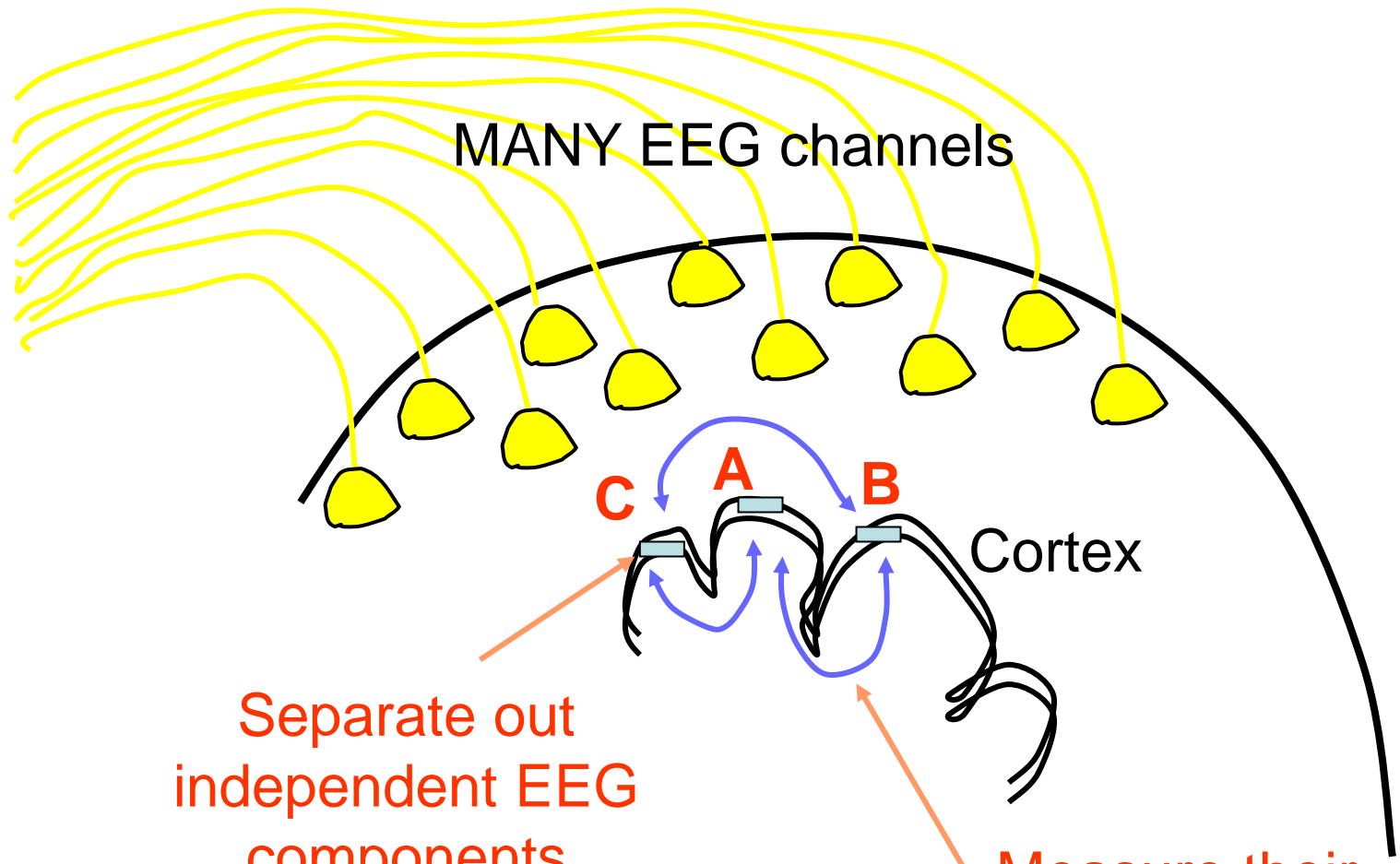
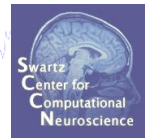
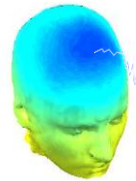
Scalp channel coherence confounds



Is the observed coherence from C getting stronger?
Or B and C becoming synchronous?

Scalp channel coherence includes source confounds!

