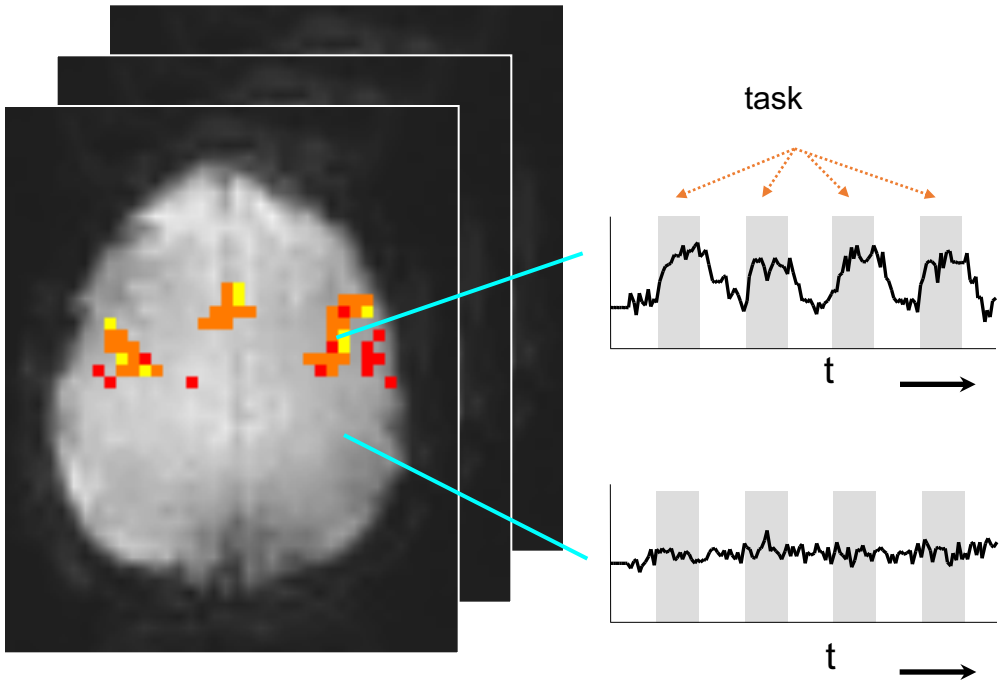
fMRI data analysis

Part 2: Model-based analysis
(General Linear Model, GLM)

How do we decide what areas are “active”?



fMRI data analysis

Model-based

- Linear regression
  - Cross-correlation
  - Multiple linear regression
  - Deconvolution
- Nonlinear regression *(i.e. curve fitting)*

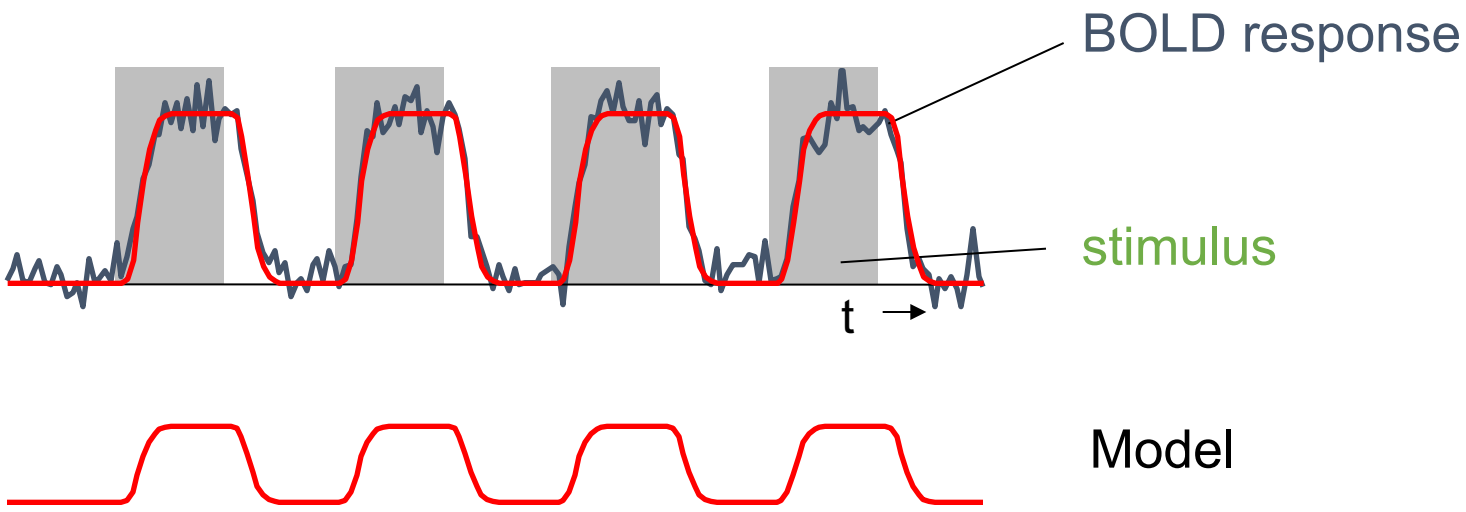
"Model-free" / data-driven

- PCA *(Principal Component Analysis)*
- ICA *(Independent Component Analysis)*

What assumptions are you willing to make?

