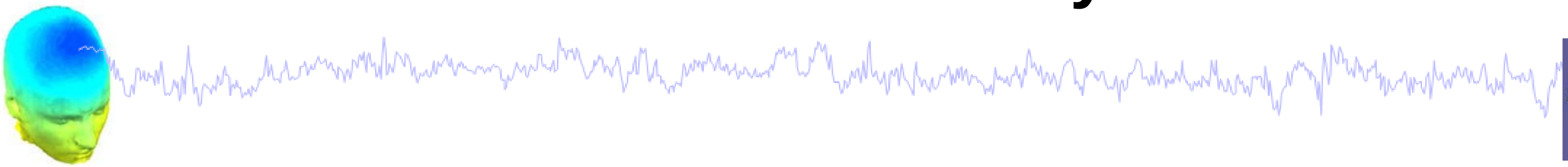
Advanced IC analysis



Task 1

Search EEG.event structure

Task 2

Use *newtimef()* to compare conditions

Task 3

Plot a RT-sorted component ERP image

Plot a type-sorted component ERP image

Plot a load-sorted component ERP image

Task 4

Use outputs from commandline ERP image

Exercise...

Advanced IC analysis

Task 1

Search EEG.event structure

Task 2

Use *newtimef()* to compare conditions

Task 3

Plot a RT-sorted component ERP image

Plot a type-sorted component ERP image

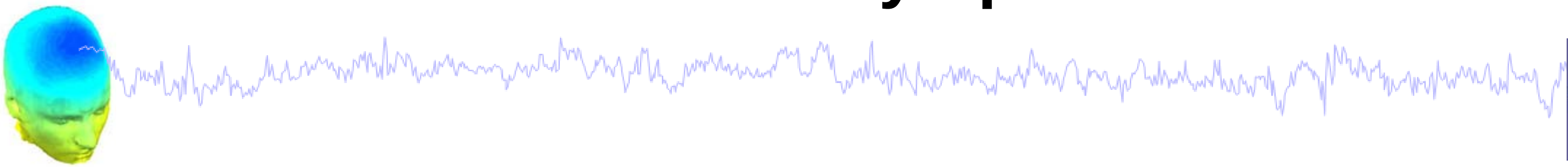
Plot a load-sorted component ERP image

Task 4

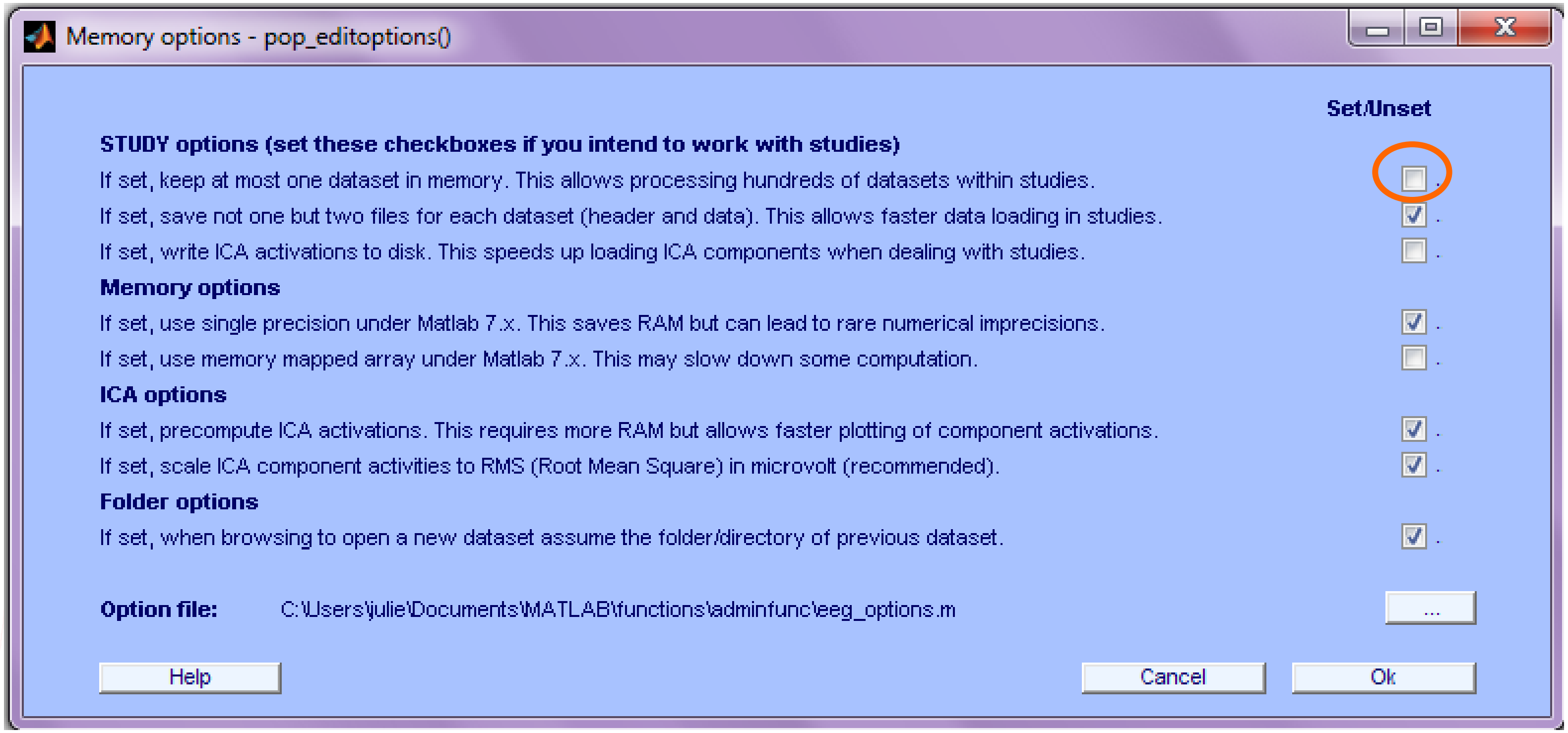
Use outputs from commandline ERP image

Exercise...

Set memory options



```
% you will need memory options to keep more than one dataset in memory at once:
pop_editoptions( 'option_storedisk', 0, 'option_savetwofiles', 1,…
 'option_saveica', 0, 'option_single', 1, 'option_memmapdata', 0,…
 'option_computeica', 1, 'option_scaleicarms', 1, 'option_rememberfolder', 1);
%-----------------------------------------------------------------------------
```



Memory options - pop_editoptions()

Set/Unset

STUDY options (set these checkboxes if you intend to work with studies)

If set, keep at most one dataset in memory. This allows processing hundreds of datasets within studies. □

If set, save not one but two files for each dataset (header and data). This allows faster data loading in studies. ☑

If set, write ICA activations to disk. This speeds up loading ICA components when dealing with studies. □

Memory options

If set, use single precision under Matlab 7.x. This saves RAM but can lead to rare numerical imprecisions. ☑

If set, use memory mapped array under Matlab 7.x. This may slow down some computation. □

ICA options

If set, precompute ICA activations. This requires more RAM but allows faster plotting of component activations. ☑

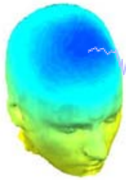
If set, scale ICA component activities to RMS (Root Mean Square) in microvolt (recommended). ☑

Folder options

If set, when browsing to open a new dataset assume the folder/directory of previous dataset. ☑

Option file: C:\Users\julie\Documents\MATLAB\functions\adminfunc\eeg_options.m

The example data: Sternberg working memory



File

../Data/stern.set

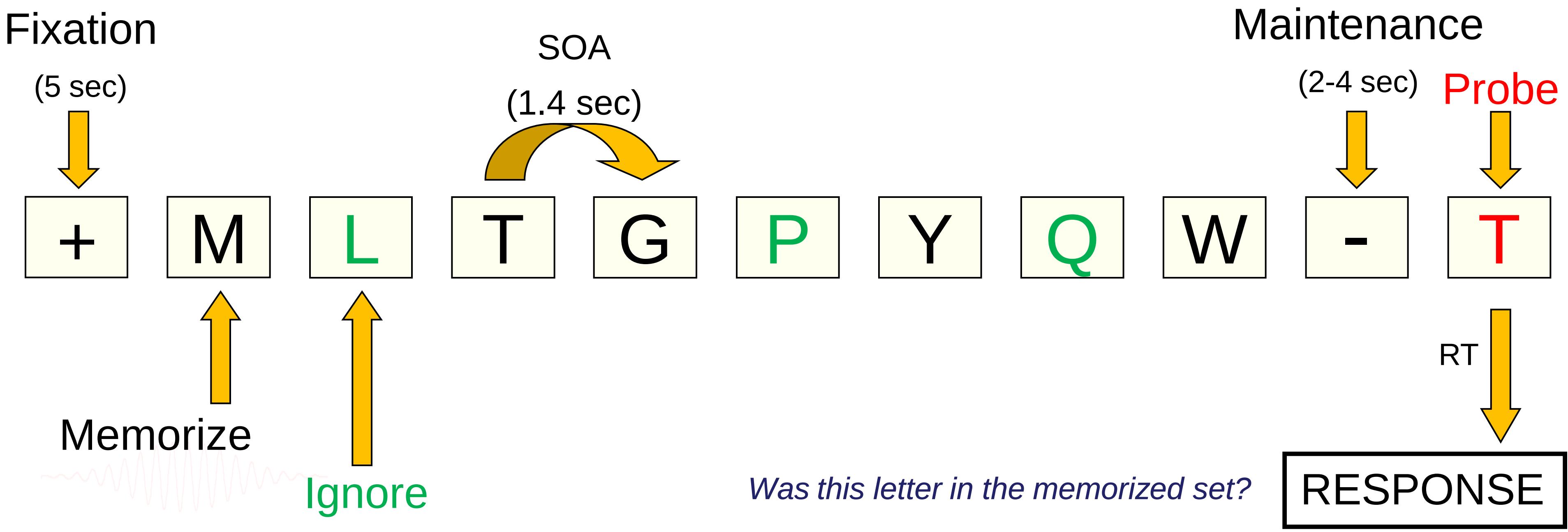
Data

Continuous data (not epoched), ref'd to right mastoid

Task

3-7 letters to memorize, among 1-5 letters to ignore

50% chance of probe letter being 'in-set'



Fixation

(5 sec)

SOA

(1.4 sec)

Maintenance

(2-4 sec)

Probe

+ M L T G P Y Q W - T

Memorize

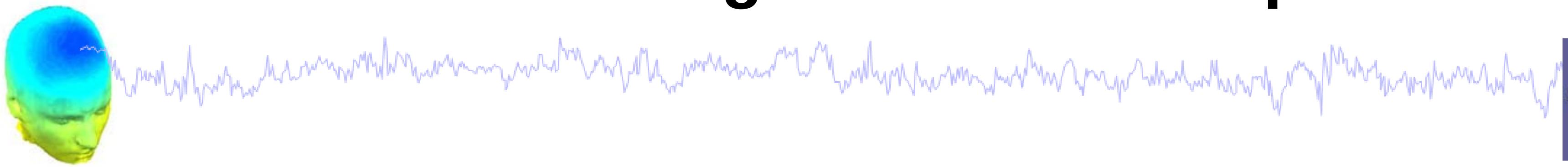
Ignore

RT

Was this letter in the memorized set?

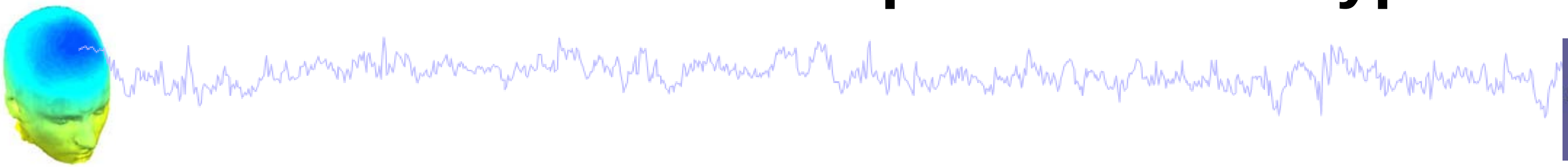
RESPONSE

Color-coding for tutorial scripts



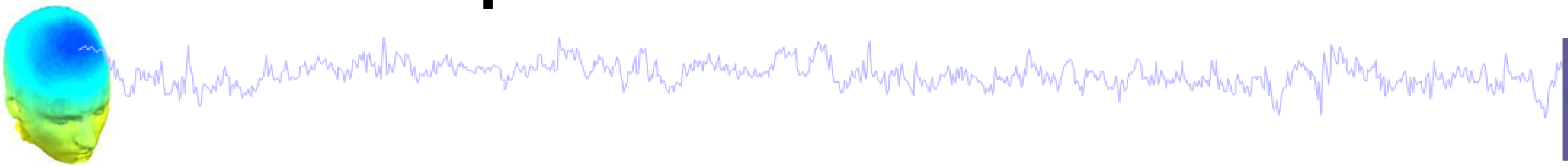
```
%%%%%  Color-coding for scripts:

% Green text is comments

myvariable (bold, red) = pre-defined variable

for ep … end = … (bold, blue) = ‘for loop’ variable

if … end = (bold, cyan) = ‘if loop’ statement

newtimef() (bold, purple) = function call

[outdata,outvar,outtrials,…] (brown, in brackets)

                  = function output variables
```

