Single-Trial Estimates

BIAC Methods Journal Club

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March 18th, 2013

Goals

- Mumford et al., 2012
  - Theory for single-trial estimates
- Creating single-trial three column files
- Setting up the FSL model
- Running featquery to extract single-trial estimates
- Considerations for data exclusion

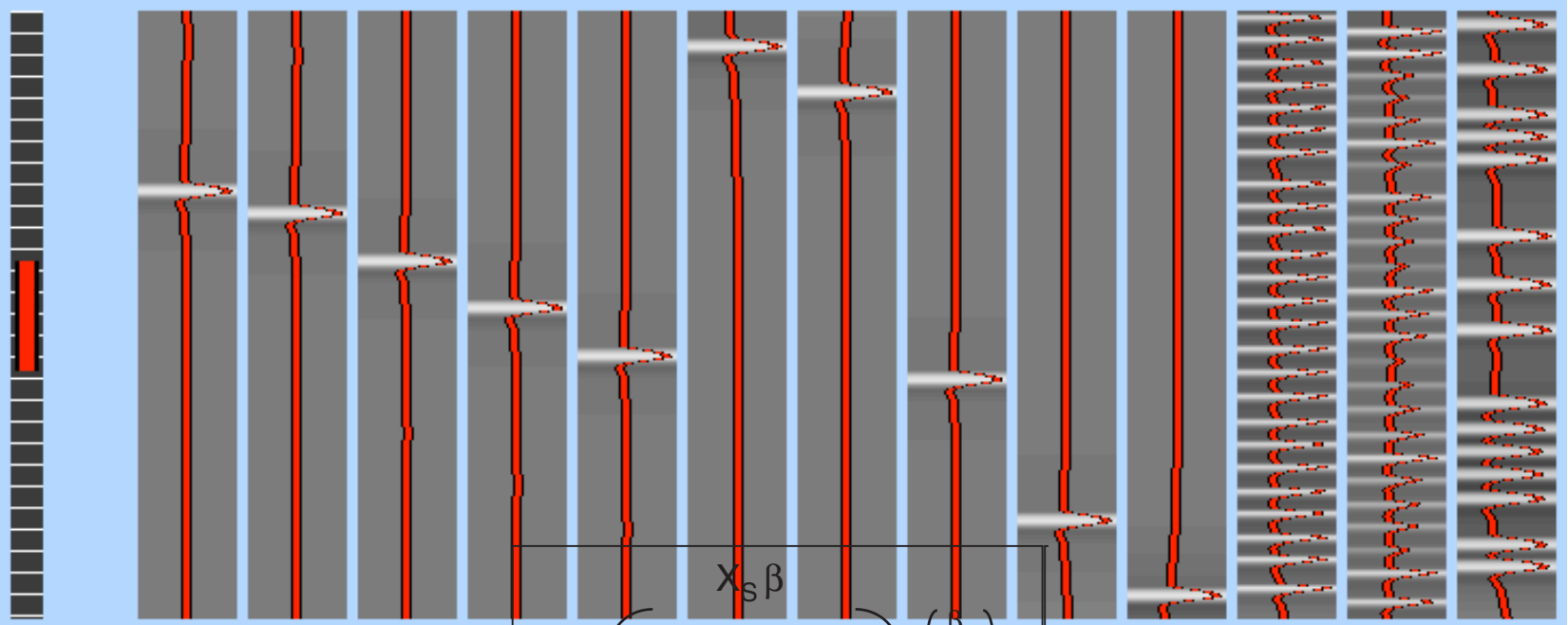
Mumford et al., 2012

- The problem:
  - Activations can be accurately separated for
    - Blocked designs
    - Slow event-related designs
  - More difficult for fast event-related designs
    - Hard to differentiate adjacent trials

Mumford et al., 2012

- The test:
  - 8 different methods for estimating single trials
  - Tested on real and simulated data

