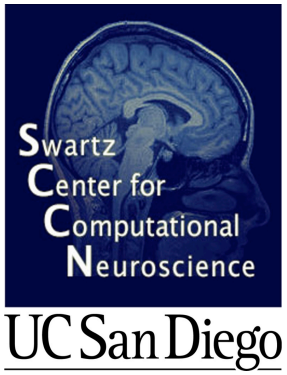
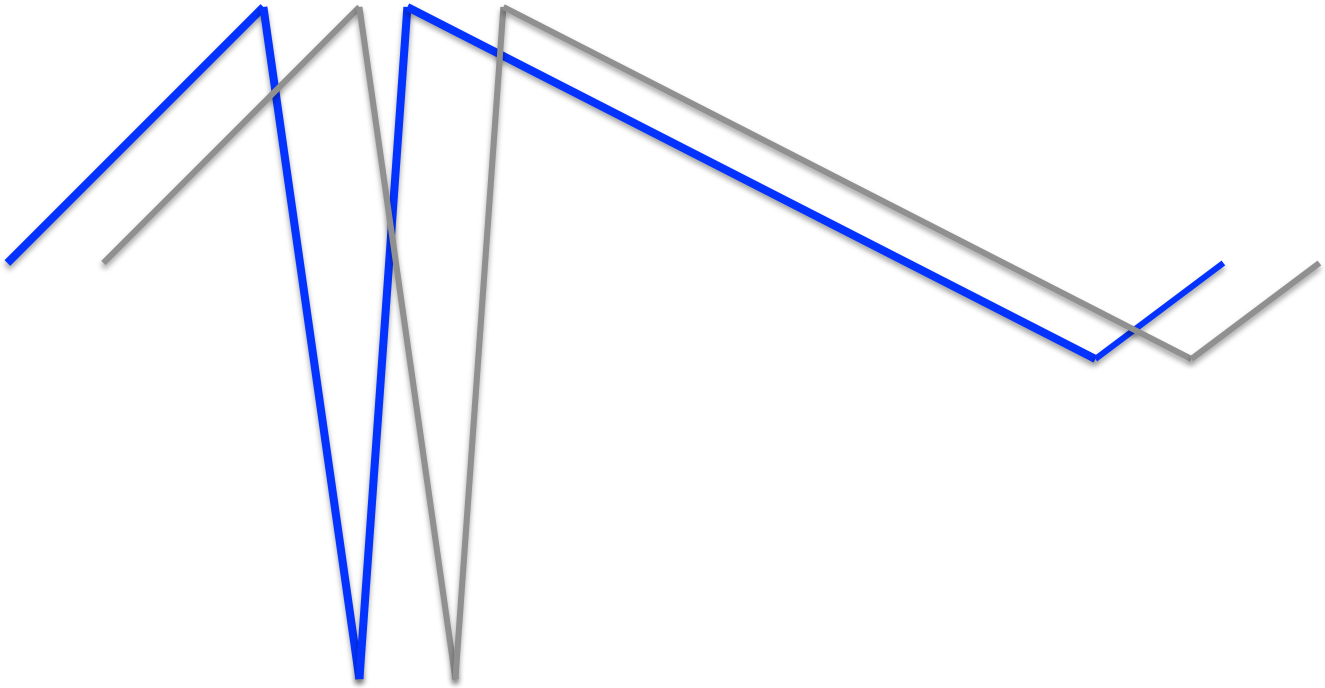


Joint Modeling of Temporarily Overlapping Responses

Matthew Burns



Overview

- Previous Work and Background
- Event Related Potential Regression
- Experimental Validation
- rERP Toolbox Walkthrough

Previous Work

H. Hinrichs, M. Scholz, C. Tempelmann, M. G. Woldorff, A. M. Dale, and H. J. Heinze, "Deconvolution of event-related fMRI responses in fast-rate experimental designs: tracking amplitude variations," *Journal of Cognitive Neuroscience,* vol. 12, pp. 76-89, 2000.

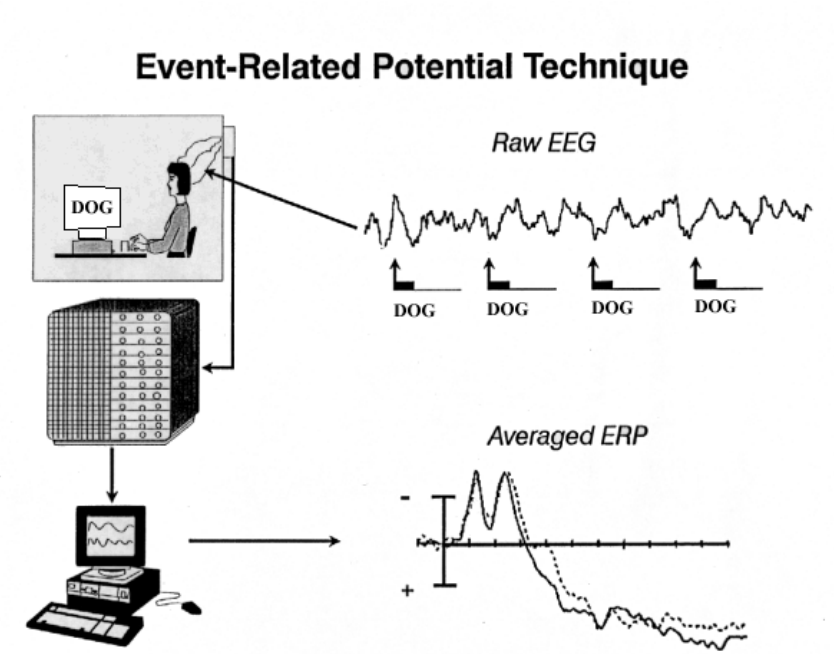
Smith, Nathaniel . “Scaling Up Psycholinguistics”. Dissertation, University of California, San Diego. 2011.

C. R. Pernet, N. Chauveau, C. Gaspar, and G. A. Rousselet, "Limo EEG: a toolbox for hierarchical linear modeling of electroencephalographic data," *Computational intelligence and neuroscience,* vol. 2011, p. 3, 2011.

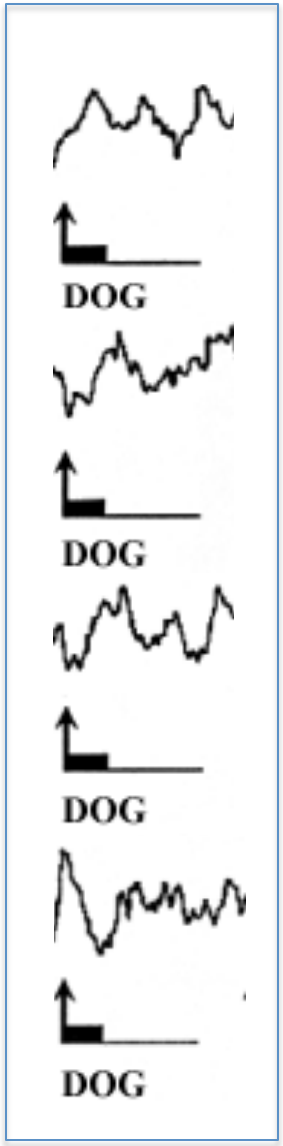
M. D. Burns, N. Bigdely-Shamlo, N. J. Smith, K. Kreutz-Delgado, and S. Makeig, "Comparison of Averaging and Regression Techniques for Estimating Event Related Potentials," presented at the 2013 IEEE Engineering in Medicine and Biology Conference. 2013.