Search events for specific event type



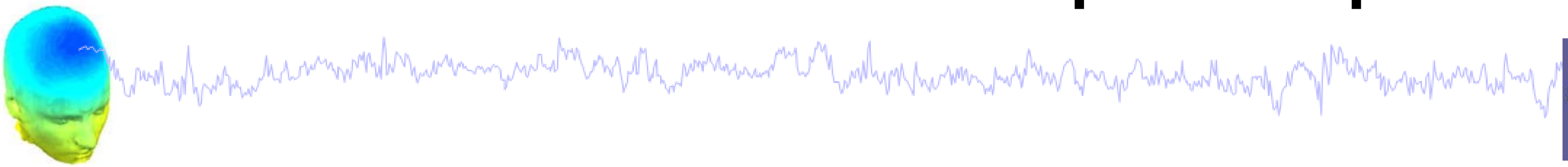
```
% OBJECTIVES:
% 1) Find all Memorize letters that were preceded by an ignore letter
% 2) Find all Memorize letters that were preceded by a memorize letter
%---------------------------------------------------------------------
% hint: ‘memorize’ event codes are single letters
epochidxM = []; % Mem preceded by a mem letter
epochidxG = []; % Mem preceded by an ignore letter
for ev = 2:length(EEG.event)
    if length(EEG.event(ev).type)==1 & length(EEG.event(ev-1).type)==1
        epochidxM = [epochidxM, ev]; % save this event
    elseif length(EEG.event(ev).type)==1 & EEG.event(ev-1).type(1)=='g'
        epochidxG = [epochidxG, ev]; % save this event
    end;
end;
```

Epoch on selected events

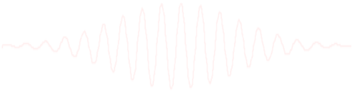


```
% Epoch continuous data around selected events
%----------------------------------------------------------------------
[EEG, indices] = pop_epoch( EEG, [], [-2 2],'eventindices',epochidxG);
[ALLEEG EEG CURRENTSET] = pop_newset(ALLEEG, EEG, 1,…
 'setname','Mem after Ignore letter','gui', 'off');
EEG = pop_autorej(EEG,  'nogui', 'on'); % Auto-reject noisy epochs
[ALLEEG EEG CURRENTSET]=pop_newset(ALLEEG,EEG,CURRENTSET,'retrieve',1);

[EEG, indices] = pop_epoch( EEG, [], [-2 2],'eventindices',epochidxM);
[ALLEEG EEG CURRENTSET] = pop_newset(ALLEEG, EEG, 1,…
 'overwrite','on', 'setname','Mem after Mem letter','gui', 'off');
EEG = pop_autorej(EEG,  'nogui', 'on'); % Auto-reject noisy epochs
eeglab redraw
```

Confirm datasets contain expected epochs



```
>> [ALLEEG EEG CURRENTSET] = pop_newset(ALLEEG, EEG, CURRENTSET, 'retrieve',1);
>> EEG.epoch(2) %--- Select several random epochs, check if correct
ans =
              event: [4 5 6]
               eventlatency: {[-1.4400e+003]  [0]  [1.4440e+003]}
               eventload: {[1]  [2]  [3]}
               eventtype: {'R'  'N'  'Z'}
               eventurevent: {[5]  [6]  [7]}
>> [ALLEEG EEG CURRENTSET] = pop_newset(ALLEEG, EEG, 2, 'retrieve',2);
>> EEG.epoch(2)
ans =
                event: [4 5 6]
                eventlatency: {[-1.4400e+003]  [0]  [1.4440e+003]}
                eventload: {[0]  [0]  [1]}
                eventtype: {'gC'  'Z'  'L'}
                eventurevent: {[15]  [16]  [17]}
```



Advanced IC analysis

Task 1

Search EEG.event structure

Task 2

Use *newtimef()* to compare conditions

Task 3

Plot a RT-sorted component ERP image

Plot a type-sorted component ERP image

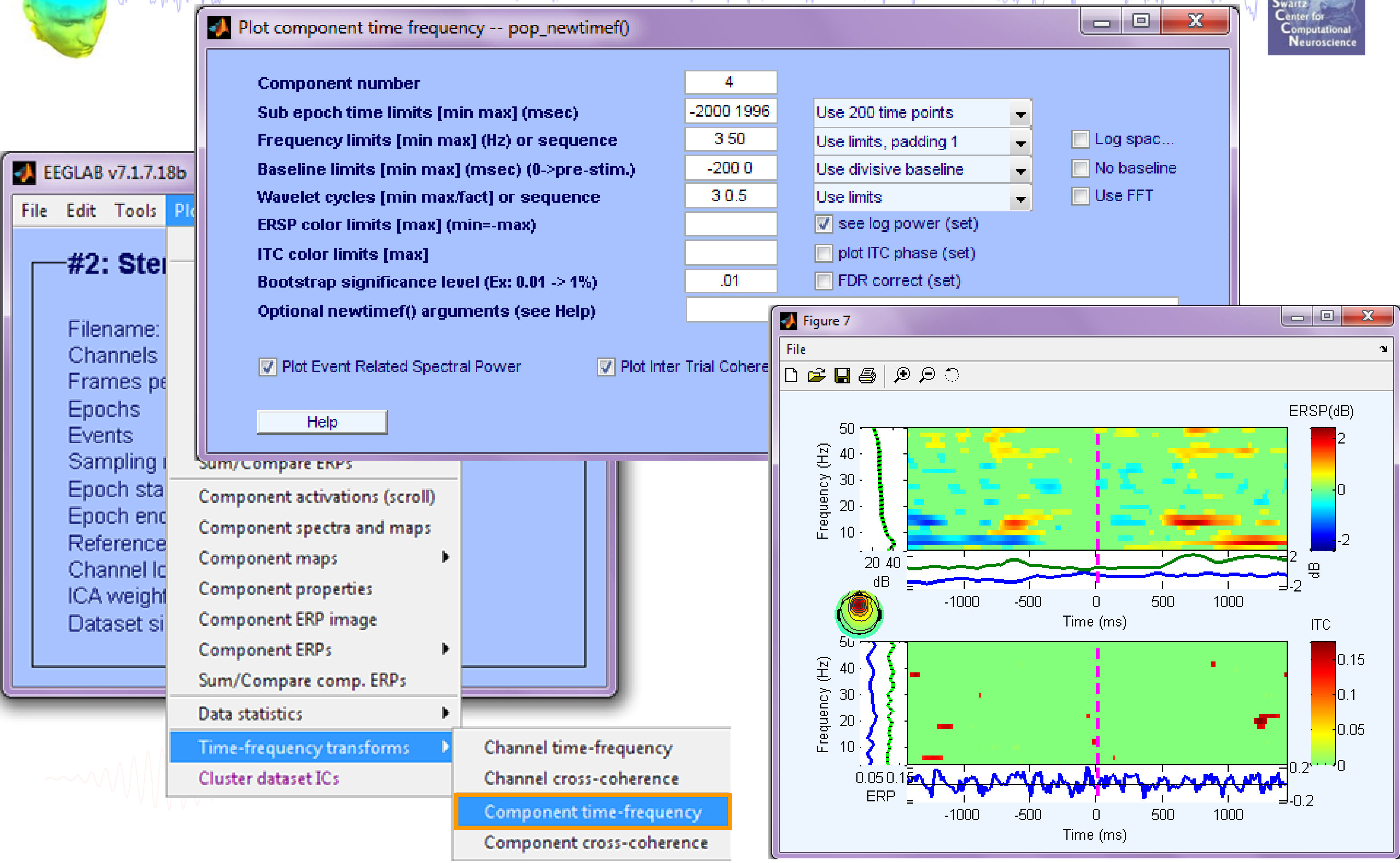
Plot a load-sorted component ERP image

Task 4

Use outputs from commandline ERP image

Exercise...

Get *newtimef()* command from GUI call



Plot component time frequency -- pop_newtimef()

Component number	4		
Sub epoch time limits [min max] (msec)	-2000 1996	Use 200 time points	
Frequency limits [min max] (Hz) or sequence	3 50	Use limits, padding 1	□ Log spac...
Baseline limits [min max] (msec) (0->pre-stim.)	-200 0	Use divisive baseline	□ No baseline
Wavelet cycles [min max/fact] or sequence	3 0.5	Use limits	□ Use FFT
ERSP color limits [max] (min=-max)		☑ see log power (set)	
ITC color limits [max]		□ plot ITC phase (set)	
Bootstrap significance level (Ex: 0.01 -> 1%)	.01	□ FDR correct (set)	
Optional newtimef() arguments (see Help)			

☑ Plot Event Related Spectral Power

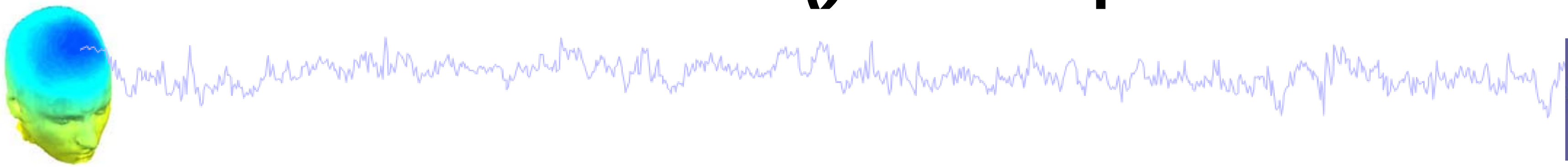
☑ Plot Inter Trial Cohere

Help

Use *newtimef()* to compare conditions

```
>> eegh


figure; pop_newtimef( EEG, 0, 4, [-2000  1996], [3 0.5] ,…
 'topovec', EEG.icawinv(:,4), 'elocs', EEG.chanlocs,…
 'chaninfo', EEG.chaninfo, 'baseline',[-200 0], 'alpha',.01,…
 'freqs', [3 50], 'plotphase', 'off', 'padratio', 1);


>> help newtimef
 Example using data from two conditions (EEG versus ALLEEG(2)):
    >> [ersp,itc,powbase,times,freqs,erspboot,itcboot] = ...
        newtimef({EEG.data(chan,:,:) ALLEEG(2).data(chan,:,:)}, …
        EEG.pnts, [EEG.xmin EEG.xmax]*1000, EEG.srate, cycles);
```

Task 3: Use *newtimef()* to compare conditions



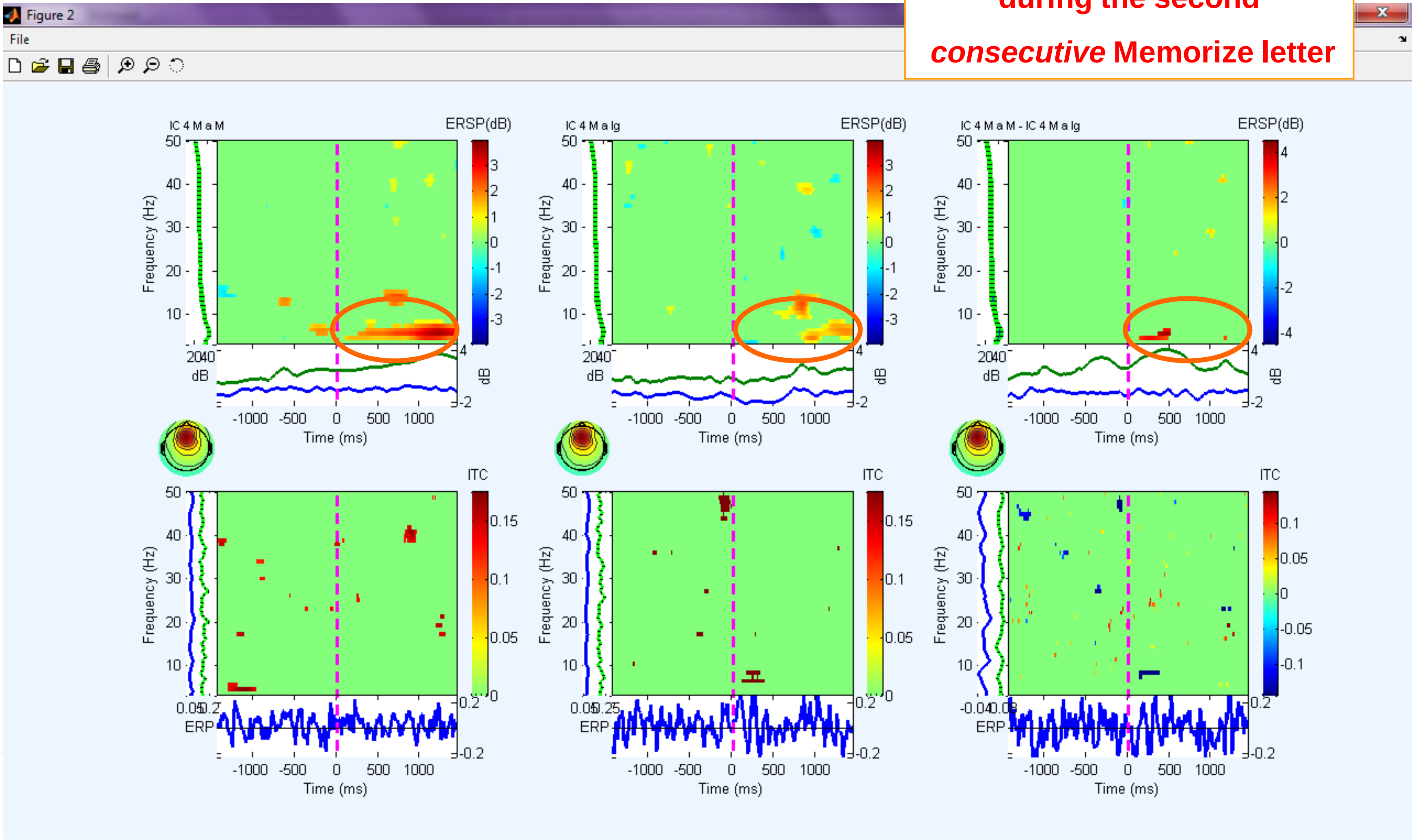
```
% adapt to your script:---------------------------
% data from datasets 1 (mem after mem)
% and 2 (mem after ignore)
ic = 4; % choose a component
[ersp,itc,powbase,times,freqs,erspboot,itcboot] =  …
                                data
newtimef({ALLEEG(1).icaact(ic,:),ALLEEG(2).icaact(ic,:)}, …
EEG.pnts, [EEG.xmin EEG.xmax]*1000, EEG.srate, [3 .5],…
'type', 'phasecoher', 'topovec', EEG.icawinv(:,ic), …
'elocs', EEG.chanlocs, 'chaninfo', EEG.chaninfo, …
                   condition 1
'title',{[‘IC ',int2str(ic),' M a M'],…
                   condition 2
         [‘IC ',int2str(ic),' M a Ig']},…
'baseline',[-200 0], 'alpha',.01,'padratio', 1,…
'plotphase','off', 'freqs', [3 50]);
```