1. Beta-series regression



$$X_S \beta$$

$$\begin{pmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_N \end{pmatrix}$$

		pe1	pe2	pe3	pe4	pe5	pd6	pd7	pd8	pd9	pd10	pic nu	response	other	trial
C1	pe1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	pe2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C3	pe3	0	0	1	0	0	0	0	0	0	0	0	0	0	0
C4	pe4	0	0	0	1	0	0	0	0	0	0	0	0	0	0
C5	pe5	0	0	0	0	1	0	0	0	0	0	0	0	0	0
C6	pd1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C7	pd2	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C8	pd3	0	0	0	0	0	0	0	1	0	0	0	0	0	0
C9	pd4	0	0	0	0	0	0	0	0	1	0	0	0	0	0
C10	pd5	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Other Options

- 3 (LS but change regression structure)
  - Just get the peak (take TP at 6s)
  - Just get peri-peak (take TPs at 4-6s)
  - Separate GLM (1 regressor for trial of interest, everything else in nuissance)

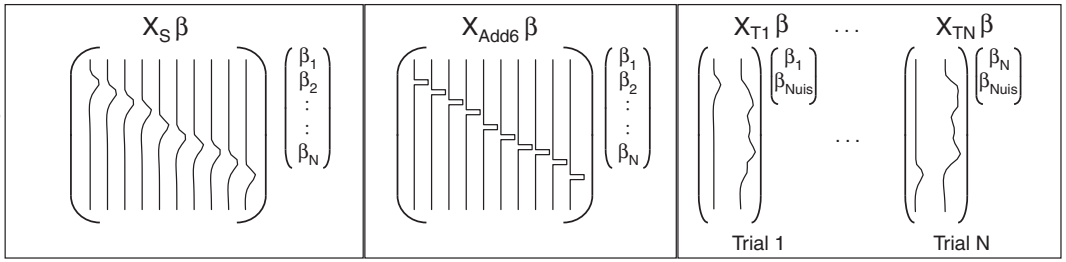
- 3 (additional regularization to change the estimation of the ridge parameter)
  - Partial least squares
  - Support vector regression
  - Ridge regression (2x)

Least Squares-All
Ridge Regression (2x)
Partial Least Squares
Support Vector regression