Model-based data analysis

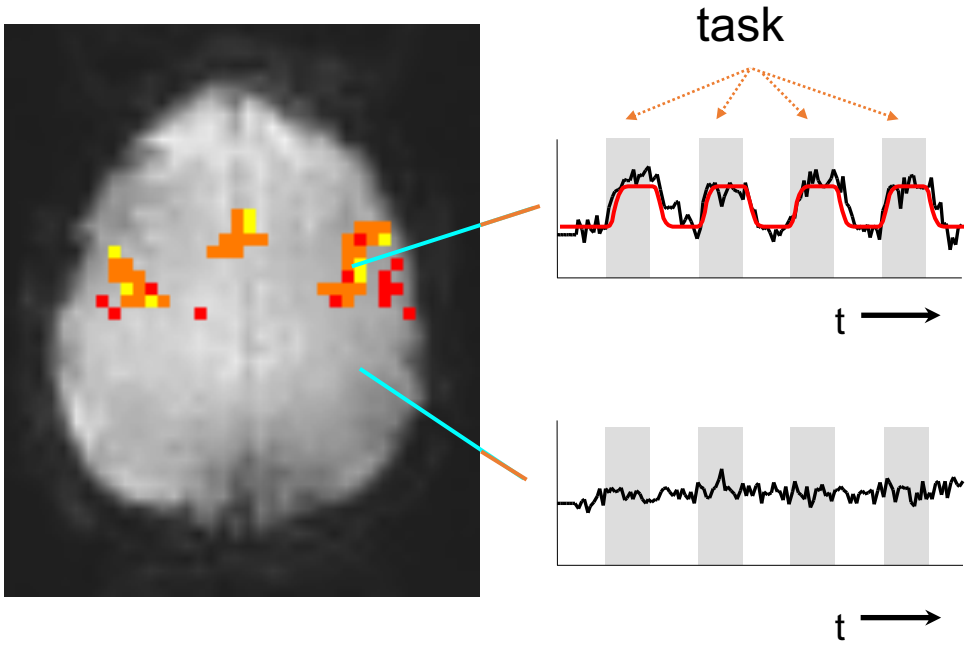
1. Signal Model (what are we looking for)
2. Fit this model
3. Look how good the model fits (statistics)



