A short tutorial for RIDE toolbox

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---- from Sep 2015 ----------
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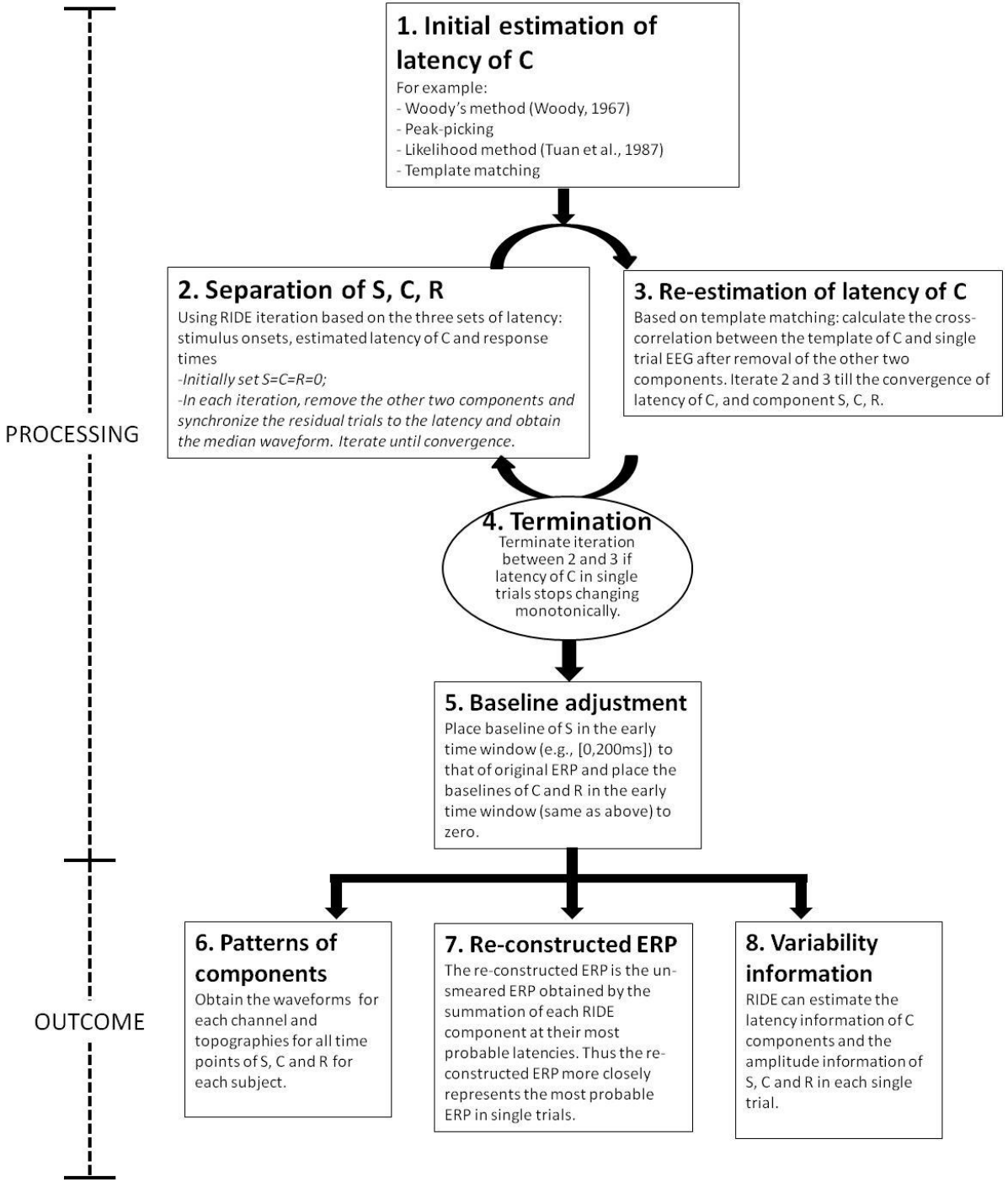
- Overview of algorithm modules
- Procedure
- Outcome
- Tips & Cautions
- Practice



Ouyang et al., 2015,
Psychophysilology

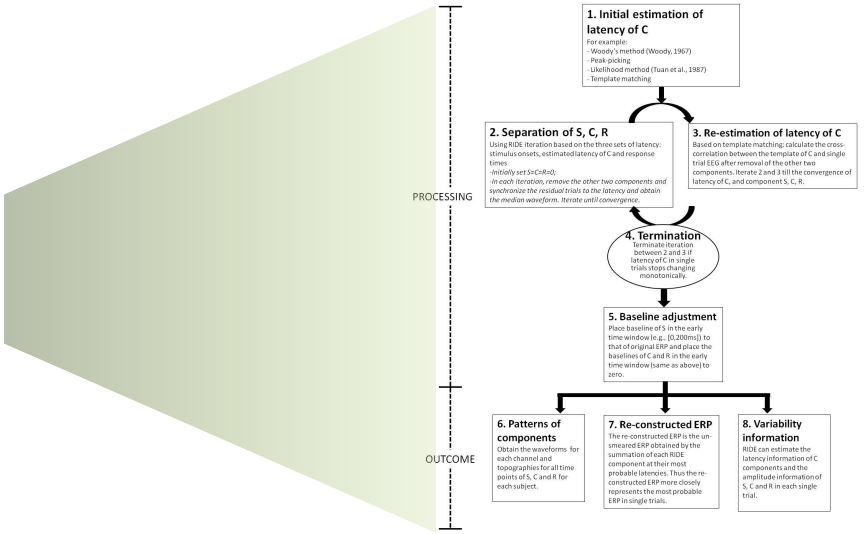
– The Procedure

export EEG data from your EEG softwares

import data into Matlab

run RIDE script (several lines)

collect the outcome and do the analyses



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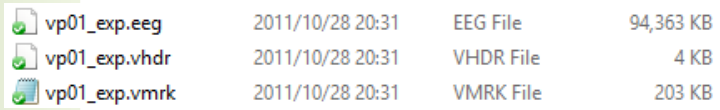
- Brain Product

e.g.,



- Neuroscan

e.g.,

- etc…

– The Procedure

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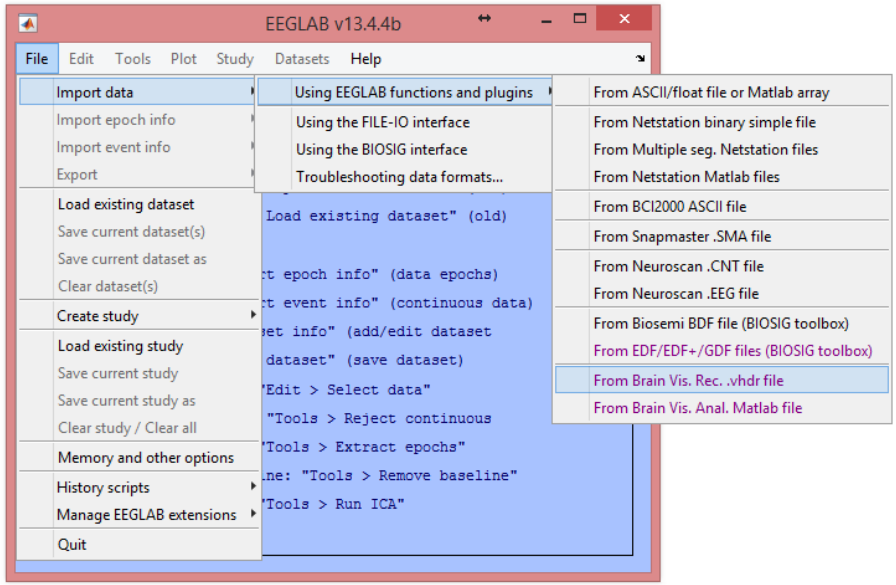
EEGLAB

http://sccn.ucsd.edu/eeglab/



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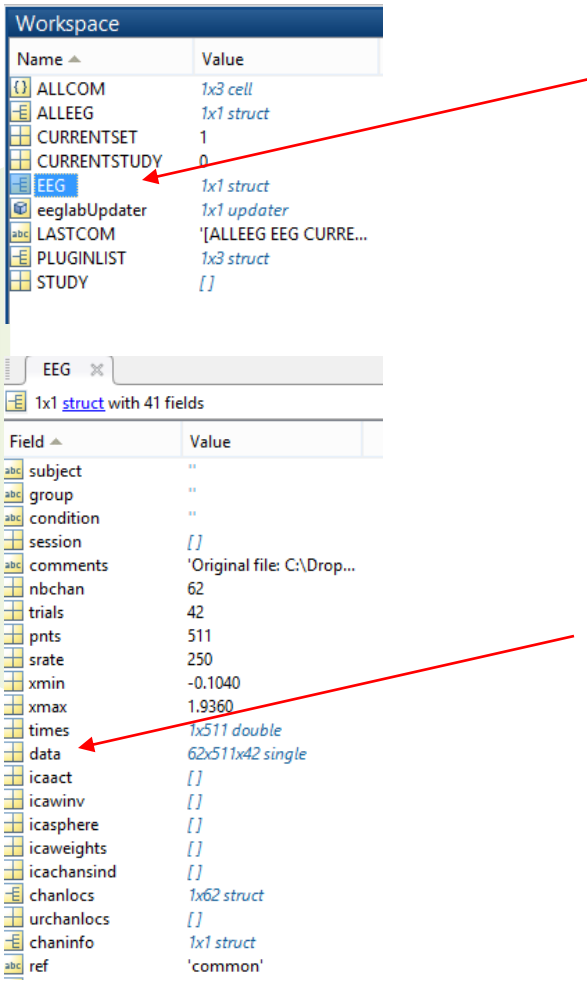
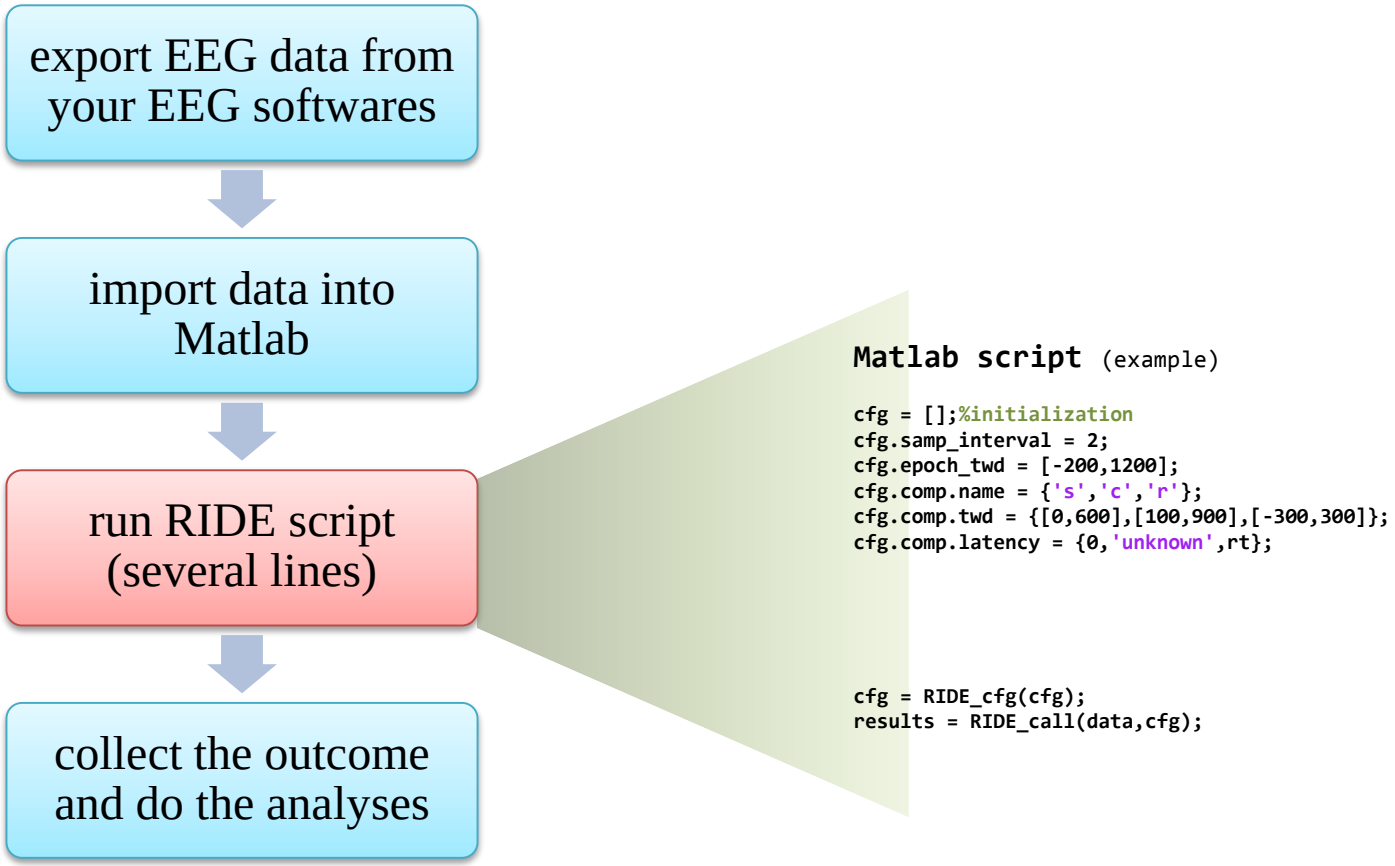


– The Procedure



– The Procedure

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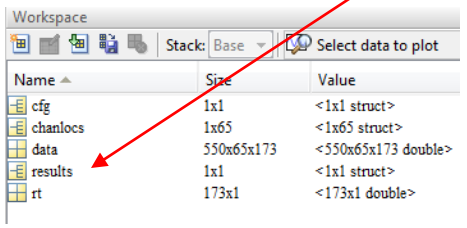
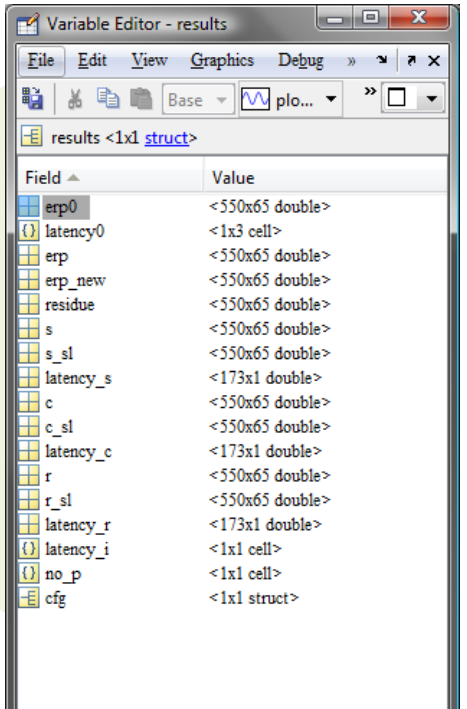




– About RIDE toolbox

- RIDE is a package of Matlab code

  http://cns.hkbu.edu.hk/RIDE.htm

- Implementation of RIDE is just a few lines of code.
- After implement RIDE, the results is saved in data matrix, one can choose:
  - either do all the analysis and plottings in Matlab (require basic Matlab scripting background)
  - or export the data into your favorite softwares (spss) or programming environments (python, R).

– Start RIDEing

– add the RIDE package to the Matlab path

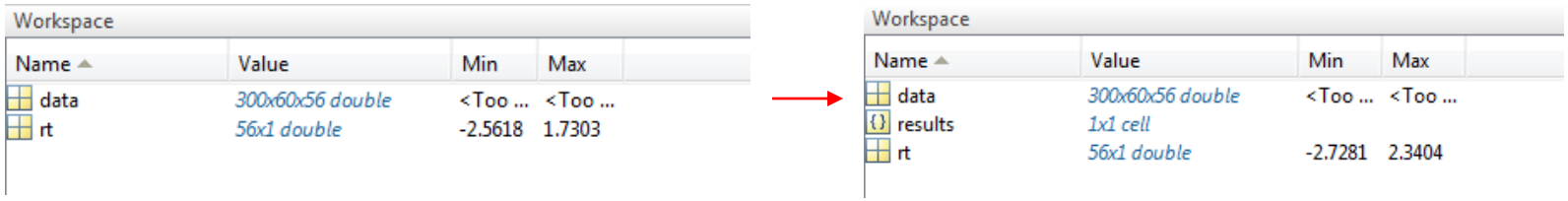
– Create a new m-script and type the following:

Configure the separation scheme and parameters

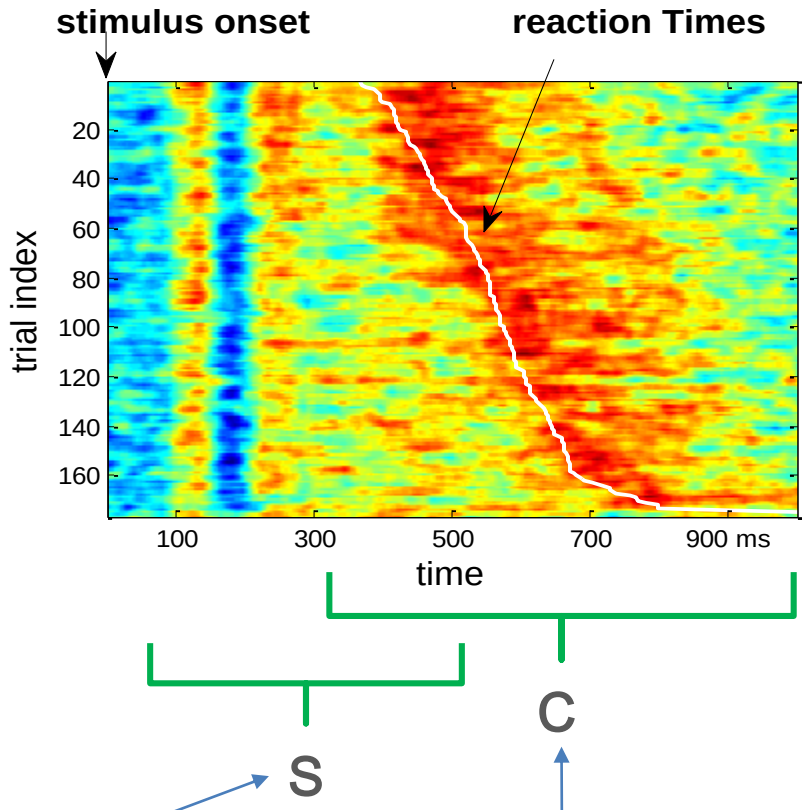
```
cfg = [];%initialization
cfg.samp_interval = 2;
cfg.epoch_twd = [-200,1200];
cfg.comp.name = {'s','c','r'};
cfg.comp.twd = {[0,500],[100,900],[-300,300]};
cfg.comp.latency = {0,'unknown',rt};
```