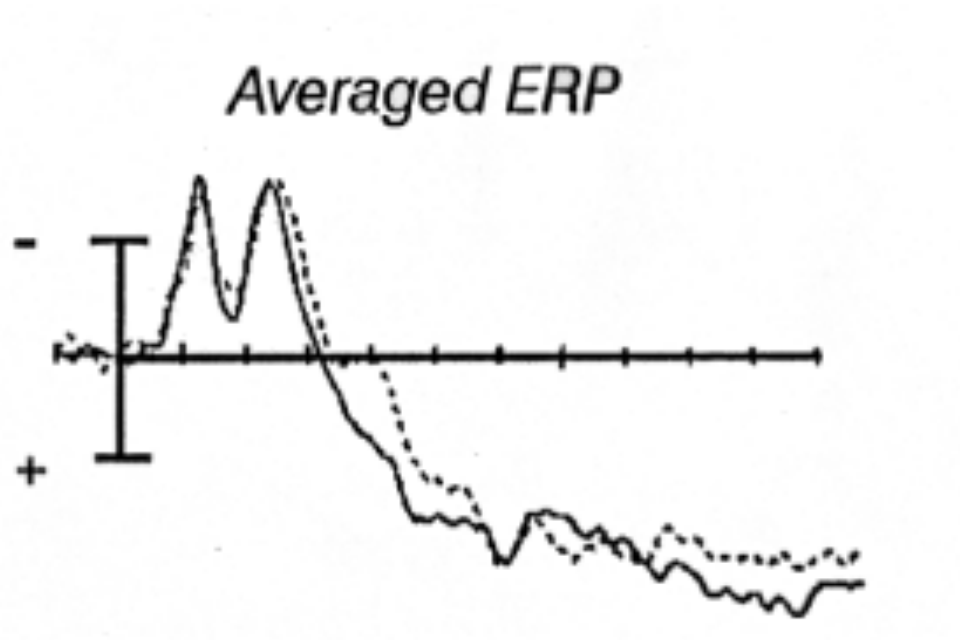
Background

ERP

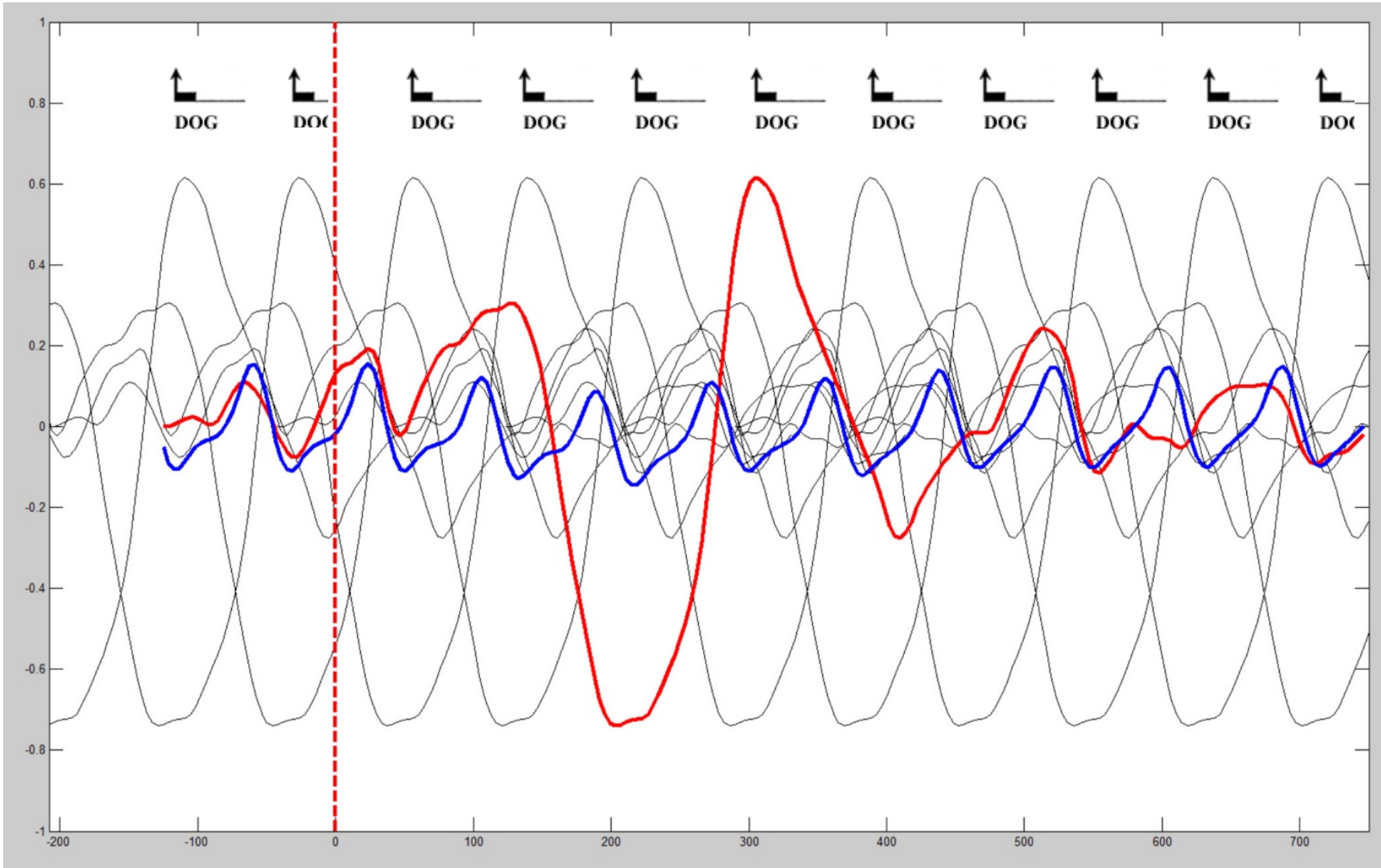


Averaged Event Related Potential

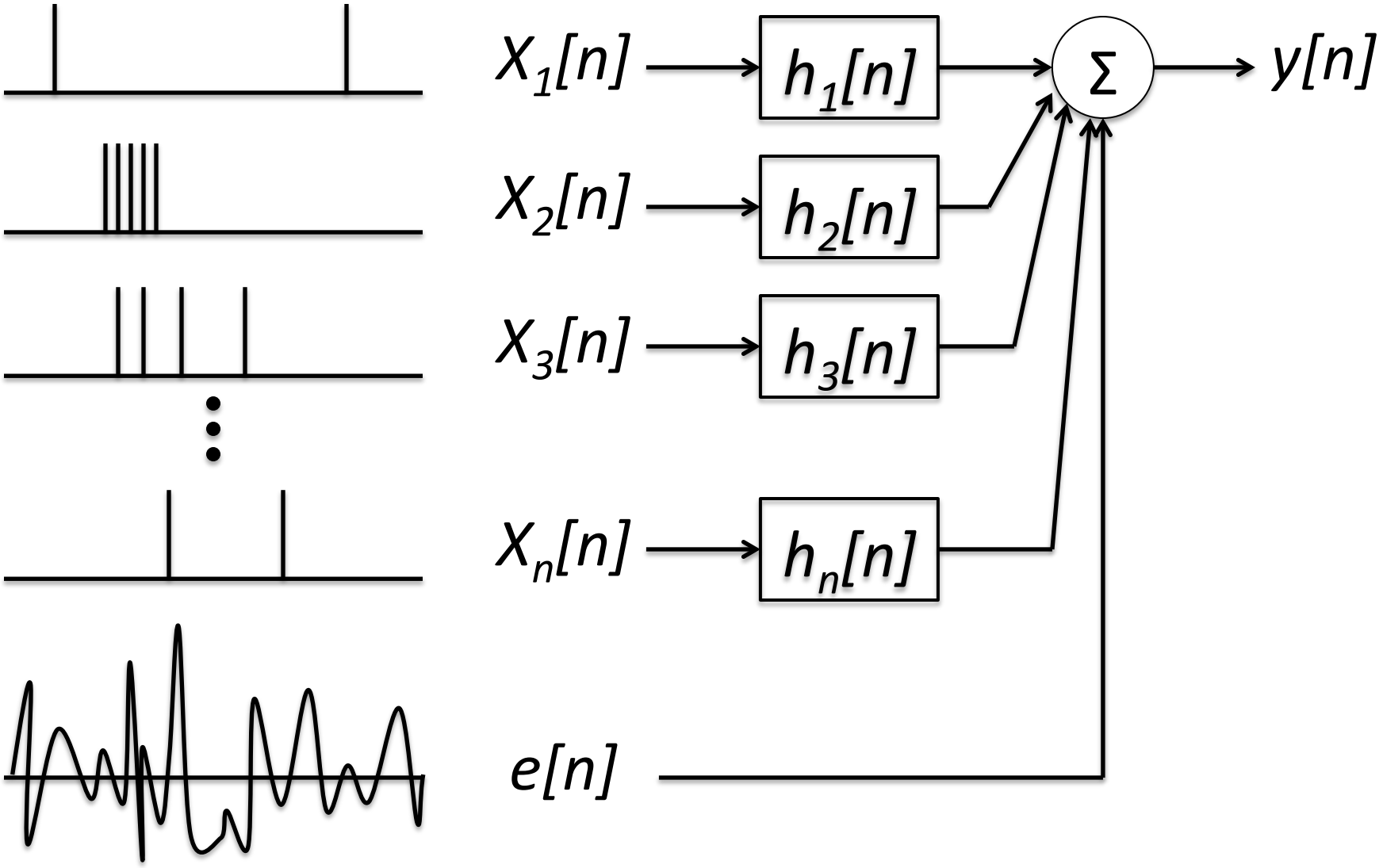




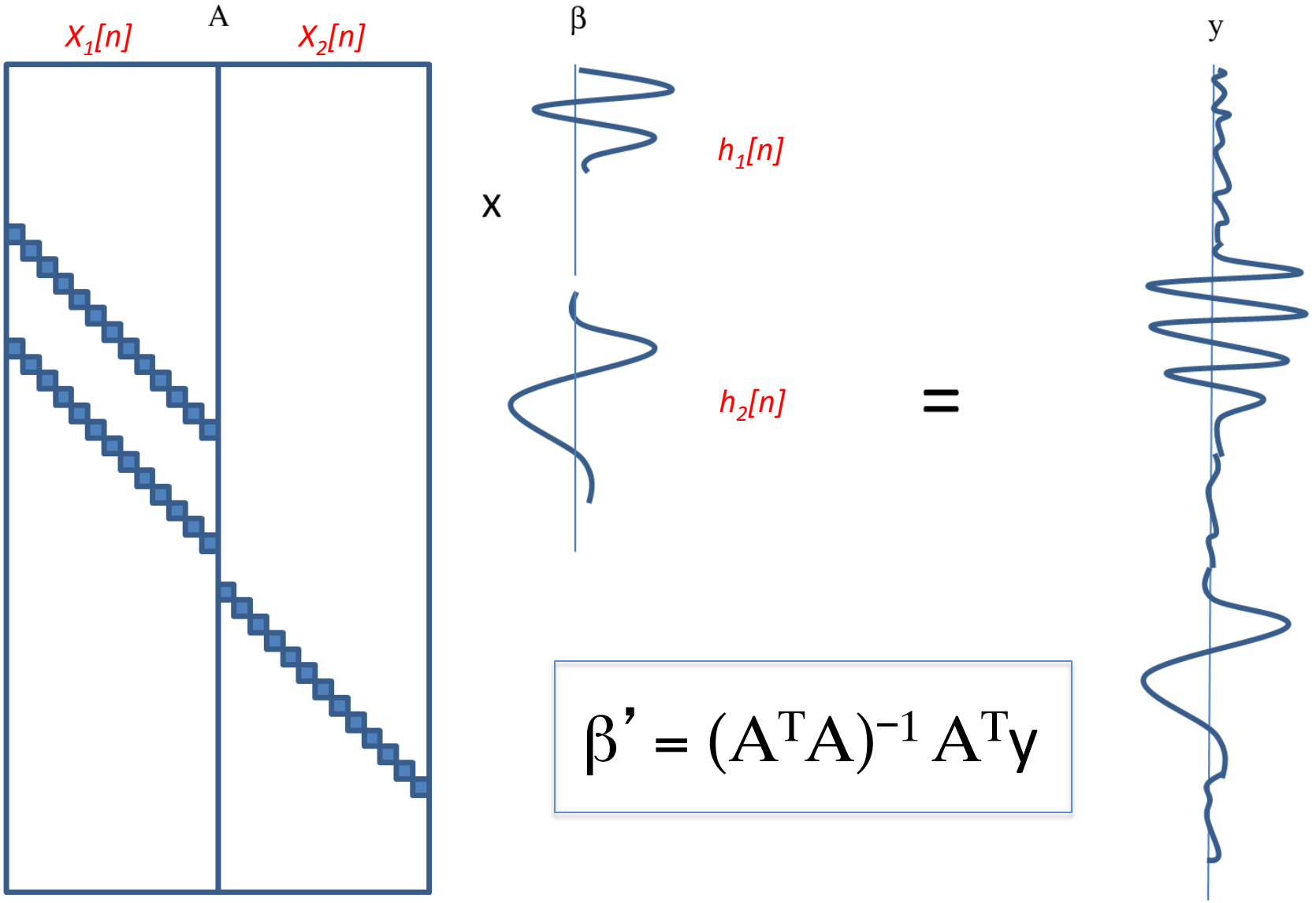
A Problem With Averaging



Linear Time Invariant Model



Regression Framework



$$\beta' = (A^T A)^{-1} A^T y$$

Rapid Serial Visual Presentation

Experiment - RSVP

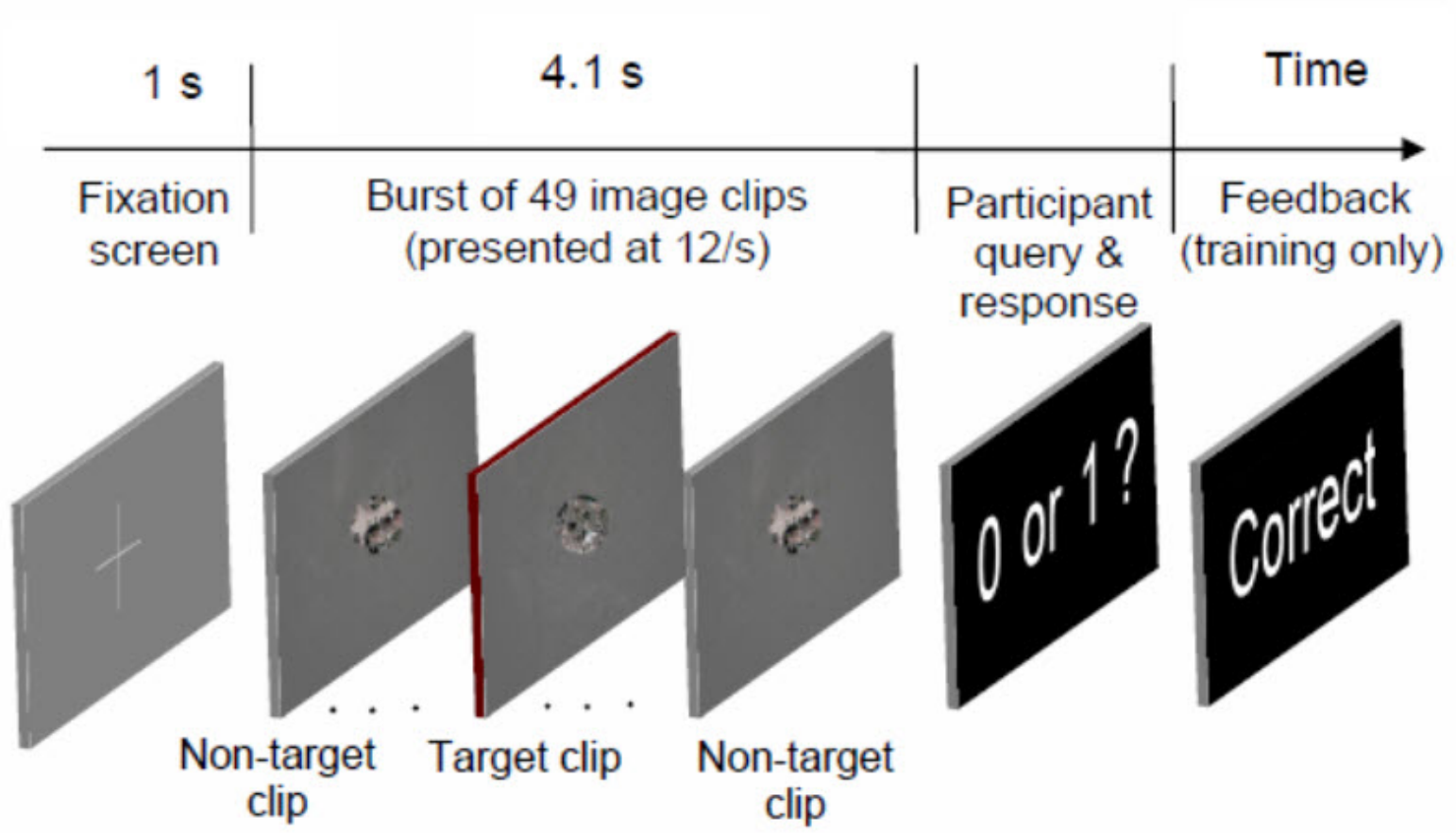


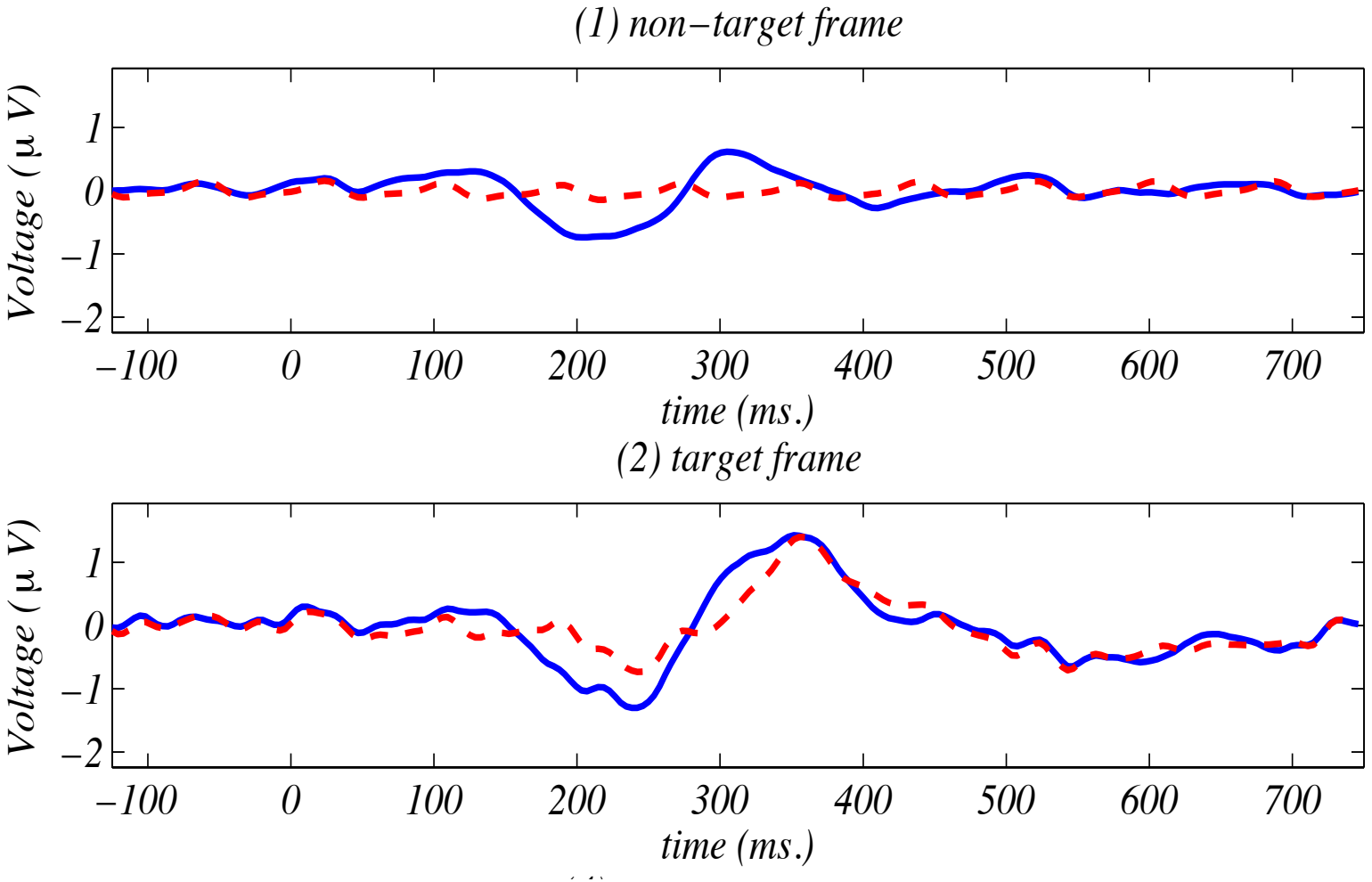
Fig. 2. Time-line of each RSVP burst. Participant response feedback ('Correct' or 'Incorrect') was delivered only during Training sessions (rightmost panel).