Add 6

Least Squares-Separate

Xβ options



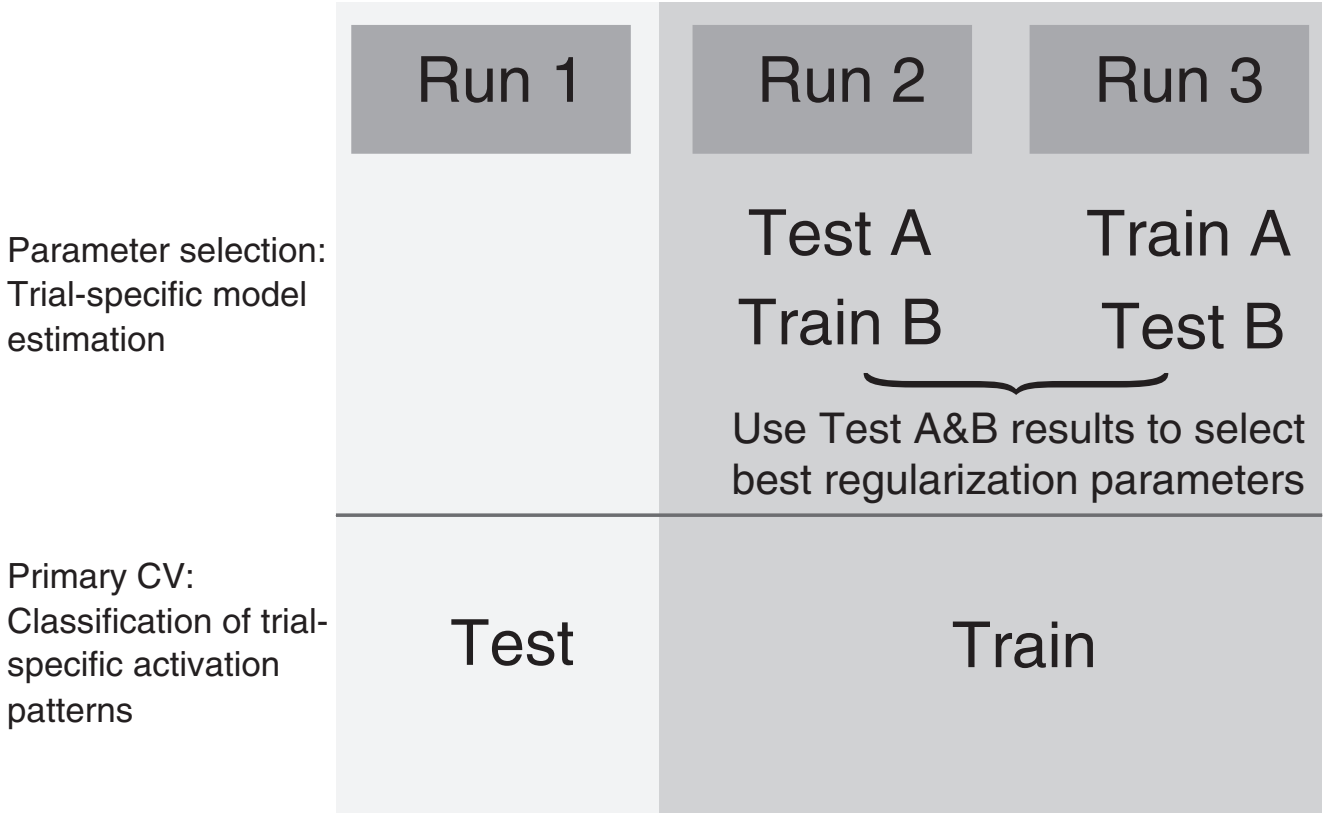
Approaches

Model	Estimation	Regularization parameter	Name
$Y=X_s\beta+\varepsilon$	Least Squares	None	LS-A
$Y=X_s\beta+\varepsilon$	Ridge Regression	λ: Hoerl-Kennard	Ridge (HKB)
$Y=X_s\beta+\varepsilon$	Ridge Regression	λ: 2 fold CV	Ridge (CV)
$Y=X_s\beta+\varepsilon$	Partial Least Squares	#components: 2 fold CV	PLS
$Y=X_s\beta+\varepsilon$	Support Vector Regression	e & C: 2 fold CV	SVR
$Y=X_{Add6}\beta+\varepsilon$	Least Squares	None	Add6
$Y=X_{Add4\text{-}6}\beta+\varepsilon$	Least Squares	None	Add4-6
$Y=X_{Ti}\beta+\varepsilon$	Least Squares	None	LS-S

Simulation Analysis

- Two task types
- Outcome is cross-validation
  - Train on run 2 and 3; test on run 1 (I think)
- 500 simulations
  - 12 different designs
    - Varied by SNR and collinearity
      - Shorter ITIs = more collinearity