Run

```
cfg = RIDE_cfg(cfg);
results = RIDE_call(data,cfg);
```



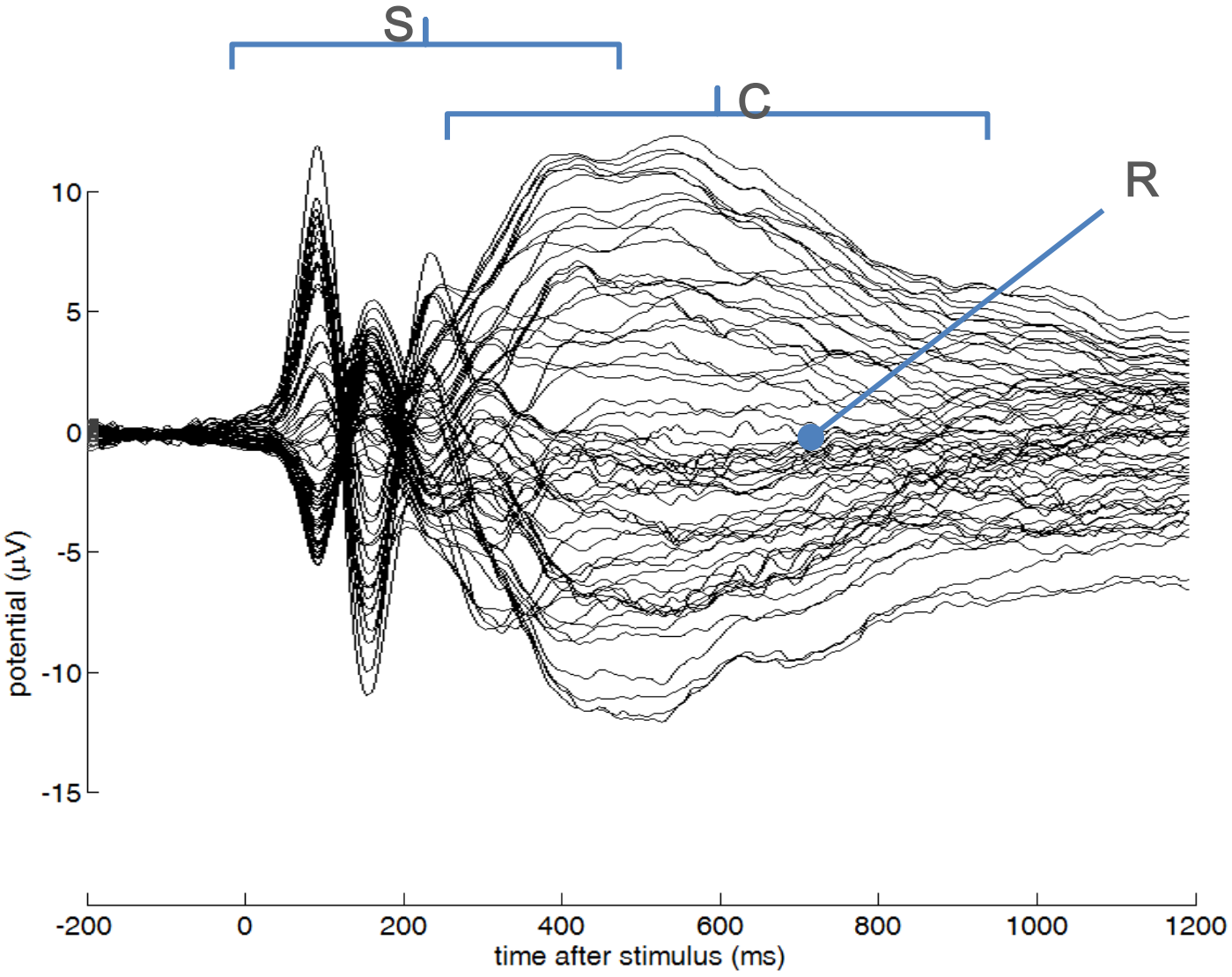
Time window selection



S for capturing the early, stimulus-locked component, empirically, [0, 500]

C for capturing the latency-variable component cluster
Time window is selected from the beginning and termination of the hump (see next slide)

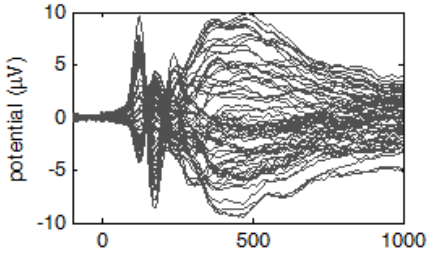
– An example of separating ERP into one C components



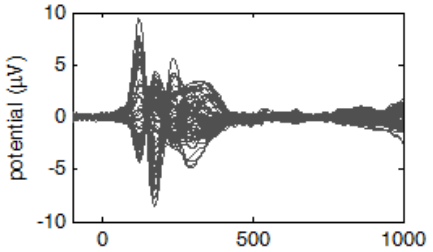
Time window selection

A general scenario of RIDE separation: (grand averaged ERP)

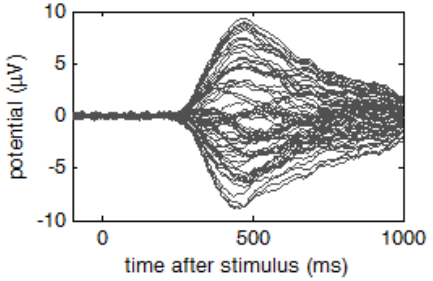
ERP



S

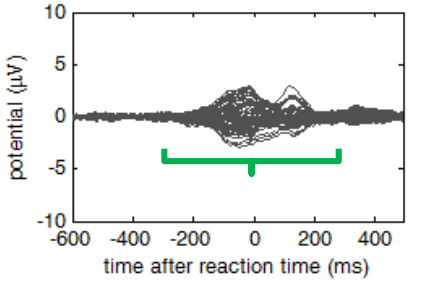


C



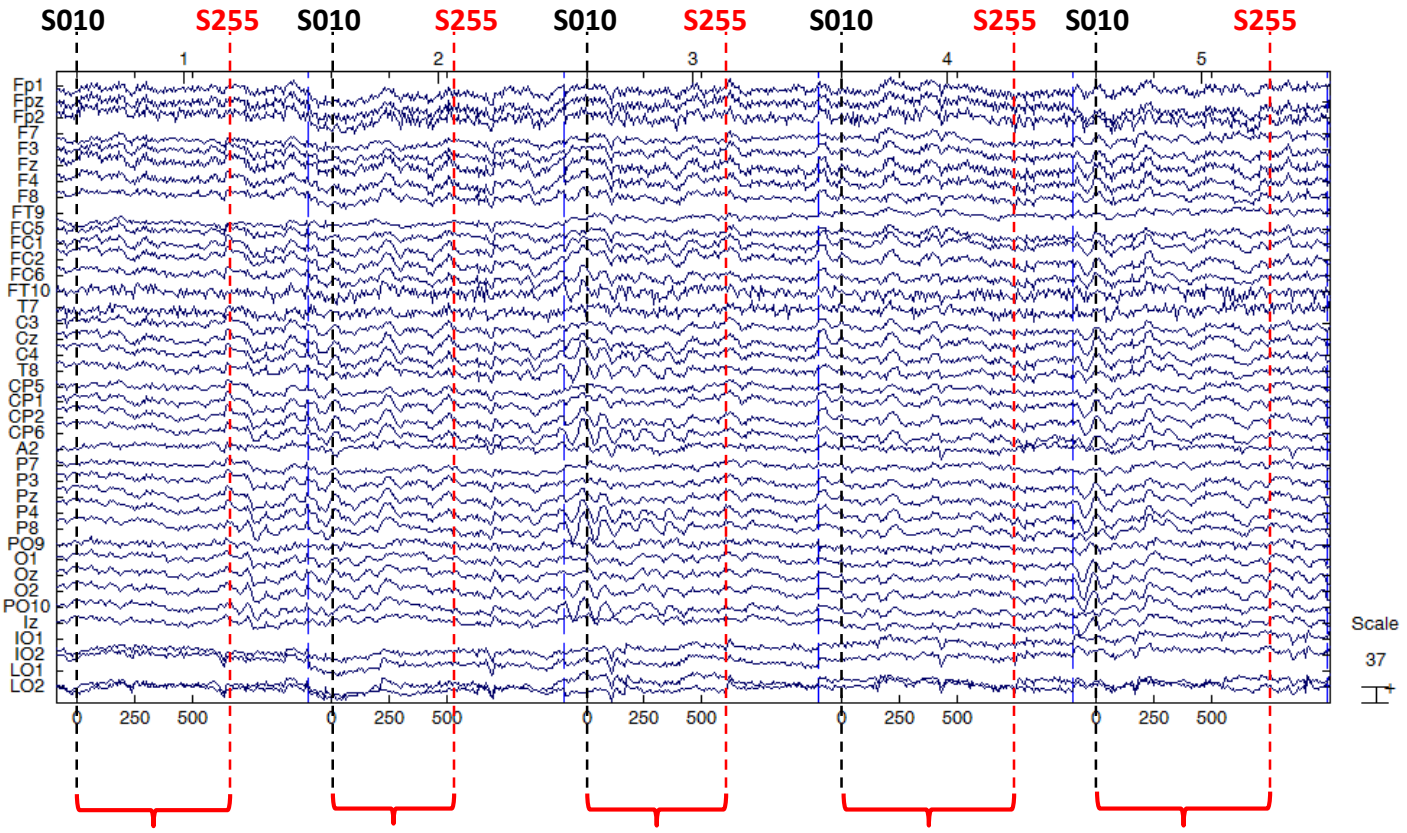
R component is set as [-300 300] around RT assuming that the RT-locked cluster is within this time window. The pattern of the R is in line with the assumption (right).

R



– Data and RT extracting

Do not involve 'non-brain channels!



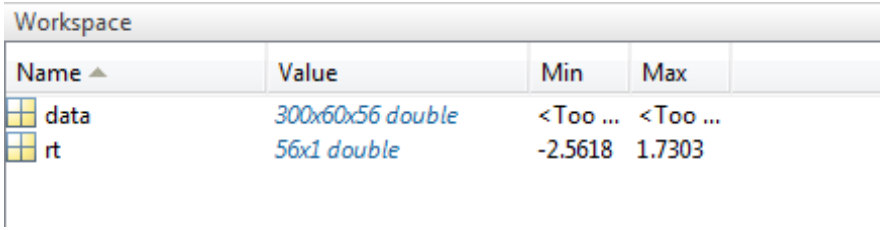
When data is imported by EEGLAB, the data and event information is stored in EEG.data and EEG.event. We need a few lines of script to extract the RT. We have an example in RIDE_call/example/Snippet for data and rt extraction

– Data and RT extracting

Finally the data prepared like this is ready for RIDE

Importance:

- ‘data’ only contain a single subject and single condition
- RT matches data trial by trial.



– Different RIDEing Schemes, for examples:

- Typical task with RT:

  S+C+R

- Nogo trials:

  S+C

- Reading task:

  S+C1(N400) + C2(P600)

- Extremely simple task:

  S + R

- etc..

– Different RIDEing Schemes

– Create an new m-script and type the following:

S+C+R

```
cfg = [];%initialization
cfg.samp_interval = 2;
cfg.epoch_twd = [-100,1000];
cfg.comp.name = {'s','c','r'};
cfg.comp.twd = {[0,500],[100,900],[-300,300]};
cfg.comp.latency = {zeros(size(data,3),1),'unknown',rt};
cfg = RIDE_cfg(cfg);

results = RIDE_call(data,cfg);
```

– Different RIDEing Schemes

– Create an new m-script and type the following:

S+C

```
cfg = [];%initialization
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cfg.epoch_twd = [-100,1000];
cfg.comp.name = {'s','c'};
cfg.comp.twd = {[0,500],[100,900]};
cfg.comp.latency = {zeros(size(data,3),1),'unknown'};
cfg = RIDE_cfg(cfg);

results = RIDE_call(data,cfg);
```

– Different RIDEing Schemes

– Create an new m-script and type the following:

S+C1+C2+R

```
cfg = [];%initialization
cfg.samp_interval = 2;
cfg.epoch_twd = [-100,1000];
cfg.comp.name = {'s','c1','c2','r'};
cfg.comp.twd = {[0,500],[100,600],[400,900],[-300,300]};
cfg.comp.latency = {zeros(size(data,3),1), 'unknown', 'unknown', rt};
cfg = RIDE_cfg(cfg);

results = RIDE_call(data,cfg);
```

– Different RIDEing Schemes

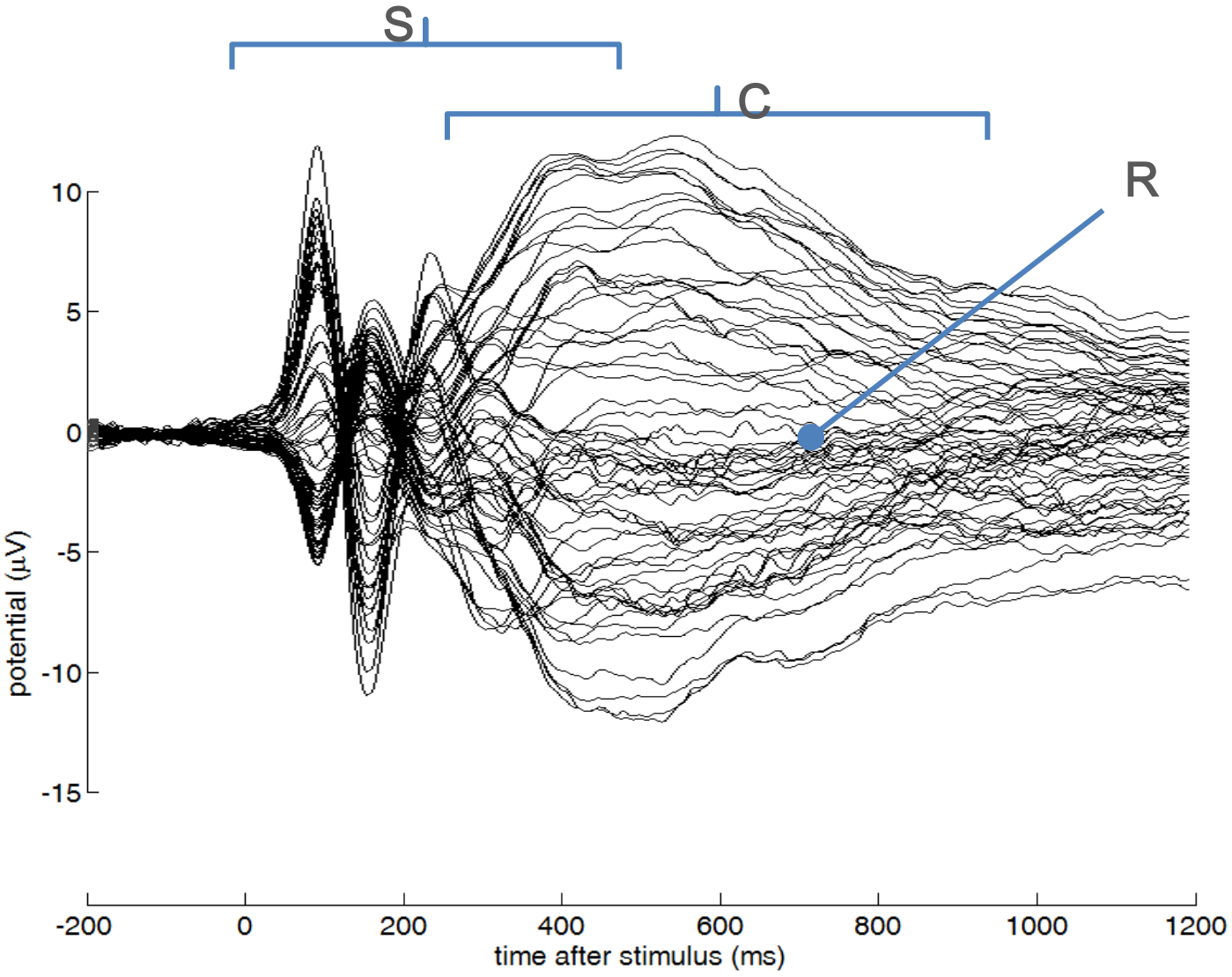
– Create an new m-script and type the following:

S+R

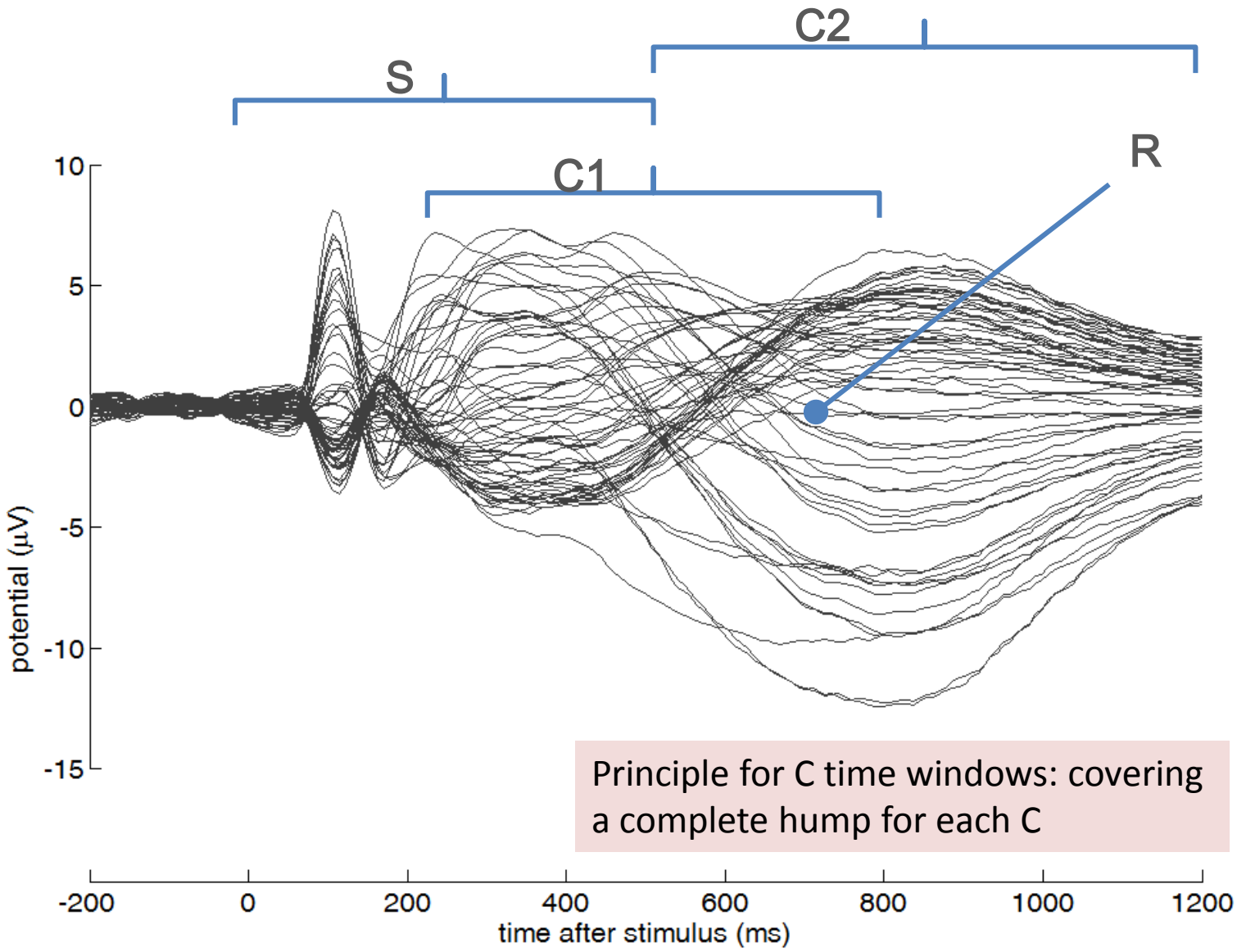
```
cfg = [];%initialization
cfg.samp_interval = 2;
cfg.epoch_twd = [-100,1000];
cfg.comp.name = {'s','r'};
cfg.comp.twd = {[0,500], [-300,300]};
cfg.comp.latency = {zeros(size(data,3),1), rt};
cfg = RIDE_cfg(cfg);

results = RIDE_call(data,cfg);
```

– An example of separating ERP into one C components



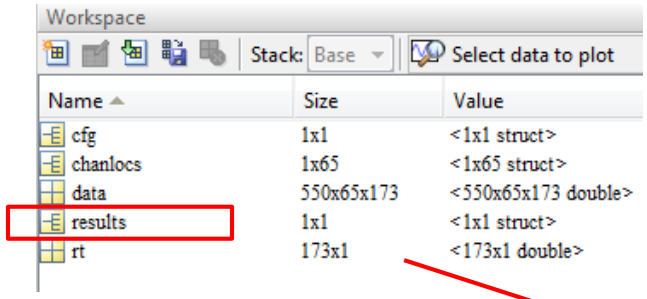
– An example of separating ERP into two C components

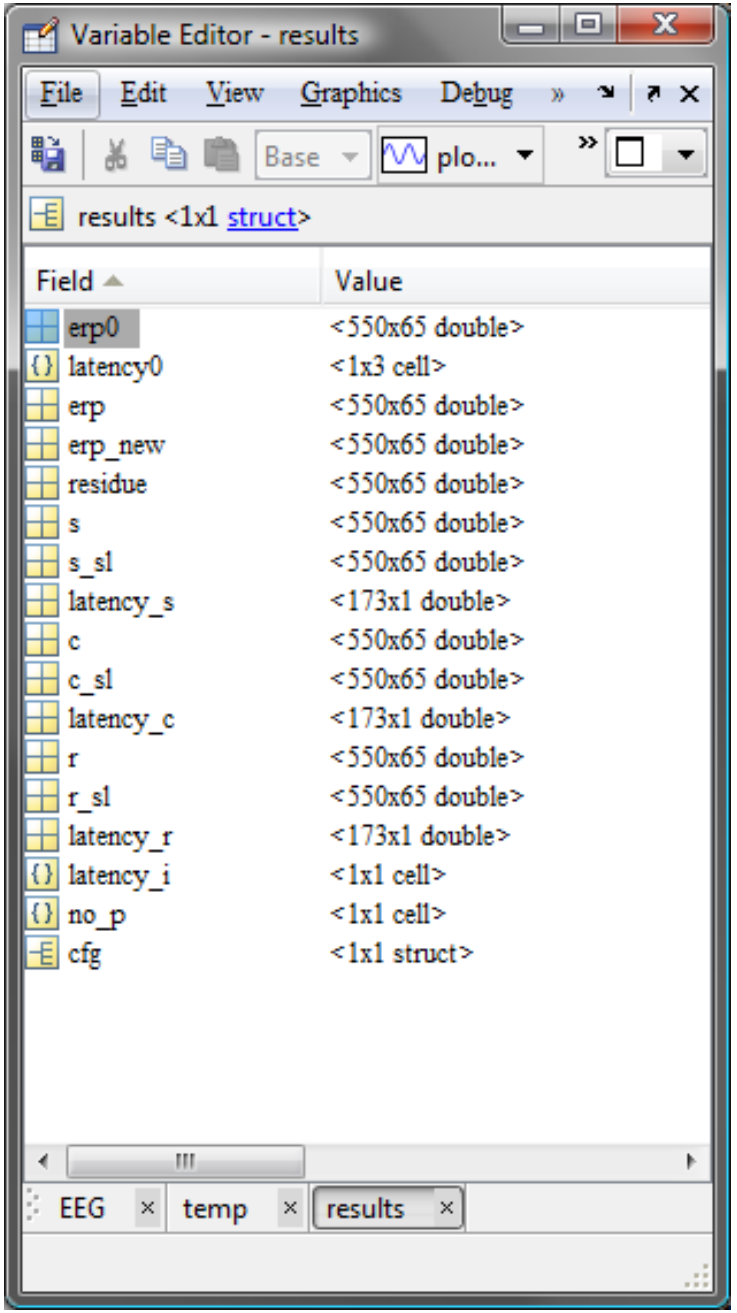


Principle for C time windows: covering a complete hump for each C

– After RIDEing

– Know how to see the results

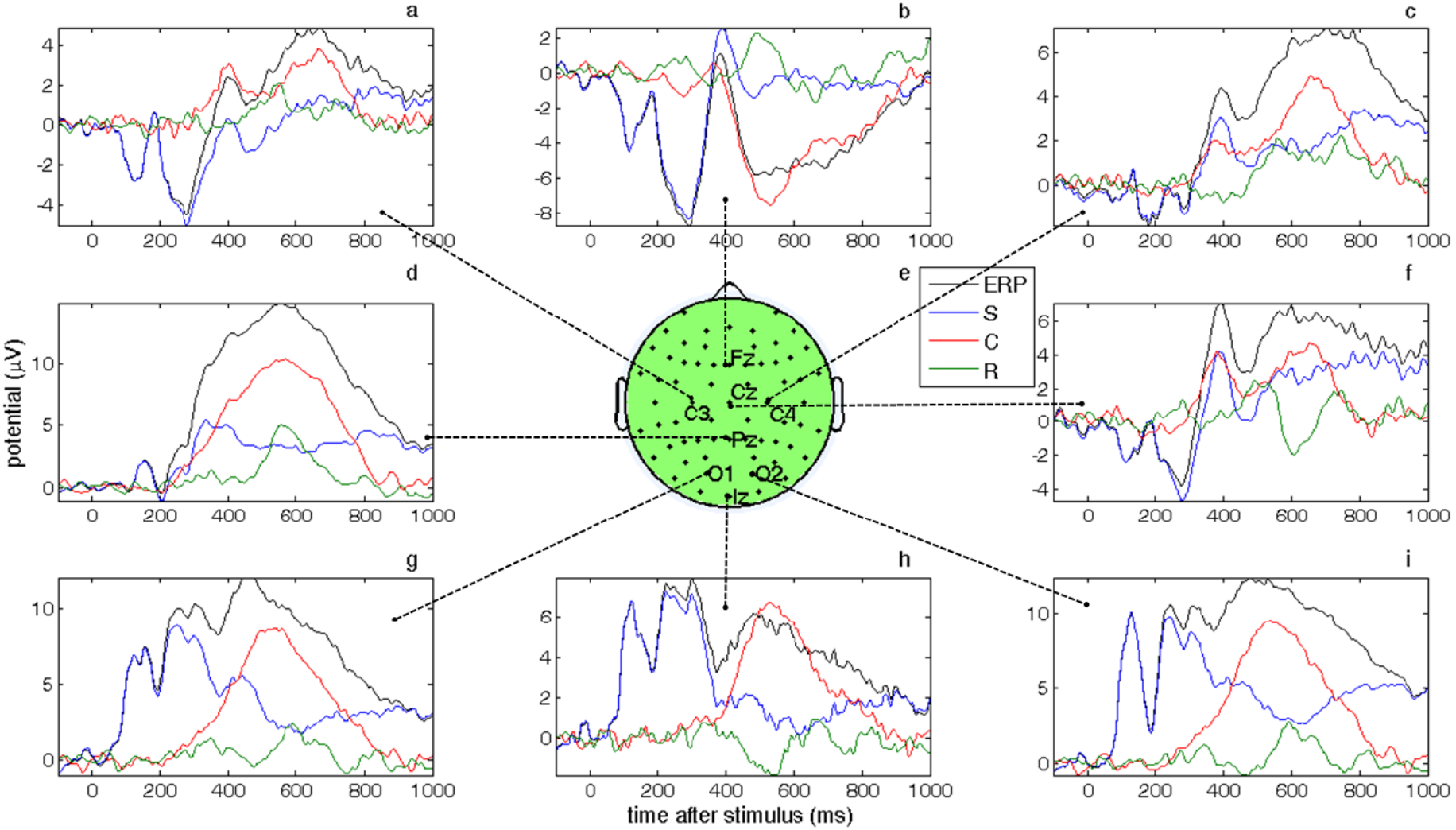




Please refer to the handbook for detailed explanation for all of the meanings of the variables in the outcome

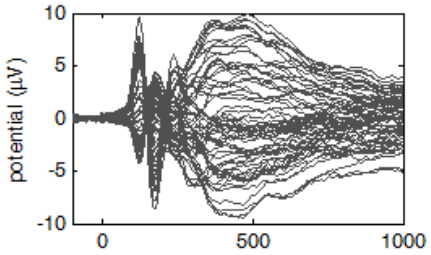
- **The Outcome**
  - separated components
    - Time courses
    - Topographies
  - reconstructed ERP
  - single trial variability

– The outcome (waveforms of separated components)

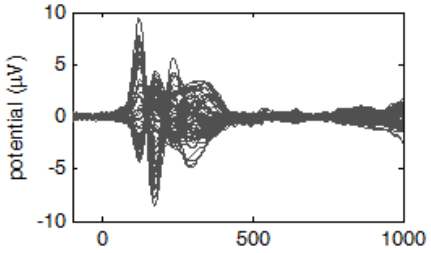


– The outcome (waveforms of separated components)

ERP



S



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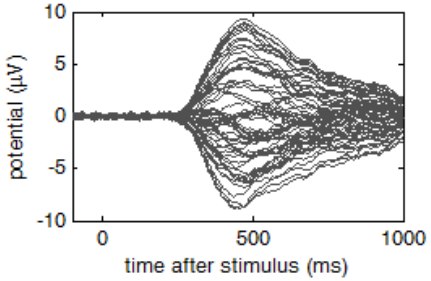
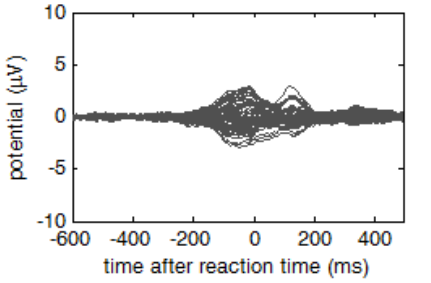
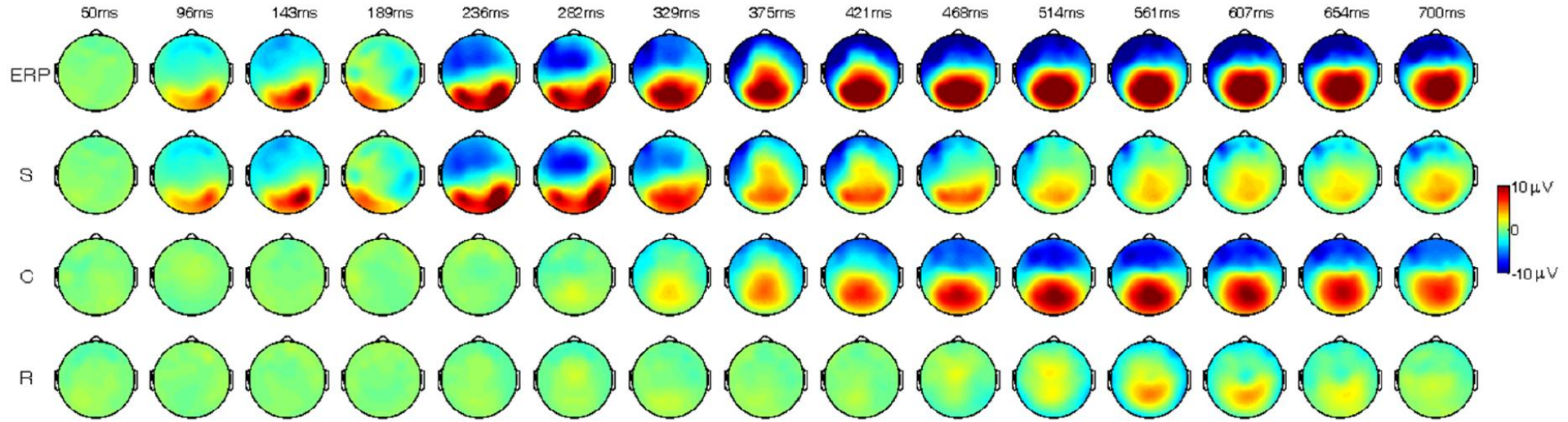


← grand mean

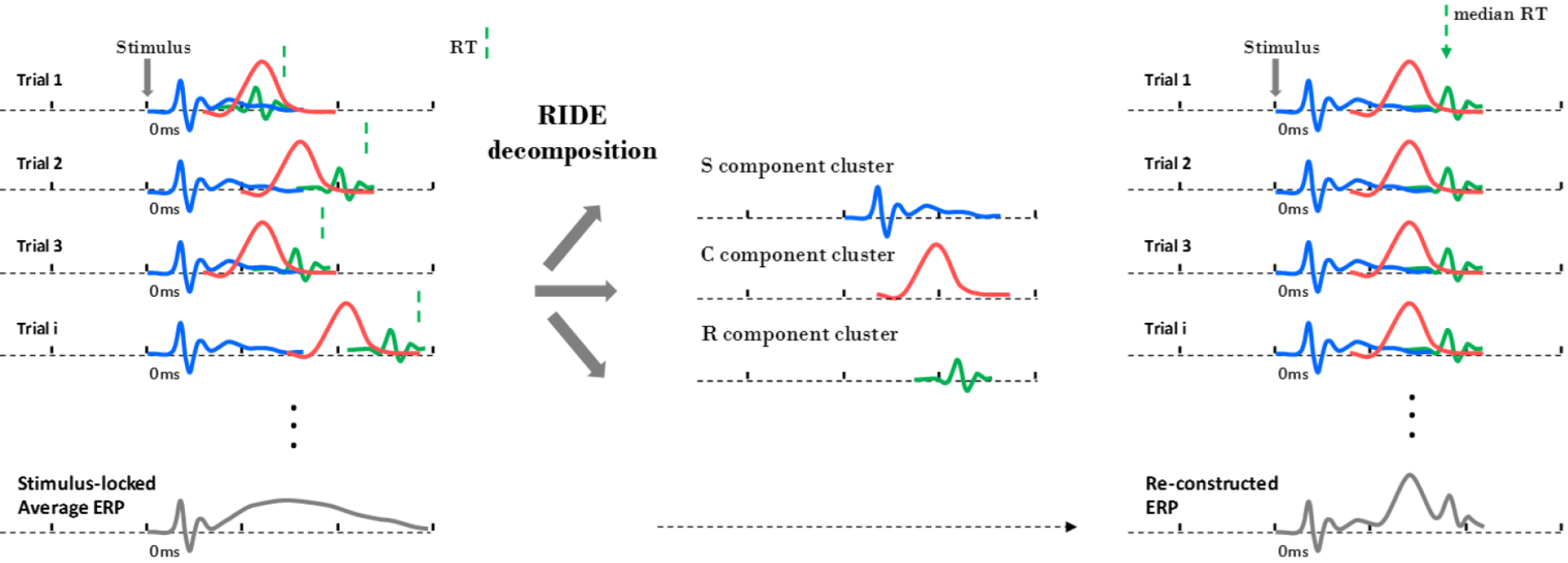
R



– The outcome (topography)