Scalp channel coherence confounds

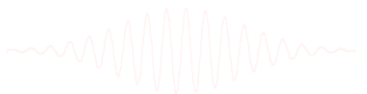


MANY EEG channels

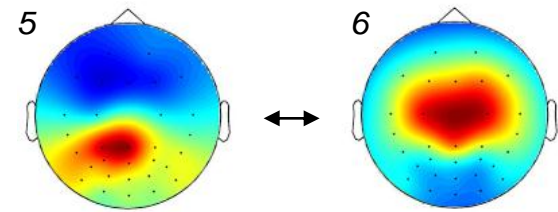
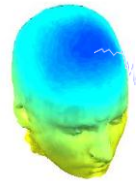
Cortex

Separate out independent EEG components

Measure their synchronization



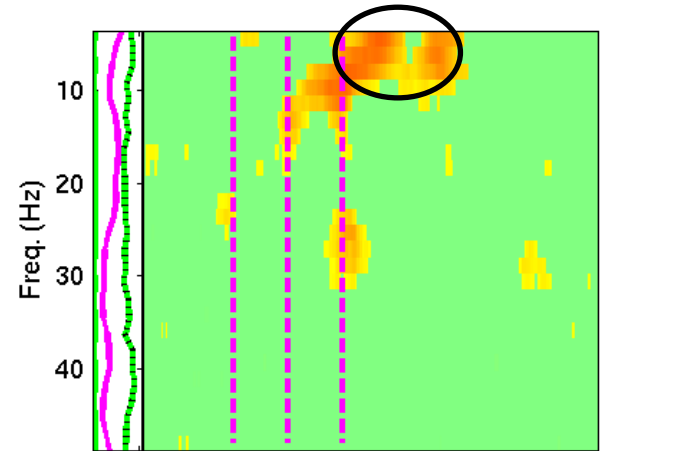
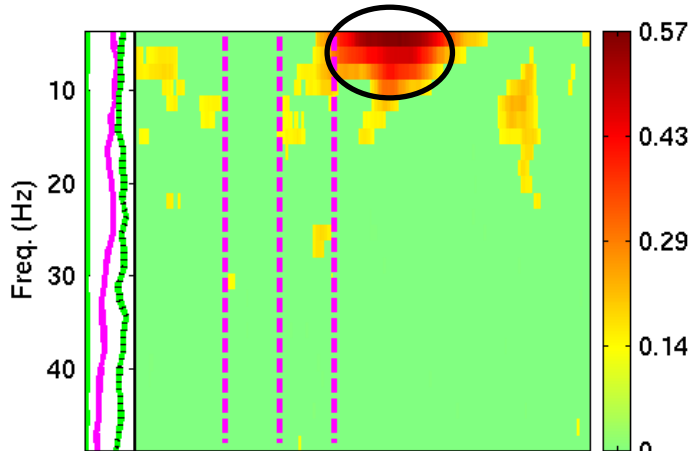
Cross-coherence amplitude and phase



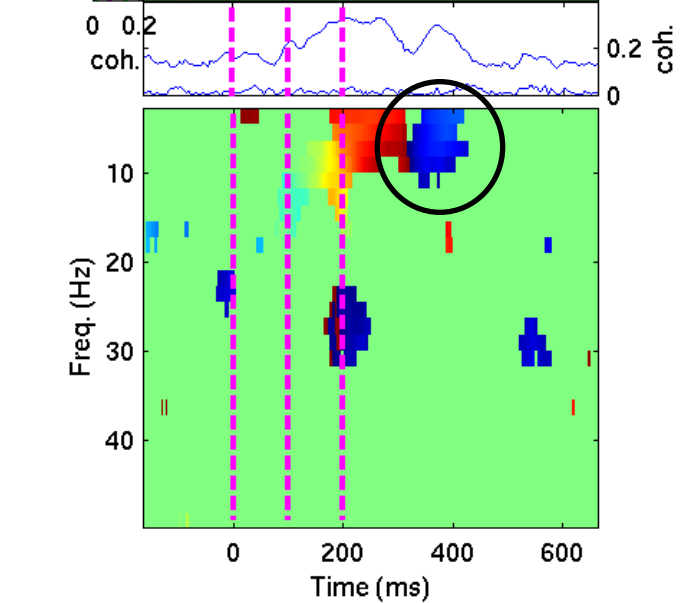
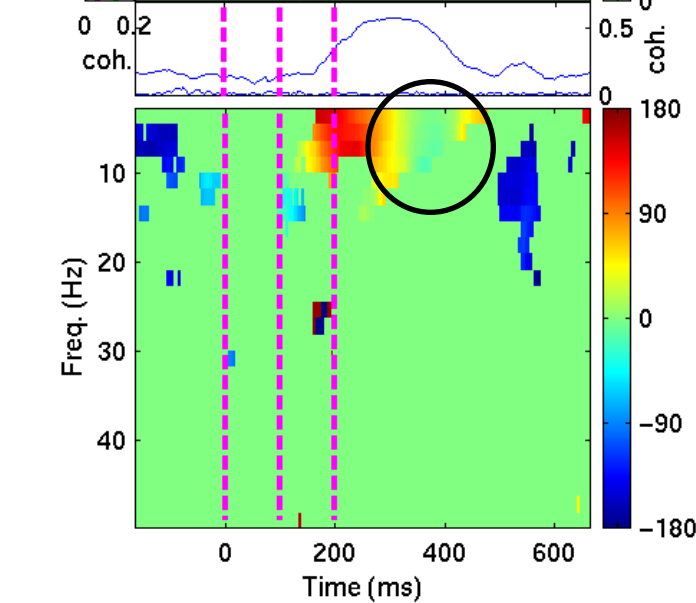
Animal picture