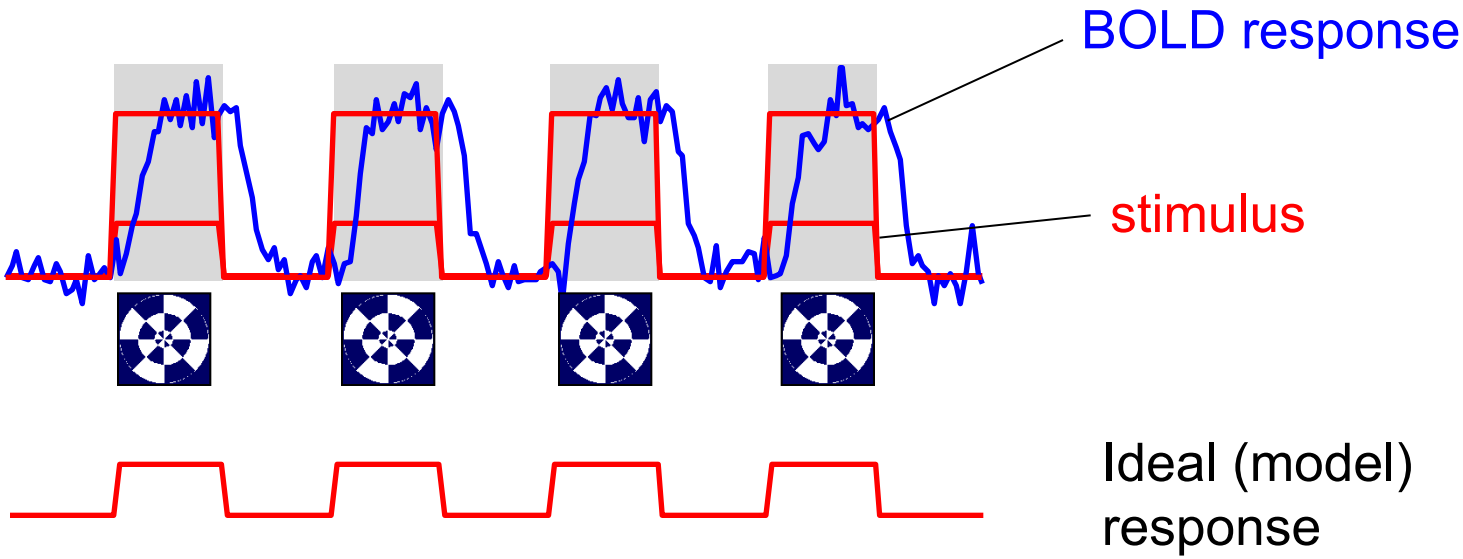
fMRI data analysis

Univariate analysis

Treat each voxel time course independently



Regression analysis – task vs. control



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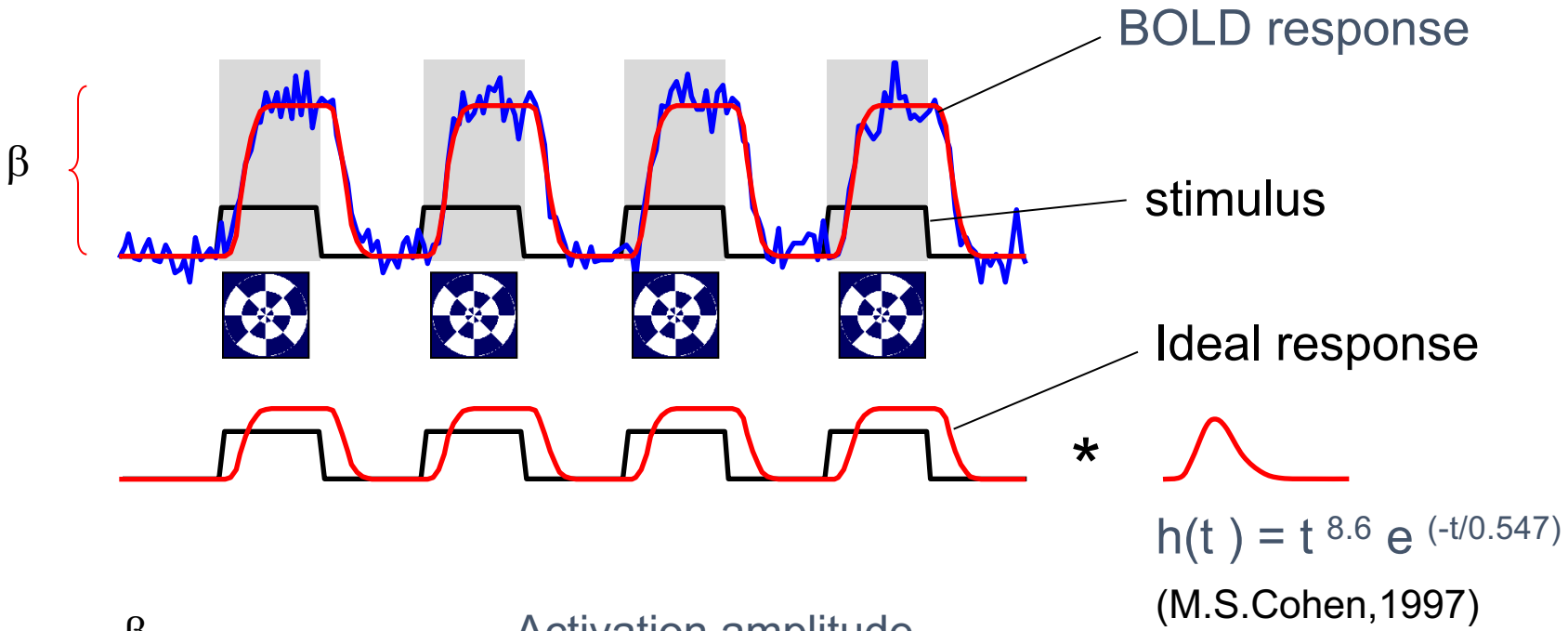
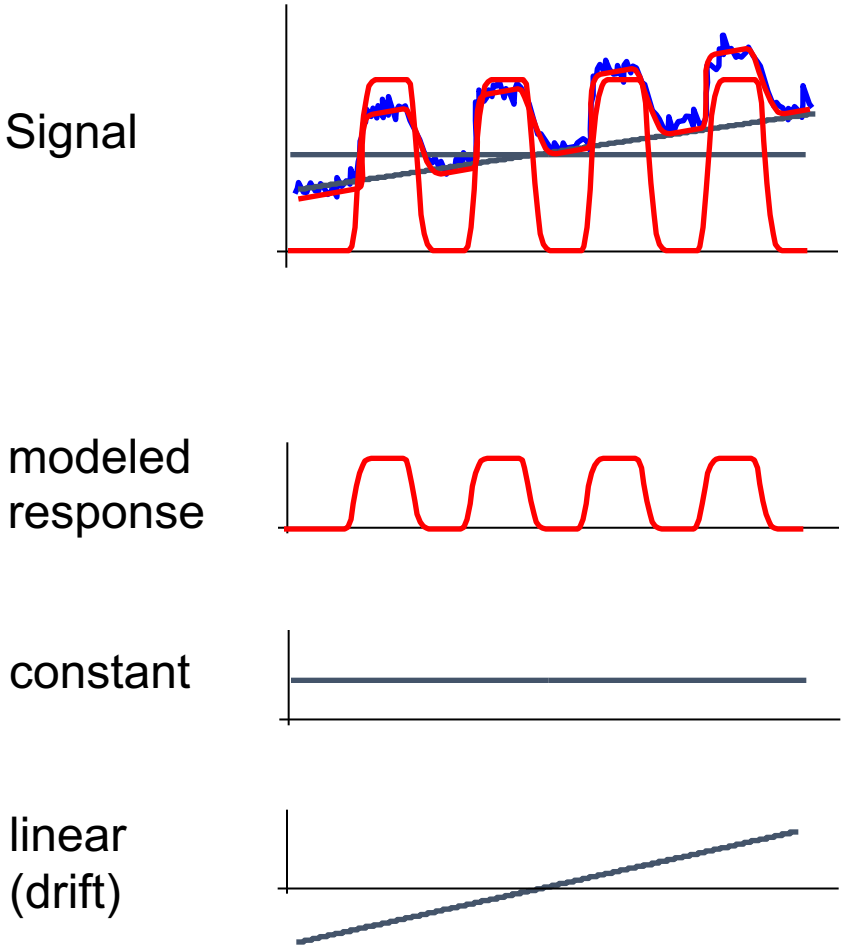