Event Type	Description
1	Non-target frame
2	Target frame (contains airplane)
4	“No targets” response
5	“One target” response
6	Block start
16	Start of trial
32	“Correct” feedback given to participant
64	“Incorrect” feedback given to participant
129	Burst start

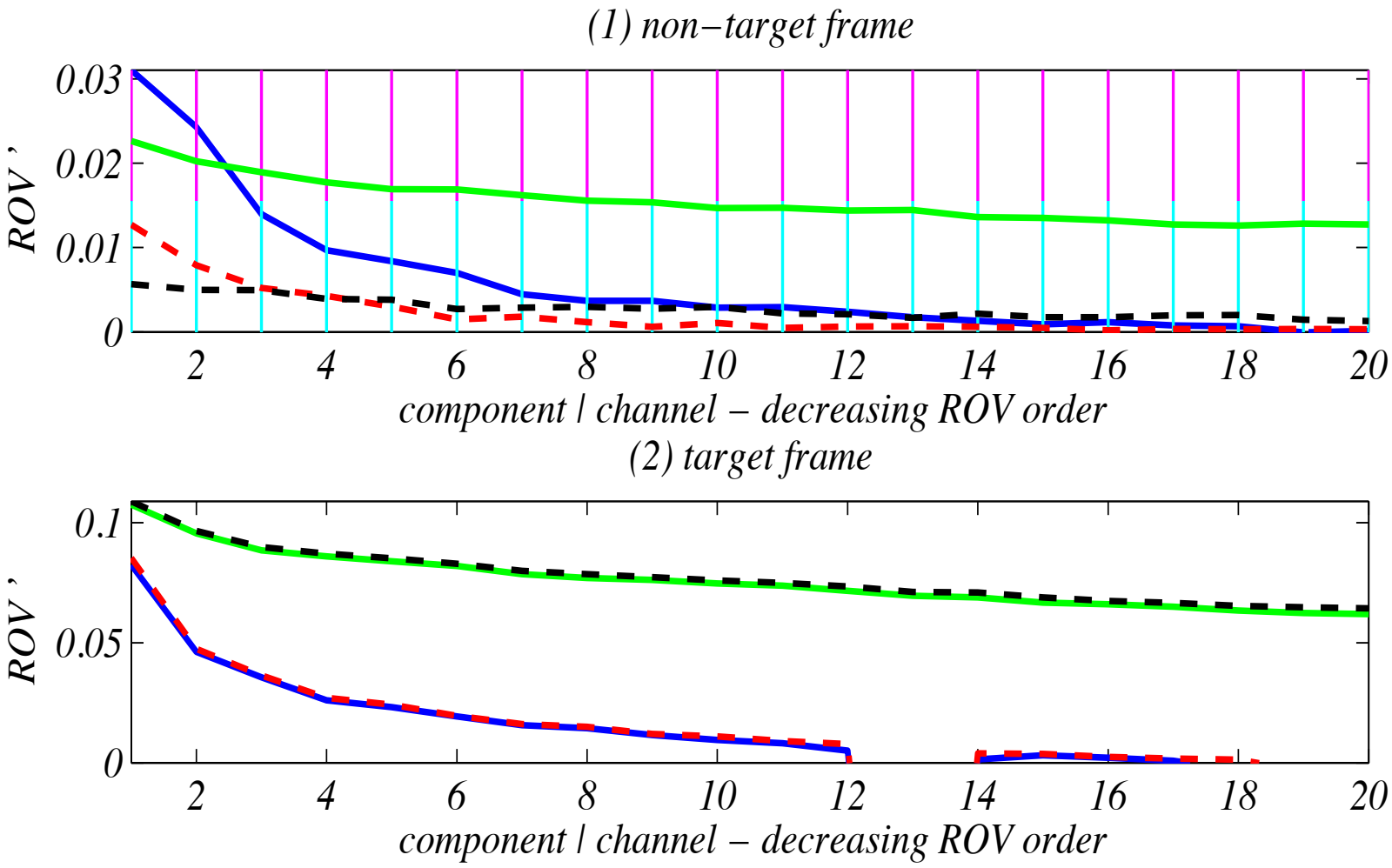
Analysis

- Compute ERP and rERP for all 127 channels.
- At each event, subtract the ERP and combined rERP estimates from original signal (noise).
- Subtract variance of noise from variance of original signal (**Reduction of Variance**: *AKA ROV or* R^2 *or Coefficient of Determination*).

Comp 17– ERP & rERP Estimates



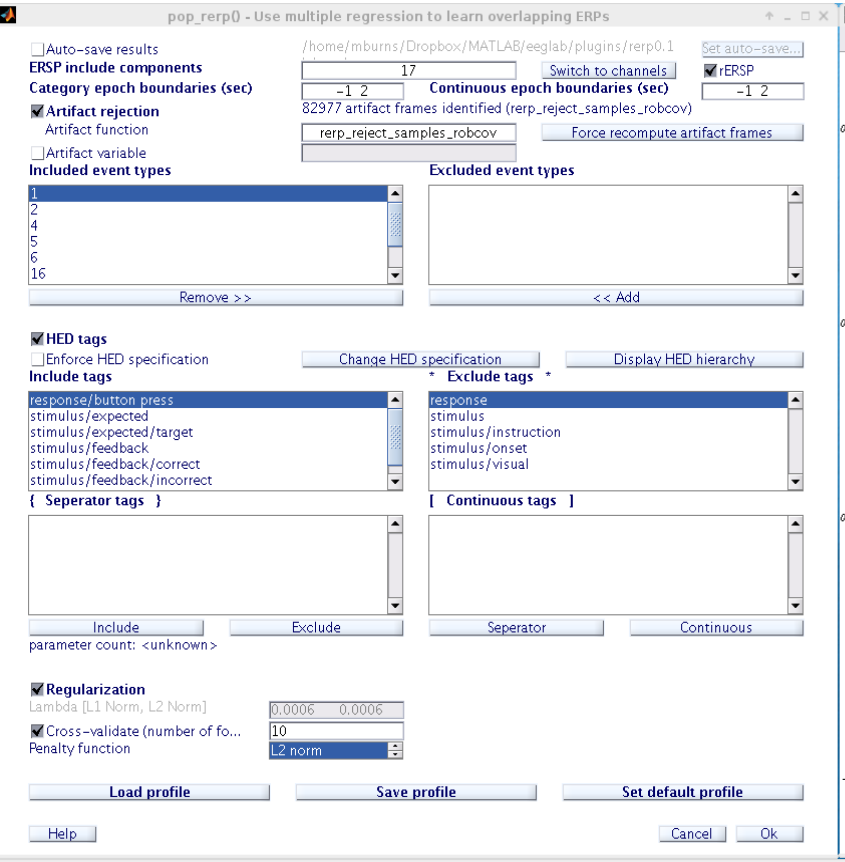
ERP & rERP R^2

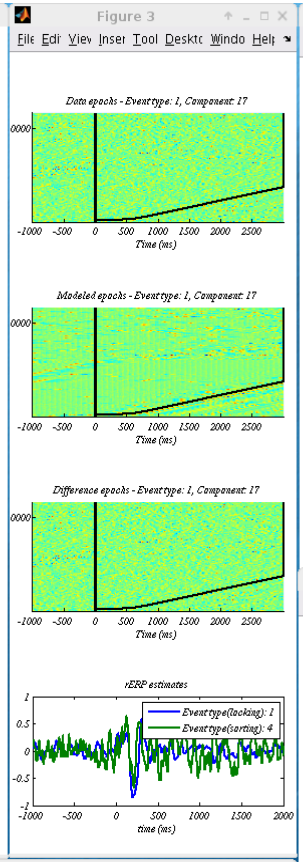

(1) non−target frame
ROV '
0.03
0.02
0.01
0
2
4
6
8
10
12
14
16
18
20
component | channel − decreasing ROV order
(2) target frame
ROV '
0.1
0.05
0
2
4
6
8
10
12
14
16
18
20
component | channel − decreasing ROV order

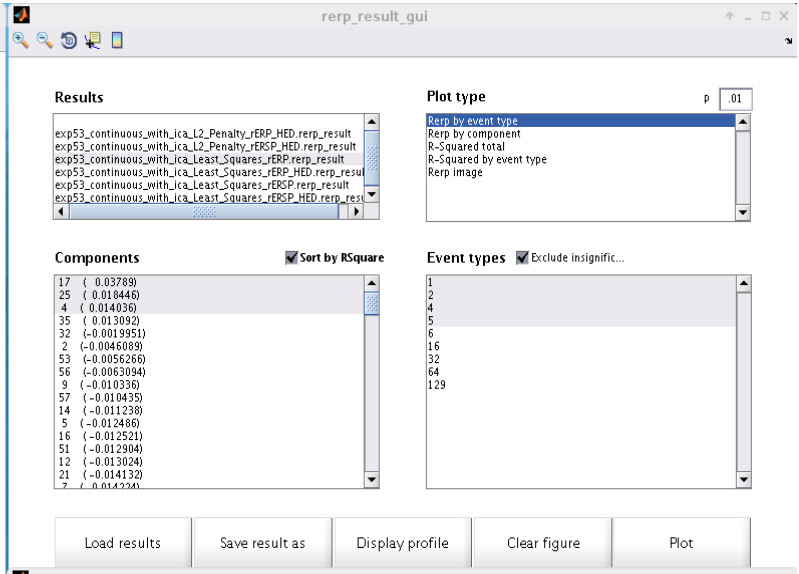
Conclusions

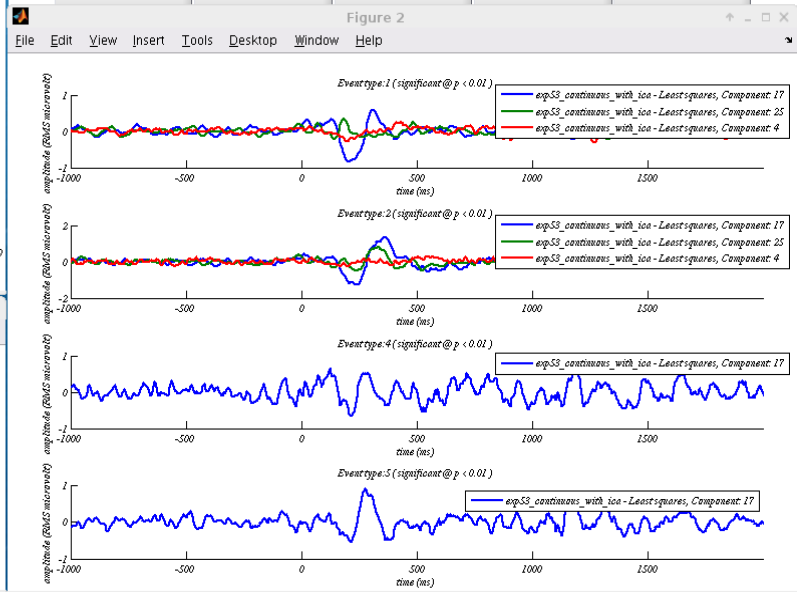
- Regression *better* than averaging?
  - If there is ***systematic overlap*** with other ERPs, ***yes***. Caveat: we can not yet say whether a particular part or bump in an estimate is better one way or the other.
  - If there is ***no overlap***, regression produces the ***same results*** as averaging.
- *ICA components* show a higher concentration of R^2 compared with channels for both methods.