Compare conditions with *newtimef()*

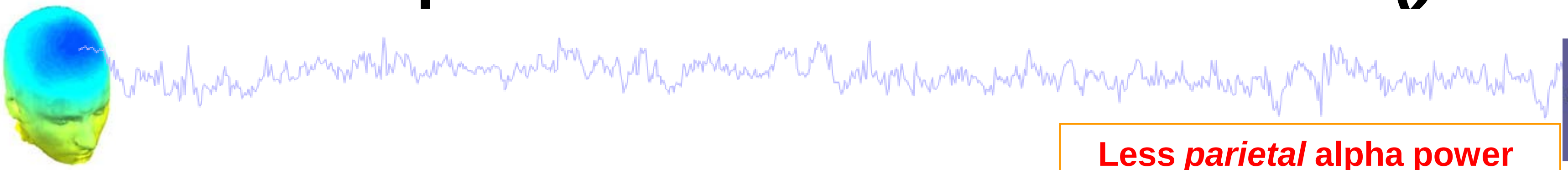
Higher frontal theta

during the second

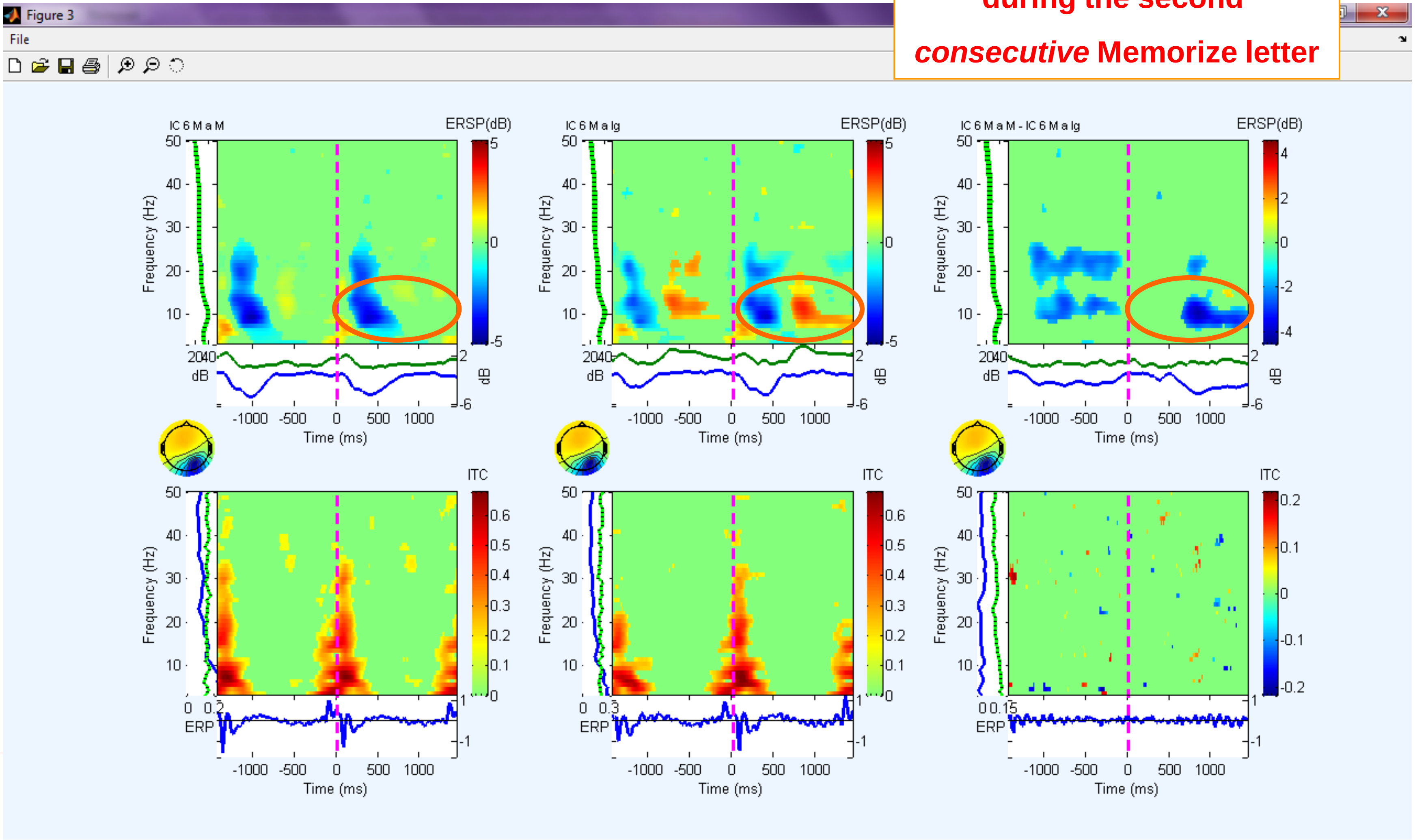
consecutive Memorize letter



Compare conditions with *newtimef()*

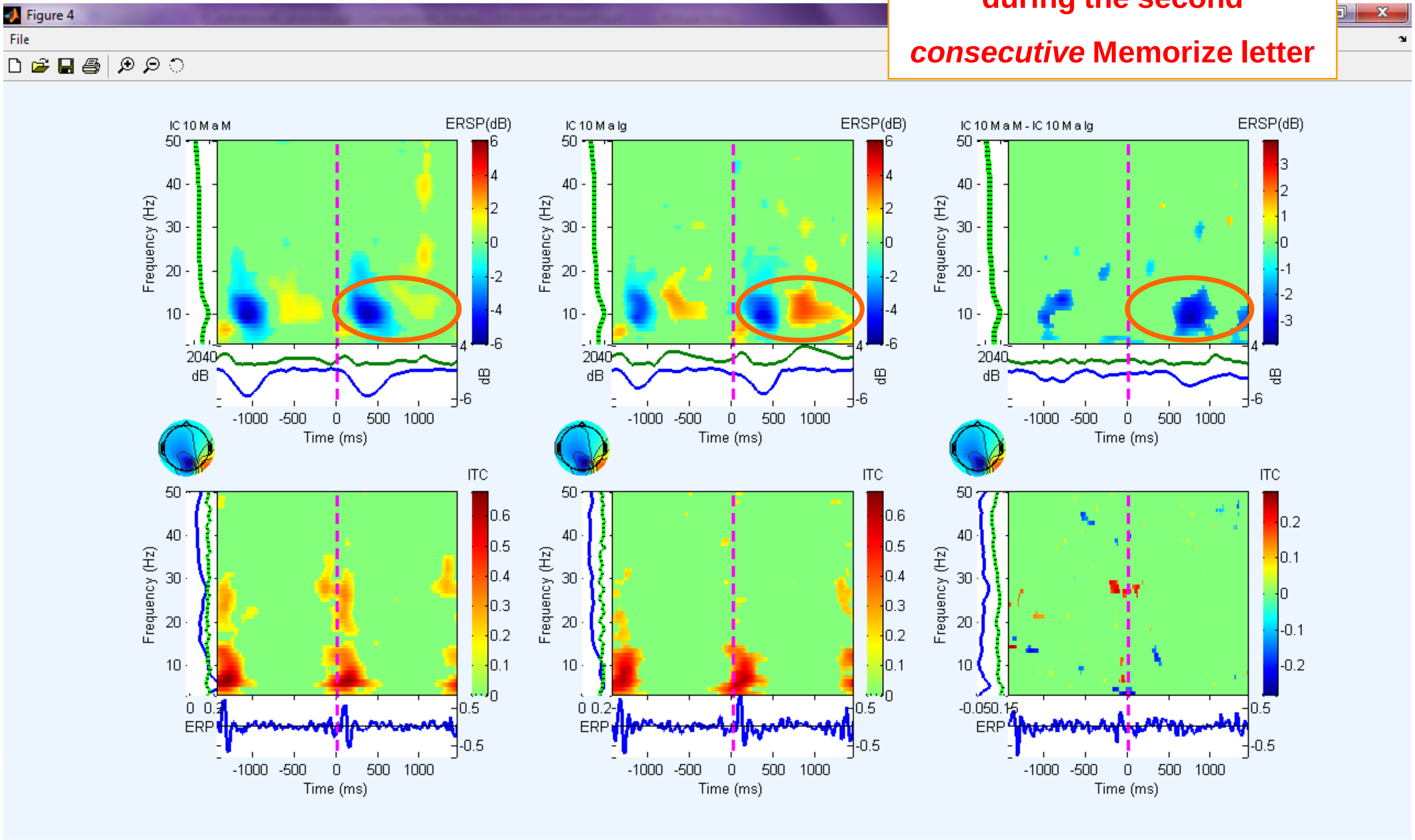


Less *parietal* alpha power during the second *consecutive* Memorize letter

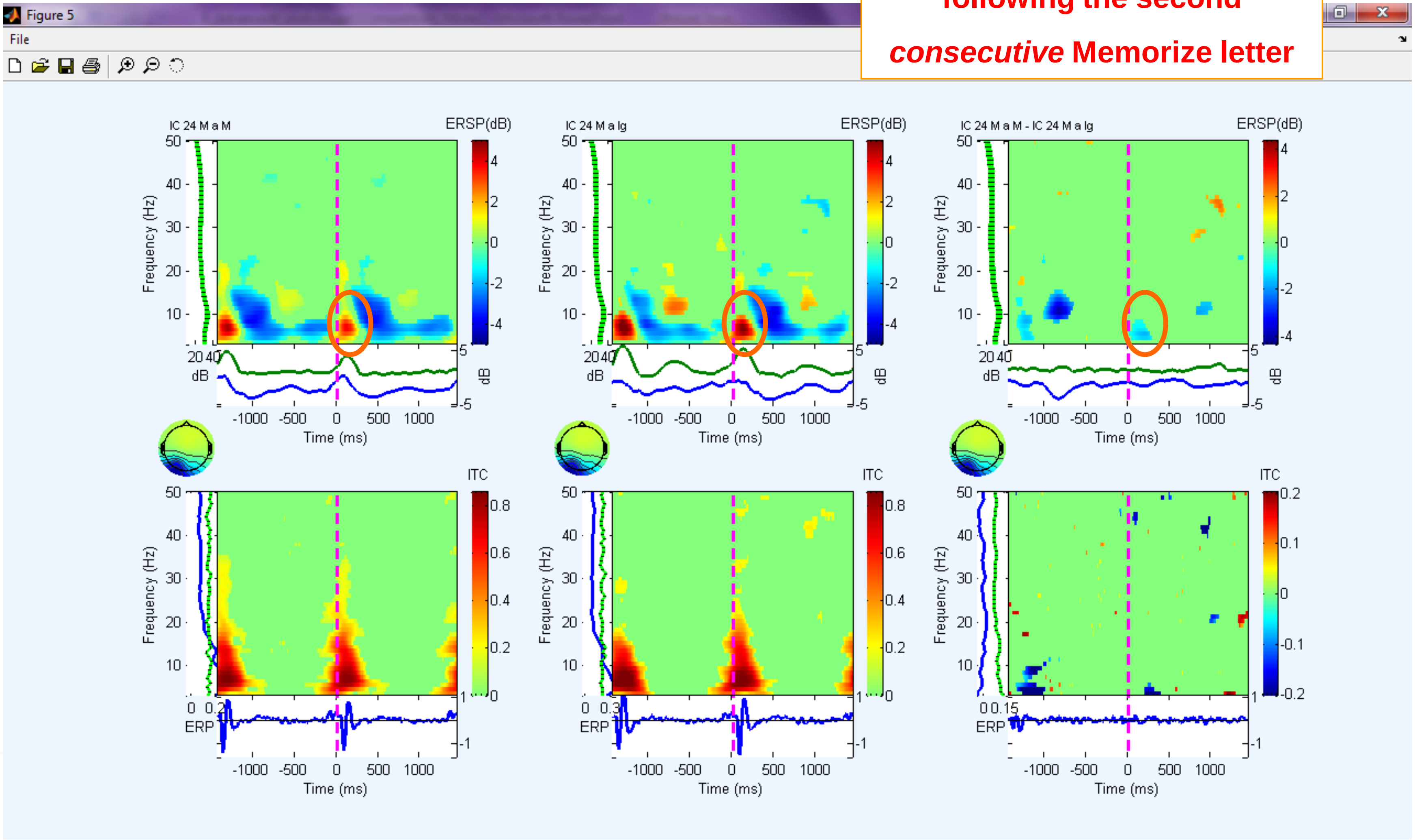


Compare conditions with *newtimef()*

Less *occipital* alpha power during the second *consecutive* Memorize letter

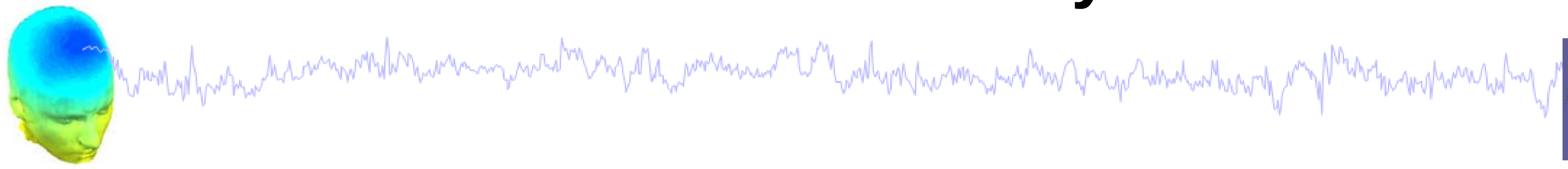


Compare conditions with *newtimef()*



Less visual evoked potential following the second *consecutive* Memorize letter

Advanced IC analysis



Task 1

Search EEG.event structure

Task 2

Use *newtimef()* to compare conditions

Task 3

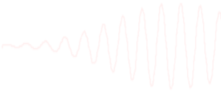
Plot a RT-sorted component ERP image

Plot a type-sorted component ERP image

Plot a load-sorted component ERP image

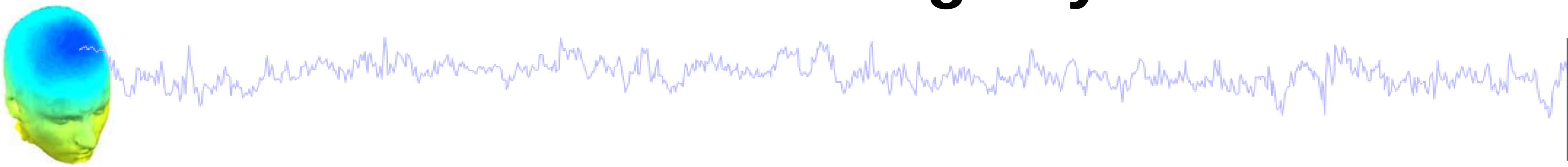
Task 4

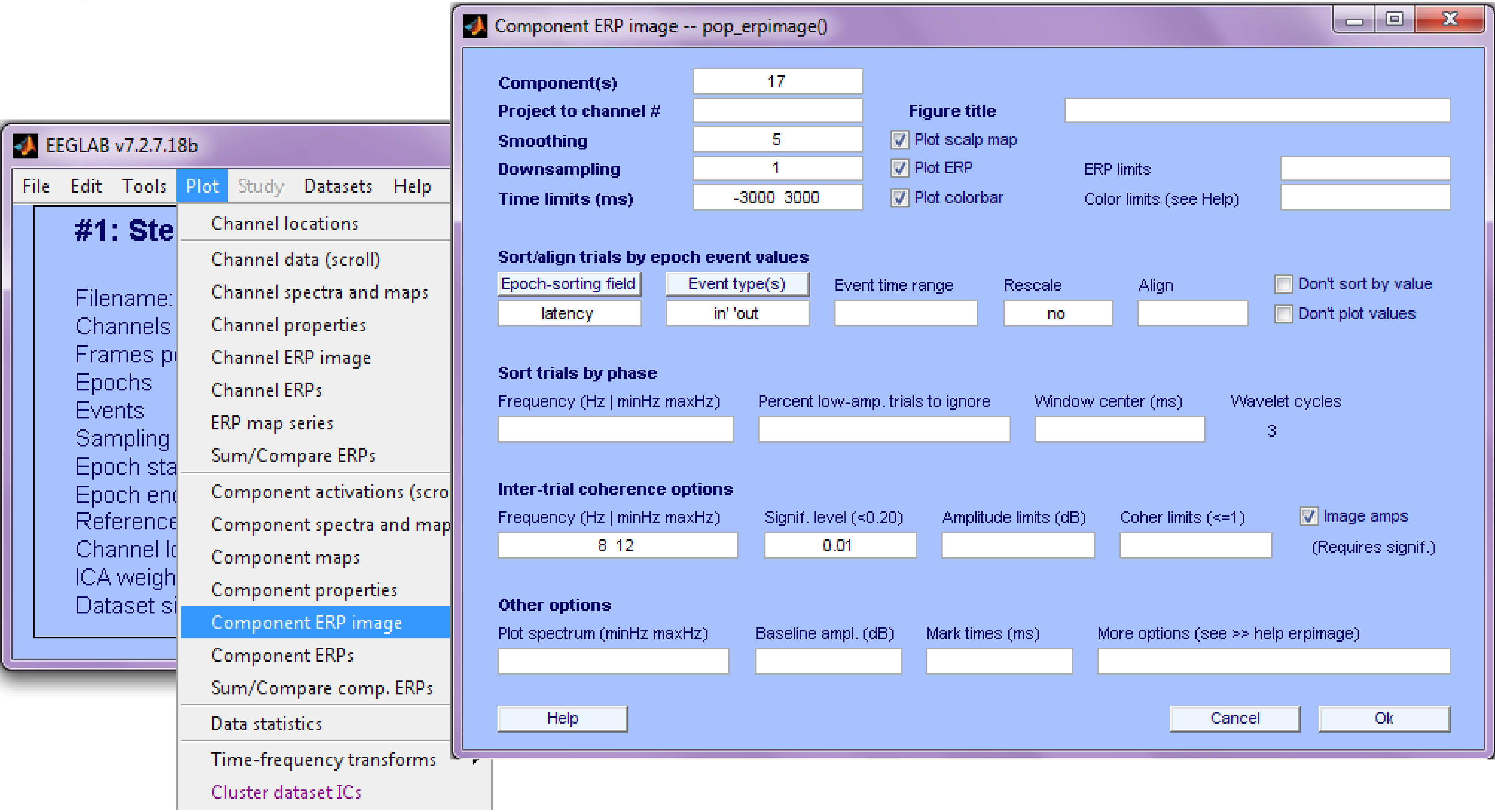