β – Activation amplitude

t-stat, CC, … – how well does it fit?

Other factors we may need to model

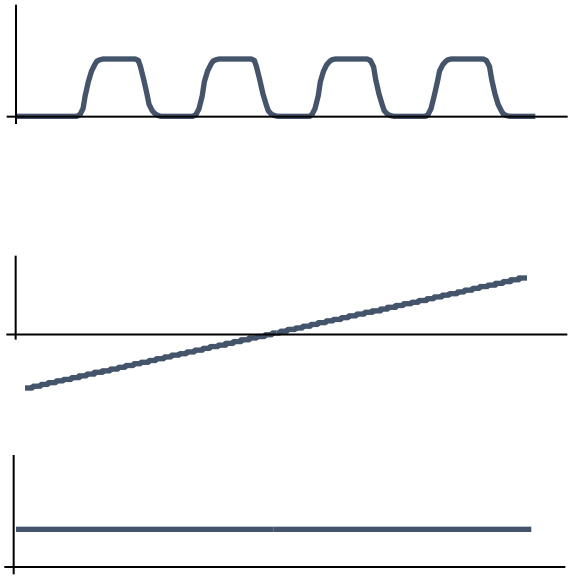


"Nuisance Variables"

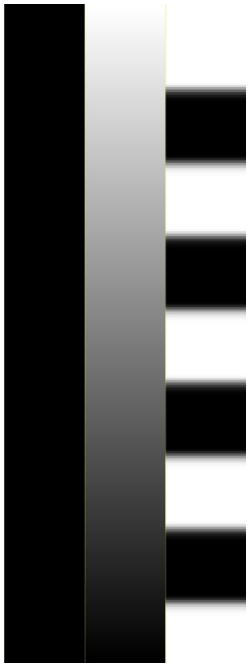
- Constant
- Drift
- Motion
- Cardiac fluctuations
- Respiration
- …