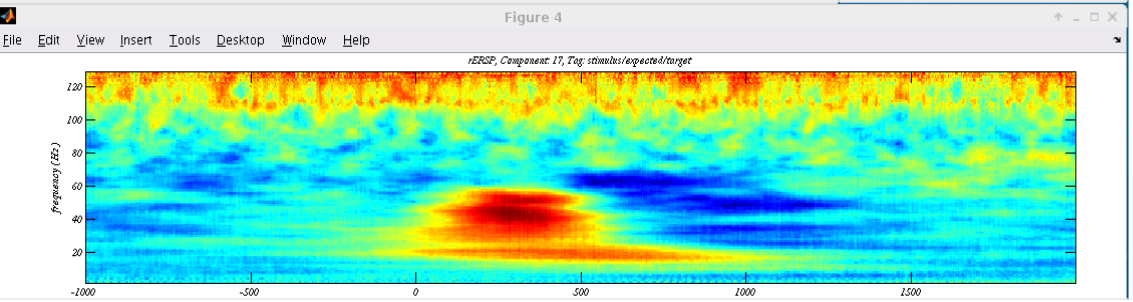
rERP Toolbox Overview











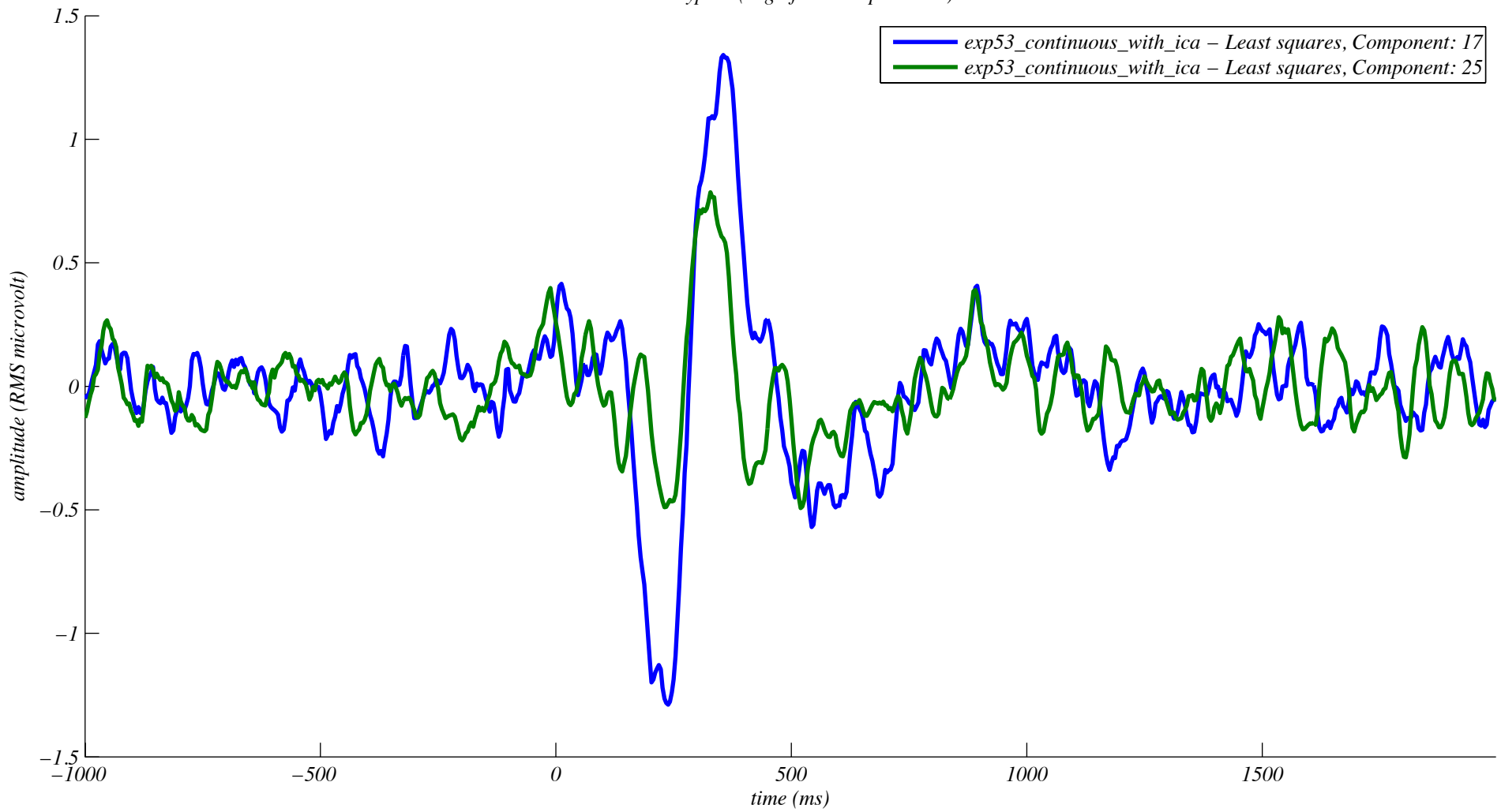
Logistics

- **download:** github.com/mattb243/rERP
  - Will be available in plugin manager in the future

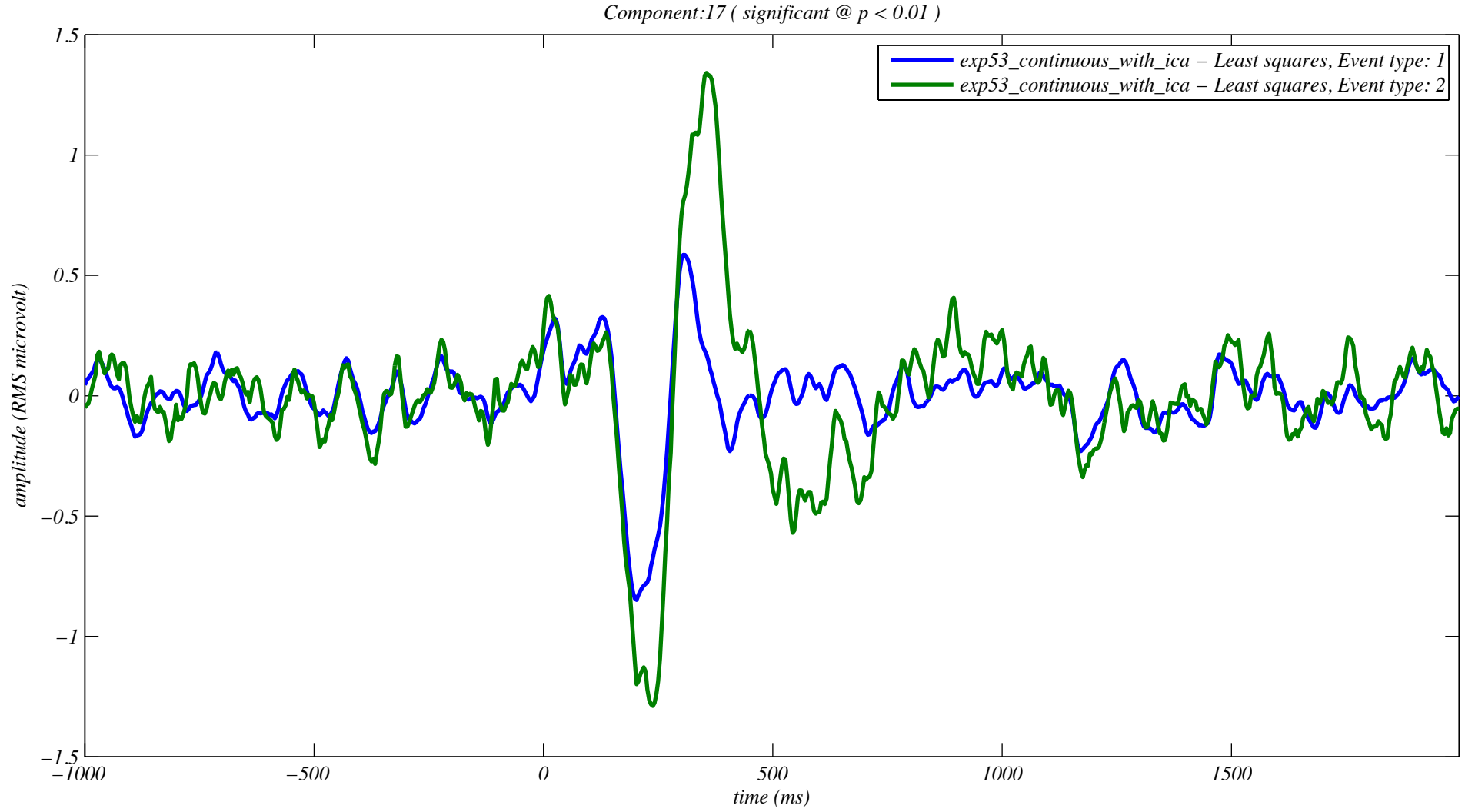
- **support:** rerptoolbox@gmail.com
  - Bug reports
  - Subject "ADD" to receive updates on this project, new pubs, etc.

- **doc:** http://sccn.ucsd.edu/wiki/EEGLAB/RERP

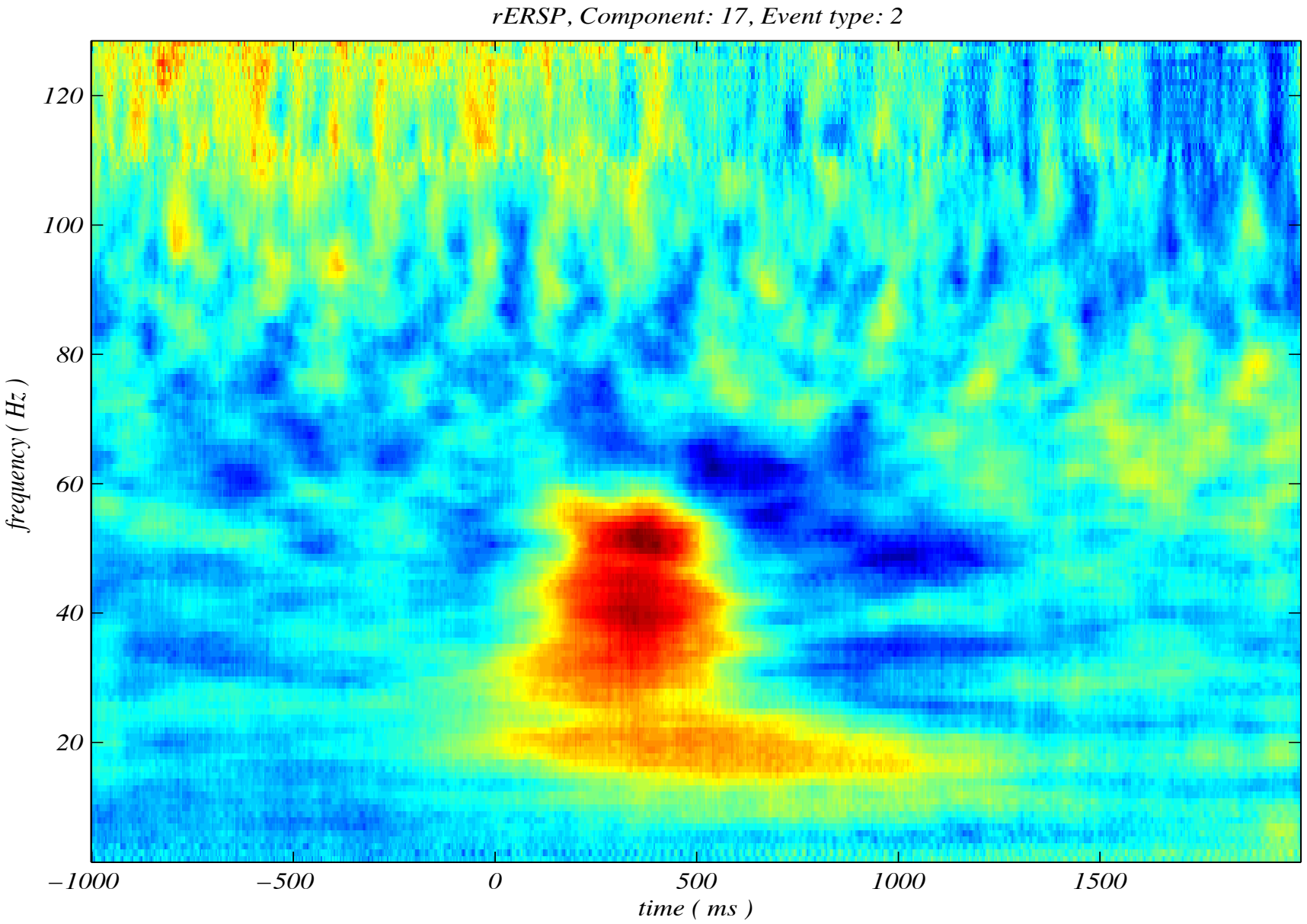
rERP


Event type:2 (significant @ p < 0.01)
exp53_continuous_with_ica – Least squares, Component: 17
exp53_continuous_with_ica – Least squares, Component: 25
amplitude (RMS microvolt)
1.5
1
0.5
0
−0.5
−1
−1.5
−1000
−500
0
500
1000
1500
time (ms)