Use outputs from commandline ERP image



Exercise...

Sort ERP image by RT





Component ERP image -- pop_erpimage()

Component(s)	17				
Project to channel #		Figure title			
Smoothing	5	☑ Plot scalp map			
Downsampling	1	☑ Plot ERP		ERP limits	
Time limits (ms)	-3000 3000	☑ Plot colorbar		Color limits (see Help)	

Sort/align trials by epoch event values

Epoch-sorting field	Event type(s)	Event time range	Rescale	Align	
latency	in' 'out		no		☐ Don't sort by value ☐ Don't plot values

Sort trials by phase

Frequency (Hz | minHz maxHz)	Percent low-amp. trials to ignore	Window center (ms)	Wavelet cycles
			3

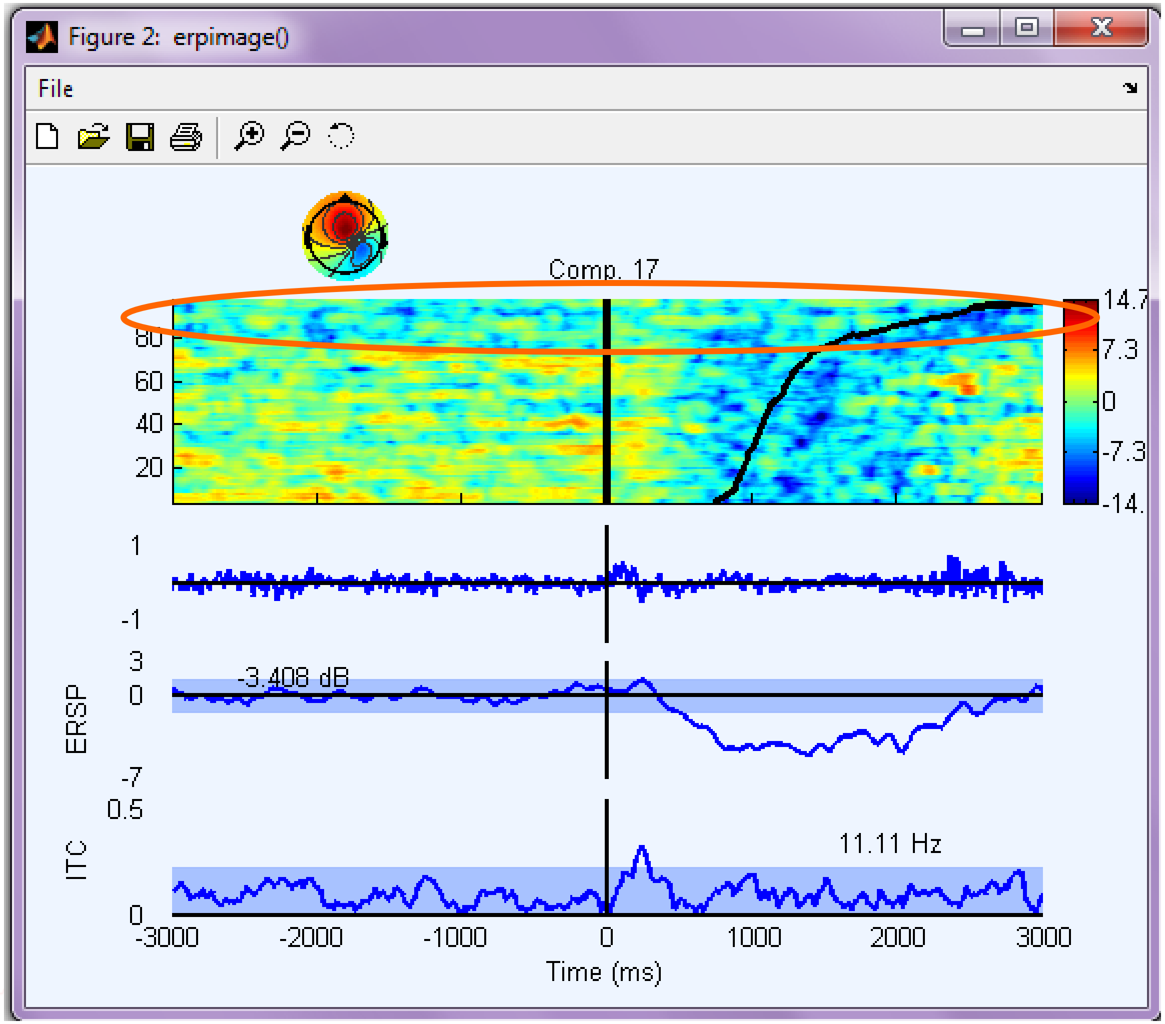
Inter-trial coherence options

Frequency (Hz | minHz maxHz)	Signif. level (<0.20)	Amplitude limits (dB)	Coher limits (<=1)	☑ Image amps
8 12	0.01			(Requires signif.)

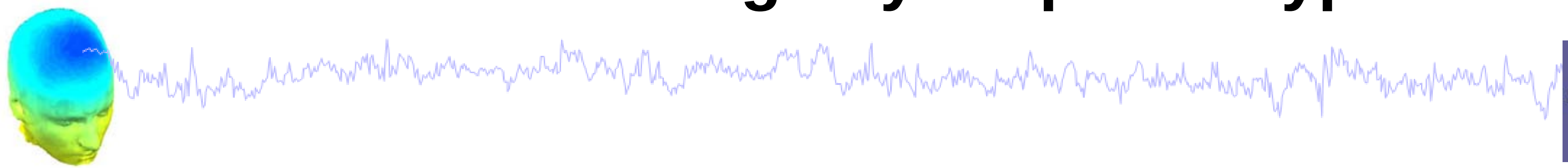
Other options

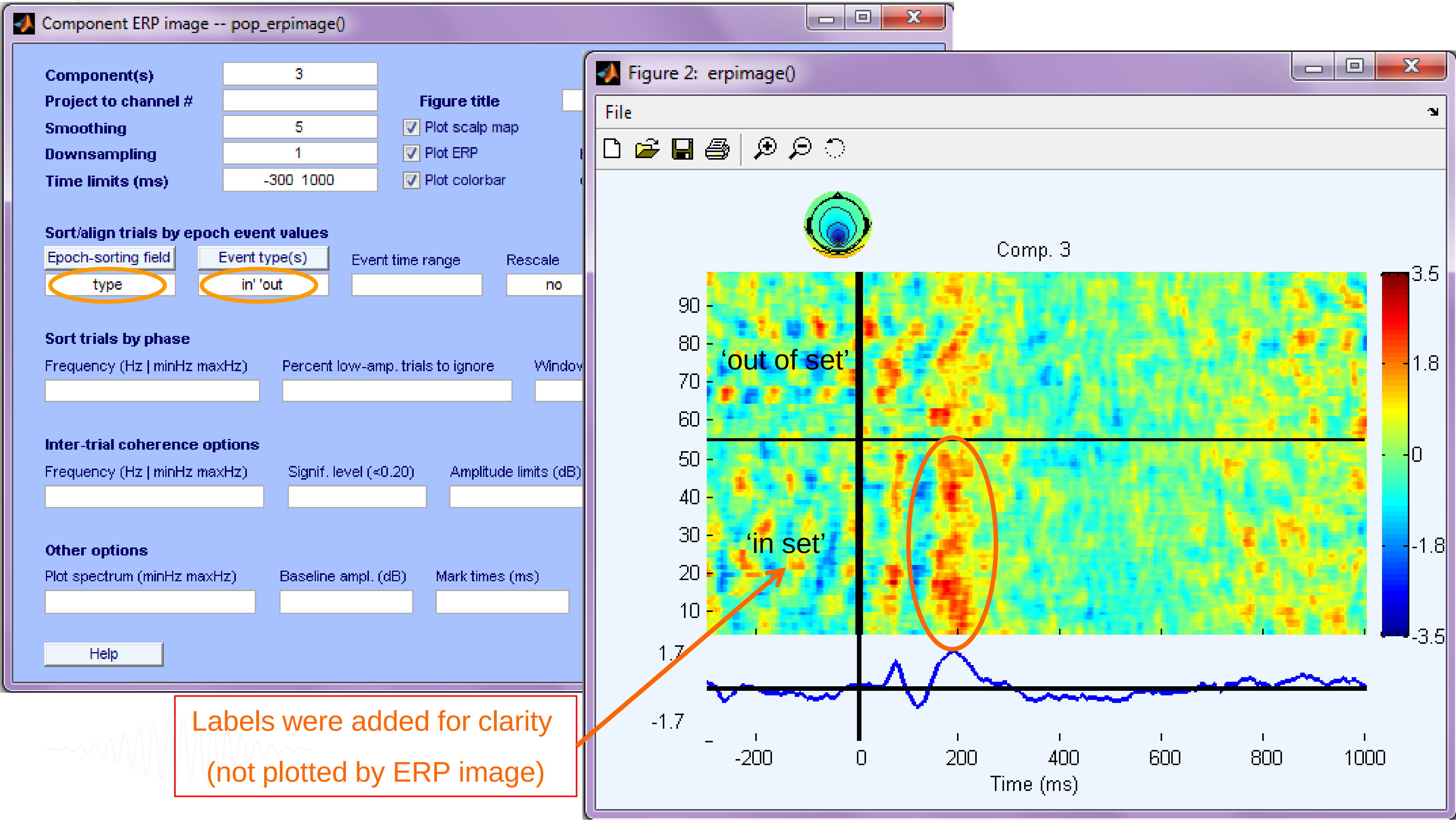
Plot spectrum (minHz maxHz)	Baseline ampl. (dB)	Mark times (ms)	More options (see >> help erpimage)