Baseline parameters

Regressors – 1 task vs. control



Design Matrix

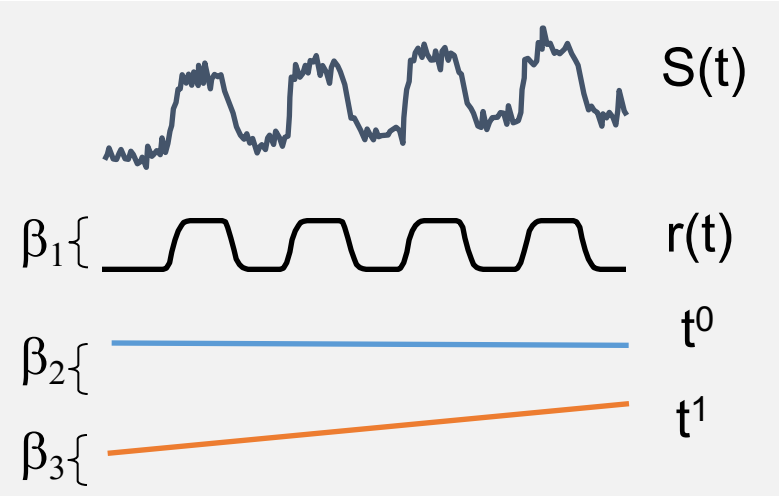


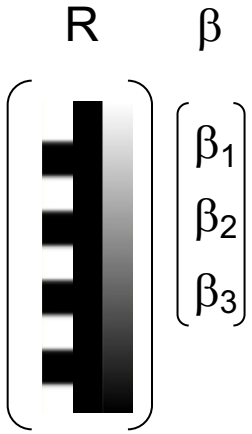
The Math

$$S(t) = \beta_1 r(t) + \beta_2 + \beta_3 t + \eta$$

$$S = R\beta + \eta$$

$$\beta = (R^T R)^{-1} R^T S$$



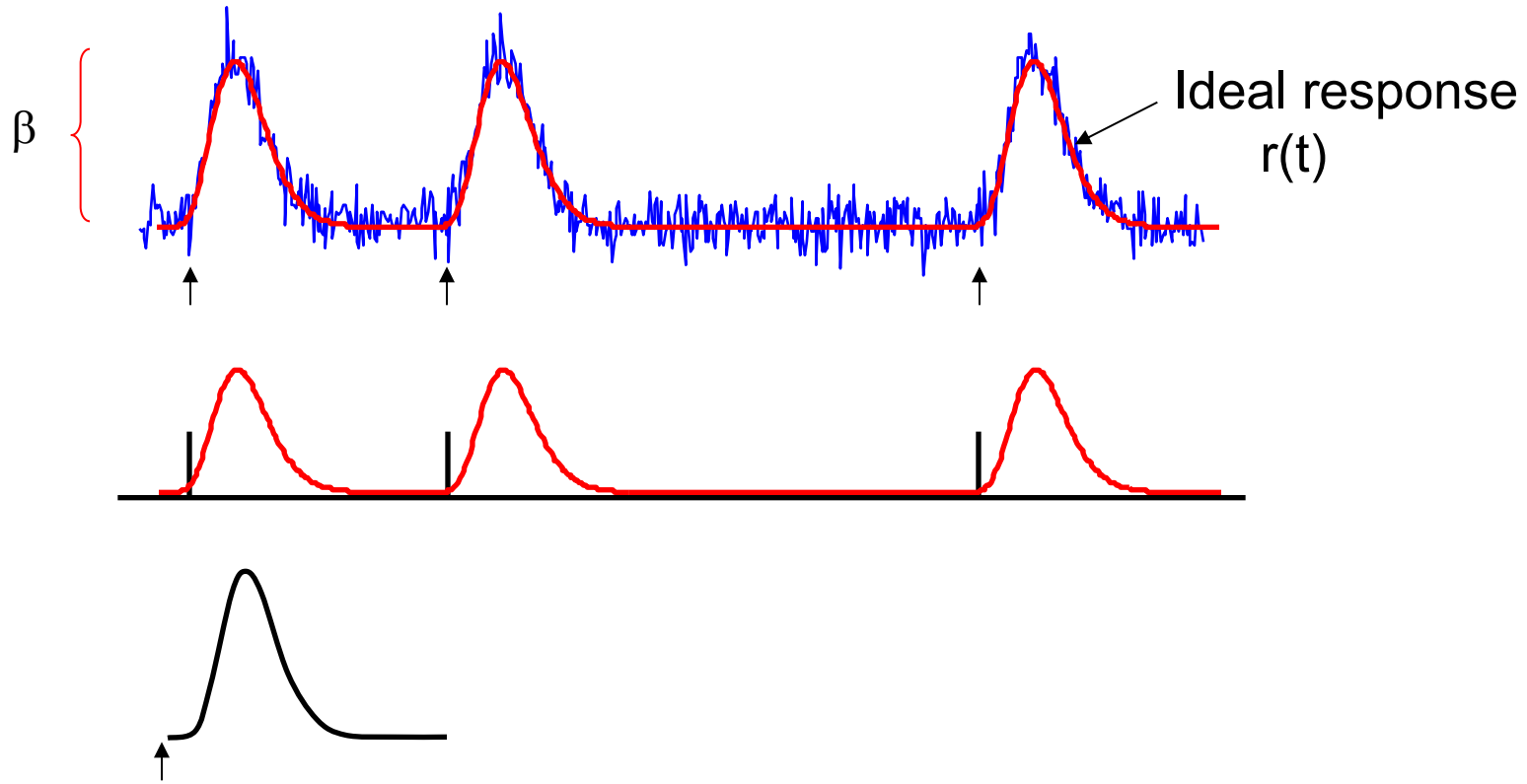


$$t_{\beta_i} = \frac{\beta_i}{\sigma_{\beta_i}} = \frac{\beta_i}{\sigma_\eta \sqrt{(R^T R)^{-1}_{i,i}}}$$

i = the row/column in the matrix corresponding to the regressor of interest (in this example i=1)