– The outcome (reconstructed ERP)



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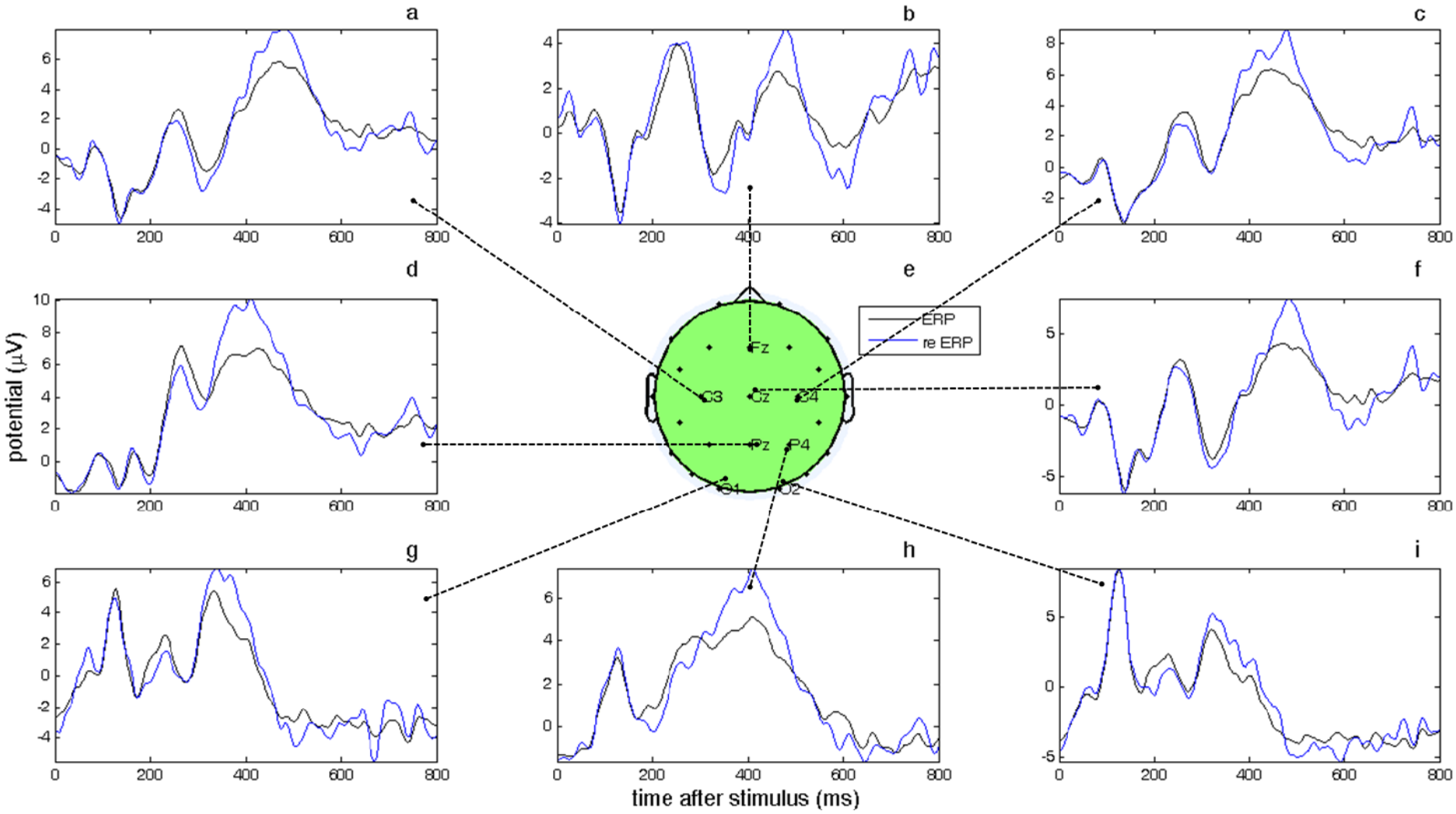
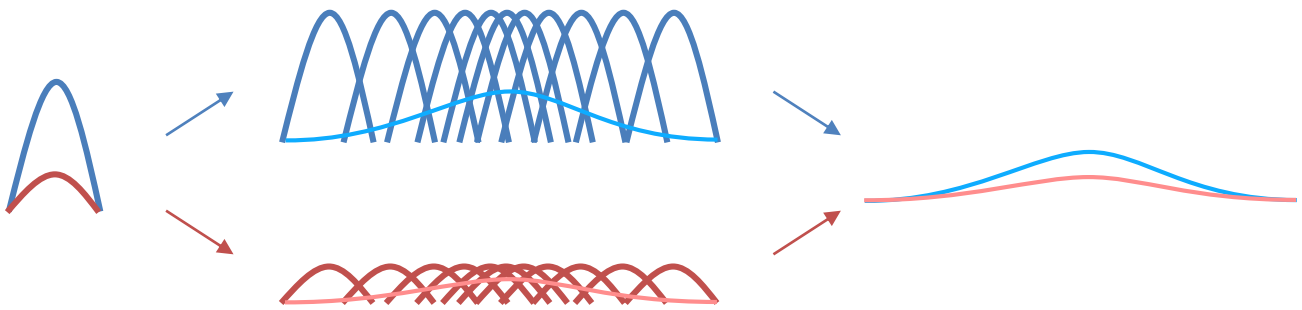


RIDE Outcome: ERP re-construction: conditional effects

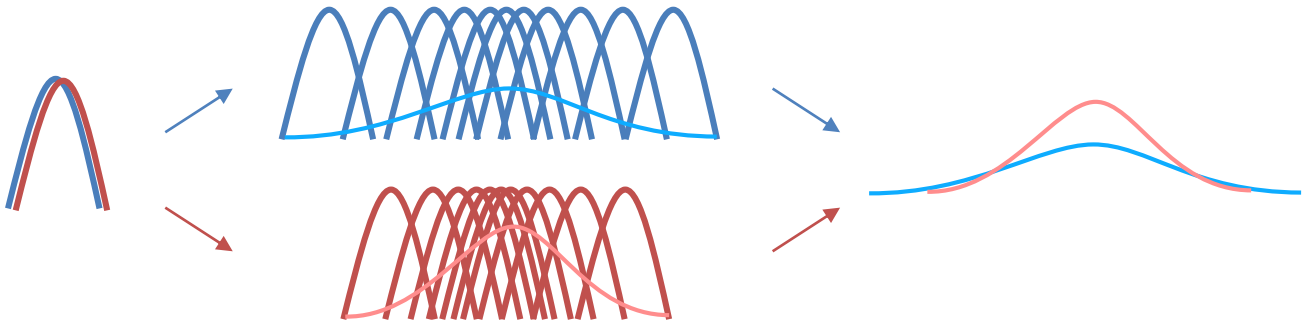
To solve the smearing effect due to latency variability

Cond. 1
Cond. 2

Case I1. Latency variability reduces the amplitude effect



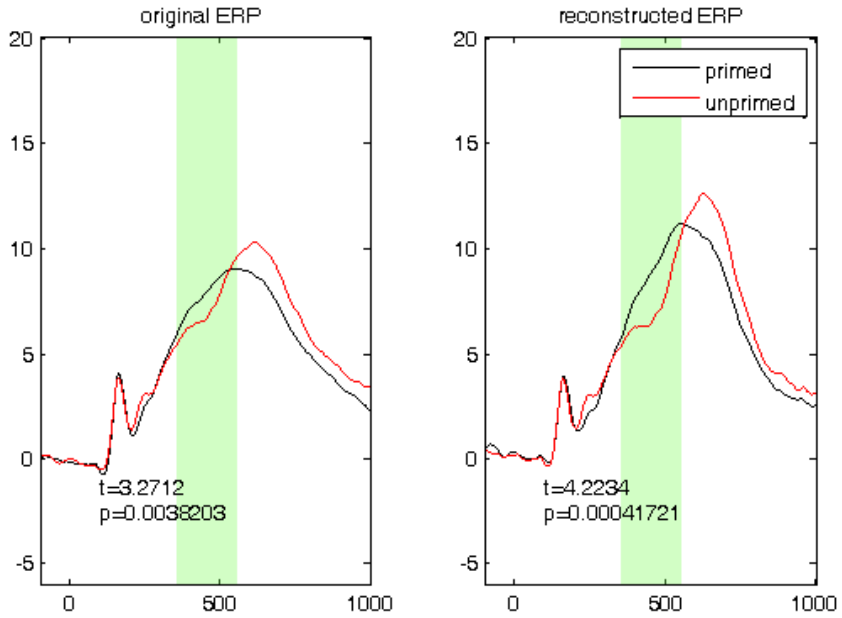
Case I2. Different latency variability makes to amplitude effect



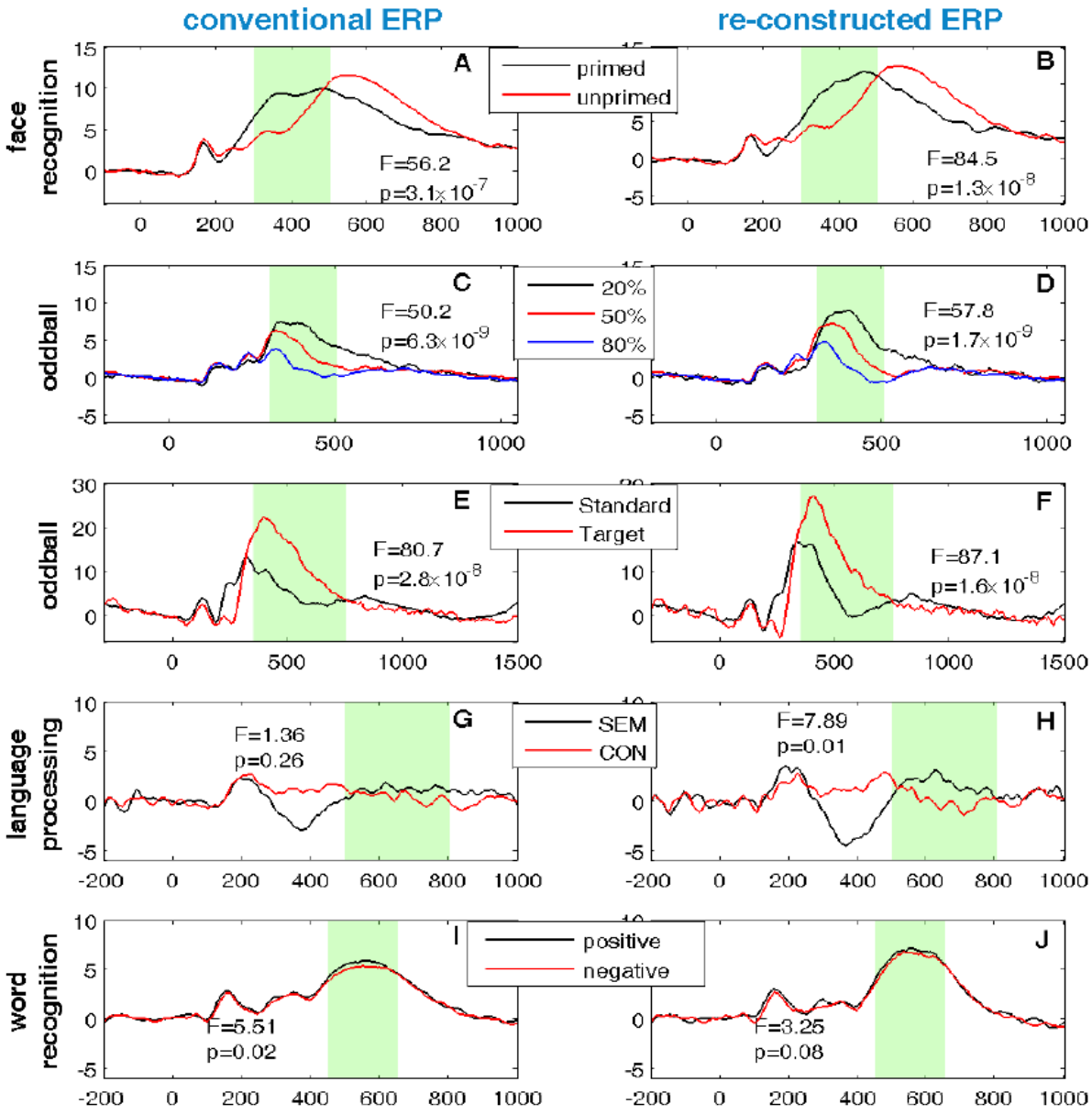
– The outcome (reconstructed ERP)

– What to see?

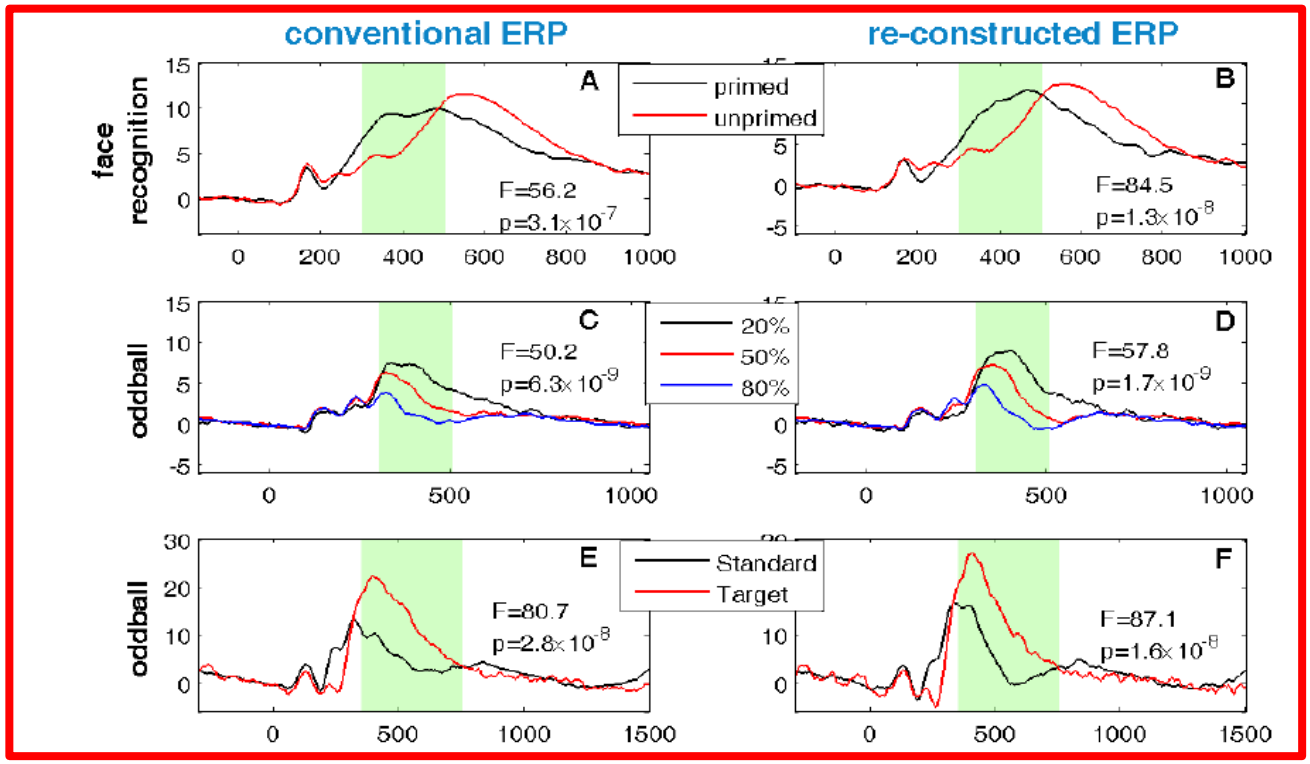
• **Example:** statistical testing on reconstructed ERP

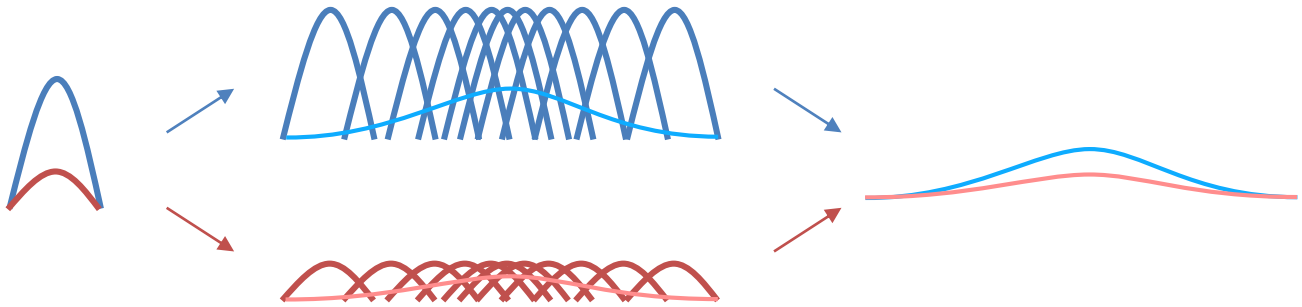


– The outcome (reconstructed ERP)



– The outcome (reconstructed ERP)