Sort ERP image by RT



Sort ERP image by response type





Component ERP image -- pop_erpimage()

Component(s) 3

Project to channel #

Smoothing 5

Downsampling 1

Time limits (ms) -300 1000

Figure title

☑ Plot scalp map

☑ Plot ERP

☑ Plot colorbar

Sort/align trials by epoch event values

Epoch-sorting field	Event type(s)	Event time range	Rescale
type	in' 'out		no

Sort trials by phase

Frequency (Hz | minHz maxHz)

Percent low-amp. trials to ignore

Window

Inter-trial coherence options

Frequency (Hz | minHz maxHz)

Signif. level (<0.20)

Amplitude limits (dB)

Other options

Plot spectrum (minHz maxHz)

Baseline ampl. (dB)

Mark times (ms)

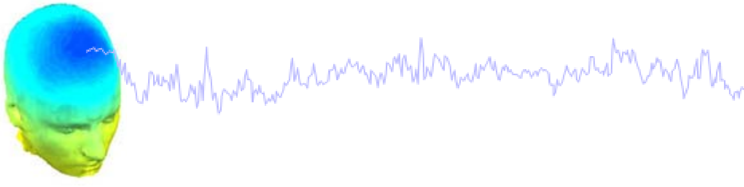
Help

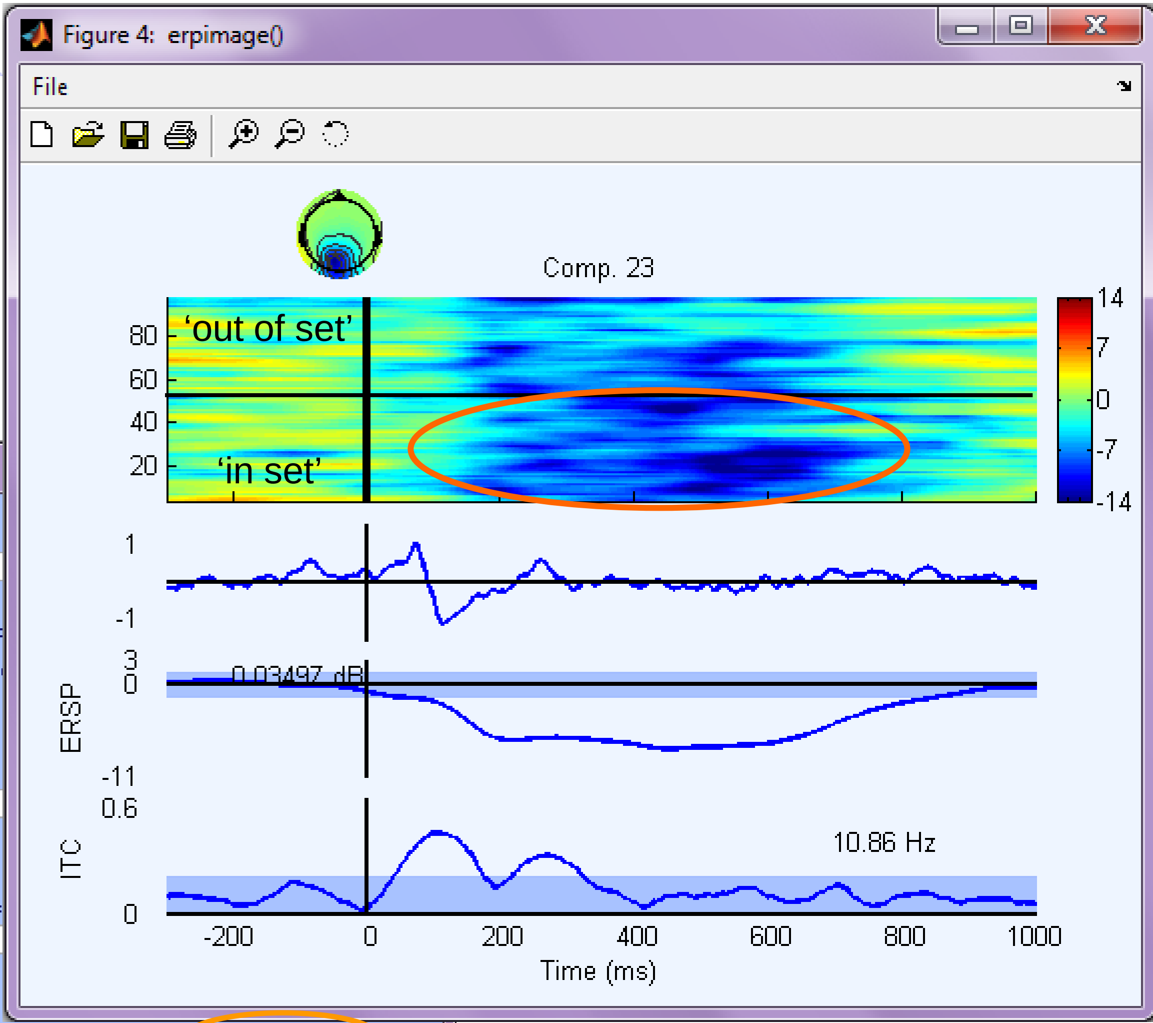
Figure 2: erpimage()

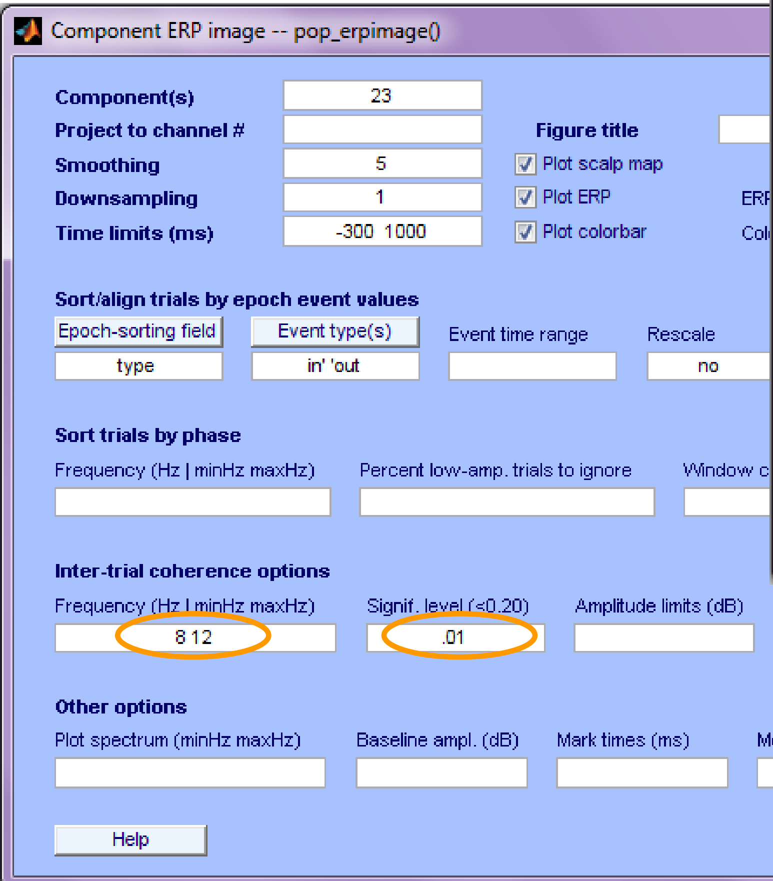
Labels were added for clarity

(not plotted by ERP image)

Sort ERP image by response type






Component ERP image -- pop_erpimage()

Component(s) 23

Project to channel #

Smoothing 5

Downsampling 1

Time limits (ms) -300 1000

Figure title

☑ Plot scalp map

☑ Plot ERP

☑ Plot colorbar

ERP

Col

Sort/align trials by epoch event values

Epoch-sorting field	Event type(s)	Event time range	Rescale
type	in' 'out		no

Sort trials by phase

Frequency (Hz | minHz maxHz)

Percent low-amp. trials to ignore

Window c

Inter-trial coherence options

Frequency (Hz	minHz maxHz)	Signif. level (<0.20)	Amplitude limits (dB)	Coher limits (<=1)	☑ Image amps
8 12	.01			(Requires signif.)

Other options

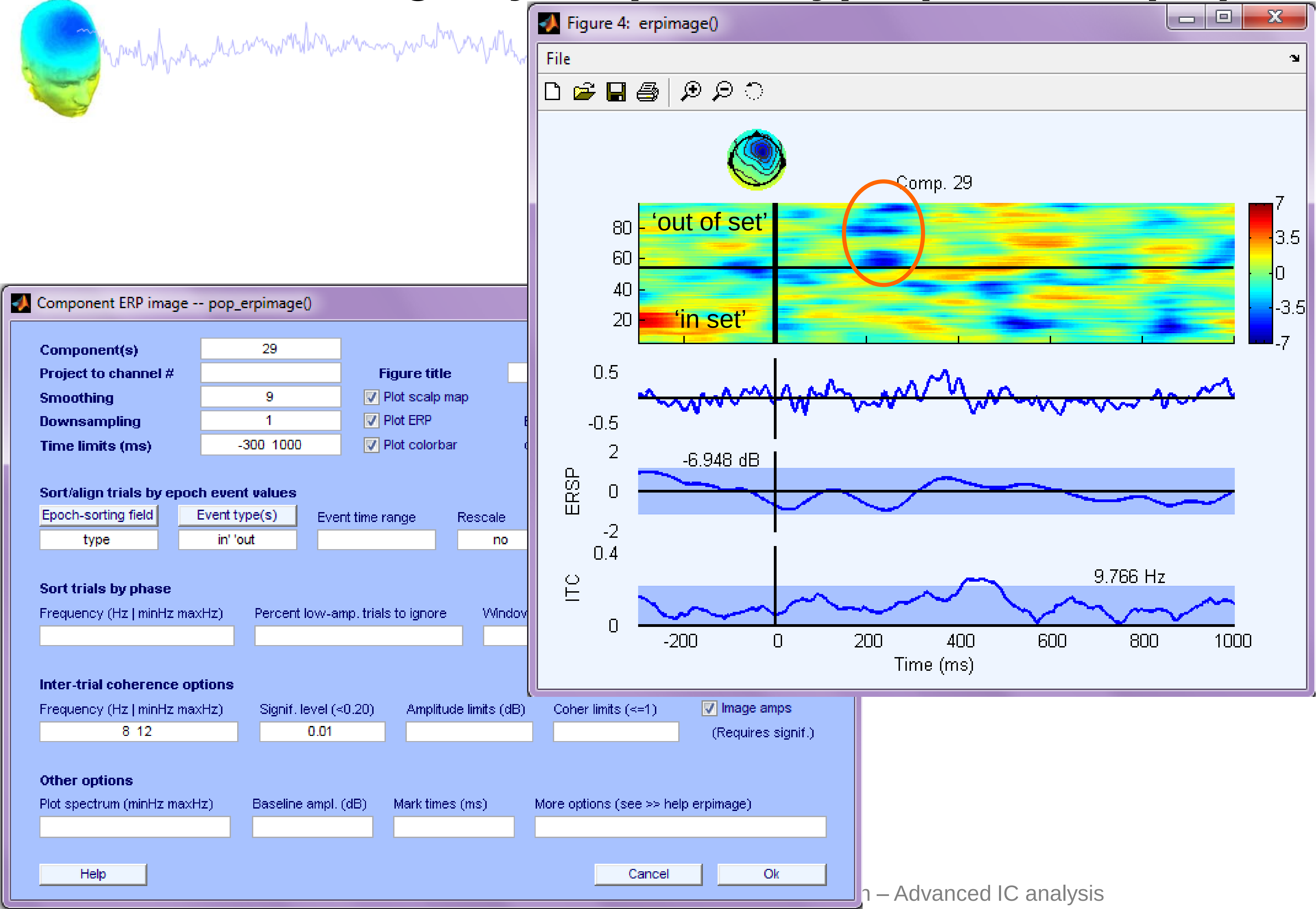
Plot spectrum (minHz maxHz)

Baseline ampl. (dB)

Mark times (ms)

More options (see >> help erpimage)

Sort ERP image by response type (2^{nd} example)



Component ERP image -- pop_erpimage()

Component(s)	29		
Project to channel #		Figure title	
Smoothing	9	☑ Plot scalp map	
Downsampling	1	☑ Plot ERP	
Time limits (ms)	-300 1000	☑ Plot colorbar	