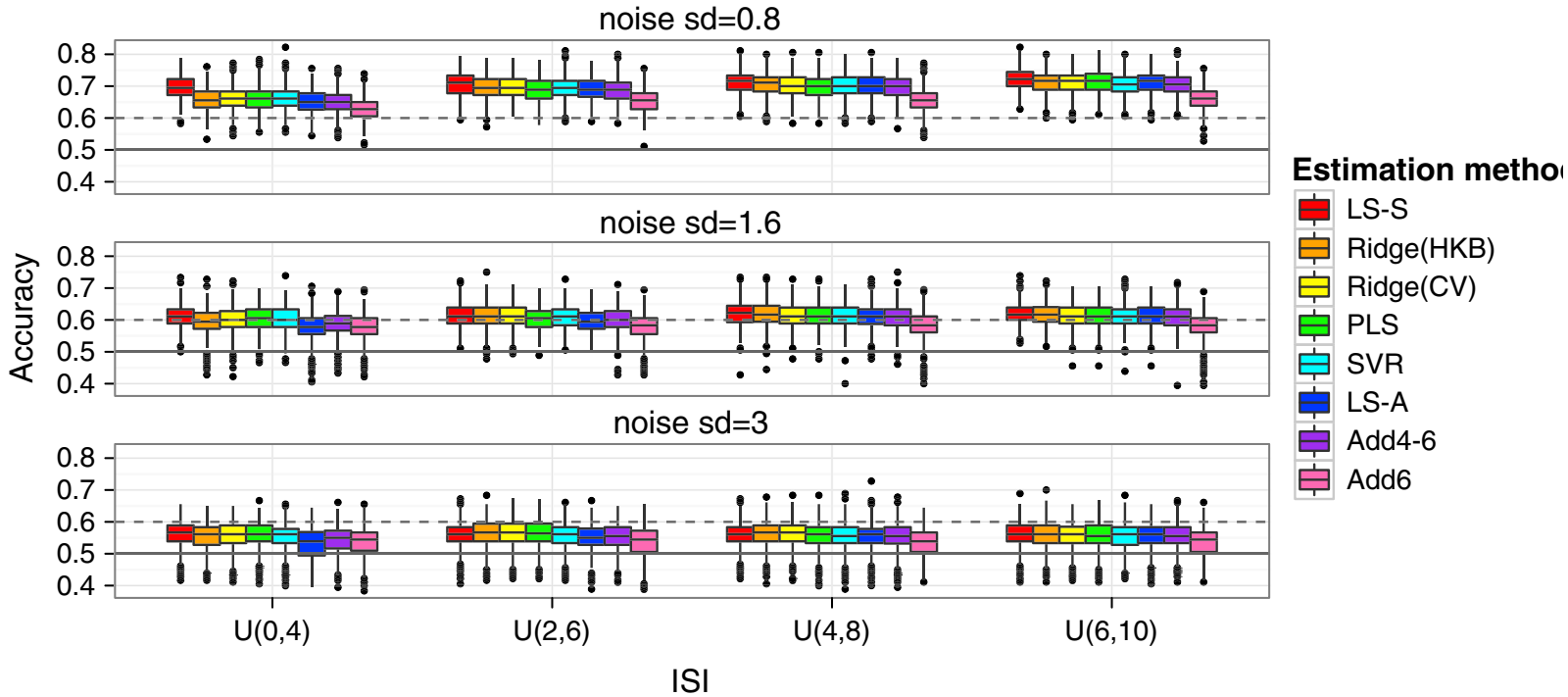
Double Cross-Validation



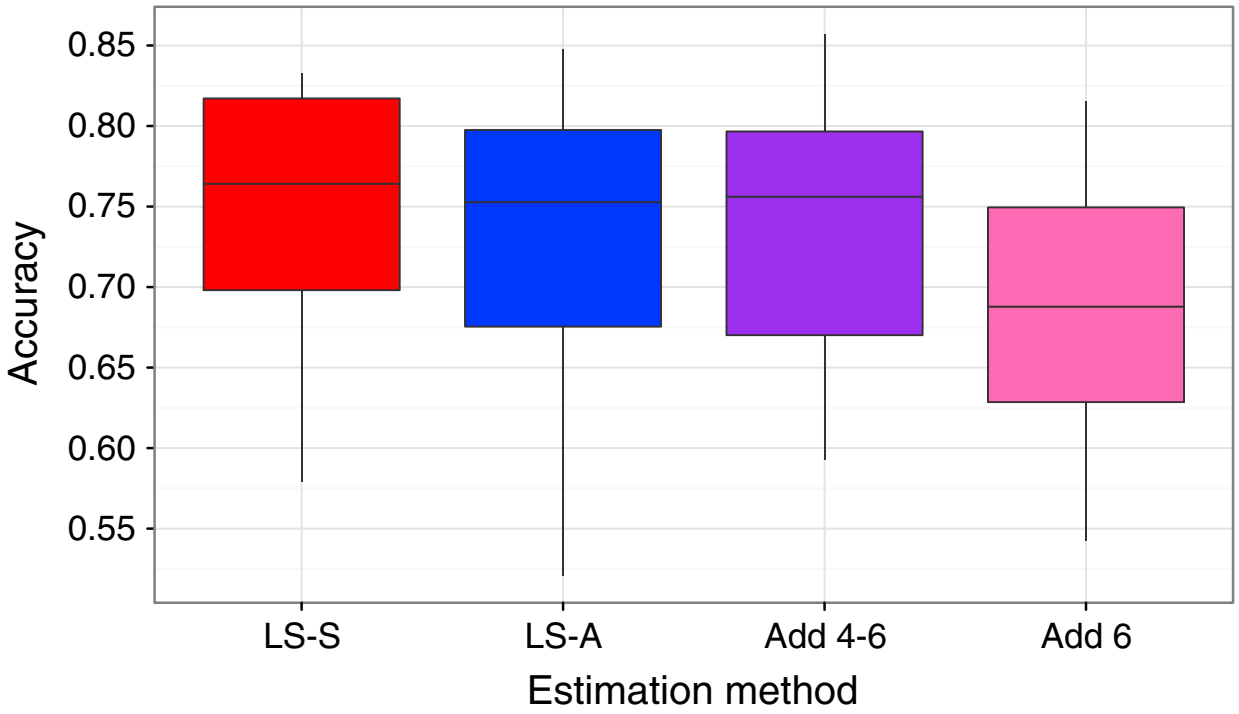
Real Data Analysis

- Read plain words, mirrored words, decide whether it is living or non-living
- Only used LS-A, Add6, Add4-6 and LS-S
  - From simulation performance: LS-S > LS-A > Add6

Results: Simulation



Results: Real Data



Take Home Points

- Increase ITIs to decrease collinearity not super important depending on SNR.
- LS-S approach performs at least as well and maybe better than other analysis approaches.
- Add6 approach performed worst.

Implementation

- Create one three column file for the trial of interest and one that includes all the trials but the trial of interest. You will need these two files for each of your trials.
  - Behavioral File: Example_run_file.rtf
  - Three-column script: three_column_iterative.rtf