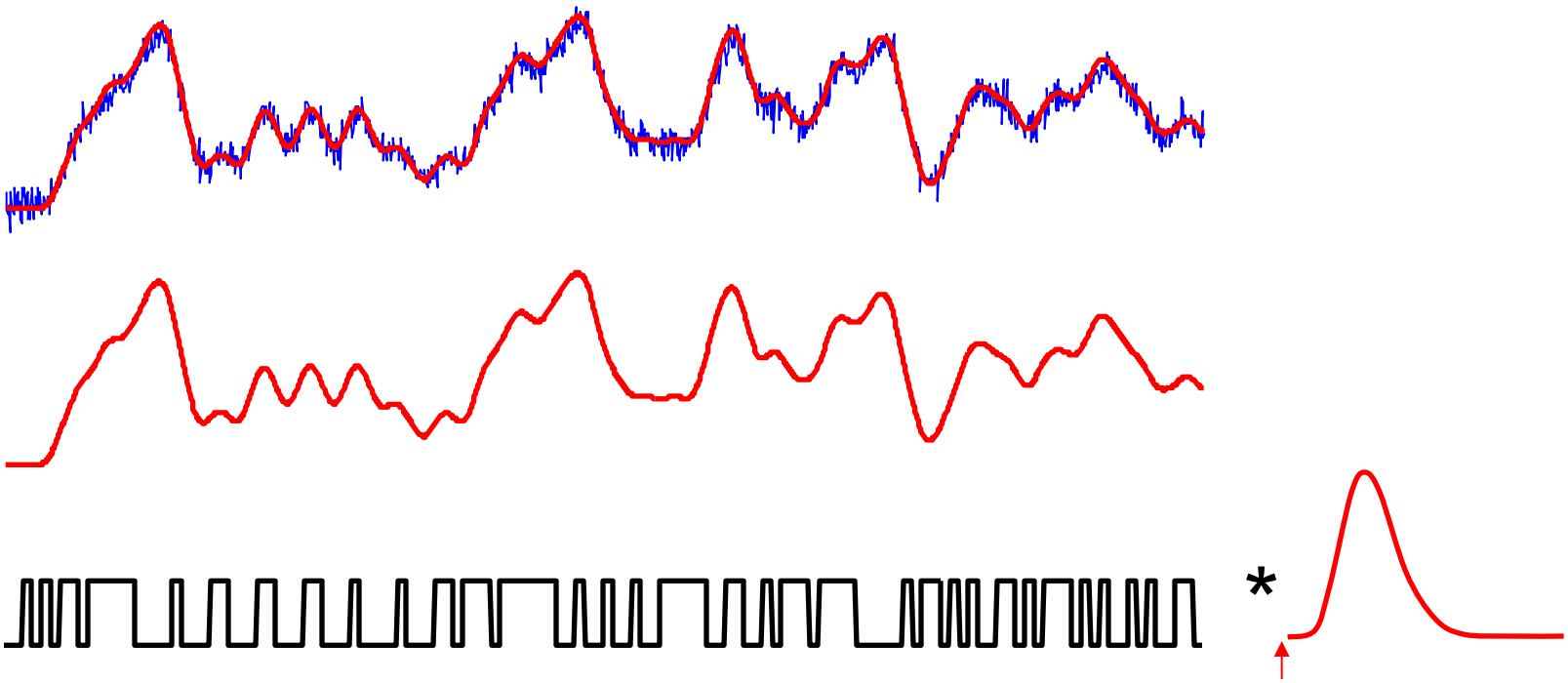
Regression analysis – 1 task vs. control

Event-related design



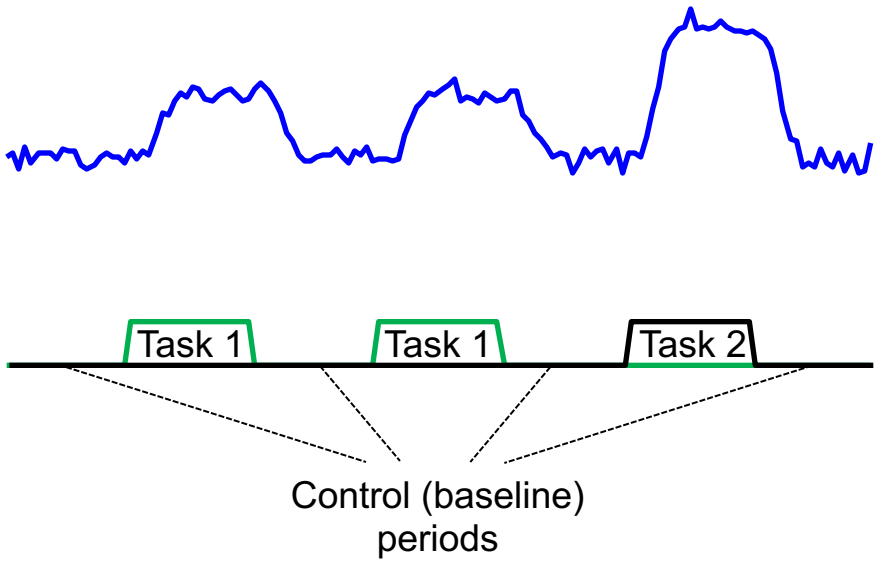
Regression analysis – 1 task vs. control