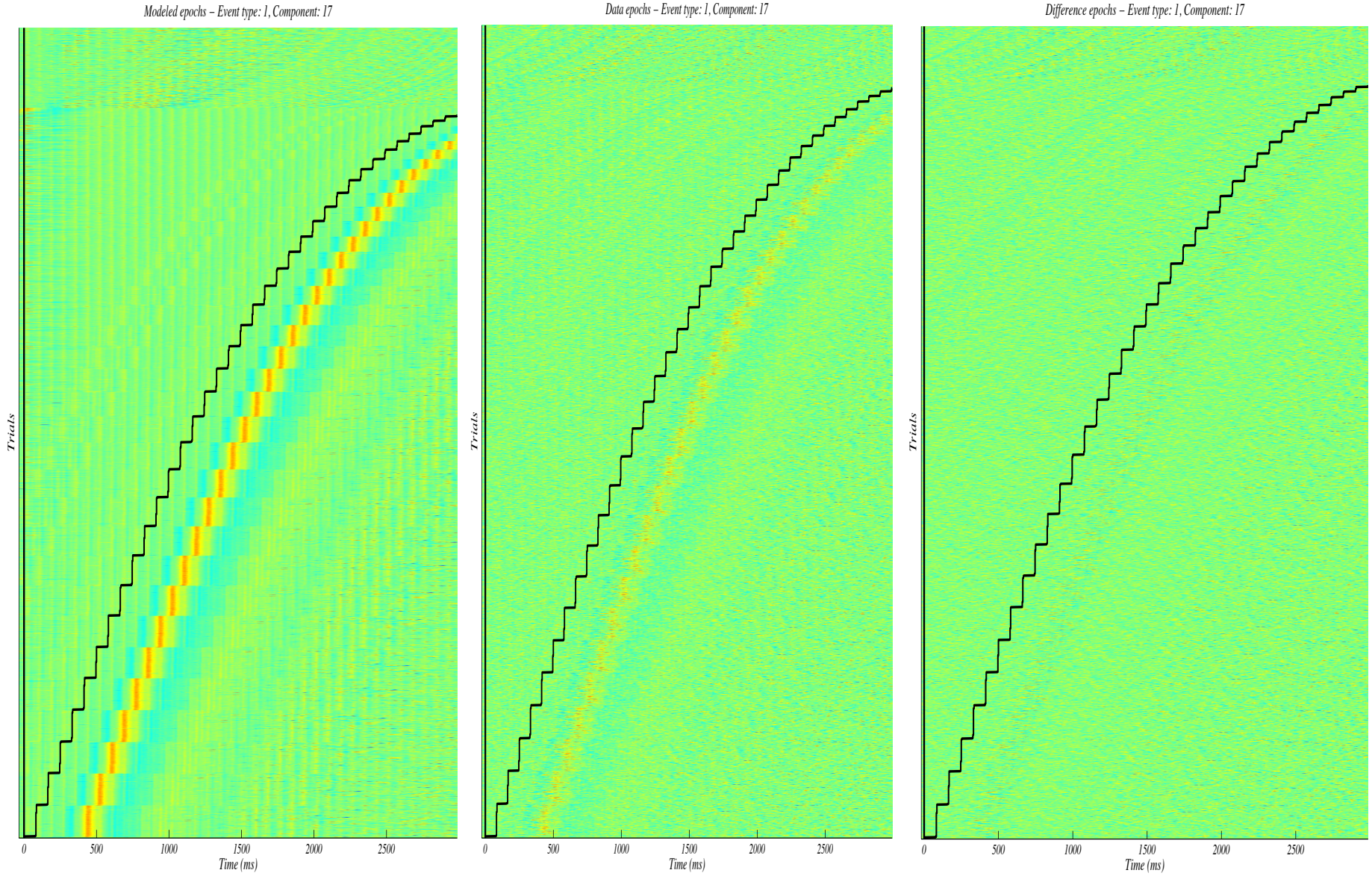
rERP


Component:17 (significant @ p < 0.01)
exp53_continuous_with_ica – Least squares, Event type: 1
exp53_continuous_with_ica – Least squares, Event type: 2
amplitude (RMS microvolt)
1.5
1
0.5
0
−0.5
−1
−1.5
−1000
−500
0
500
1000
1500
time (ms)

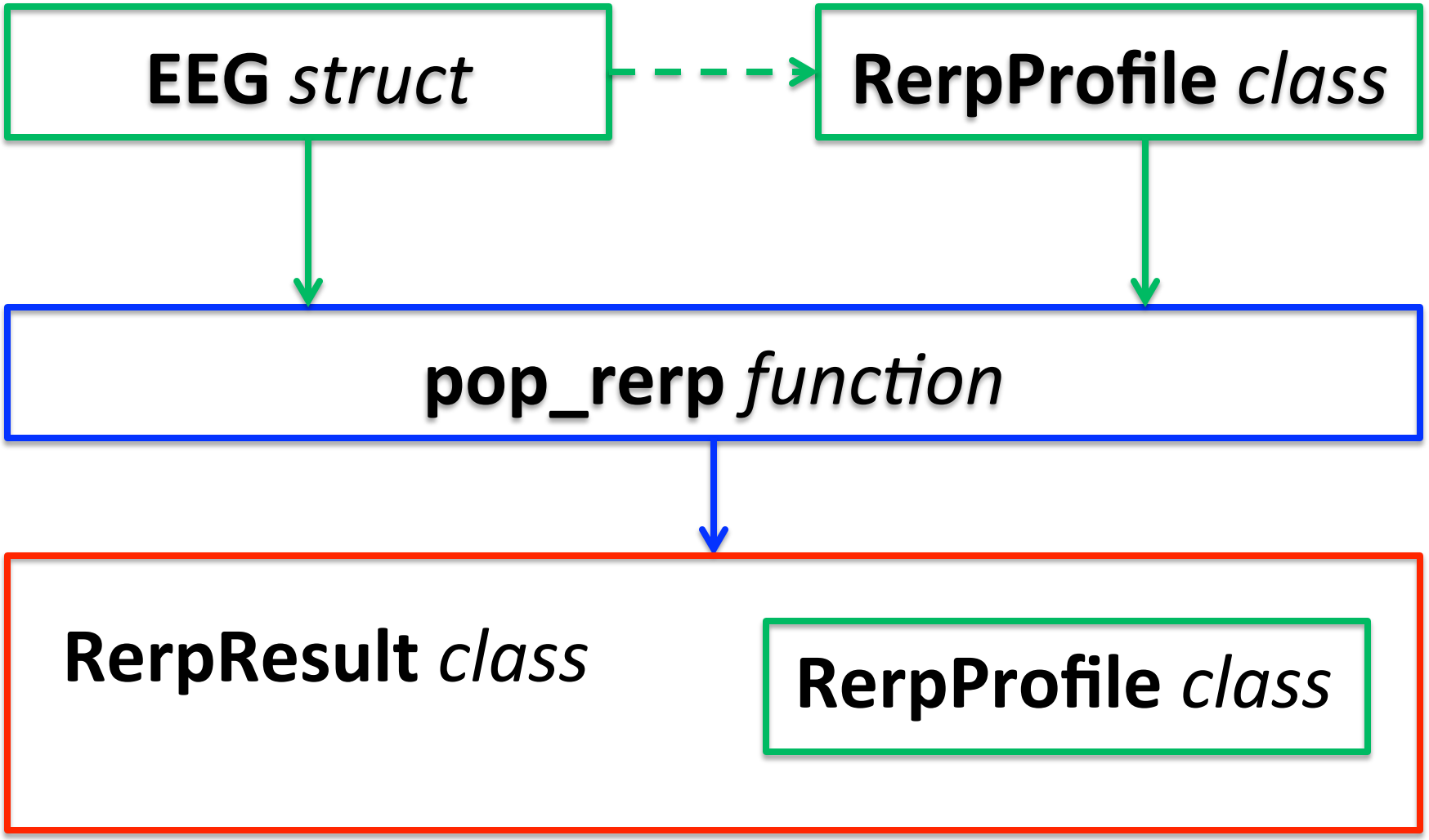
rERSP


rERSP, Component: 17, Event type: 2
120
100
80
60
40
20
frequency (Hz)
−1000
−500
0
500
1000
1500
time (ms)

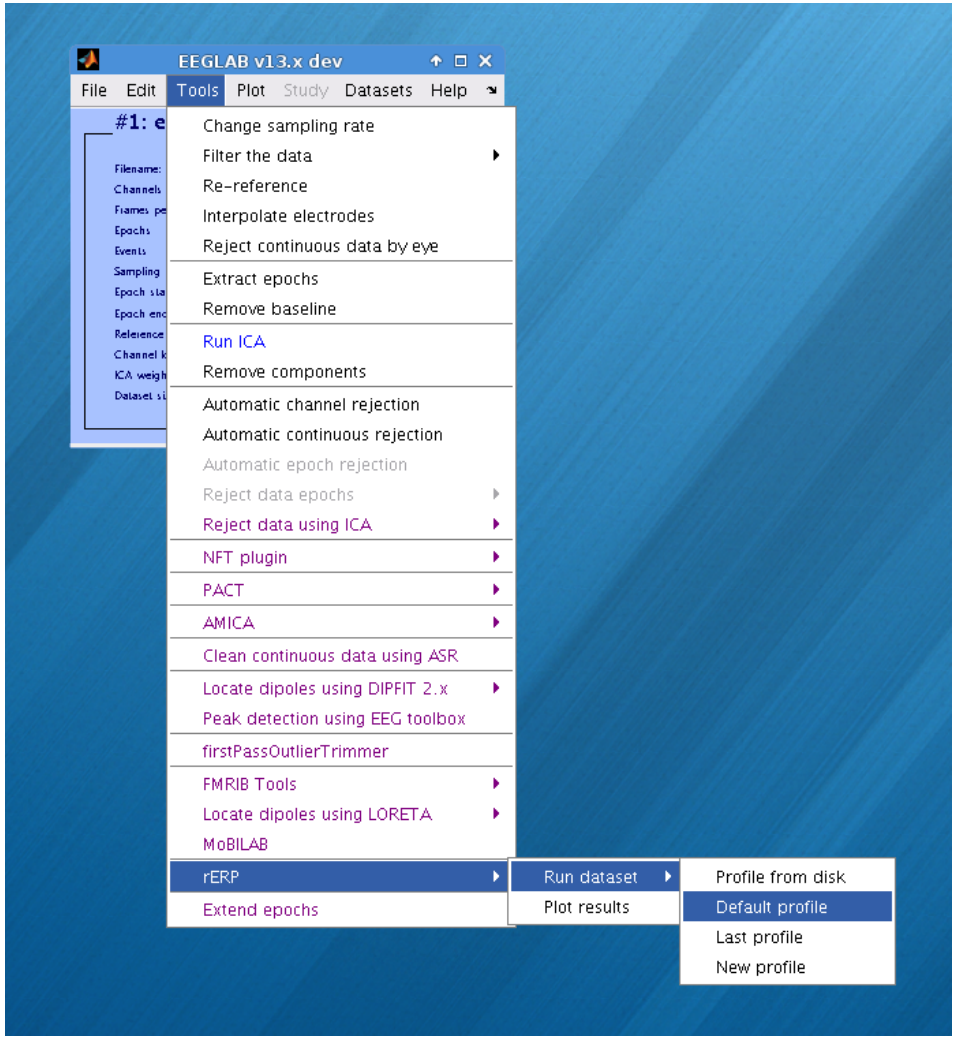
rERPimage


Modeled epochs – Event type: 1, Component: 17
Data epochs – Event type: 1, Component: 17
Difference epochs – Event type: 1, Component: 17
Trials
0
500
1000
1500
2000
2500
Time (ms)