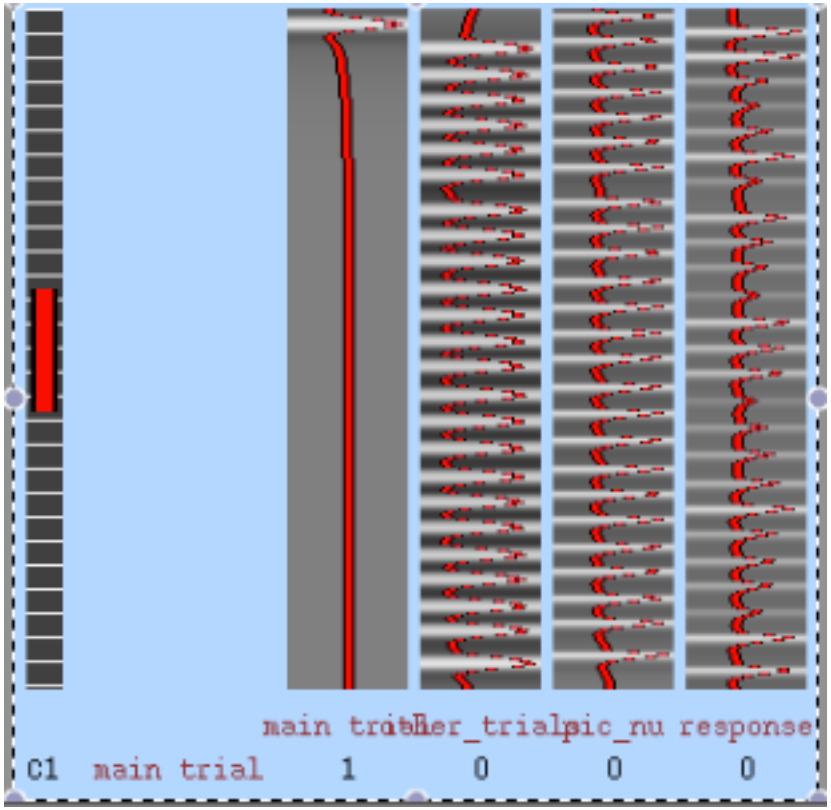
Behavioral File

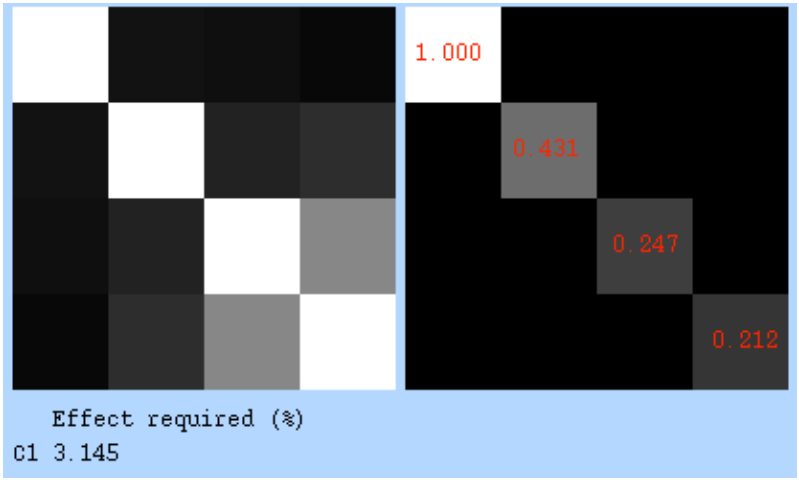
2840.000	0.000	0.000	0.017	2.017
1463.000	1.000	1.000	20.170	22.170
9622.000	-1.000	0.000	41.961	43.961
8400.000	1.000	1.000	62.759	64.759
1205.000	-1.000	0.000	83.524	85.524
6313.000	-1.000	0.000	103.710	105.710
6150.000	0.000	0.000	124.922	126.922
2216.000	1.000	0.000	154.291	156.291
5450.000	1.000	0.000	175.007	177.007
3266.000	-1.000	1.000	196.037	198.037
1650.000	1.000	0.000	219.482	221.482
9571.000	-1.000	1.000	241.074	243.074
8031.000	1.000	0.000	262.700	264.700
3550.000	-1.000	1.000	283.383	285.383
1722.000	1.000	0.000	307.341	309.341
8340.000	1.000	1.000	329.083	331.083
7380.000	-1.000	1.000	351.304	353.304
7179.000	0.000	0.000	375.097	377.097
9630.000	-1.000	0.000	395.796	397.796
9500.000	-1.000	0.000	417.024	419.024
5510.000	0.000	0.000	439.609	441.609
5626.000	1.000	1.000	459.878	461.878
2190.000	0.000	0.000	482.281	484.281
6021.000	-1.000	1.000	502.401	504.401
7220.000	1.000	1.000	529.305	531.305

FSL

- Run your first levels as usual.
  - Template file: ST_iterative_template.rtf

Example Outputs





FSL

- Run your first levels as usual.
  - Template file: ST_iterative_template.rtf
  - First-level script: first_level.rtf
- Run featquery using your ROI of interest on your first levels (e.g., the first level analysis you ran for every single trial)
  - Featquery_biac.rtf
- Consolidate your featquery trials as you would normally

Data Clean Up

- Add motion parameters
- Run regression diagnostics to find outliers
- Get rid of trials where there was a bad timepoint
  - Find_bad_timepoint_final.m