Event-related design – varying ISI*



* ISI = inter-stimulus interval

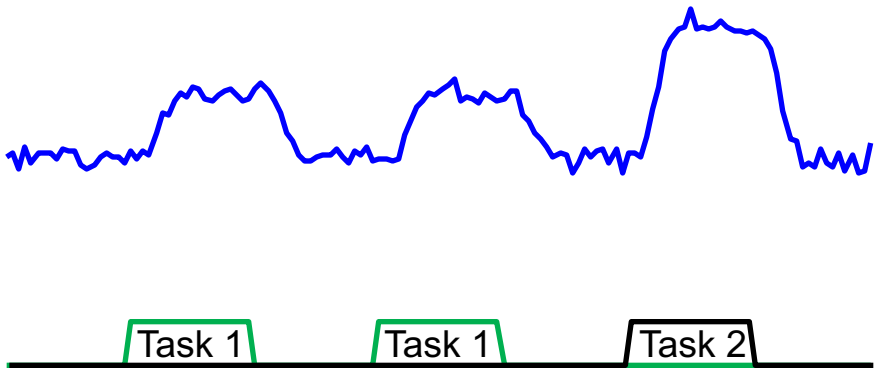
Regression – Multiple conditions



Here is an example w/ 3 conditions:

- Task 1
- Task 2
- “Control”

Regression – Multiple conditions



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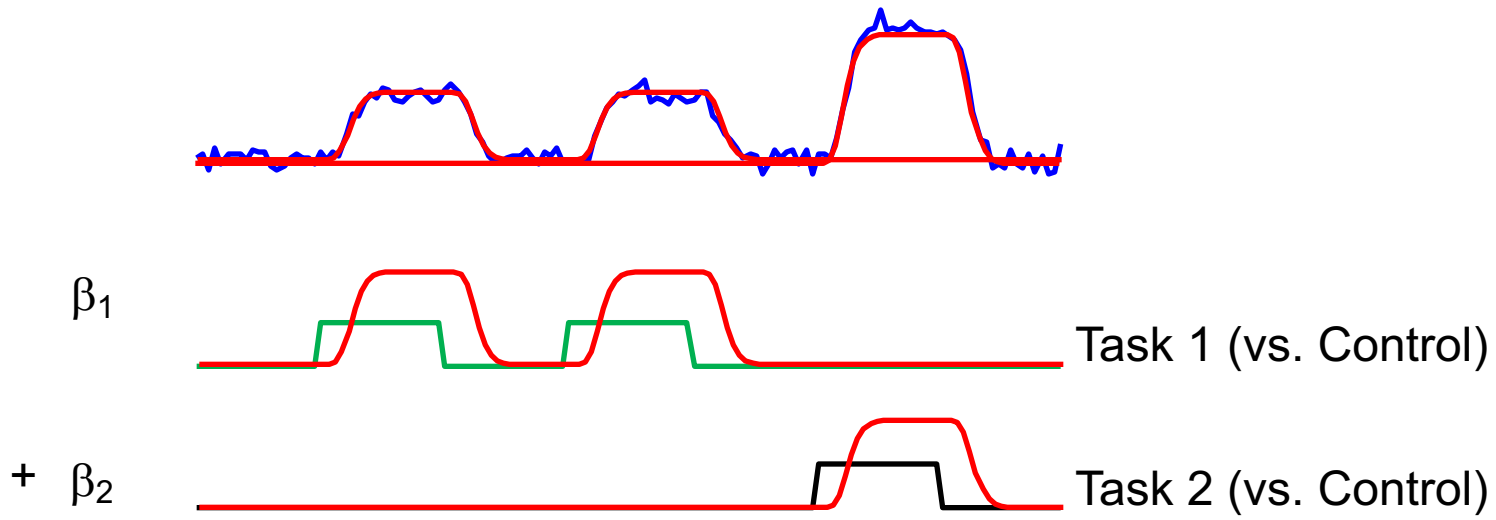
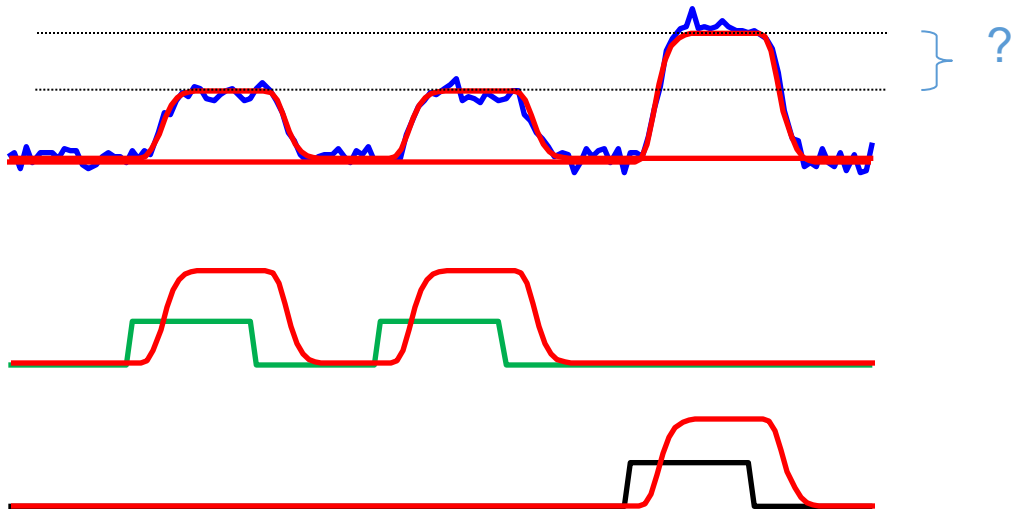
Regression – Multiple conditions