Basic Design



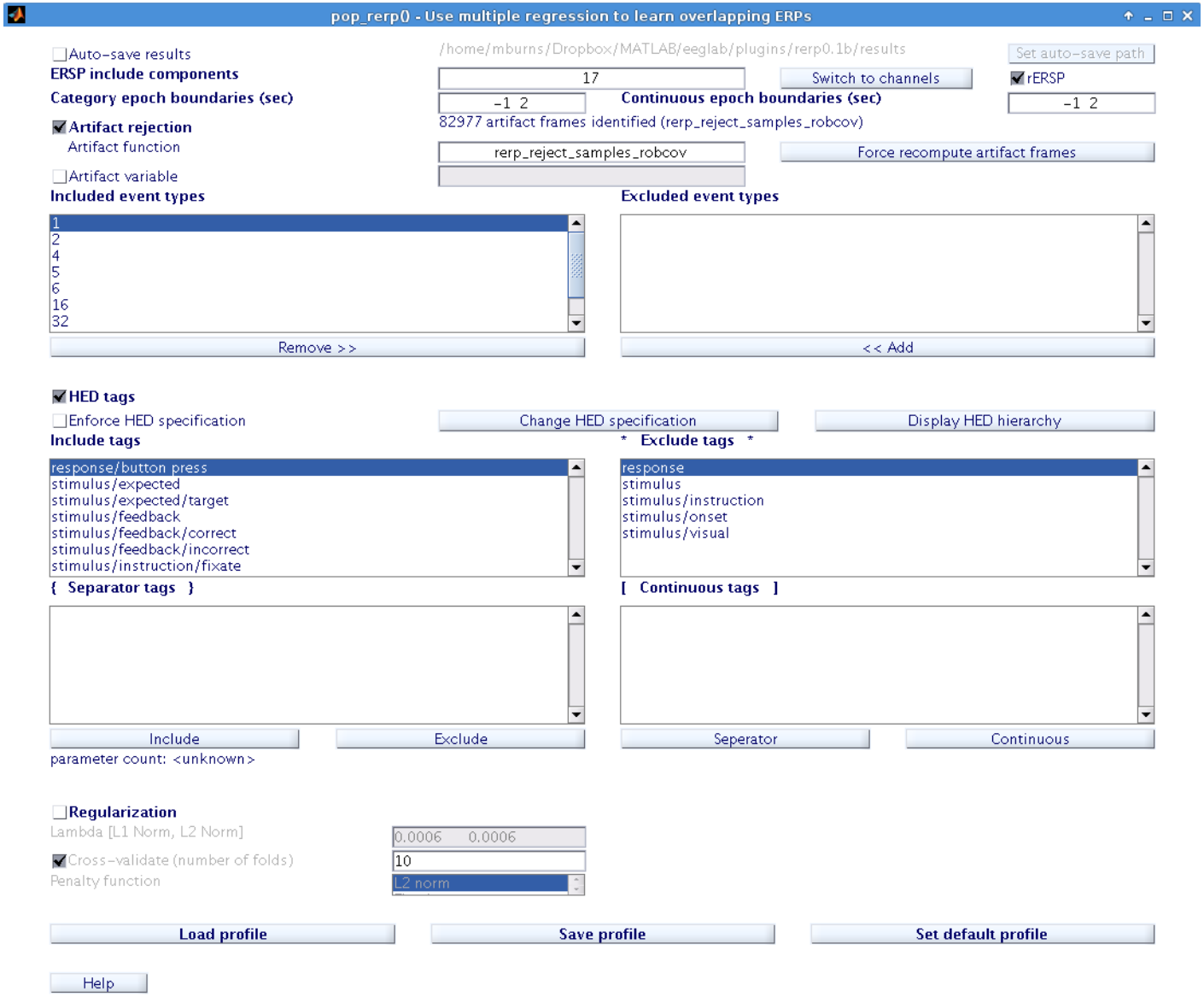
Profile: GUI



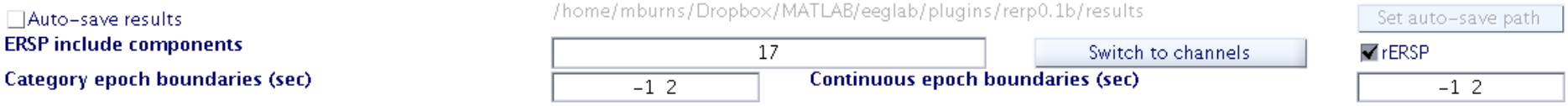
- Get started quickly by using the EEGLAB GUI menu: ***Tools-> rERP-> Run Dataset-> New profile***

- To view and edit an existing profile: ***pop_rerp(EEG, profile, 'force_gui', 1);***

Profile: GUI


pop_rerp() - Use multiple regression to learn overlapping ERPs
Auto-save results
/home/mburns/Dropbox/MATLAB/eeglab/plugins/rerp0.1b/results
Set auto-save path
ERSP include components
17
Switch to channels
rERSP
Category epoch boundaries (sec)
-1 2
Continuous epoch boundaries (sec)
-1 2
Artifact rejection
82977 artifact frames identified (rerp_reject_samples_robcov)
Artifact function
rerp_reject_samples_robcov
Force recompute artifact frames
Artifact variable
Included event types
Excluded event types
1
2
4
5
6
16
32
Remove >>
<< Add
HED tags
Enforce HED specification
Change HED specification
Display HED hierarchy
Include tags
* Exclude tags *
response/button press
stimulus/expected
stimulus/expected/target
stimulus/feedback
stimulus/feedback/correct
stimulus/feedback/incorrect
stimulus/instruction/fixate
response
stimulus
stimulus/instruction
stimulus/onset
stimulus/visual
{ Separator tags }
[Continuous tags]
Include
Exclude
Seperator
Continuous
parameter count: <unknown>
Regularization
Lambda [L1 Norm, L2 Norm]
0.0006 0.0006
Cross-validate (number of folds)
10
Penalty function
L2 norm
Load profile
Save profile
Set default profile
Help

Profile: general settings



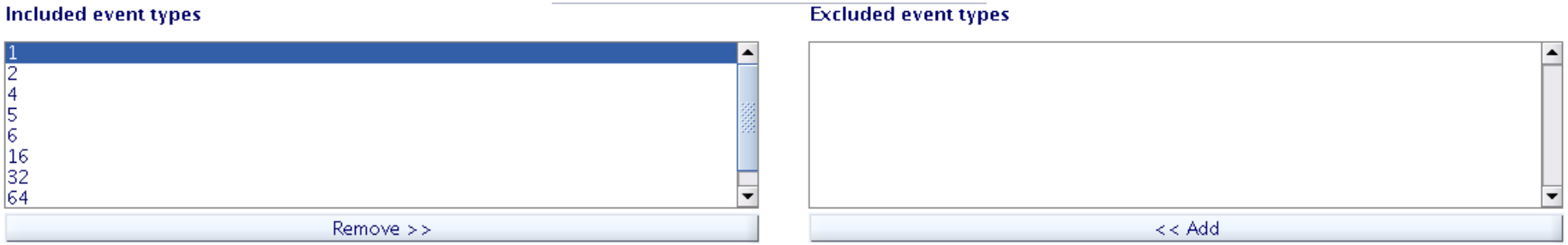
- Choose channels or components
- Choose rERP or rERSP (time-frequency)
- Enable automatic result saving
- Set epoch boundaries

Profile: artifact settings

- Enable automatic artifact rejection
- Enter the name of custom artifact function

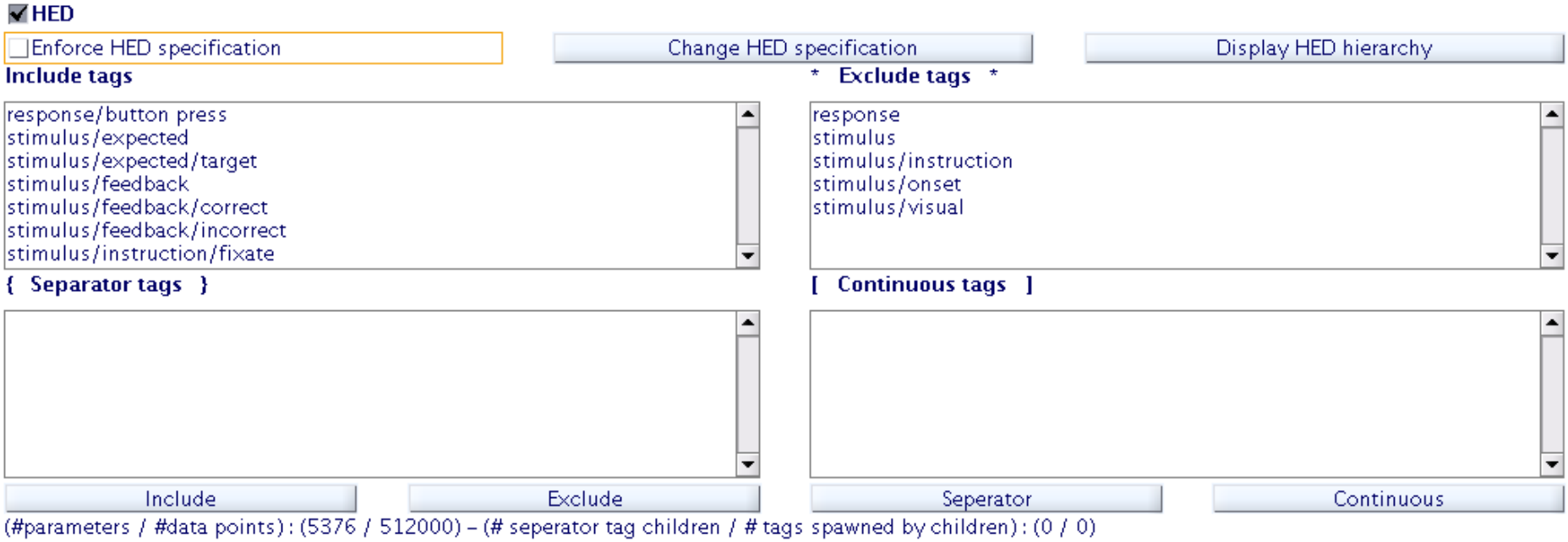
  or
- Use a logical index artifact variable from the workspace.

Profile: event types



- Choose event types to be included in the regression framework.

Profile: Hierarchical Event Description (HED) Tags

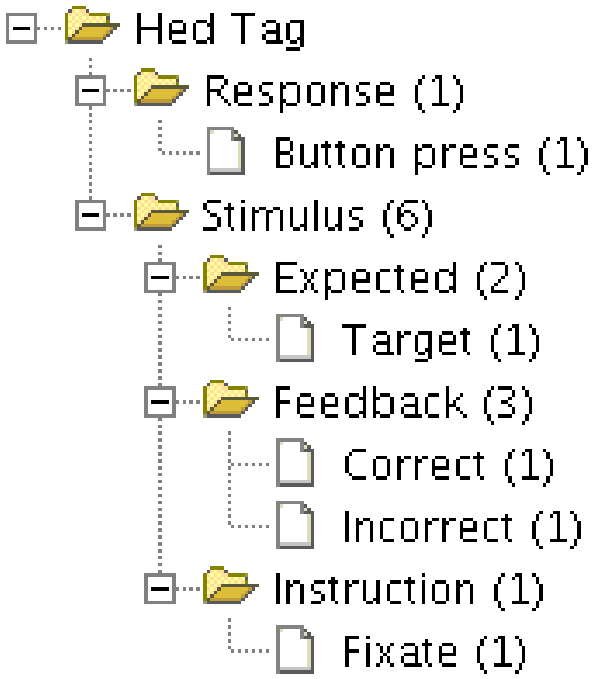


- Enable and configure <u>hierarchical regression</u>
  - *Hint: EEG struct must be tagged: (i.e. EEG.event(i).hedTag = hedString;)*