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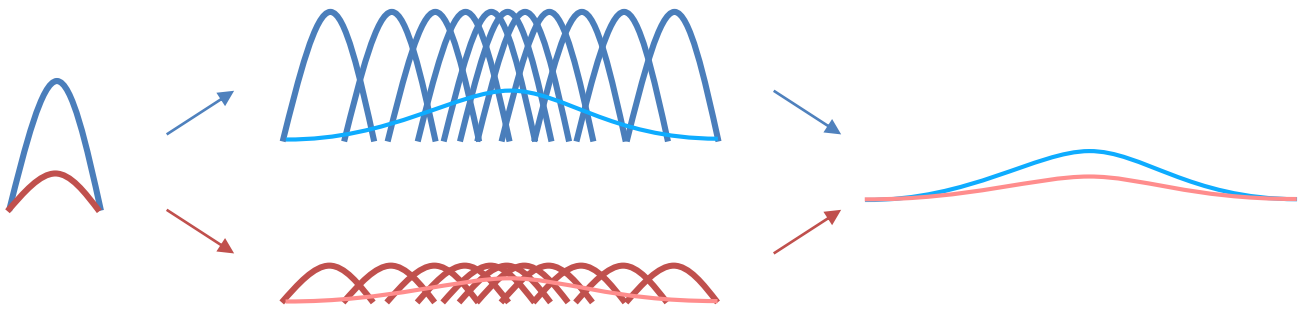
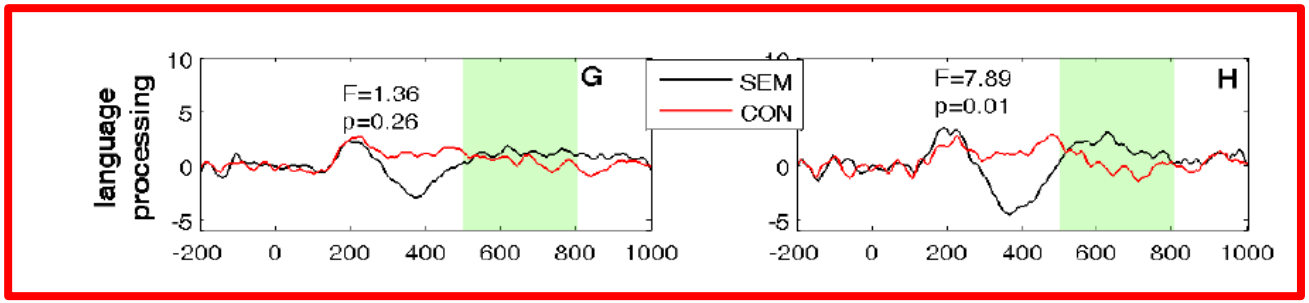
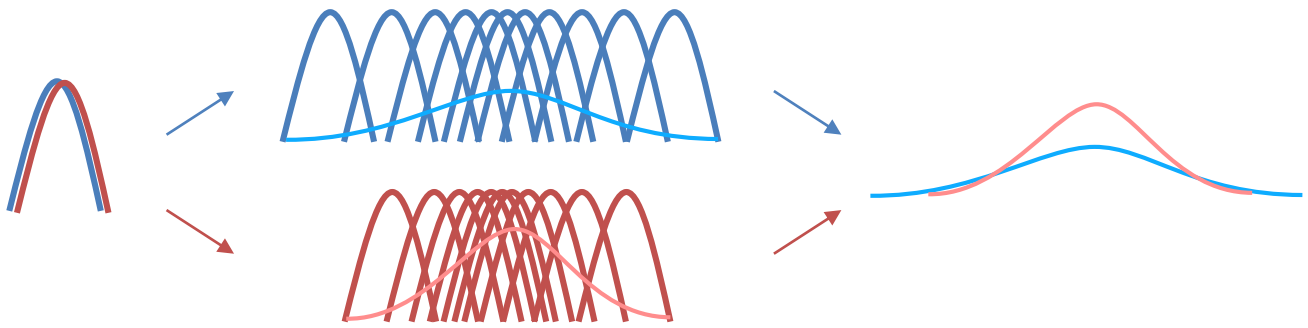
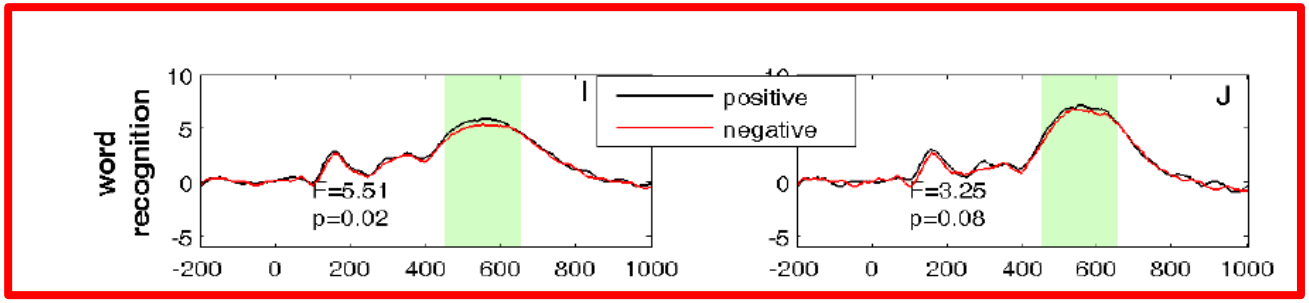


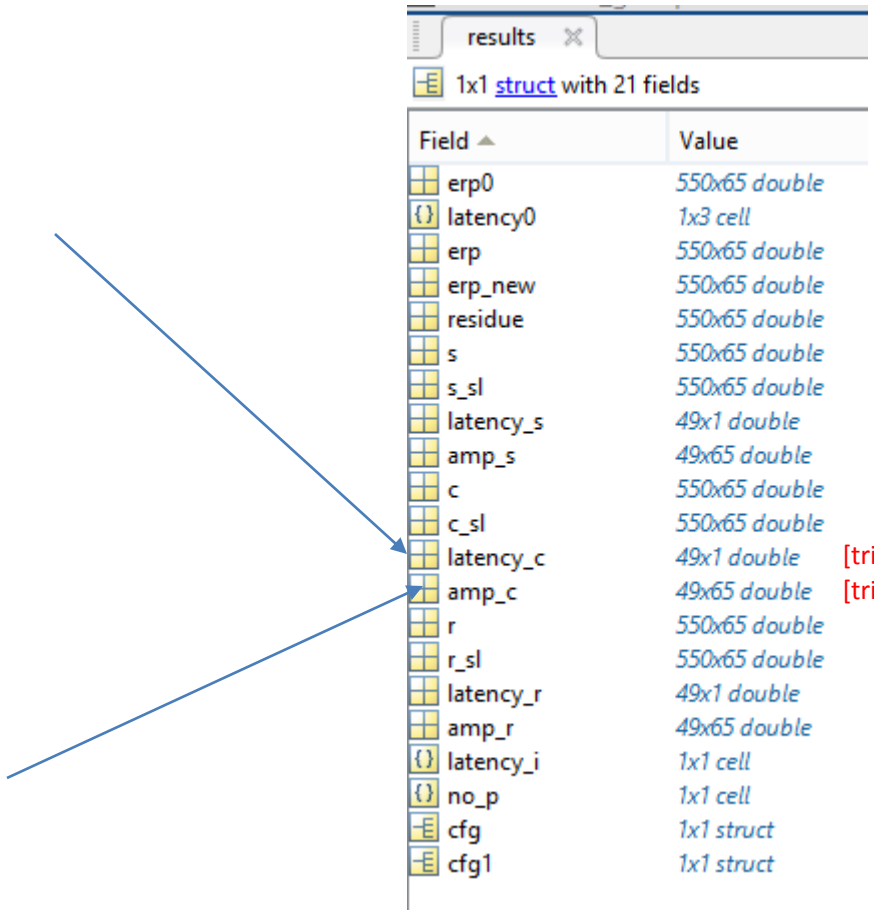


– The outcome (reconstructed ERP)





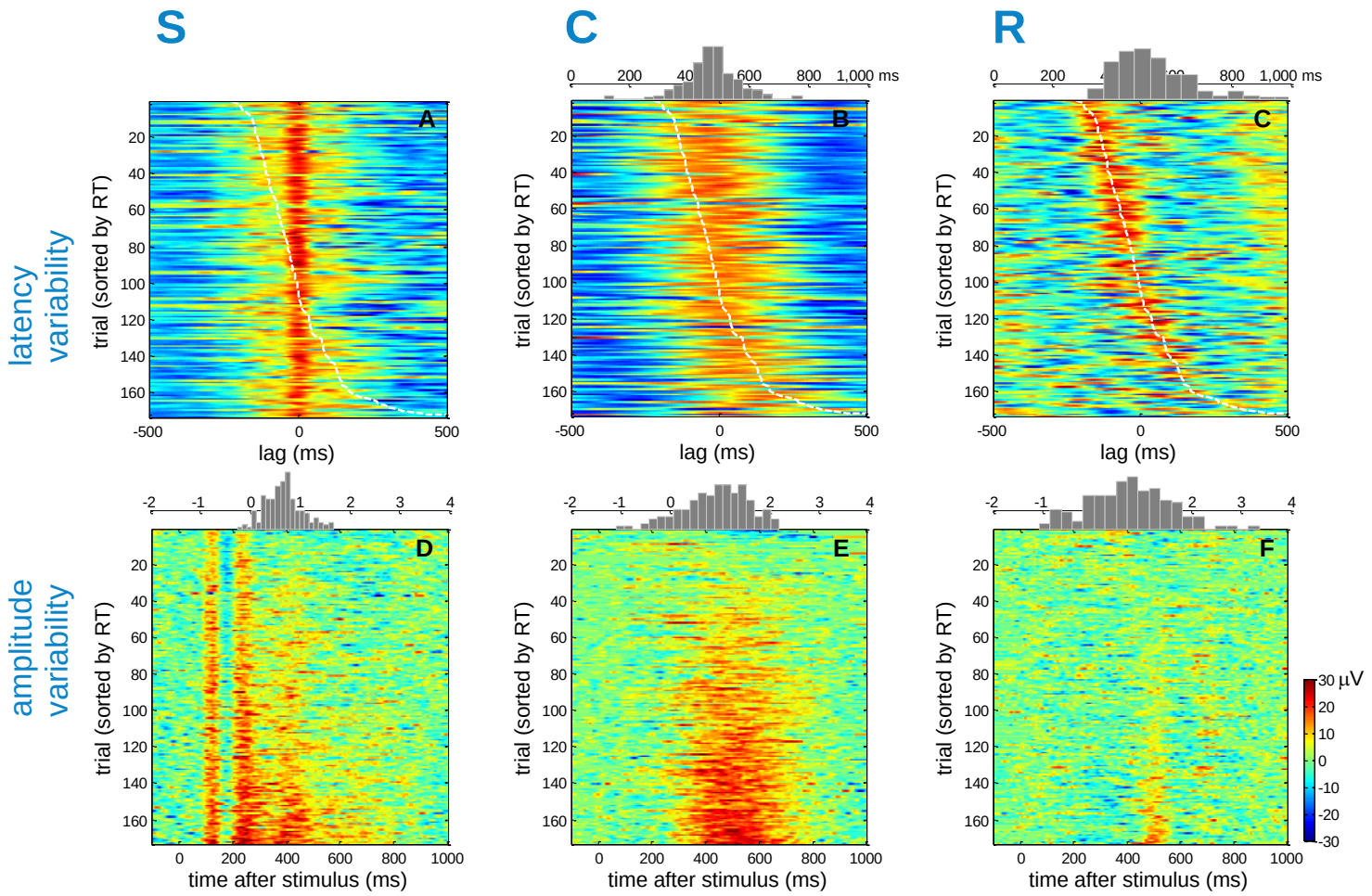
– The outcome (variability)



[trials × 1]

[trials × electrodes]

– The outcome (variability)



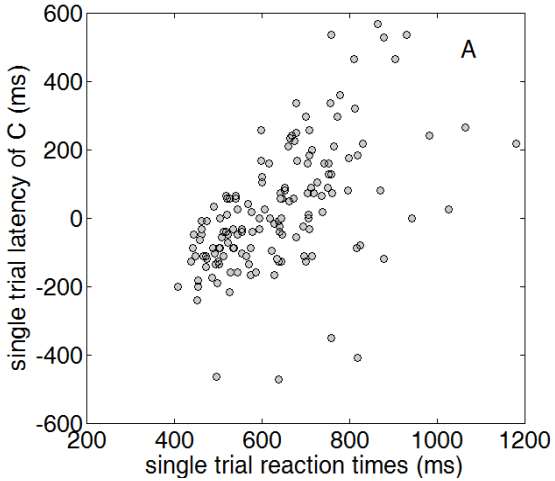
– The outcome (variability)

Variability information:

S
- Amplitude
- Latency (stimulus onset)

C
- Latency
- amplitude

R
- Amplitude
- Latency (RT)



Behavior

Individual difference

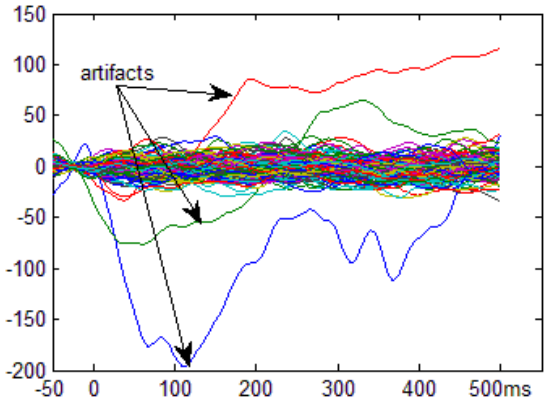
Genetics

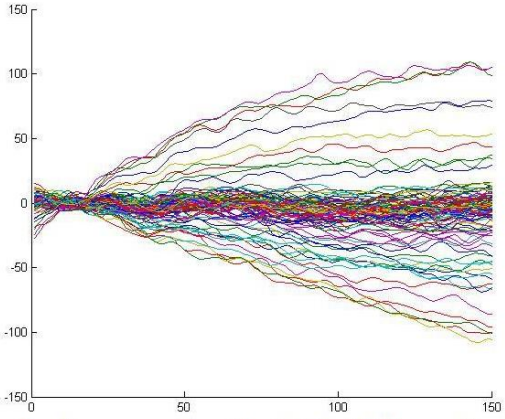
Diseases

– Hints and Cautions

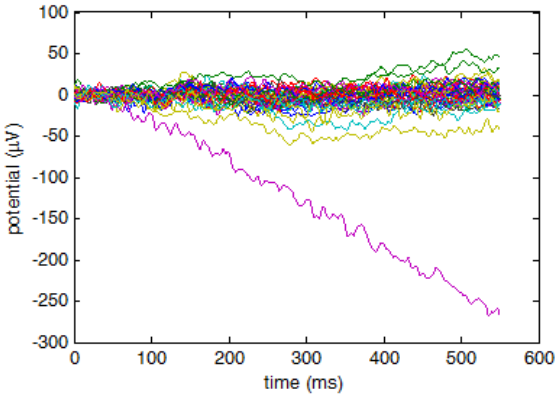
– Data quality

• The general quality of data is important for the quality of outcome. Be careful of the quality of your data. Better to have a visual inspection of your data before applying RIDE.





Another example of bad data (drifting artifact)

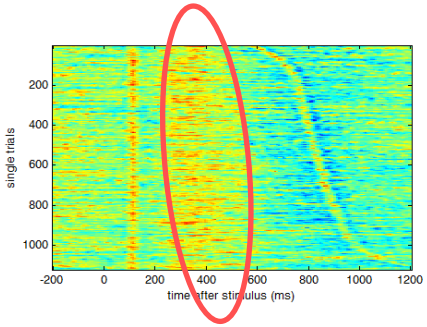


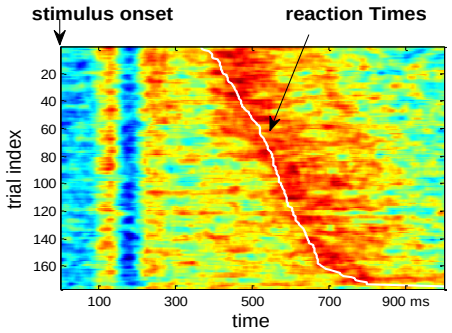
Examples of bad data

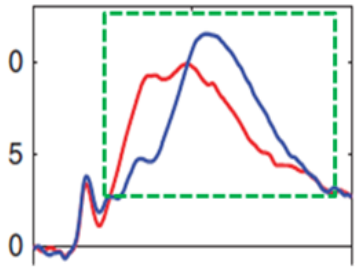
– Hints and Cautions

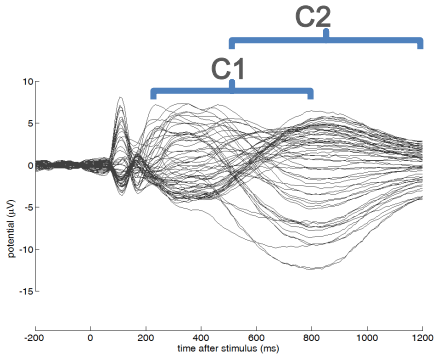
Why do we separate C component and when it is perhaps not suitable to separate C?