Sort/align trials by epoch event values

Epoch-sorting field	Event type(s)	Event time range	Rescale
type	in' 'out		no

Sort trials by phase

Frequency (Hz | minHz maxHz)	Percent low-amp. trials to ignore	Windov

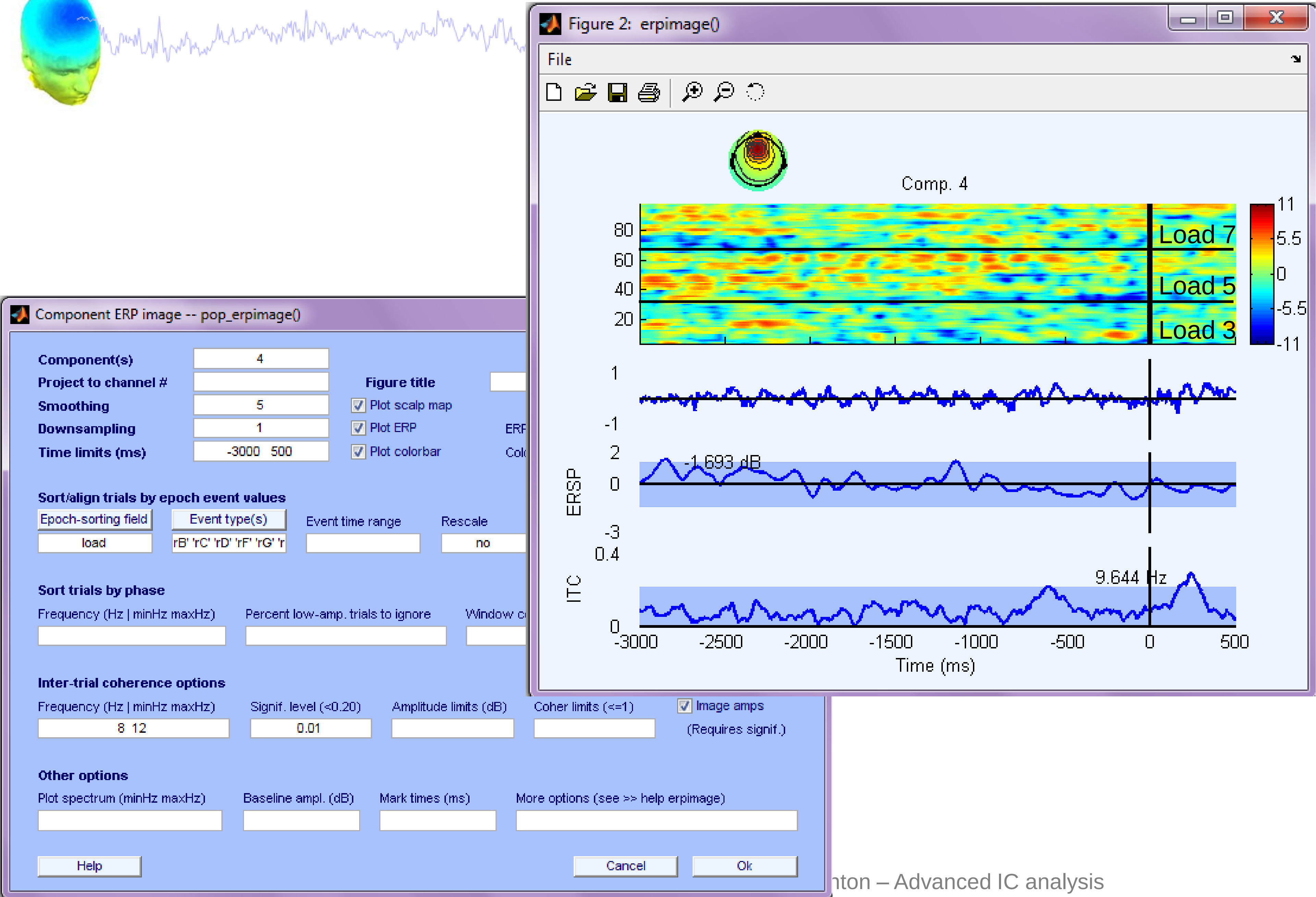
Inter-trial coherence options

Frequency (Hz | minHz maxHz)	Signif. level (<0.20)	Amplitude limits (dB)	Coher limits (<=1)	☑ Image amps (Requires signif.)
8 12	0.01			

Other options

Plot spectrum (minHz maxHz)	Baseline ampl. (dB)	Mark times (ms)	More options (see >> help erpimage)

Sort ERP image by memory load



Component ERP image -- pop_erpimage()

Component(s) 4

Project to channel #

Smoothing 5

Downsampling 1

Time limits (ms) -3000 500

Figure title

☑ Plot scalp map

☑ Plot ERP

☑ Plot colorbar

ERI

Colo

Sort/align trials by epoch event values

Epoch-sorting field: load

Event type(s): rB' 'rC' 'rD' 'rF' 'rG' 'r

Event time range:

Rescale: no

Sort trials by phase

Frequency (Hz | minHz maxHz):

Percent low-amp. trials to ignore:

Window c

Inter-trial coherence options

Frequency (Hz | minHz maxHz): 8 12

Signif. level (<0.20): 0.01

Amplitude limits (dB):

Coher limits (<=1):

☑ Image amps (Requires signif.)

Other options

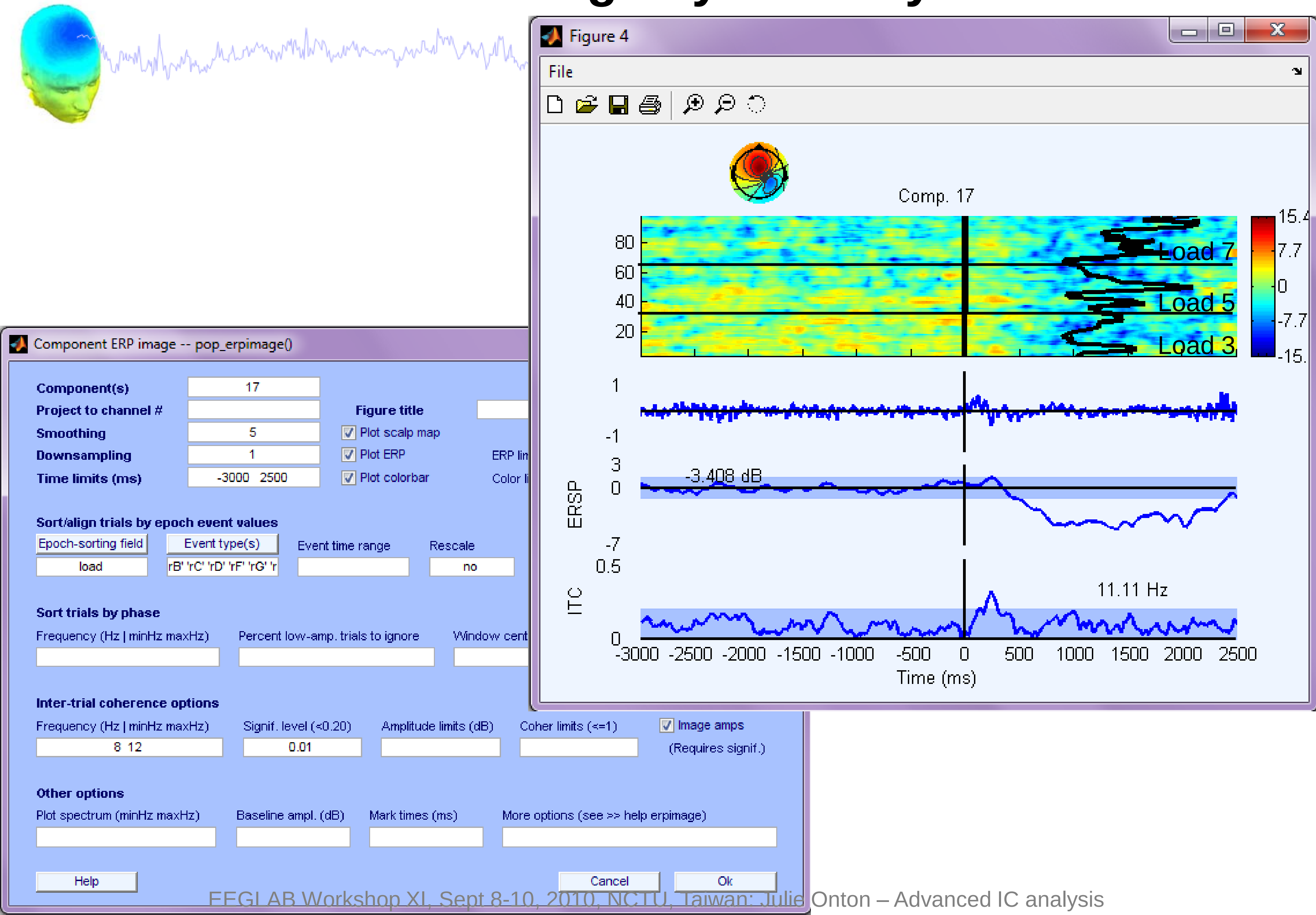
Plot spectrum (minHz maxHz):

Baseline ampl. (dB):

Mark times (ms):

More options (see >> help erpimage):

Sort ERP image by memory load



Component ERP image -- pop_erpimage()

Component(s): 17

Project to channel #:

Smoothing: 5

Downsampling: 1

Time limits (ms): -3000 2500

Figure title:

☑ Plot scalp map

☑ Plot ERP

☑ Plot colorbar

ERP lin

Color li

Sort/align trials by epoch event values

Epoch-sorting field: load

Event type(s): rB' 'rC' 'rD' 'rF' 'rG' 'r

Event time range:

Rescale: no

Sort trials by phase

Frequency (Hz | minHz maxHz):

Percent low-amp. trials to ignore:

Window cent

Inter-trial coherence options

Frequency (Hz | minHz maxHz): 8 12

Signif. level (<0.20): 0.01

Amplitude limits (dB):

Coher limits (<=1):

☑ Image amps (Requires signif.)

Other options

Plot spectrum (minHz maxHz):

Baseline ampl. (dB):

Mark times (ms):

More options (see >> help erpimage):

Advanced IC analysis

Task 1

Search EEG.event structure

Task 2

Use *newtimef()* to compare conditions

Task 3

Plot a RT-sorted component ERP image

Plot a type-sorted component ERP image

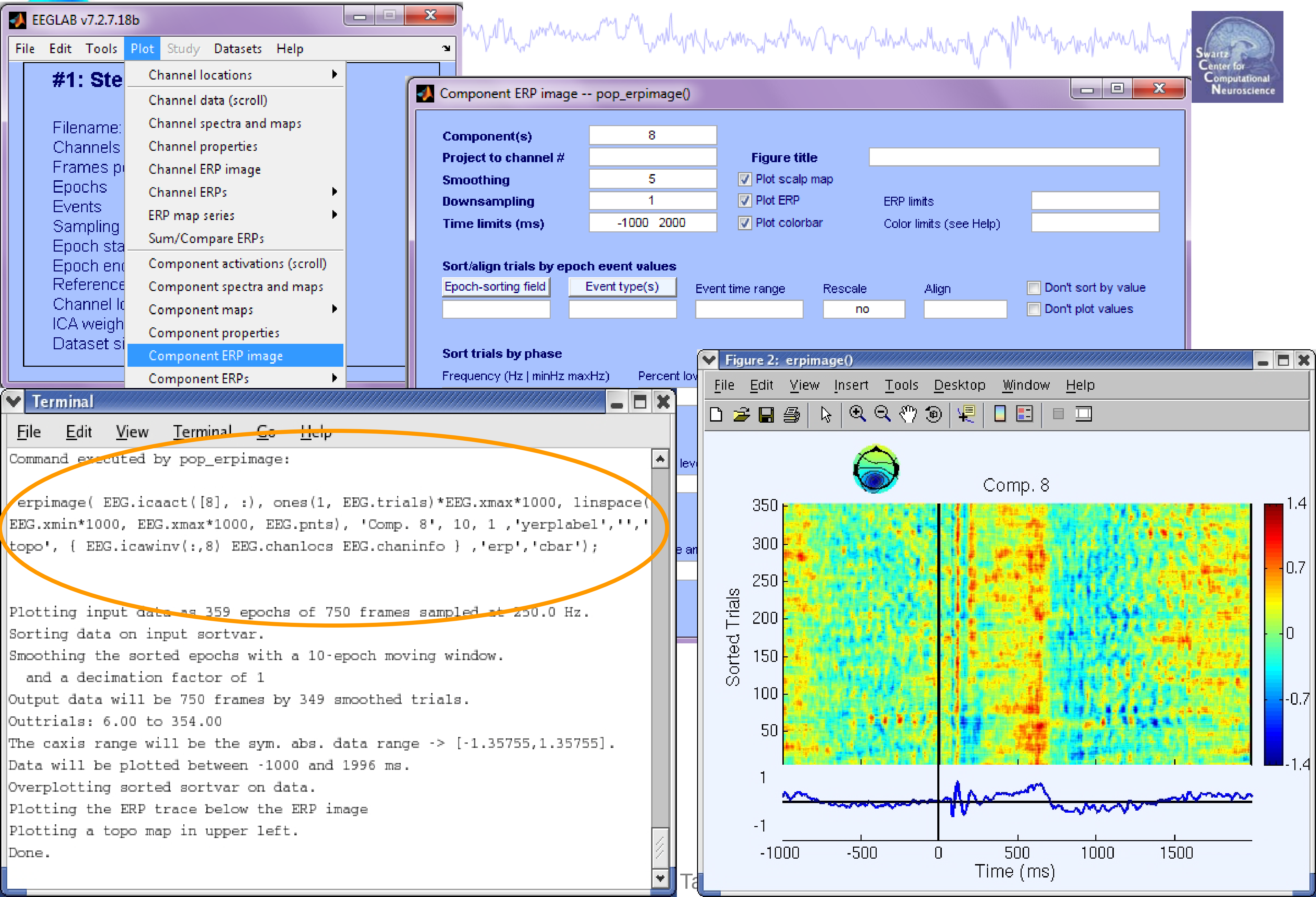
Plot a load-sorted component ERP image

Task 4

Use outputs from commandline ERP image

Exercise...