Distractor picture

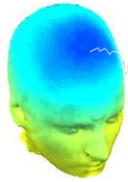
Amplitude (0-1)



Phase (degree)



IC cross coherence



Plot component cross-coherence -- pop_newcrossf()

First component number: 13

Second component number: 29

Epoch time range [min max] (msec): -1000 1996

Wavelet cycles (0->FFT, see >> help timef): 3 0.5

[set]->log. scale for frequencies (match STUDY):

[set]->Linear coher / [unset]->Phase coher:

Bootstrap significance level (Ex: 0.01 -> 1%): .001

Optional timef() arguments (see Help): ,freqs',[3 35], 'nfreqs',100, 'freqscale','log'

Plot coherence amplitude

Plot coherence phase

Buttons: Help, Cancel, Ok

Be sure to mask by bootstrap significance limits

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File Edit Tools Plot Study Data

#2: Step

Filename:
Channels:
Frames per
Epochs:
Events:
Sampling rate:
Epoch start:
Epoch end:
Reference:
Channel location:
ICA weights:
Dataset size:

Channel location
Channel data (s)
Channel spectra
Channel properties
Channel ERP image
Channel ERPs
ERP map series
Sum/Compare

Component activation
Component spectra
Component maps
Component properties
Component ERP image
Component ERPs
Sum/Compare comp. ERPs