- C is clearly visible in the standard ERP

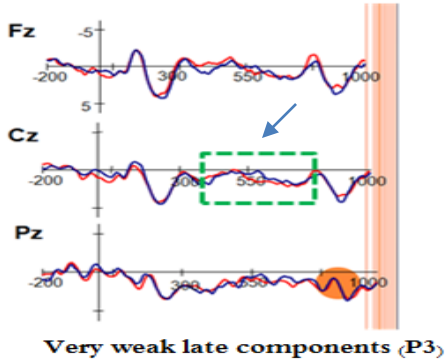






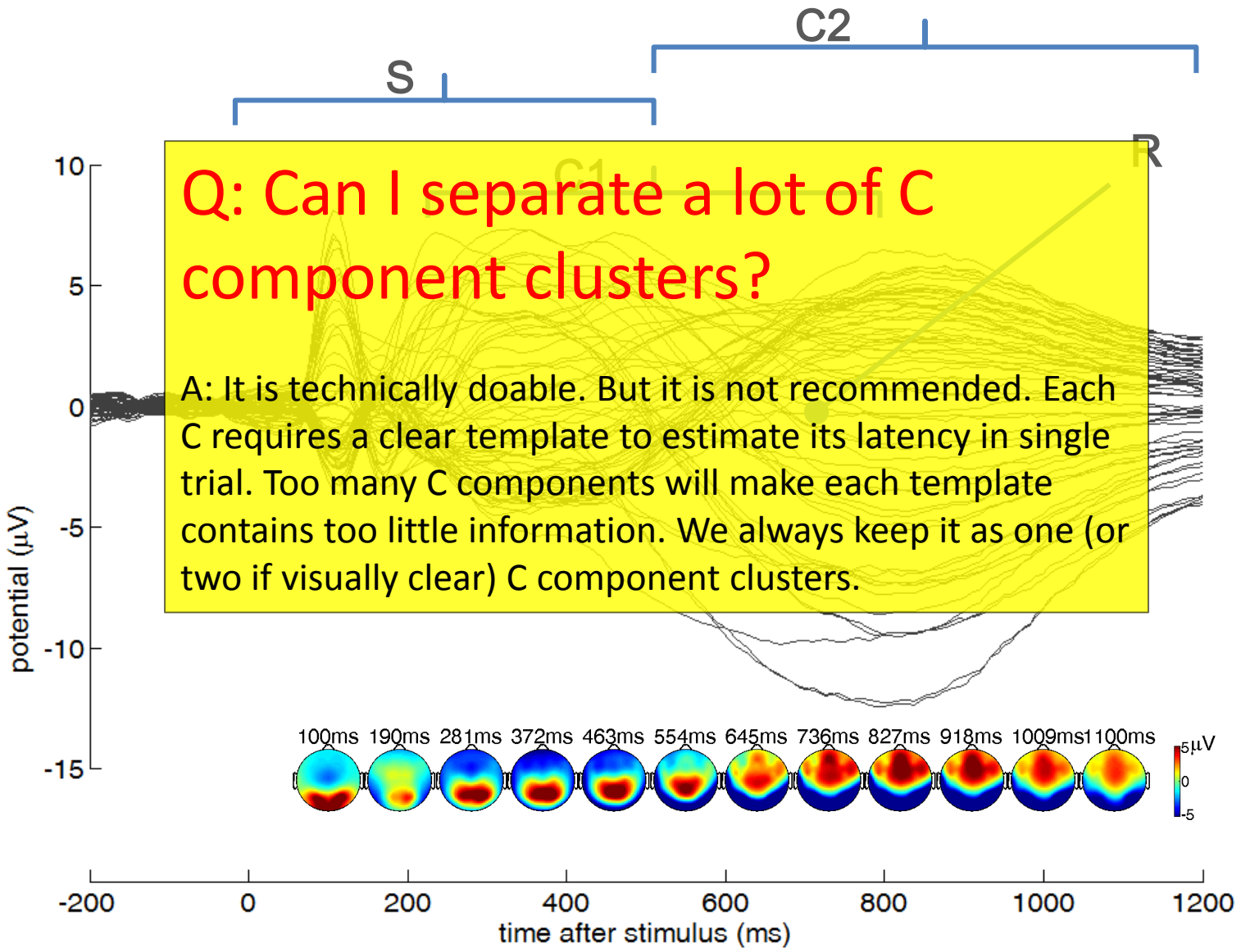


- If a ‘C’ is not even visible from standard ERP, then RIDE might not be able to extract it.

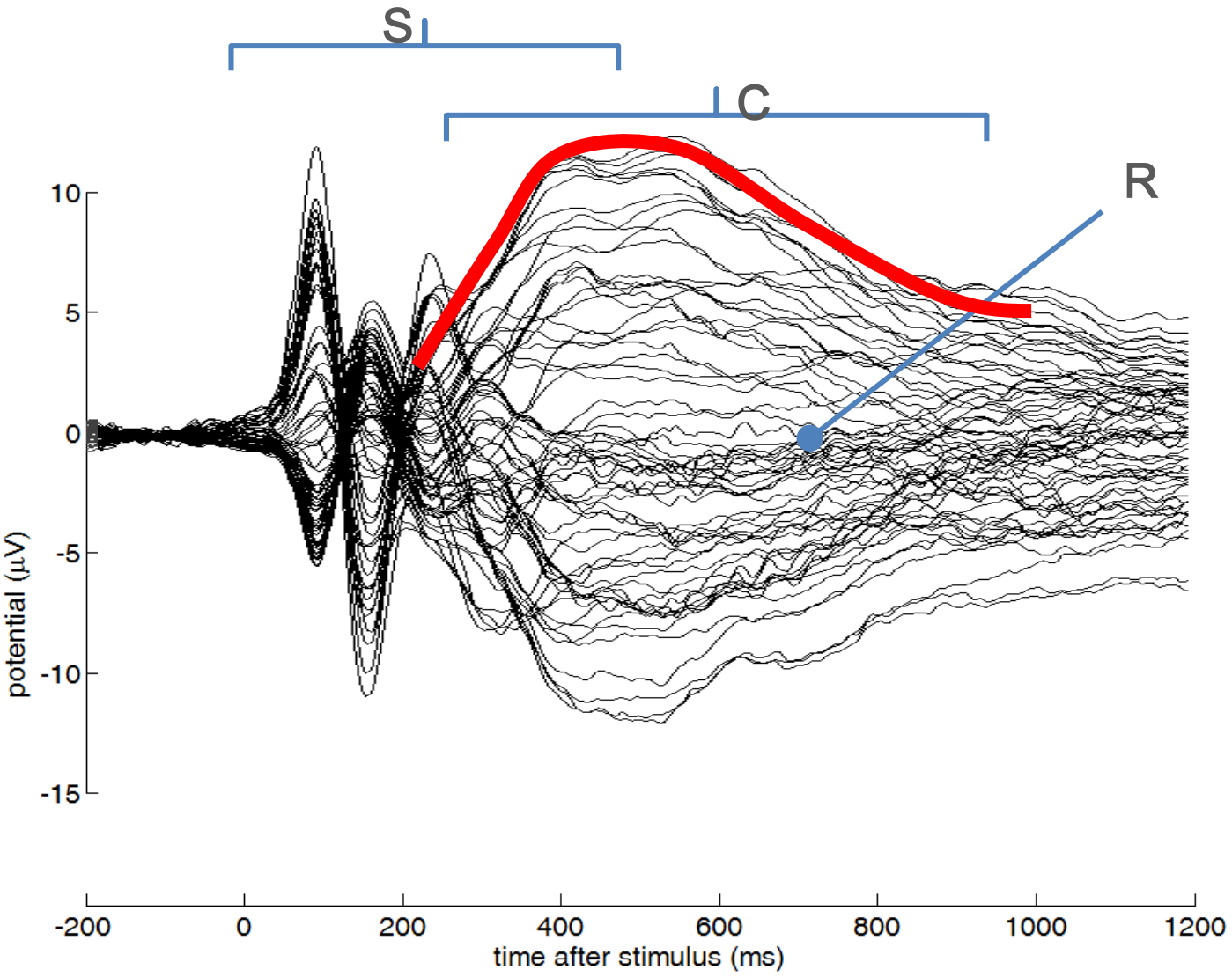


RIDE restores component from blurring, not creating components.

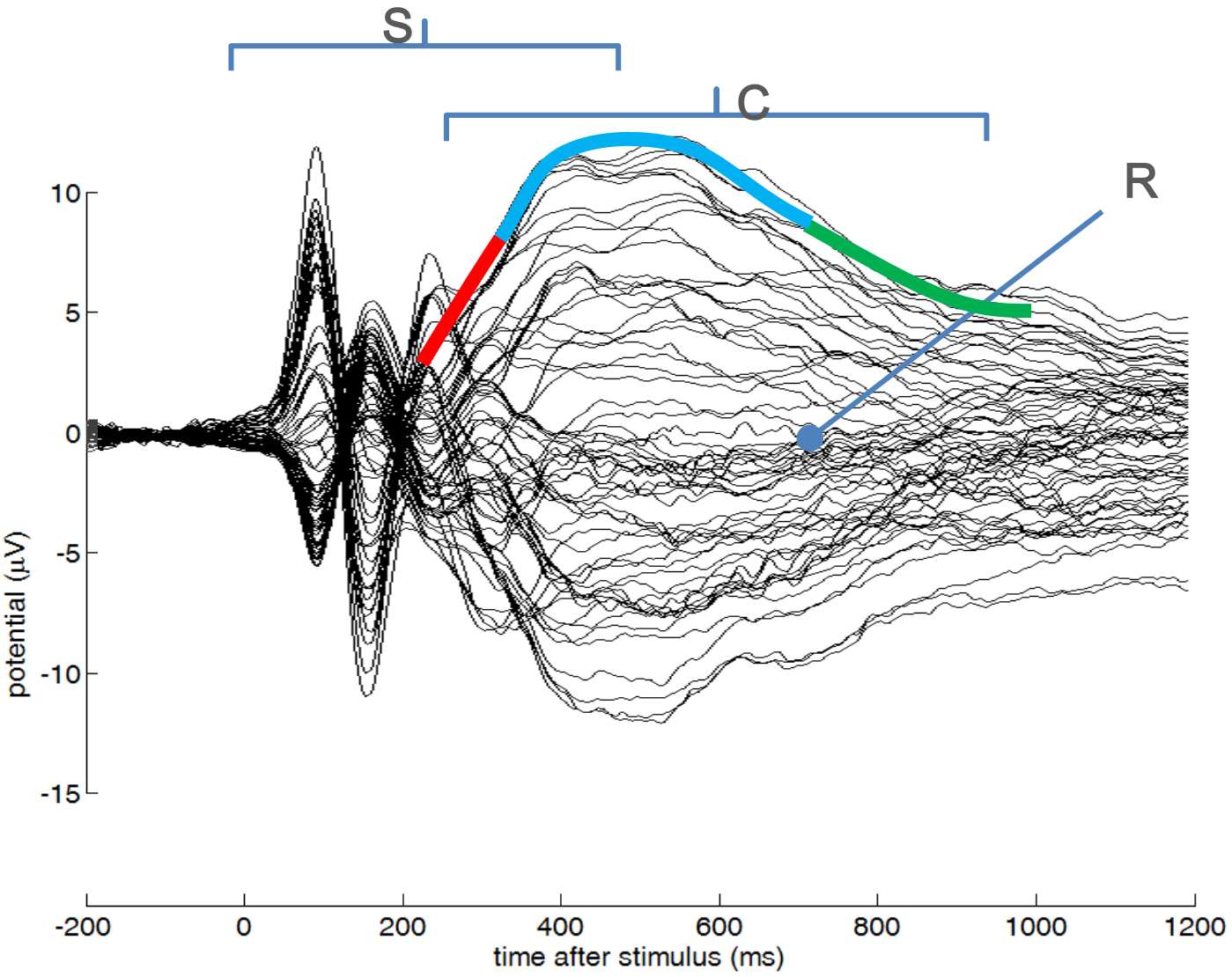
– An example of separating ERP into two C components



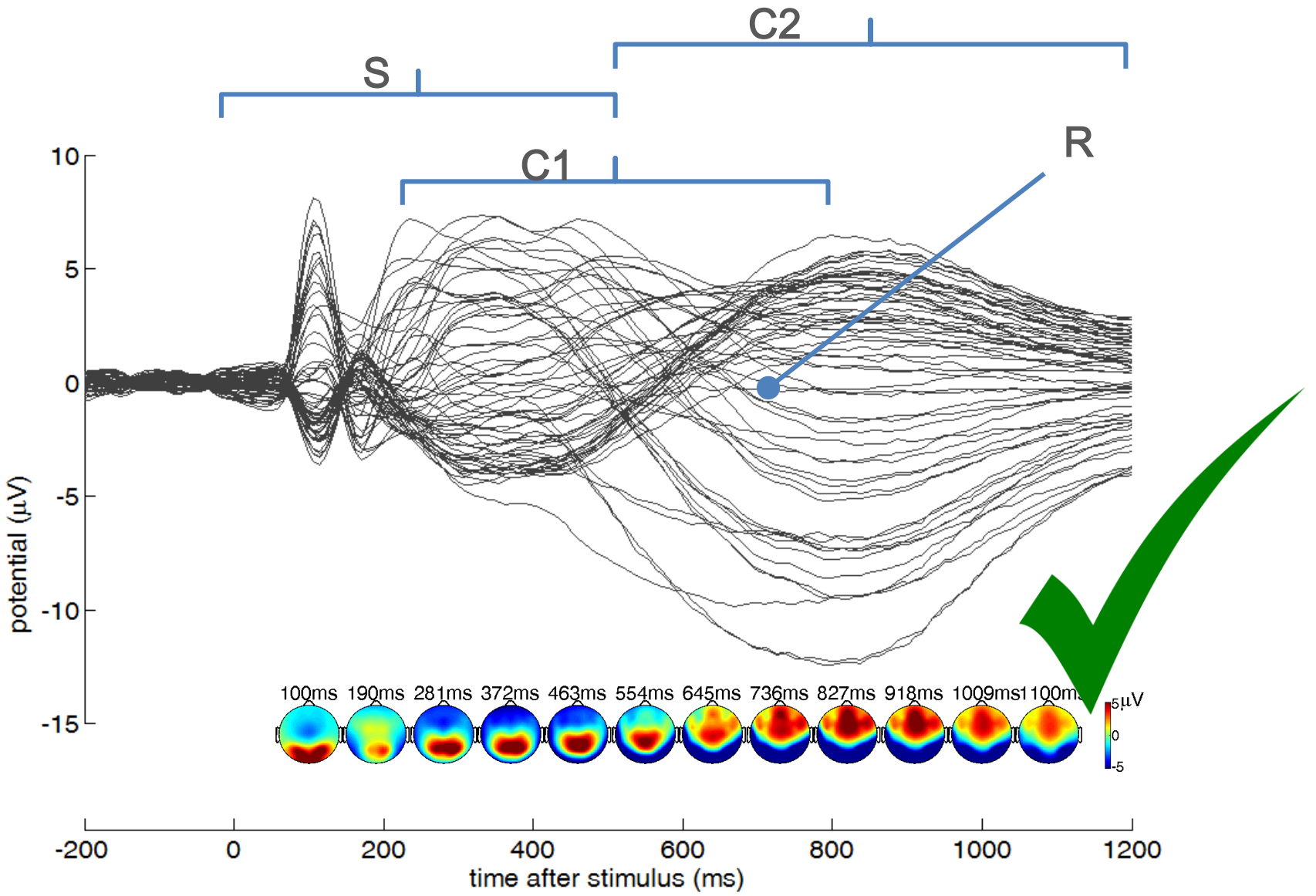
– An example of separating ERP into one C components



– An example of separating ERP into one C components



– An example of separating ERP into two C components (two humps)



– Hints and Cautions

Reduce sampling rate to improve computation speed

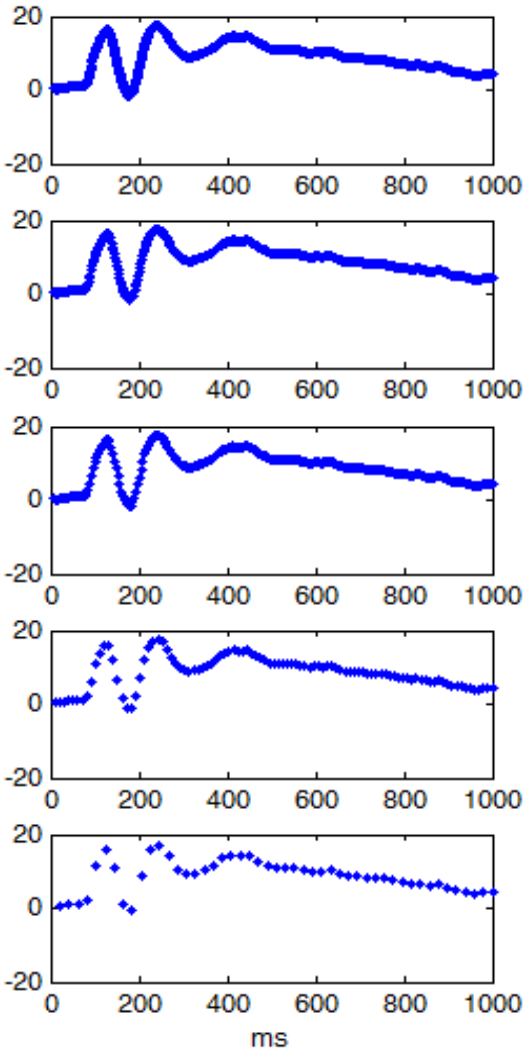
Sampling rate = 1000

Sampling rate = 500

Sampling rate = 250

Sampling rate = 100

Sampling rate = 50



Too high is not necessary
And reduce speed

Above this is OK

– Hints and Cautions

–Do not involve non-brain channels (e.g., M1,M2,VEOU,VEOL,EOG,ECG etc)

–Clearly remove artifacts, especially serious drifting

–Observe the grand mean to specify the time windows for RIDE components.

…

–More hints and cautions please refer to the manual (cns.hkbu.edu.hk/RIDE.htm)

Go through it

RIDE website: *cns.hkbu.edu.hk/RIDE.htm*

Download:

- RIDE toolbox
- Slides of introduction of RIDE
- Slides of implementation of RIDE
- RIDE manual

Set path:

Unzip RIDE toolbox, put the folder RIDE_call in the folder 'toolbox' under Matlab direactory. For example: "C:\Program Files\MATLAB\R2014a\toolbox\".

Launch Matlab -> set path -> add with subfolders -> choose the folder of 'RIDE_call' -> select folder -> save -> close.

Download EEGLAB (for topography ploting)

It is also useful to download EEGLAB toolbox (*sccn.ucsd.edu/eeglab*). Because we need to use the function 'topoplot' from EEGLAB to plot the topography of the results. And besides, EEGLAB is very powerful in EEG data importing from commercial EEG softwares. When adding the EEGLAB toolbox to Matlab, remember to choose 'add with subfolder' rather than 'add folder'.

Practice

- apply on an single subject in Matlab format
- Example of load file from Brain Product and obtain RT information
- Example of load file from Neuroscan
- Example of batch script
- Examples of plotting and basic analysis

Practice: apply on an single subject already in Matlab format

Load example data (from a single subject, single condition):
In Matlab, load (open) the data 'samp_face.mat' under 'RIDE_call\example\'. There are three variables in it

'data' – the 3-D matrix (time*electrode*trial)
'chanlocs' – the information about channels labels and locations (the is usually obtained by EEGLAB when importing data from commercial softwars)
'rt' – the reaction time information (in millisecond) for all single trials.