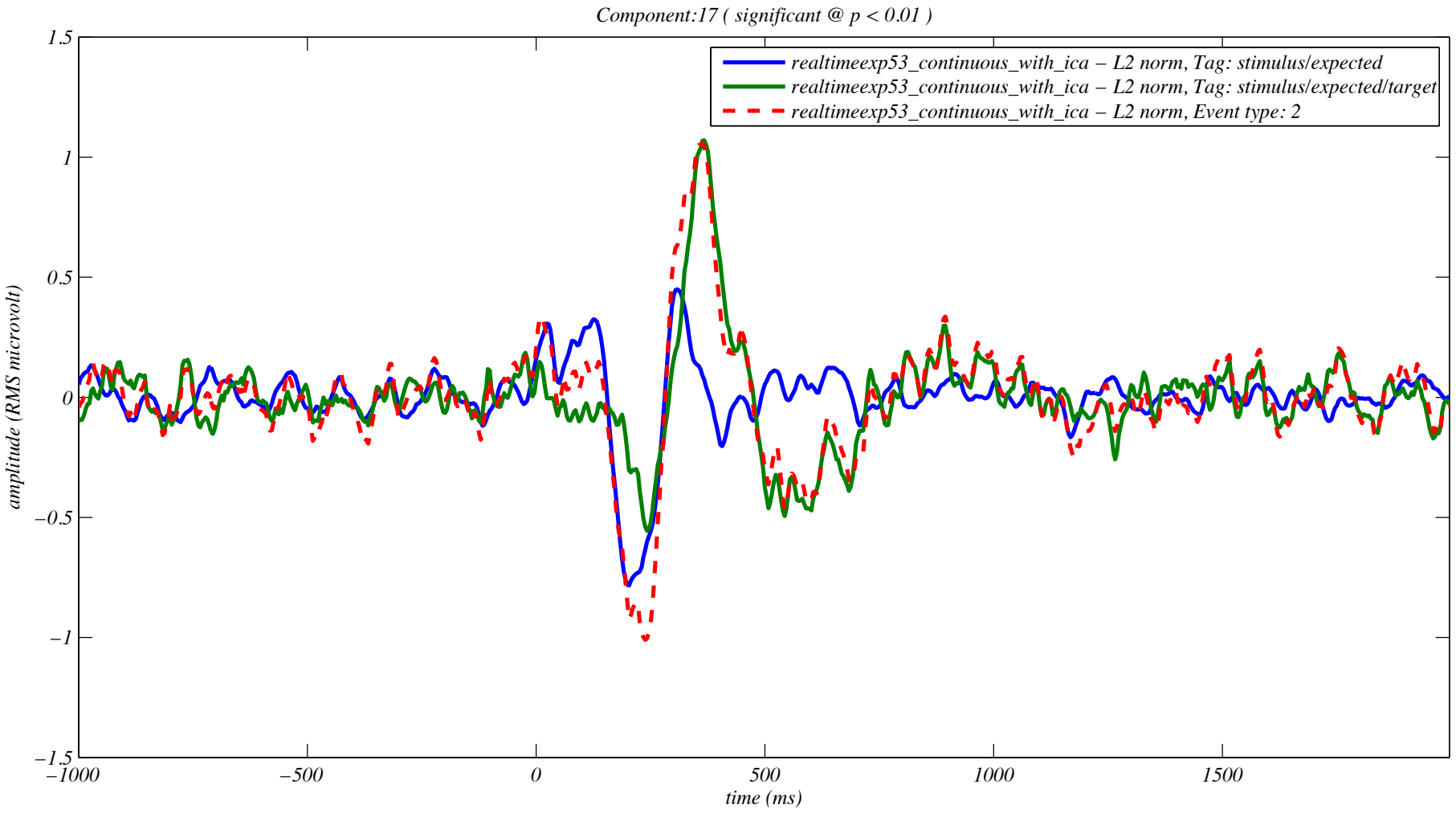
About HED Tags

Event type: Hed Tags

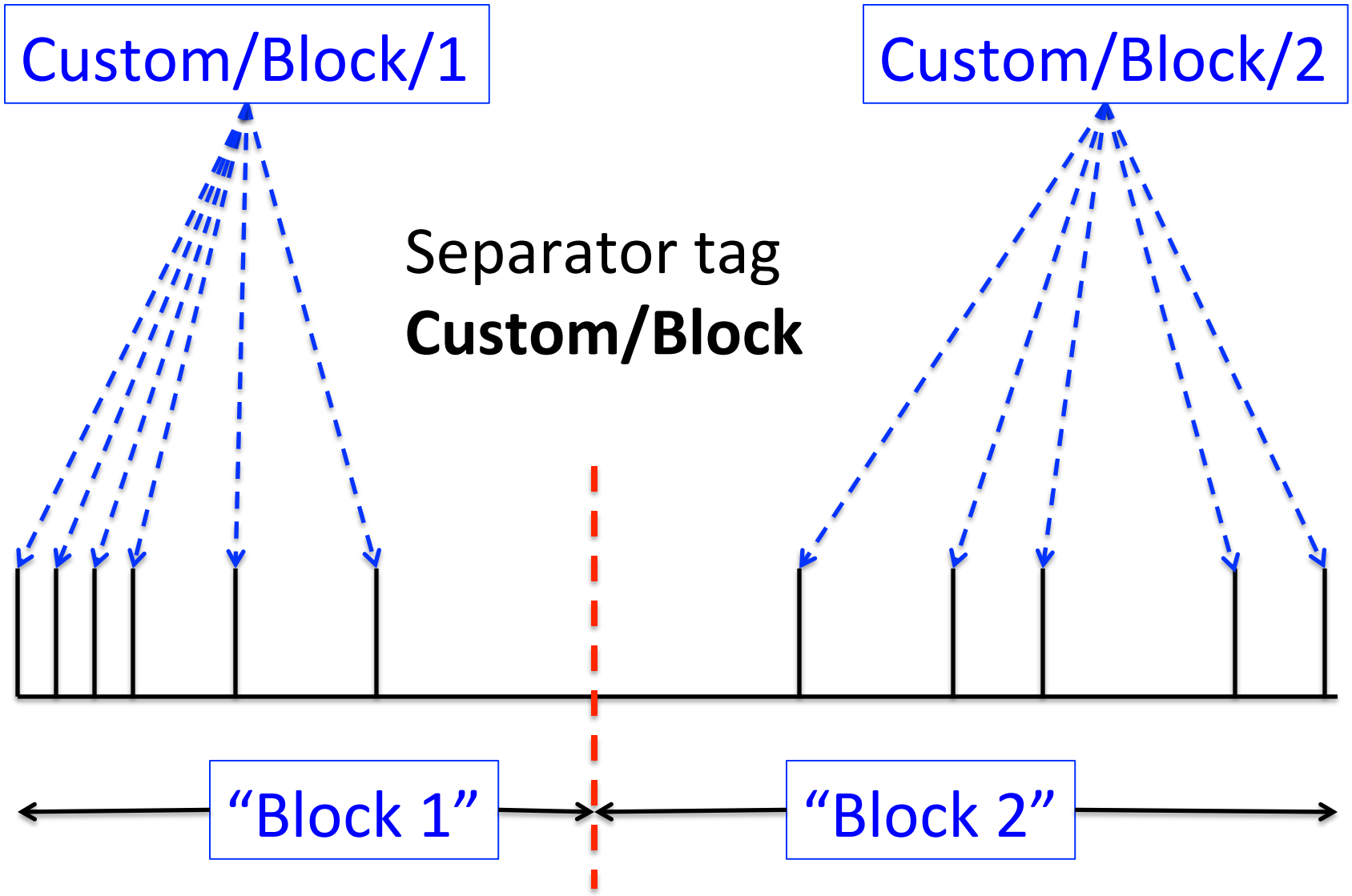
1: stimulus/visual
stimulus/expected
2: stimulus/visual
stimulus/expected/target
4: response/button press
32: stimulus/visual
stimulus/feedback/correct
64: stimulus/visual
stimulus/feedback/incorrect



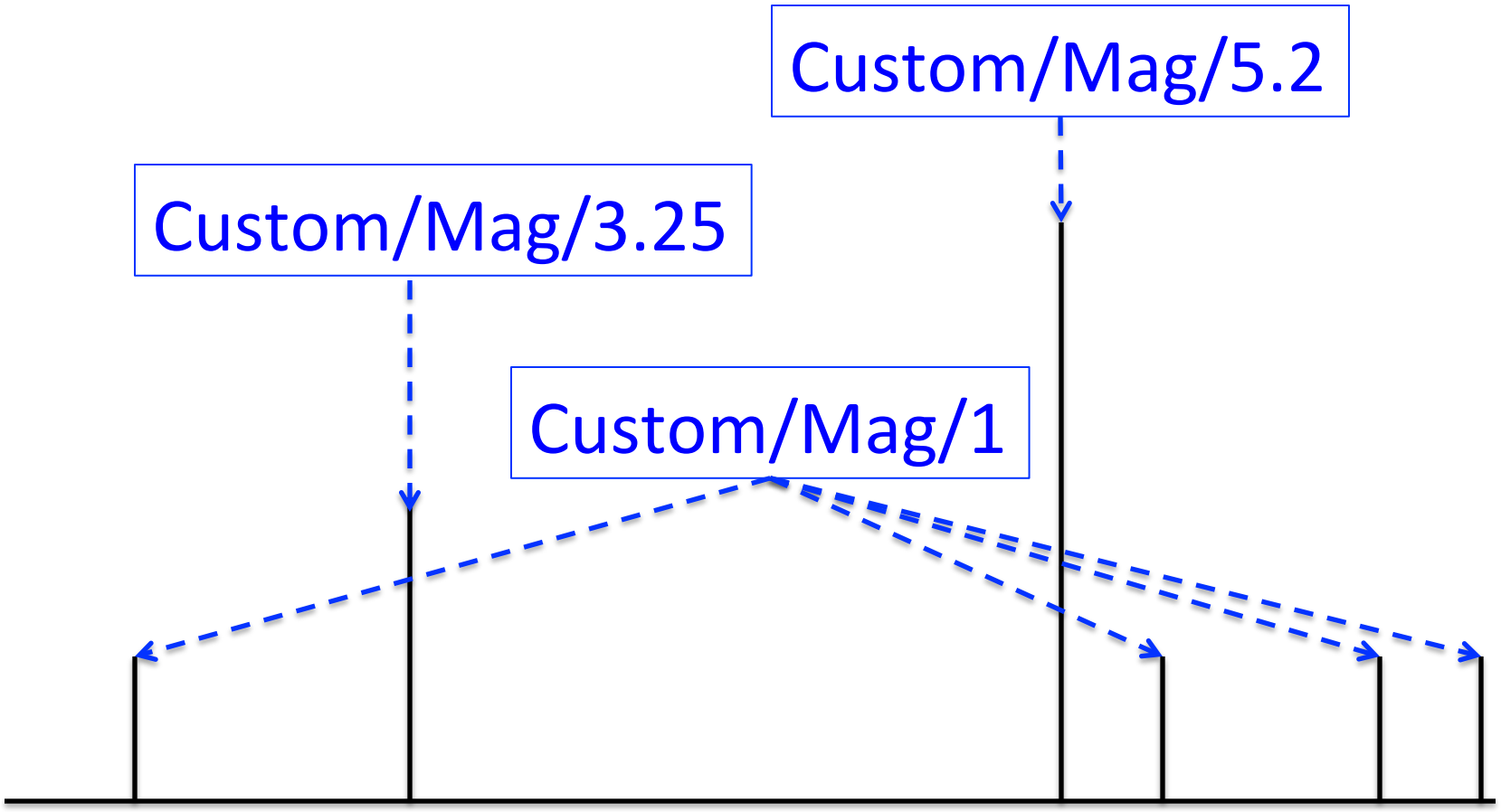
Hierarchical Regression



Profile: HED Tags *{ Separator Tags }*



Profile: HED Tags *[Continuous Tags]*



Continuous Tag

Custom/Mag

Profile: Regularization

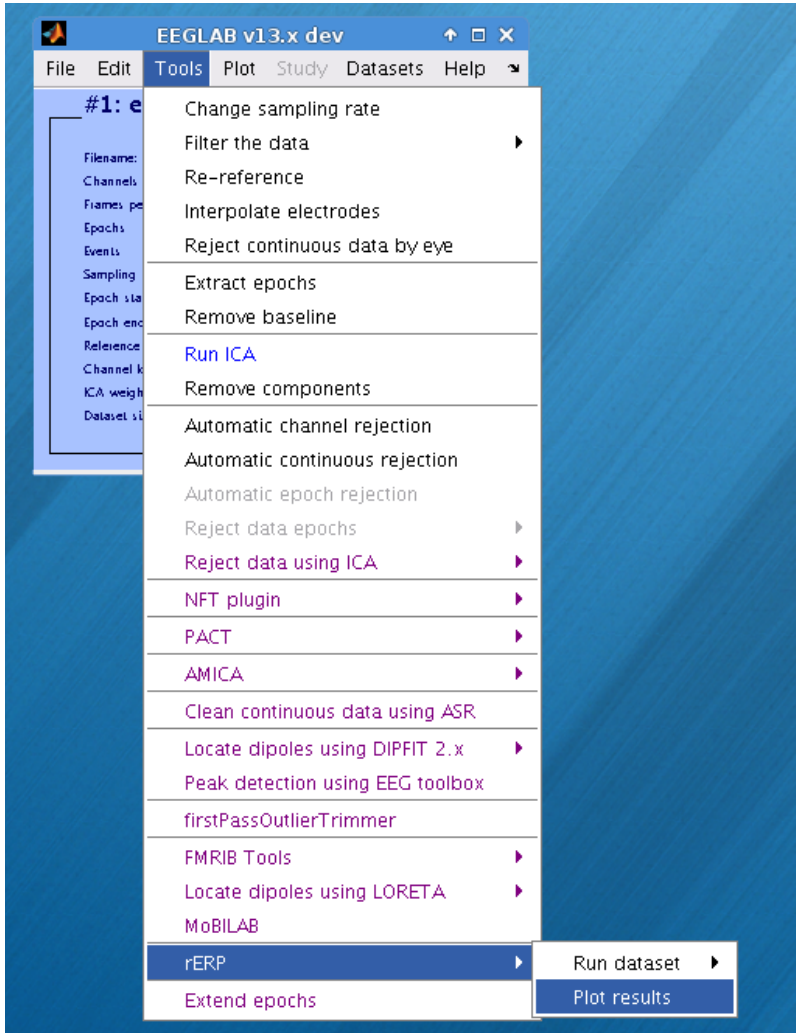
- Enable regularization (*penalized regression*)
  - *If deselected, Ordinary Least Squares*
- Select penalty function
  - *L2 Norm is fastest*
- Enable cross-validation grid search for λ
  - *If deselected, must specify λ manually*

Profile: File Operations

- Load and examine other profiles from disk
- Save the current profile for reuse with scripts
- Change the default settings for new profiles
- Run the analysis

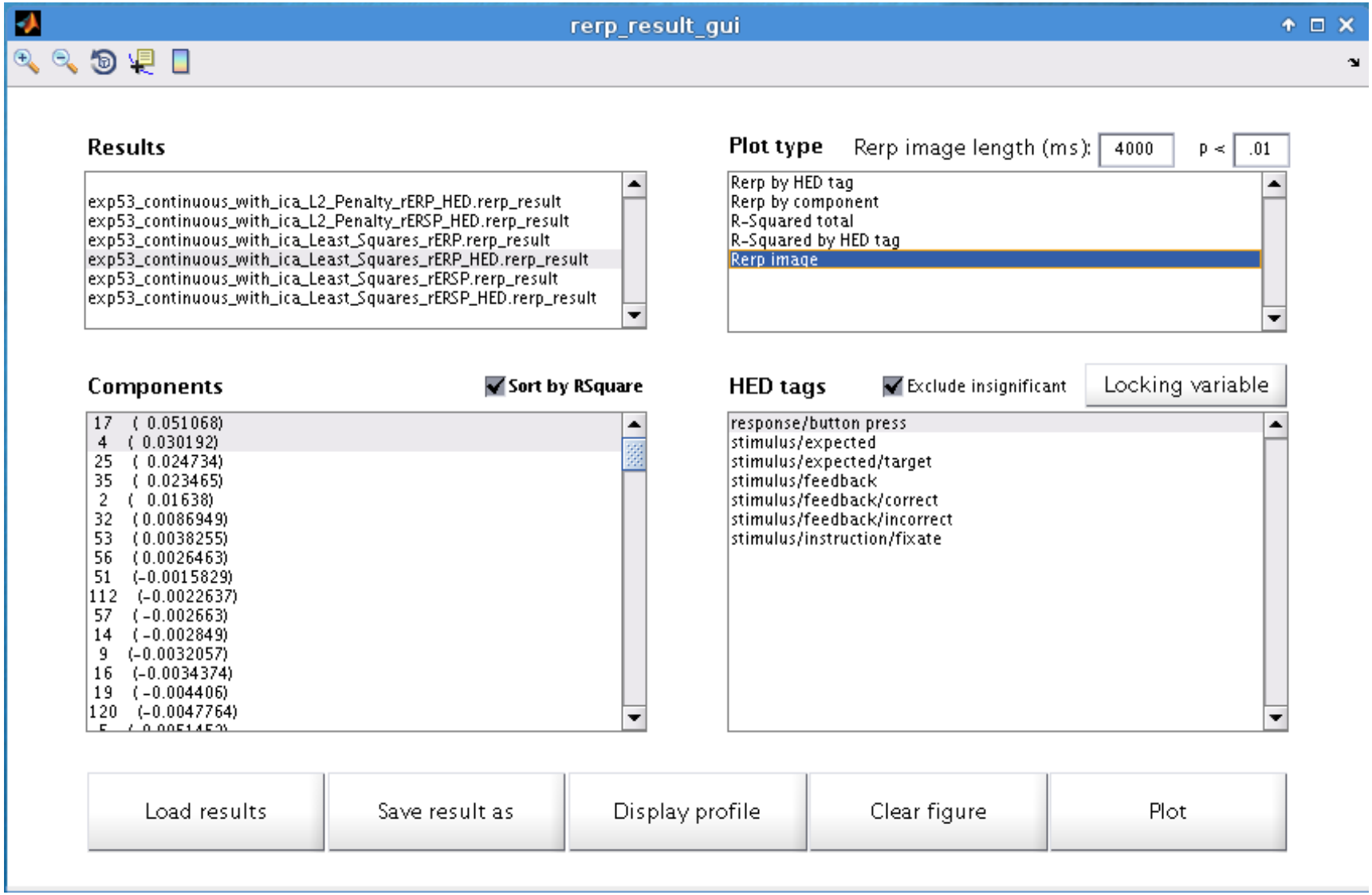
Note: Last profile used is always saved in *rerp/profiles/last.rerp_profile*