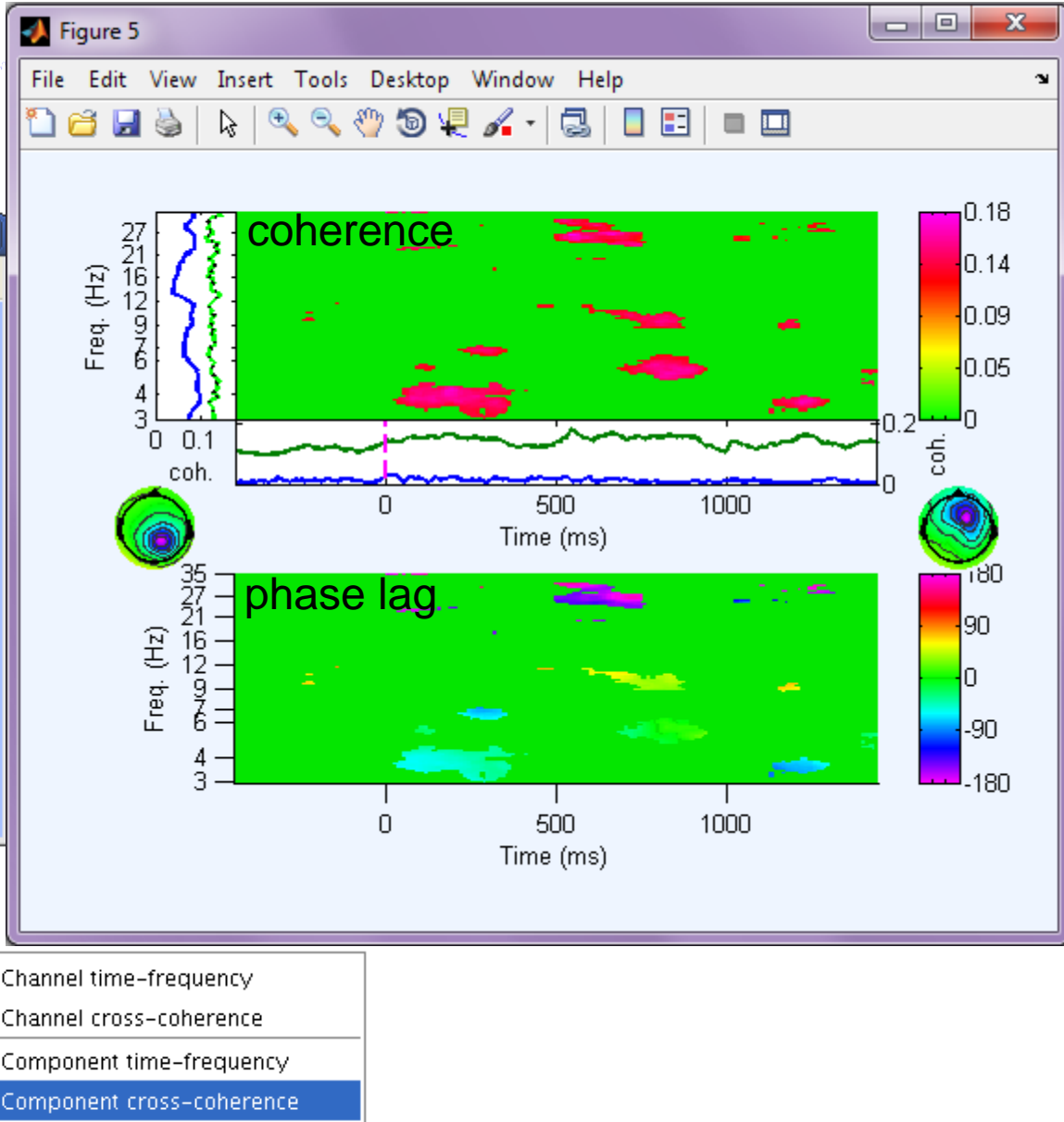
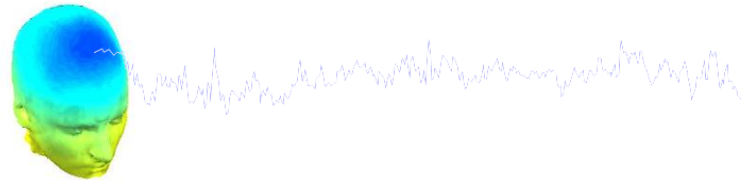
Data statistics

Time-frequency transforms

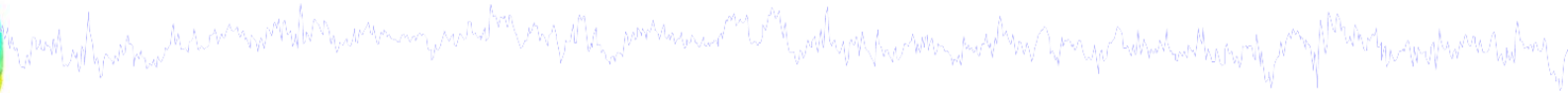
Cluster dataset ICs

Channel time-frequency
Channel cross-coherence
Component time-frequency
Component cross-coherence

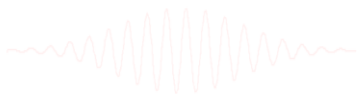
IC cross coherence



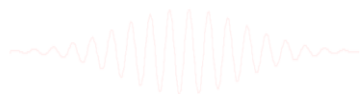
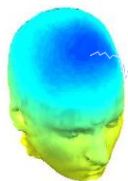
Exercise