Run RIDE. The script is saved in ("..\RIDE_call\example\single_subject.m").

```
%run the following script in Matlab (select them -> right click -> Evaluation selection

cfg = [];%initialization
cfg.samp_interval = 2;
cfg.epoch_twd = [-100,1000];%time window for the epoched data (relative to stimulus)
cfg.comp.name = {'s','c','r'};%component names
cfg.comp.twd = {[0,500],[100,900],[-300,300]}; %time windows for extracting components, for 's' and
'c' it is raltive to stimulus, for 'r' it is relative to RT
cfg.comp.latency = {0,'unknown',rt};%latency for each RIDE component

%Note: you are supposed to know the above information for your own data.
%The time windows for RIDE component is from observation of ERP


cfg.re_samp = 8; %down sampling to 125 to raise speed (optional)

cfg = RIDE_cfg(cfg);%standardize

results = RIDE_call(data,cfg); %run RIDE
```

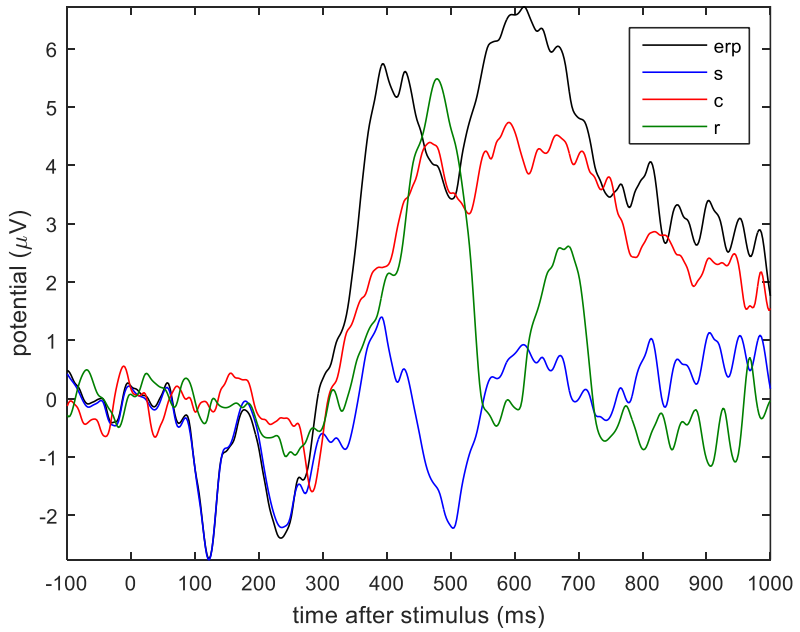
..\RIDE_call\example\single_subject.m

It takes a few minute to run this data

Practice: apply on an single subject already in Matlab format

Plot the waveform

```
chan_index  = find(strcmpi({chanlocs.labels},'Cz'));%select which
channel to plot

%plot erp and RIDE components superimposed together
figure;RIDE_plot(results,{'erp','s','c','r'},chan_index);
```



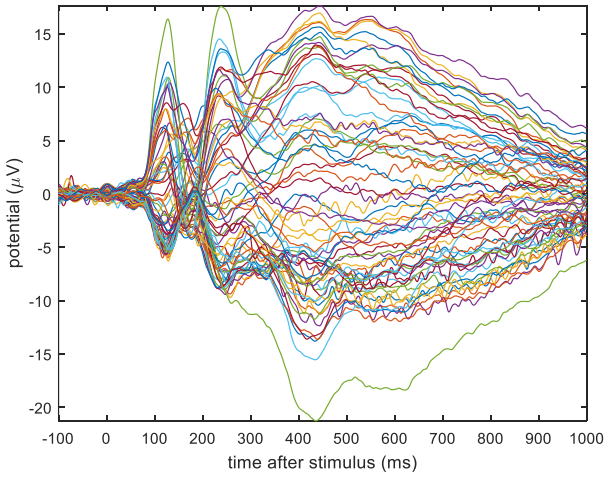
..\RIDE_call\example\single_subject.m

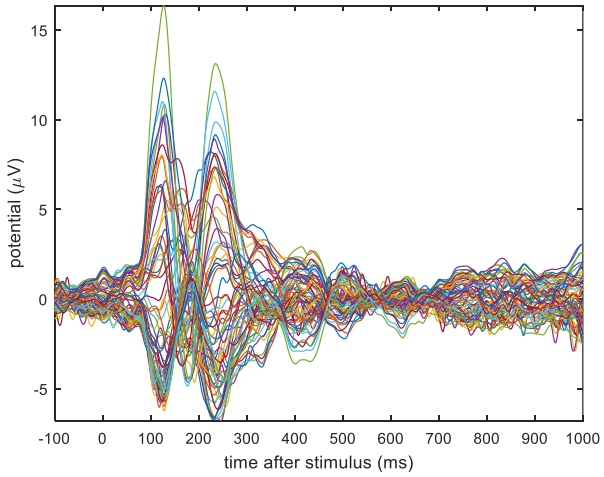
```
%or plot the ERP and reconstructed ERP superimposed
figure;RIDE_plot(results,{'erp','erp_new'},chan_index);
```

Practice: apply on an single subject already in Matlab format

Plot the waveform

```
%Plot all the time courses for all electrodes together
%set the time axis first
    t_axis = linspace(cfg.epoch_twd(1),cfg.epoch_twd(2),size(data,1));

    %plot ERP
    figure;plot(t_axis, results.erp);    axis tight;xlabel('time after
stimulus (ms)');ylabel('potential (\muV)');
    %you can simply change ERP to S
    figure;plot(t_axis, results.s);    axis tight;xlabel('time after stimulus
(ms)');ylabel('potential (\muV)');
```





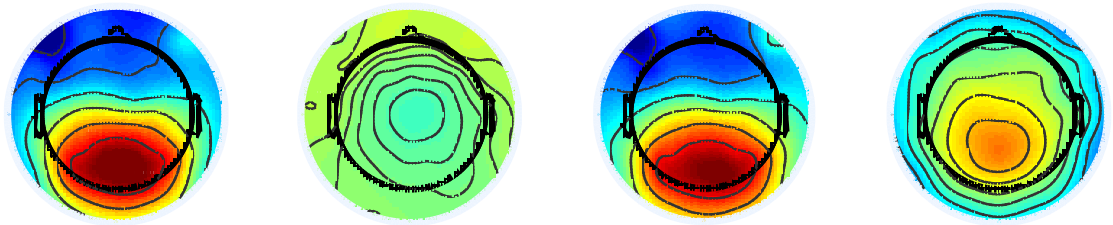
..\RIDE_call\example\single_subject.m

Practice: apply on an single subject already in Matlab format

Plot the topography

```
t = 500;%the time point to plot, in millisecond

t1 = round((t-cfg.epoch_twd(1))/cfg.samp_interval);%covert t to sampling point

c_range = [-15,15];%specify the color range
figure;subplot(1,4,1);topoplot(results.erp(t1,:),chanlocs);text(0,1,'erp');caxis(c_r
ange);
subplot(1,4,2);topoplot(results.s(t1,:),chanlocs);text(0,1,'s');caxis(c_range);
subplot(1,4,3);topoplot(results.c(t1,:),chanlocs);text(0,1,'c');caxis(c_range);
subplot(1,4,4);topoplot(results.r(t1,:),chanlocs);text(0,1,'r');caxis(c_range);
```

erp s c r

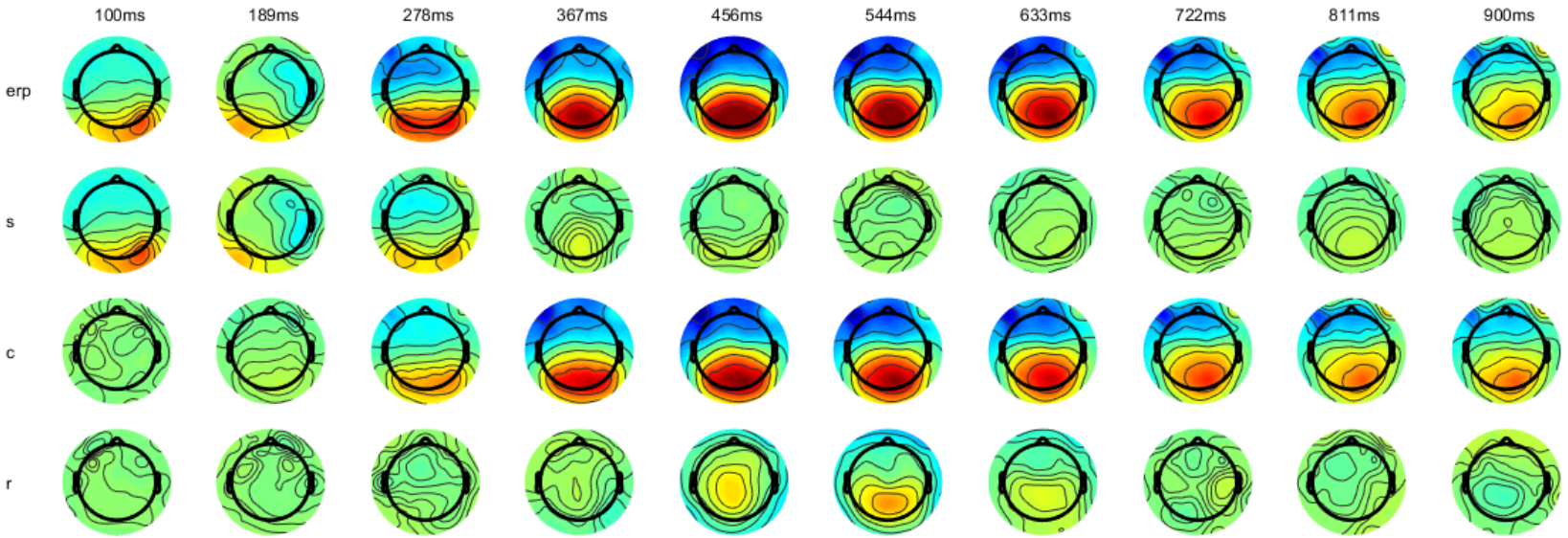


..\RIDE_call\example\single_subject.m

Practice: apply on an single subject already in Matlab format

Plot the topography evolution

```
twd = [100,900];%the time window to be plotted
n = 10; %how many topos to be shown
comp = {'erp','s','c','r'};

c_range = [-15,15];%specify the color range

temp = [];twd_s = round((twd-cfg.epoch_twd(1))/cfg.samp_interval);%convert the sampling
point
for j = 1:length(comp)
    eval(['temp{j} = results.',comp{j},'(twd_s(1):twd_s(2),:);']);
end
t_points = round(linspace(twd(1),twd(2),n));
figure;topos_scr(temp,t_points,comp,chanlocs,'maplimits',c_range);
```

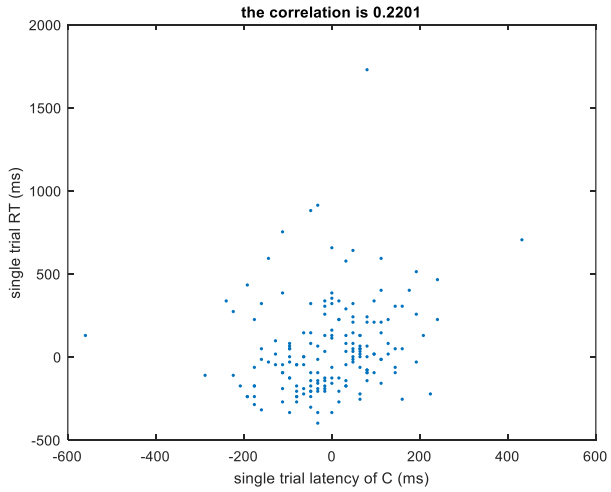


..\RIDE_call\example\single_subject.m

Practice: apply on an single subject already in Matlab format

Plot the latency of C versus RT

```
%plot the latency of c versus RT

    figure;plot(results.latency_c*cfg.samp_interval,results.latency_r*cfg.samp_interval,'.');
    xlabel('single trial latency of C (ms)');
    ylabel('single trial RT (ms)');

    title(['the correlation is ',num2str(corr(results.latency_c(:),results.latency_r(:)))]);
```

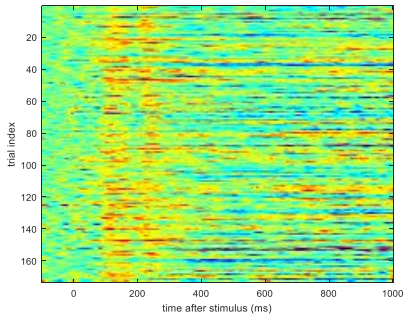


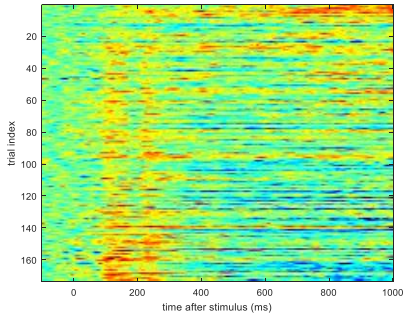
..\RIDE_call\example\single_subject.m

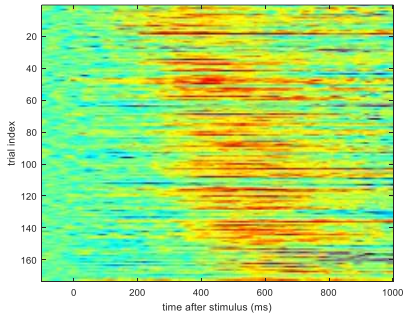
Practice: apply on an single subject already in Matlab format

Plot single trials

```
    %plot single trial ERP
    chan_index = find(strcmpi({chanlocs.labels},'Pz'));

    t_axis = linspace(cfg.epoch_twd(1),cfg.epoch_twd(2),size(data,1));%time axis;

    temp = single_trial_RIDE(data,results,'erp',chan_index);
    figure;imagesc(t_axis,1:size(data,3),temp');colormap('jet');
    xlabel('time after stimulus (ms)');
    ylabel('trial index');

    %plot single trial S
    chan_index = find(strcmpi({chanlocs.labels},'O1'));

    t_axis = linspace(cfg.epoch_twd(1),cfg.epoch_twd(2),size(data,1));%time axis;

    temp = single_trial_RIDE(data,results,'s',chan_index);
    figure;imagesc(t_axis,1:size(data,3),temp');xlabel('time after stimulus
(ms)');ylabel('trial index');colormap('jet');

    %sort by the accending order of amplitude

figure;imagesc(t_axis,1:size(data,3),temp(:,accending_index(results.amp_s(:,chan_index)))'
);colormap('jet');
    xlabel('time after stimulus (ms)');ylabel('trial index');


    %plot single trial C
    chan_index = find(strcmpi({chanlocs.labels},'Pz'));

    t_axis = linspace(cfg.epoch_twd(1),cfg.epoch_twd(2),size(data,1));%time axis;

    temp = single_trial_RIDE(data,results,'c',chan_index);
    figure;imagesc(t_axis,1:size(data,3),temp');xlabel('time after stimulus
(ms)');ylabel('trial index');colormap('jet');

    %sort by the accending order of C latency
    figure;imagesc(t_axis,1:size(data,3),temp(:,accending_index(results.latency_c))');
    xlabel('time after stimulus (ms)');ylabel('trial index');colormap('jet');
```







..\RIDE_call\example\single_subject.m

Practice: Example of load file from Brain Product and obtain RT information

- eeglab

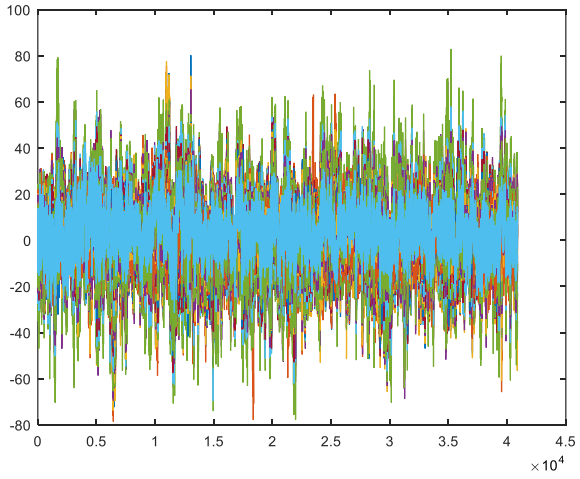
- File --> Import Data --> Using EEGLAB functions and plugins --> From Brain Vis. Rec. .vhdr file
  - After loading the data, the scipt history was saved in EEG.history
  - Because this data is a mixture of all conditions, we have to separate it into different condition
  - Open ..\RIDE_call\example\Snippet for data and rt extraction\extract_data_and_rt.m
  - This is an example of how to split the data with mixed condition into a single condition and how to extract RT.

- When the data was prepared and RT was extracted, RIDE can be applied like previous.

Practice: Example of load file from Neuroscan software

- Download and unzip 'batch_data_demo.zip' from cns.hkbu.edu.hk/RIDE.htm
  - Note: this data is already segmented into 3-D in Neuroscan. Each file only contain a single subject and condition.
- eeglab
- File --> Import Data --> Using EEGLAB functions and plugins --> From NEUROSCAN.EEG
  - Randomly select a .eeg file and load it
- Simply check the artifact:

```
figure;plot(EEG.data(:,:)');
```



Practice: Example of load file from Neuroscan software

- Prepare the data in RIDE format and then one can apply RIDE

```
data = permute(EEG.data,[2,1,3]);
```

  - Note: there is no RT info for this demo data, so one can only separate S and C
  - All the relevant info for RIDE should be in principle contained in EEG.