ERP image from the commandline



Component(s): 8

Project to channel #:

Smoothing: 5

Downsampling: 1

Time limits (ms): -1000 2000

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 range | Rescale: no | Align

□ Don't sort by value

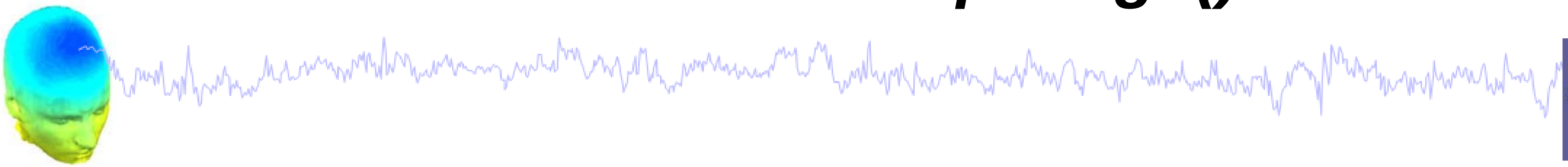
□ Don't plot values

Sort trials by phase

Frequency (Hz | minHz maxHz) Percent lov

```
Command executed by pop_erpimage:

 erpimage( EEG.icaact([8], :), ones(1, EEG.trials)*EEG.xmax*1000, linspace(
EEG.xmin*1000, EEG.xmax*1000, EEG.pnts), 'Comp. 8', 10, 1 ,'yerplabel','','
topo', { EEG.icawinv(:,8) EEG.chanlocs EEG.chaninfo } ,'erp','cbar');


Plotting input data as 359 epochs of 750 frames sampled at 250.0 Hz.
Sorting data on input sortvar.
Smoothing the sorted epochs with a 10-epoch moving window.
  and a decimation factor of 1
Output data will be 750 frames by 349 smoothed trials.
Outtrials: 6.00 to 354.00
The caxis range will be the sym. abs. data range -> [-1.35755,1.35755].
Data will be plotted between -1000 and 1996 ms.
Overplotting sorted sortvar on data.
Plotting the ERP trace below the ERP image
Plotting a topo map in upper left.
Done.
```

Task 1: Retrieve *erpimage()* call



Command executed by pop_erpimage:

```
erpimage( EEG.icaact([8], :), ones(1, EEG.trials)*EEG.xmax*1000, …
linspace(EEG.xmin*1000, EEG.xmax*1000, EEG.pnts),'Comp. 8', 10, 1 , …
’yerplabel','','topo', { EEG.icawinv(:,8) EEG.chanlocs EEG.chaninfo },…
'erp','cbar');
```

data

sortvar

EEG.times

title

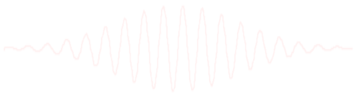
smooth/decimate

Plotting options/scalp map

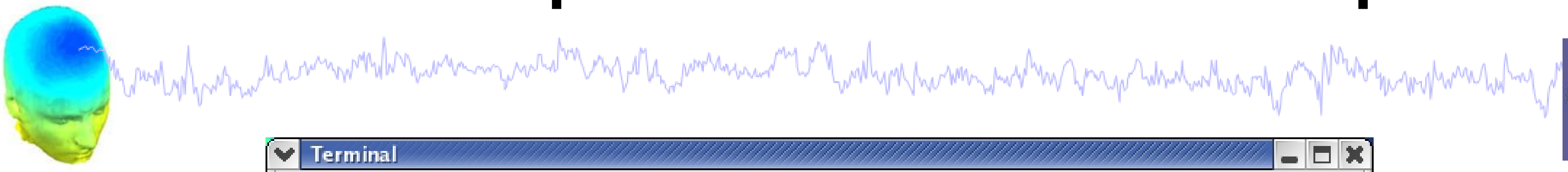
Plot ERP and colorbar

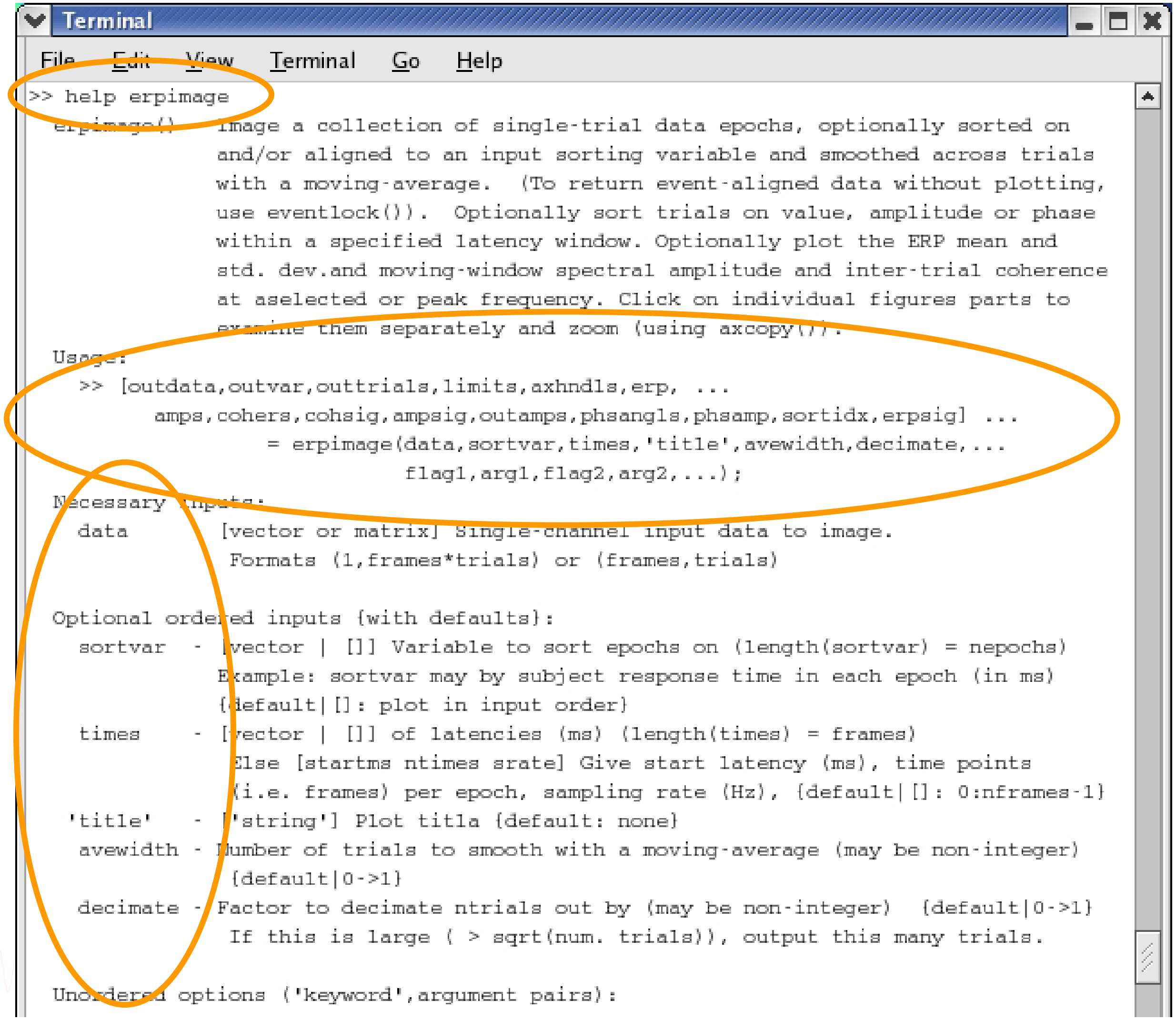
To adapt this command to include more *erpimage()* options:

>> help erpimage



Use ‘help’ command to build script

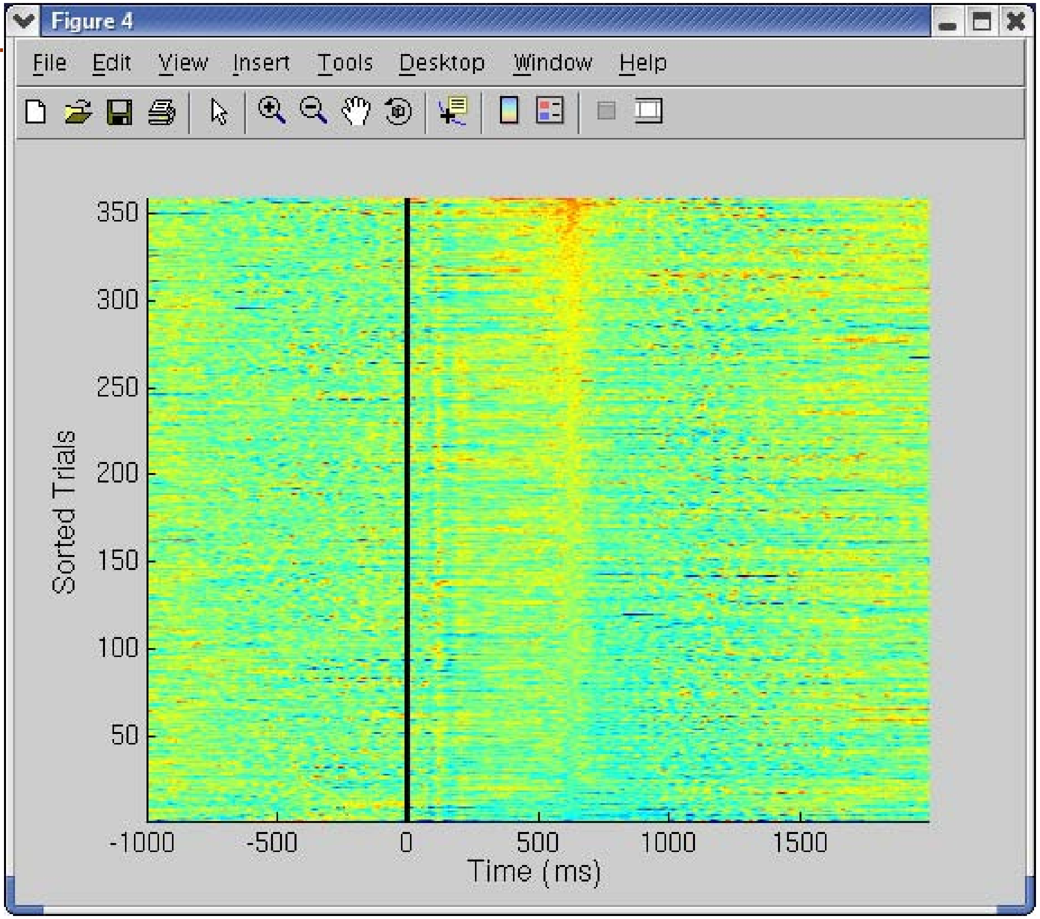


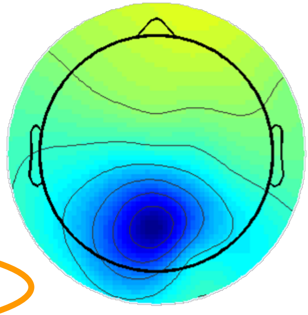


```
>> help erpimage
  erpimage()     image a collection of single-trial data epochs, optionally sorted on
                 and/or aligned to an input sorting variable and smoothed across trials
                 with a moving-average.  (To return event-aligned data without plotting,
                 use eventlock()).  Optionally sort trials on value, amplitude or phase
                 within a specified latency window. Optionally plot the ERP mean and
                 std. dev.and moving-window spectral amplitude and inter-trial coherence
                 at aselected or peak frequency. Click on individual figures parts to
                 examine them separately and zoom (using axcopy()).
  Usage:
    >> [outdata,outvar,outtrials,limits,axhndls,erp, ...
          amps,cohers,cohsig,ampsig,outamps,phsangls,phsamp,sortidx,erpsig] ...
                   = erpimage(data,sortvar,times,'title',avewidth,decimate,...
                                 flag1,arg1,flag2,arg2,...);

  Necessary inputs:
    data         [vector or matrix] Single-channel input data to image.
                  Formats (1,frames*trials) or (frames,trials)

  Optional ordered inputs {with defaults}:
    sortvar    - [vector | []] Variable to sort epochs on (length(sortvar) = nepochs)
                 Example: sortvar may by subject response time in each epoch (in ms)
                 {default|[]: plot in input order}
    times      - [vector | []] of latencies (ms) (length(times) = frames)
                  Else [startms ntimes srate] Give start latency (ms), time points
                  (i.e. frames) per epoch, sampling rate (Hz), {default|[]: 0:nframes-1}
   'title'     - ['string'] Plot titla {default: none}
    avewidth - Number of trials to smooth with a moving-average (may be non-integer)
                  {default|0->1}
    decimate - Factor to decimate ntrials out by (may be non-integer)   {default|0->1}
                  If this is large ( > sqrt(num. trials)), output this many trials.

  Unordered options ('keyword',argument pairs):
```