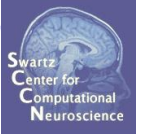
- **ALL**
 - Load stern.set, epoch on **Memorize** letters, reject noisy epochs
- **Novice**
 - From the GUI, plot component ERPs with maps
 - Plot an IC ERP image; try sorting by RT or phase, is there any effect of the time-locking event on the activation pattern?
 - Try plotting power in a specified frequency band; how consistent are any power changes across trials?
- **Intermediate**
 - Plot ERSPs for an IC; for FFT, vary the 'winsize' and 'pdratio'; for wavelets, vary number of 'cycles' and window size factor
 - Compare FFT and wavelet methods; Do the results agree?
 - Plot ERSPs with no baseline and with different baseline periods; how might this affect your results/conclusions?
- **Advanced**
 - Plot cross coherence between two selected ICs
 - > Compare this result with cross coherence between two channels that are highly weighted in the respective ICs



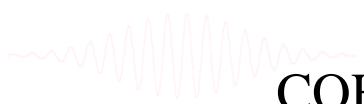
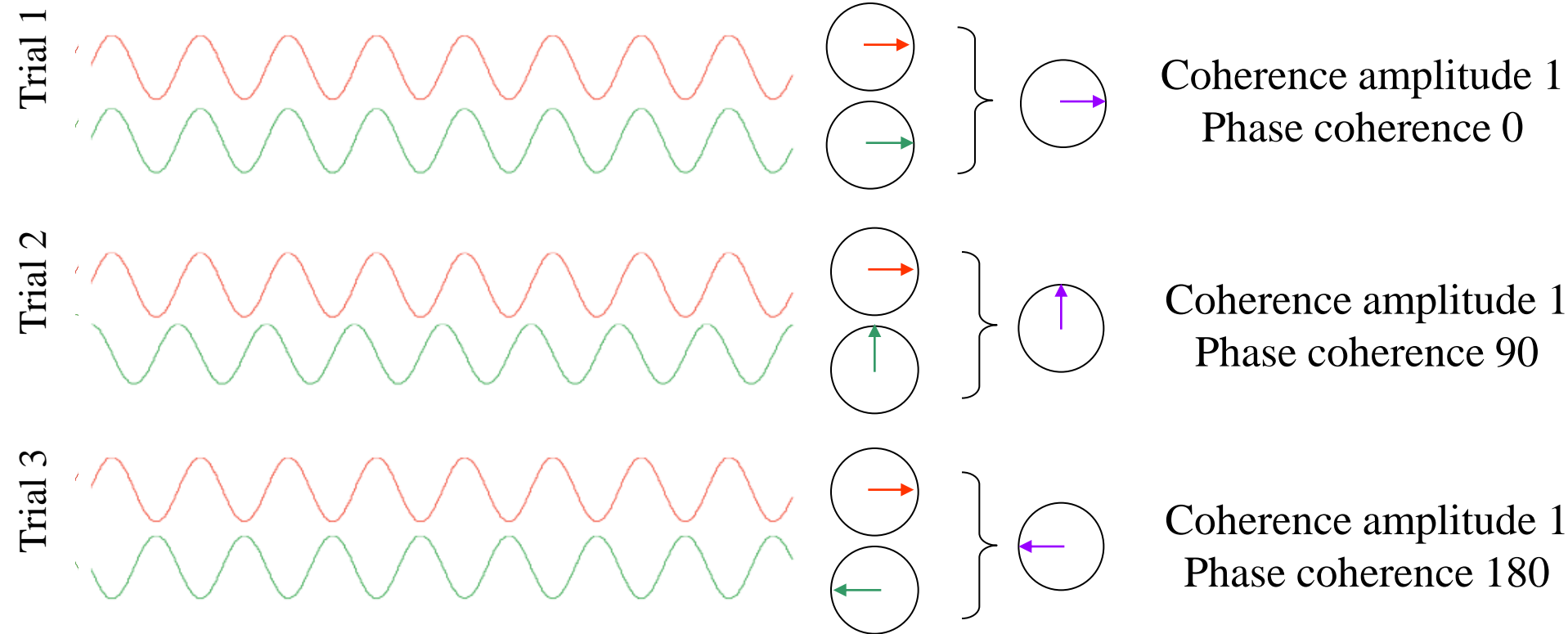
Supplementary lessons



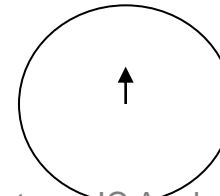
Cross-coherence amplitude and phase



2 components, comparison on the same trials



COHERENCE = mean(phase vector)