- We also need to save the channel location file as a separate .mat file for the ease of following plottings. Usually one can simply run: chanlocs = EEG.chanlocs; and save the 'chanlocs' variable as a .mat file. However, sometimes there is no information contained in EEG.chanlocs, which is probably due to the configuration of exporting process. In this case, one can use EEGLAB to fill those location infomations: edit -> channel locations -> OK -> OK. (but again, this is some issue in this function in some version of EEGLAB…).
- After EEGLAB fills the info in the EEG.chanlocs, you can extract and save it:

```
chanlocs = EEG.chanlocs;
save('..\chanlocs.mat','chanlocs');
```

Practice: Batch processing!

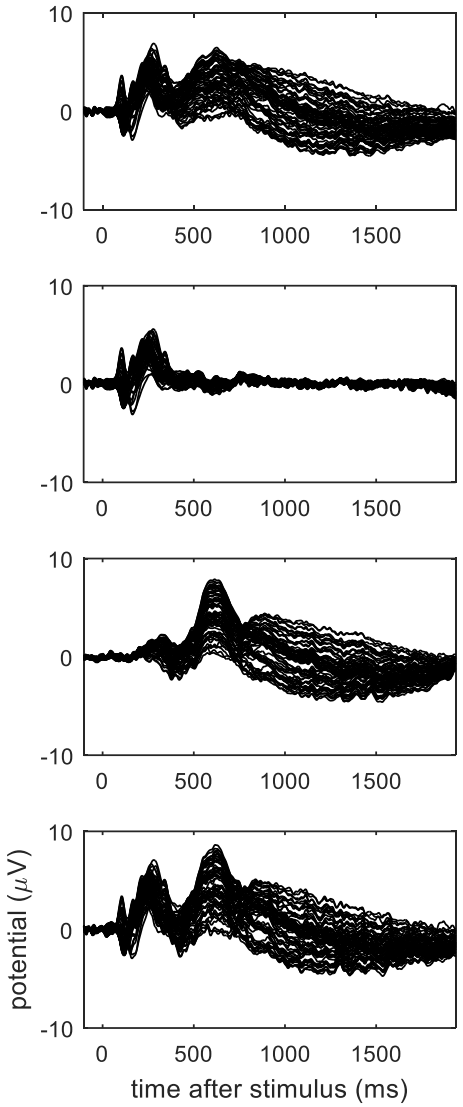
- Here is a demo to prepare a batch for applying RIDE in all subjects and conditons
- Download and unzip 'batch_data_demo.zip' from cns.hkbu.edu.hk/RIDE.htm
  - Note: this data is already segmented into 3-D in Neuroscan. Each file only contain a single subject and condition.
- Run the following batch file and then you can collect all results:

```
con = {'High','Baseline'};
% you have to make this condition names consistent with you data file
sub = {'Sub1','Sub2','Sub4','Sub5','Sub7','Sub8','Sub10','Sub11','Sub12',...
  'Sub13','Sub14','Sub15','Sub16','Sub17','Sub19','Sub20','Sub21','Sub22','Sub23','Sub24','Sub25','Sub26','Sub29','Sub30'};
% make it consistent with your subject names in your folder/data file

data_dir = 'C:\Dropbox\data\jamie\batch_data_demo\';
% the root directory of your data

for j = 1:length(sub)
    for k = 1:length(con)

     EEG = pop_loadeeg([sub{j},'_',con{k},'.eeg'], [data_dir,sub{j},'\'], 'all','all','all','all','auto');
     %this line can be found in EEG.history when you use eeglab to load a single file
     data = permute(EEG.data,[2,1,3]);

    cfg = [];%initialization
    cfg.samp_interval = 4;
    cfg.epoch_twd = [-104,1936];%time window for the epoched data (relative to stimulus)
    cfg.comp.name = {'s','c'};%component names
    cfg.comp.twd = {[0,500],[100,900]}; %time windows for extracting components, for 's' and 'c' it is relative to
stimulus, for 'r' it is relative to RT
    cfg.comp.latency = {0,'unknown'};%latency for each RIDE component
    cfg = RIDE_cfg(cfg);%standardize

    results = RIDE_call(data,cfg);

    save([data_dir,'results_',sub{j},'_',con{k},'.mat'],'results');

    end
end
```

It takes around one or two hours to finish all the data

Practice: plottings and basic analysis

- When all the data were processed, it will be saved in your computer
- But you can use the result files in 'batch_data_demo.zip' for the following demos for plottings and analysis
- Open the grand_plot.m file
    - First run the script in the first three sections: 'head', 'assemble data', 'grand average' (before that you have to change the path name)
    - You can ignore the section 'sync R to grand median RT' since there is no RT here
    - Go to the next section 'plot the separation scenario', you can plot the general scenario of RIDE separation in grand average level
    - You can change the condition name

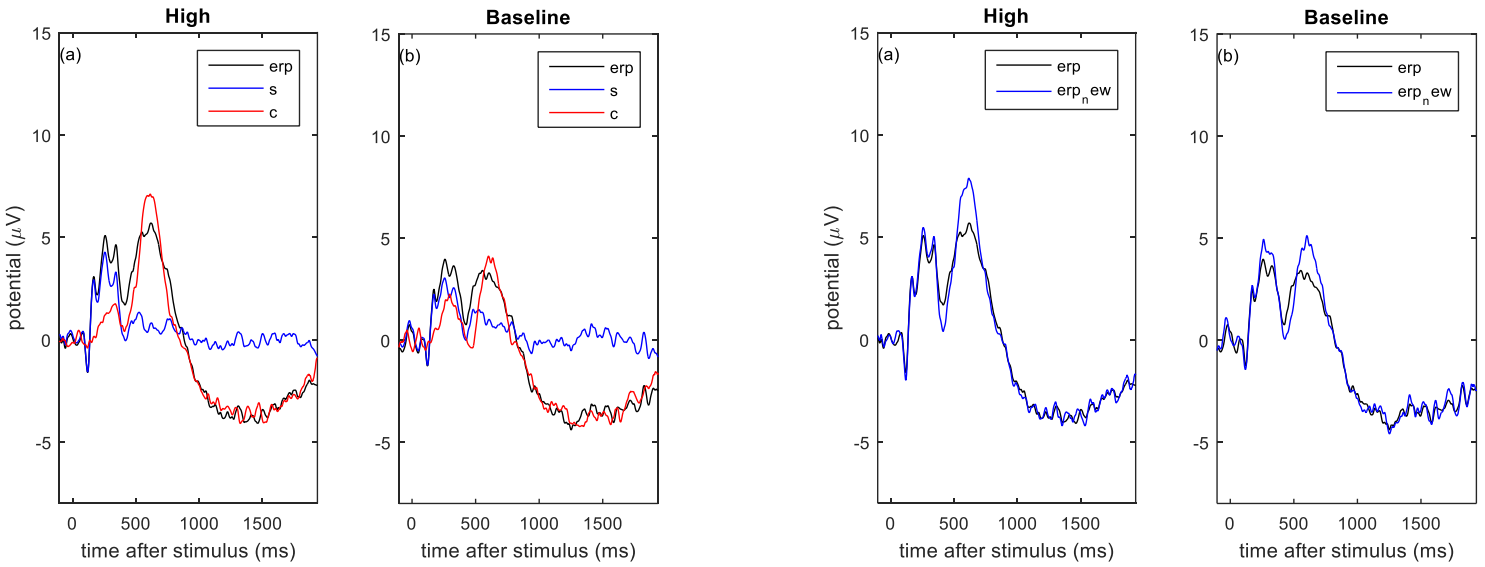


../batch_data_demo/grand_plot.m

Practice: plottings and basic analysis

- Run the section ‘plot different components in one figure’, you can plot different components or reconstructed ERP super-imposed

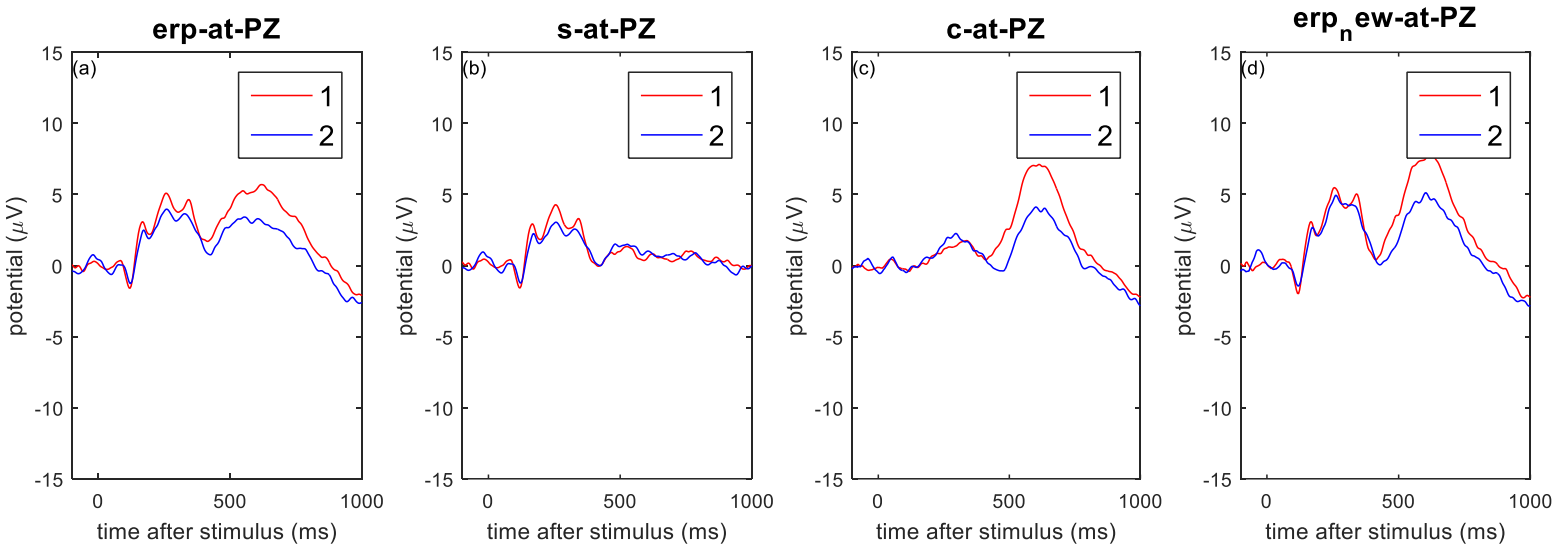
For left figure: `comp = {'erp', 's', 'c'};`
For right figure: `comp = {'erp','erp_new'};`



../batch_data_demo/grand_plot.m

Practice: plottings and basic analysis

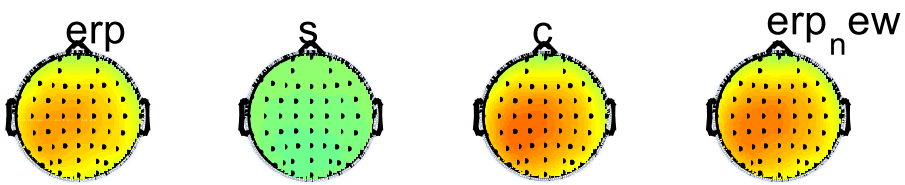
- In the following section ‘Plot (grand average) ERP, RIDE-components time courses for different conditions at specific channels’, you can compare conditions



../batch_data_demo/grand_plot.m

Practice: plottings and basic analysis

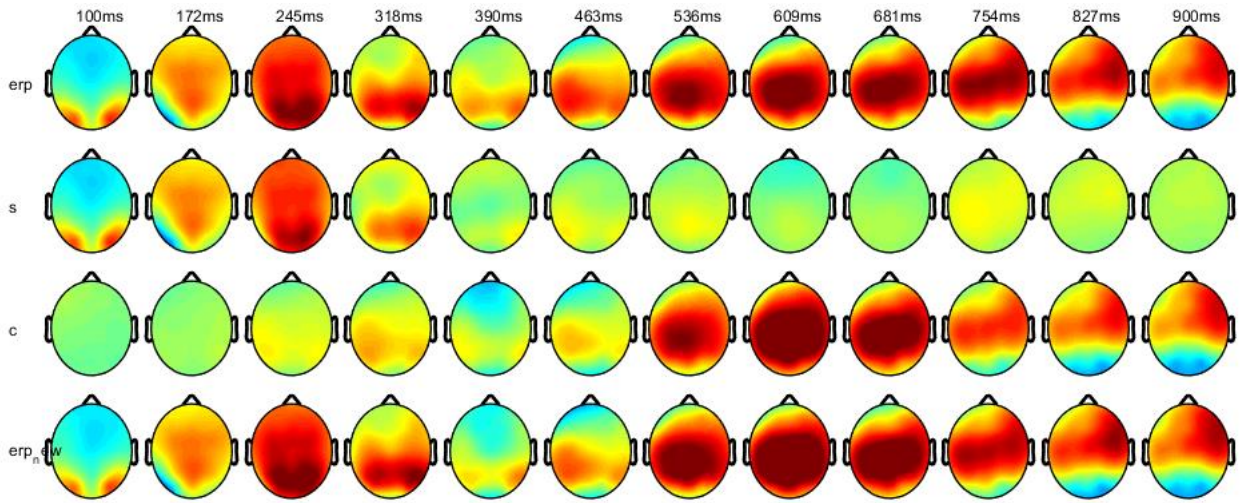
- In the following section, you can plot the map of topography difference.



../batch_data_demo/grand_plot.m

Practice: plottings and basic analysis

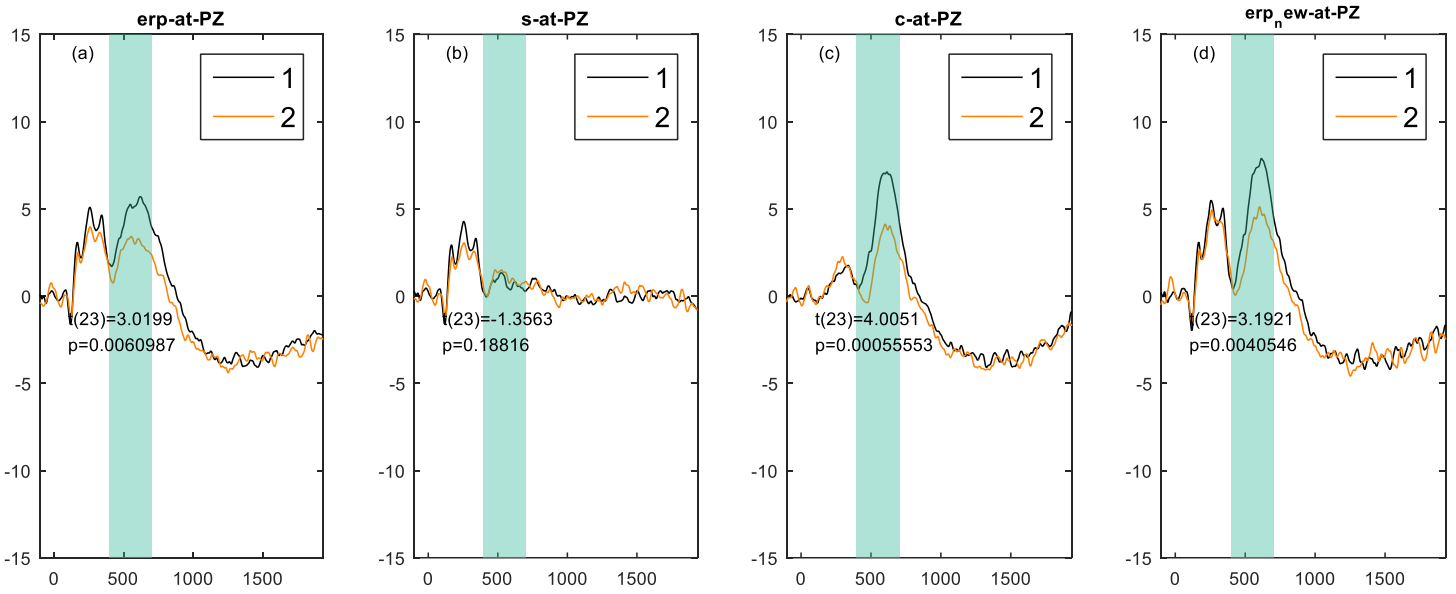
- Map evolution (and difference in a later section)



../batch_data_demo/grand_plot.m

Practice: plottings and basic analysis

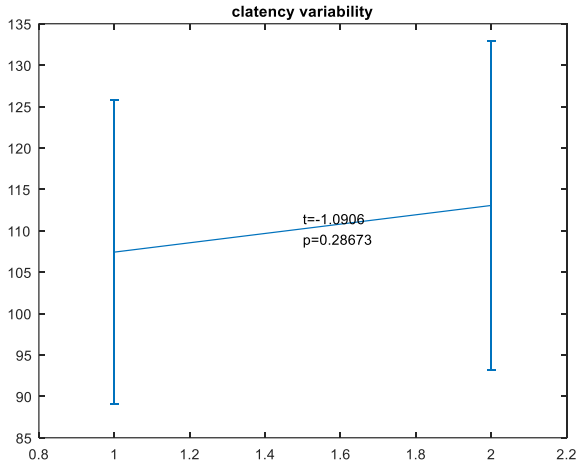
- Simple t-test on amplitude within certain time window



../batch_data_demo/grand_plot.m

Practice: plottings and basic analysis

- Test on the latency variability



- The last section is about exporting the data into text files

../batch_data_demo/grand_plot.m

Generalized to other applications

- So far you have gone through every steps of RIDE application all the way from data importing to results plottings and analysis. You can, in principle, generalize to other data. There is a step that is not covered, that is, how to set the configurations in commercial EEG softwares when exporting the data. It is required that the data should be artifact removed, epoched into 3d data matrix and separated for each single subject and single condition. But unfortunately I don't have experience on that so I could not give guidance. But a person familiar with ERP experiment should know that quite well.

- If you have some basic background about Matlab, it will be easy for you to change the demo script and adapt it to your data. If not, it is also possible to understand it a bit, look up some script from google and ask others for help.

Thank you!