Result: GUI

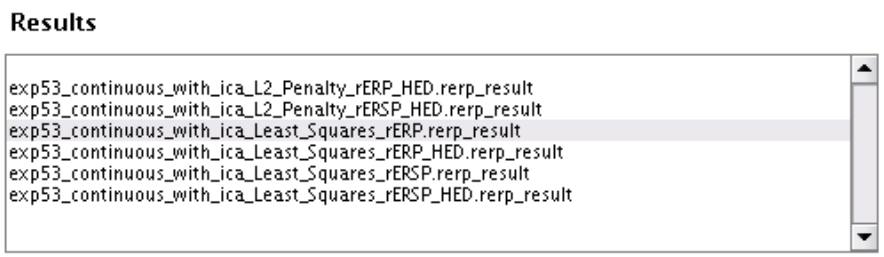


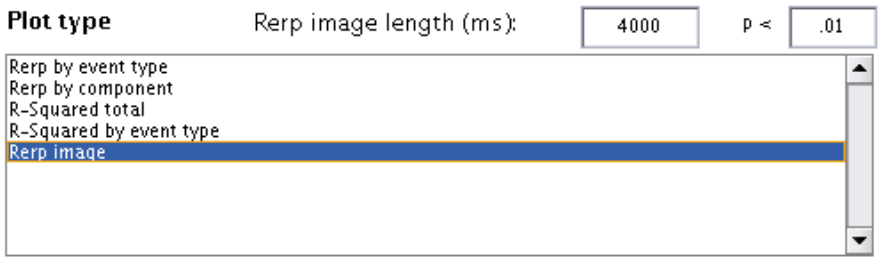
- Launch results GUI from EEGLAB or type ***rerp_results_gui*** at command line
- If scripting, RerpResult objects must be saved to disk before viewing in GUI: *rerp_result.saveRerpResult*

Result: GUI


rerp_result_gui
Results
exp53_continuous_with_ica_L2_Penalty_rERP_HED.rerp_result
exp53_continuous_with_ica_L2_Penalty_rERSP_HED.rerp_result
exp53_continuous_with_ica_Least_Squares_rERP.rerp_result
exp53_continuous_with_ica_Least_Squares_rERP_HED.rerp_result
exp53_continuous_with_ica_Least_Squares_rERSP.rerp_result
exp53_continuous_with_ica_Least_Squares_rERSP_HED.rerp_result
Plot type
Rerp image length (ms):
4000
p <
.01
Rerp by HED tag
Rerp by component
R-Squared total
R-Squared by HED tag
Rerp image
Components
Sort by RSquare
17 (0.051068)
4 (0.030192)
25 (0.024734)
35 (0.023465)
2 (0.01638)
32 (0.0086949)
53 (0.0038255)
56 (0.0026463)
51 (-0.0015829)
112 (-0.0022637)
57 (-0.002663)
14 (-0.002849)
9 (-0.0032057)
16 (-0.0034374)
19 (-0.004406)
120 (-0.0047764)
HED tags
Exclude insignificant
Locking variable
response/button press
stimulus/expected
stimulus/expected/target
stimulus/feedback
stimulus/feedback/correct
stimulus/feedback/incorrect
stimulus/instruction/fixate
Load results
Save result as
Display profile
Clear figure
Plot

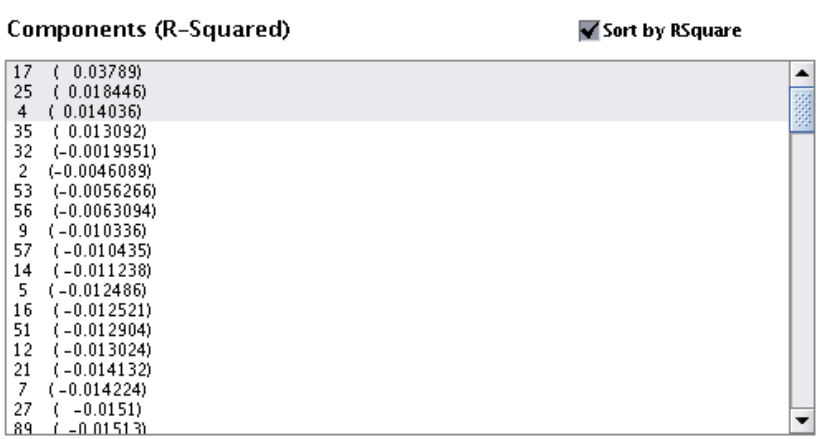
Result: Results List and Plot Type





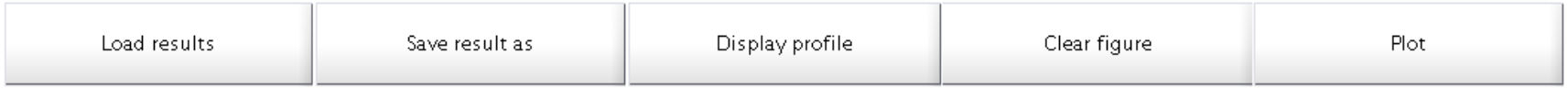
- Results list is populated from directory rerp/results and ***also*** from the path to the .set file if the 'EEG' argument is passed.
- Type of plot depends on result
- p-value threshold can be specified for statistics
- Image length for rERPimage can be adjusted

Result: Channels/ICs and Events/Tags



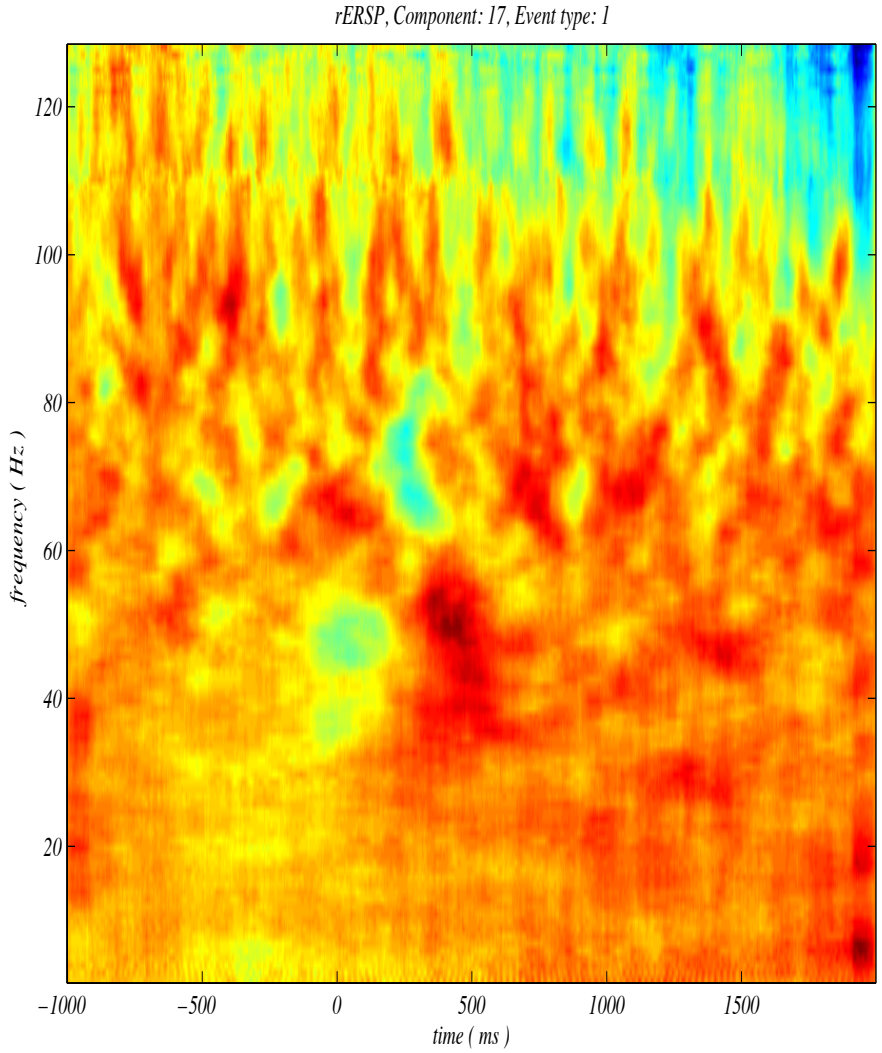
- *Multiple select* of both Channels/ICs and Events/Tags is available for most plot types
- Exclude insignificant rERP estimates based on p-value threshold of ttest of R^2 across folds
- Cycle between Locking/Sorting variable for rERPimage

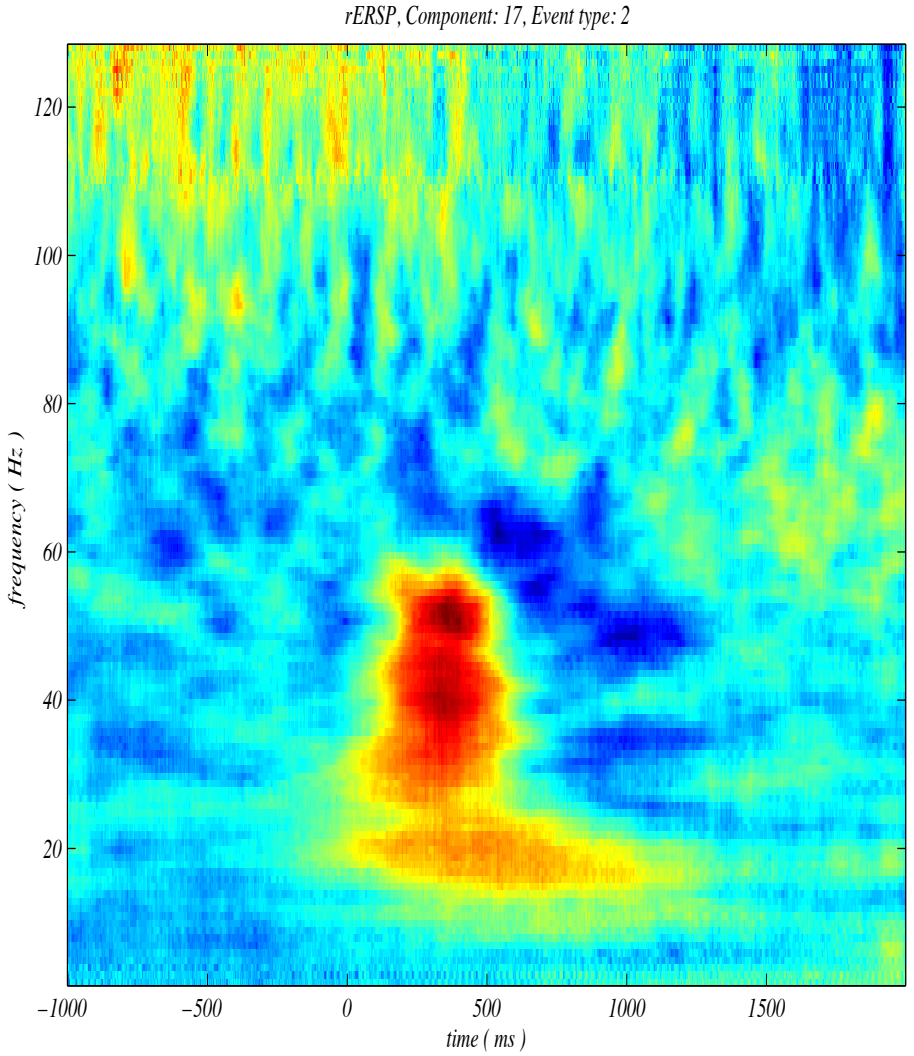
Result: Plotting and Publishing



- Load other results from disk, resave them and view their profiles
- Plot on same graph, possibly from different plot types and different Results
- Right click on the axes or image to save only that graph

Questions ?


rERSP, Component: 17, Event type: 1
120
100
80
60
40
20
frequency (Hz)
−1000
−500
0
500
1000
1500
time (ms)


rERSP, Component: 17, Event type: 2
120
100
80
60
40
20
frequency (Hz)
−1000
−500
0
500
1000
1500
time (ms)