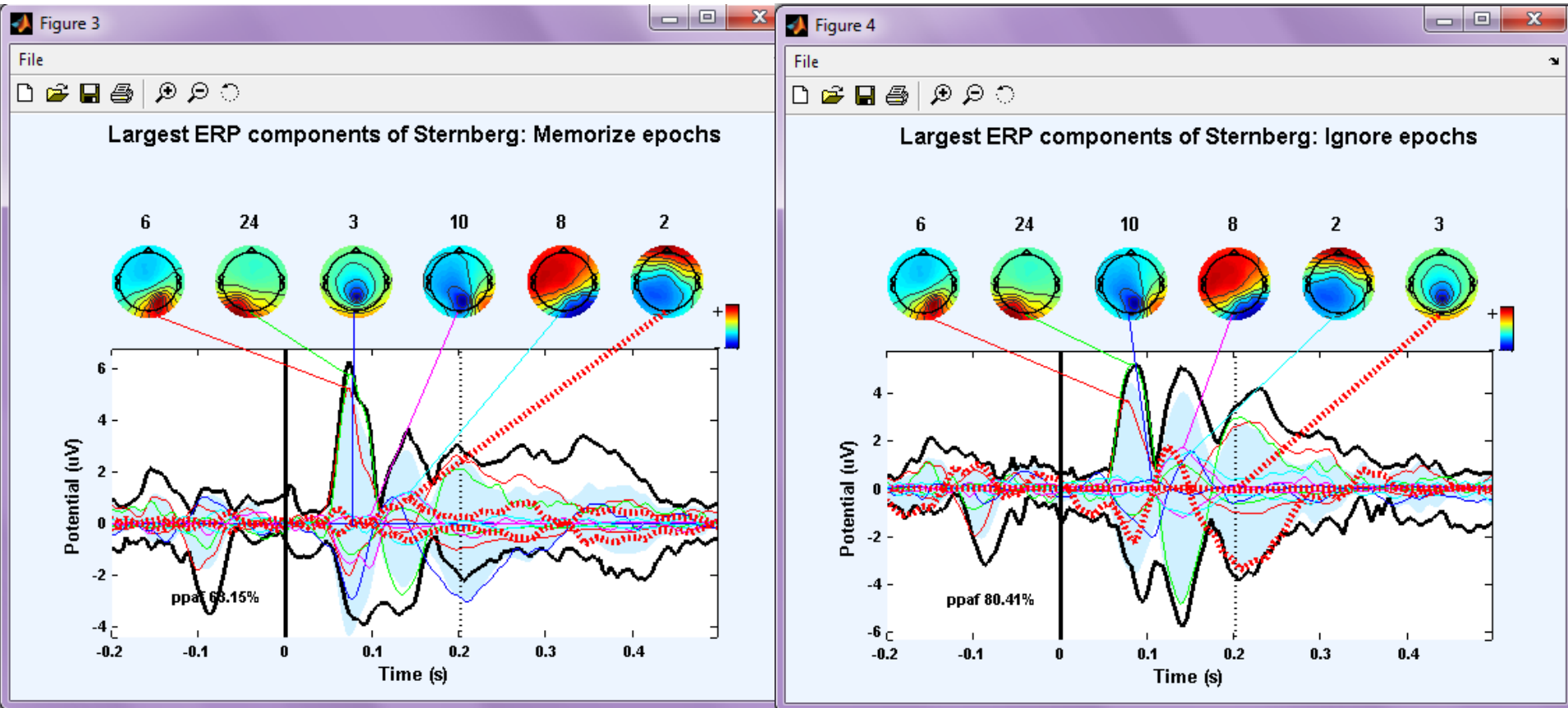


Norm 0.33
Phase 90 degree

IC ERP difference



What is the IC ERP difference between these 2 conditions?



IC ERP difference



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File Edit Tools **Plot** Study Datasets Help

#3: Ste

- 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 pe
Epochs
Events
Sampling
Epoch sta
Epoch end
Reference
Channel lo
ICA weight
Dataset si

Dataset indices to subtract (Ex: '1 2'-> 1-2): 2 3

Enter time range (in ms) to plot: -200 496

Enter time range (in ms) to rank component contributions: 0 200

Number of largest contributing components to plot (7): 6

Else plot these component numbers only (Ex: 2,4,7):

Component numbers to remove from data before plotting: 1

Plot title: Largest ERP components of Memoriz

Optional topoplot() and envtopo() arguments: 'electrodes','off'

Cancel Help Ok

IC ERP difference