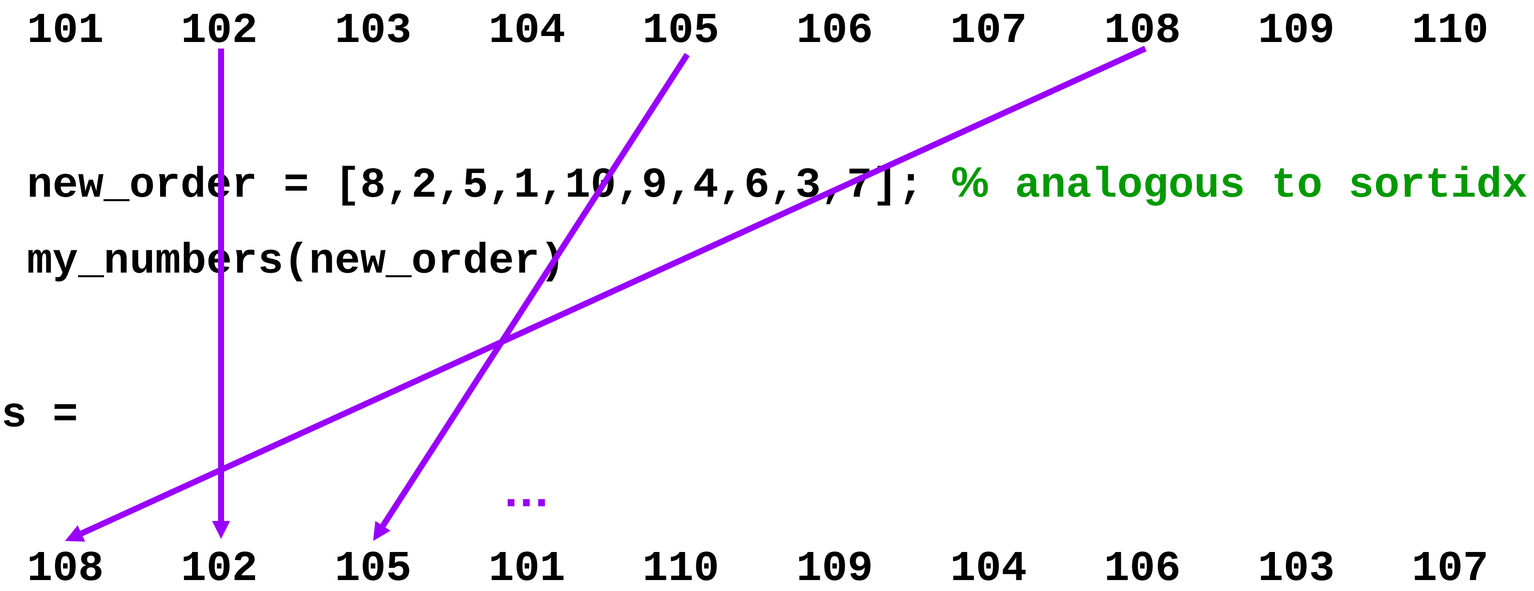
ERP image sorted by activation value

```
[outdata,outvar,outtrials,limits,axhndls,…
erp,amps,cohers,cohsig,ampsig,outamps,…
phsangls,phsamp,sortidx,erpsig] = …
erpimage(data, sortvar, times, 'title',…
avewidth, decimate, flag1, arg1,...);

%%%%% VARIABLES %%%%%%%%%%%%%%%%%%%%
comp1 = 8;  % Comp number to plot
data = squeeze(EEG.icaact(comp1,:,:));
sortvar = []; % no sorting
startms = 580; % ms
endms   = 620; % ms
smoothby = 1;
%%%%% PLOT ERPIMAGE %%%%%%%%%%%%%%%%%%%
figure;
[outdata,outvar, outtrials,limits, axhndls, erp, …
amps, cohers, cohsig, ampsig, outamps, phsangls, …
phsamps, sortidx, erpsig] …
                  = erpimage( data, sortvar, EEG.times, …
                            ‘’, smoothby , 1, ‘valsort’, [startms endms]);
```





Matlab index definition

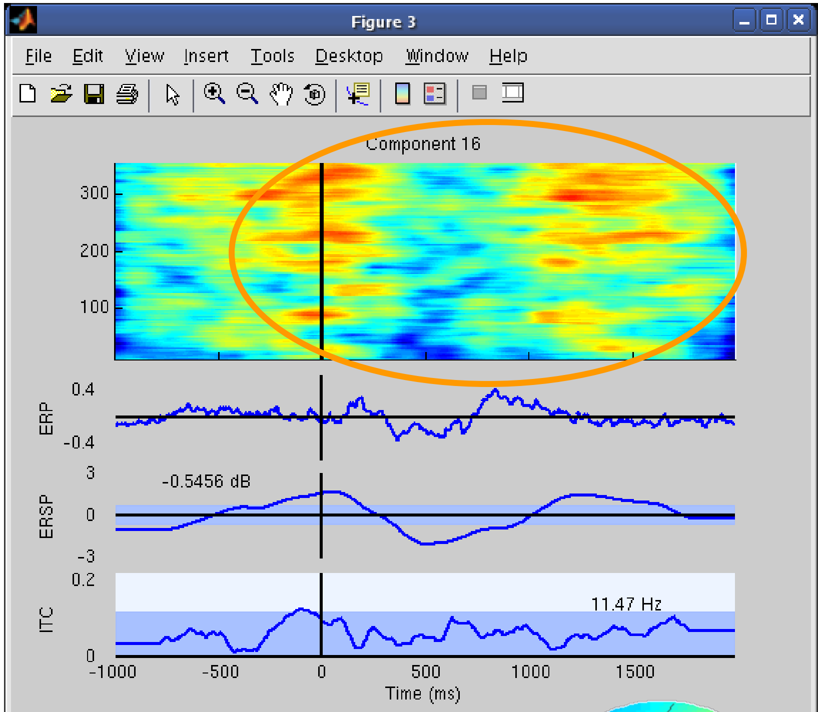


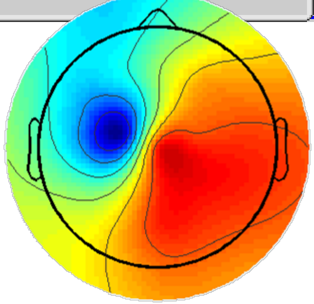
```
>> my_numbers = [101,102,103,104,105,106,107,108,109,110];
my_numbers =


   101   102   103   104   105   106   107   108   109   110


>> new_order = [8,2,5,1,10,9,4,6,3,7]; % analogous to sortidx
>> my_numbers(new_order)


ans =


   108   102   105   101   110   109   104   106   103   107
```

Use sort index to sort a *new* ERP image

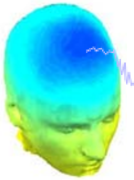
Objective: Use sort order (***sortidx***) from ' **valsort** ' of comp1 to create a new ERP image of another component with the same sort order

```
%%%%% VARIABLES  %%%%%%%%%%%%%%%%%%%%%%%%%
comp1 = 8;
data = squeeze(EEG.icaact(comp1,:,:));
sortvar = [];
startms = 580;
endms    = 620;
smoothby = 1;
%%%%% 1st ERPIMAGE %%%%%%%%%%%%%%%%%%%%
figure;
[outdata,outvar, outtrials,limits, axhndls, erp, …
amps, cohers, cohsig, ampsig, outamps, phsangls, …
phsamps,sortidx, erpsig] = erpimage(data,sortvar,…
EEG.times,'',smoothby , 1,'valsort',[startms endms]);

%%%%% 2nd ERPIMAGE %%%%%%%%%%%%%%%%%%%%
%%%%% Sort by previous sort order %%%%%%%%%%%
comp2 = 16;
data2 = squeeze(EEG.icaact(comp2,:, sortidx));
minfrq = 9;          % specify freq range for
maxfrq = 12;         % amplitude plot
smoothby = 20;
figure;
[outdata,outvar, outtrials,limits, axhndls, erp, amps, …
cohers, cohsig, ampsig, outamps, phsangls,phsamps, sortidx2, erpsig] …
     = erpimage( data2, sortvar, EEG.times, ['Component ',int2str(comp2)],…
            smoothby , 1, 'coher', [minfrq maxfrq .01],'plotamps');
```





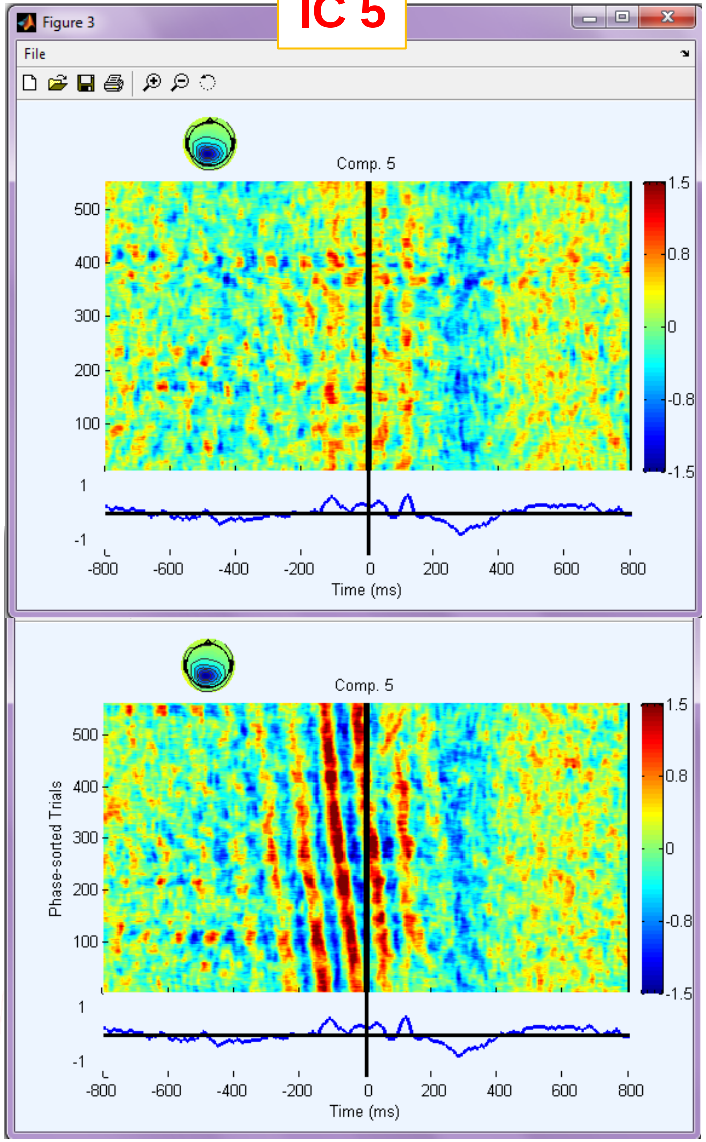
Phase-sort applied to second IC



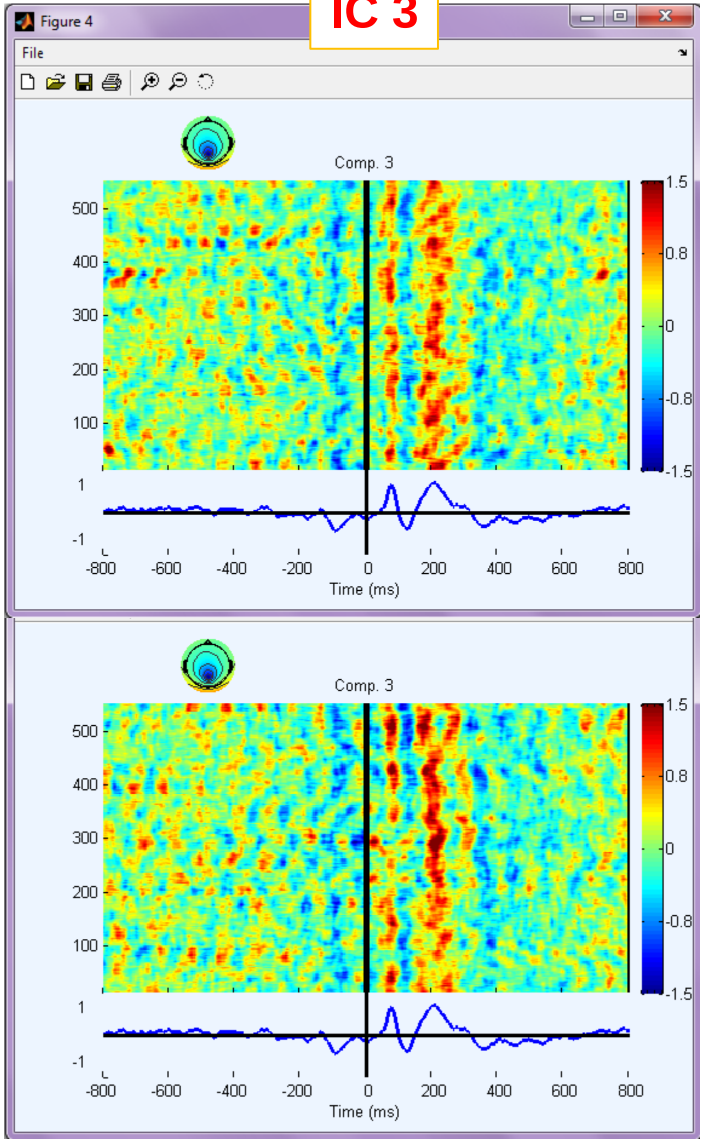
No sort

Phase-sort
-75 ms
center

IC 5



IC 3



No sort

Sorted by
IC 5
phase-sort

Exercise

- **Intermediate:**
  - Use EEG.event structure to select specific trial types.
    - -Epoch on these trials and plot ERSP and/or ERP images
  - •Plot a two-condition ERSP of a chosen IC (start with loading continuous data, epoching, etc)
  - Start with GUI call and adapt a script using 'eegh'
  - •Collect RTs and include in ERP image plots

•Advanced:

- •From a *'valsort'* ERP image, collect ***sortidx*** output
- Apply sort order to an ERP image of *another* component (try different smoothing factors)

** Example scripts for exercises can be found in …/Scripts/Tutorial_6_ICanalysis.m