Here is an example w/ 3 conditions:

- Task 1
- Task 2
- “Control”

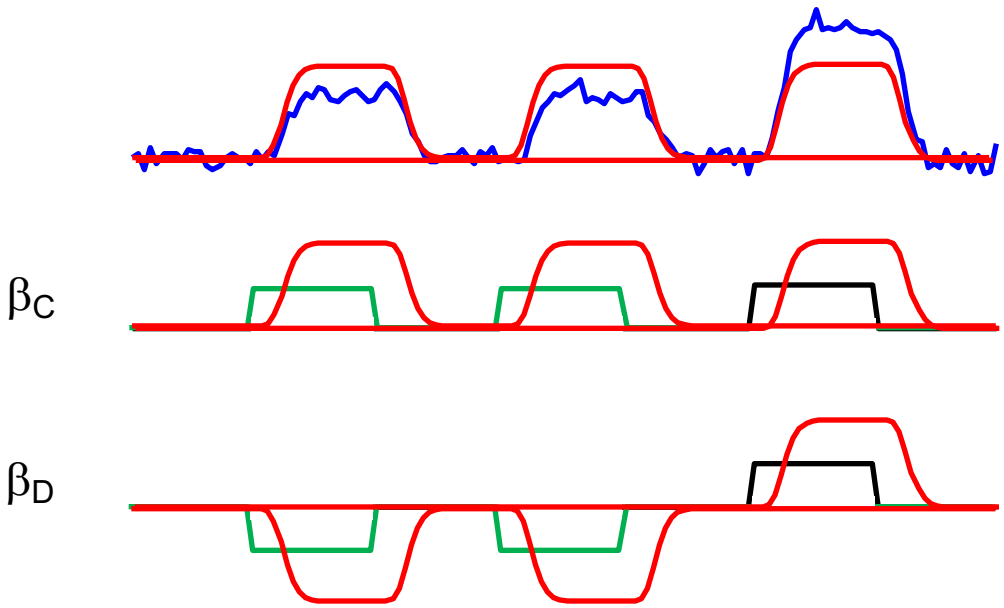
General Linear Tests (GLTs)



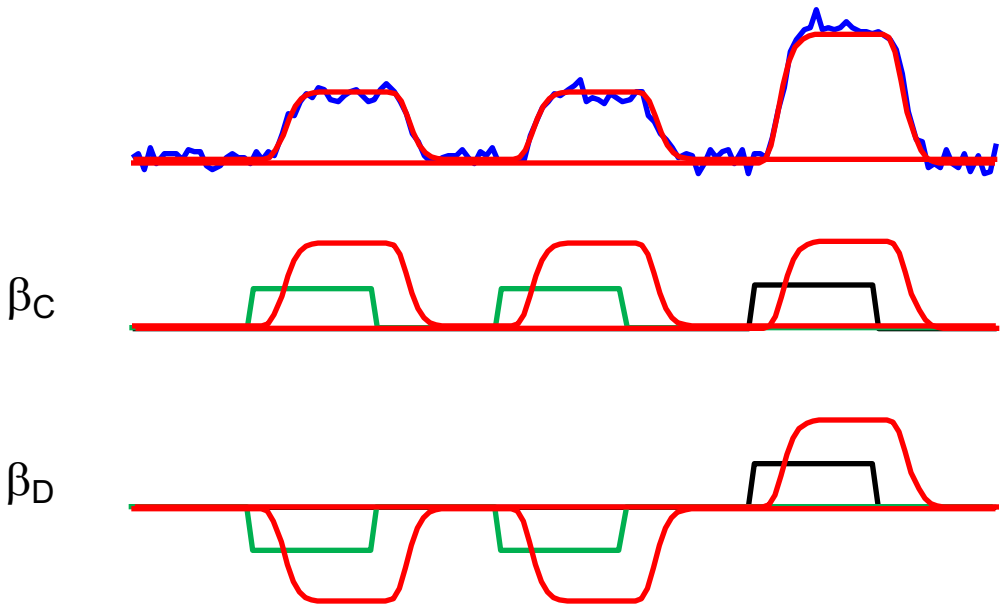
test: $\beta_1 \neq \beta_2$ ➡ $\beta_1 - \beta_2 \neq 0$

$$\begin{bmatrix} 1 & -1 \end{bmatrix}$$

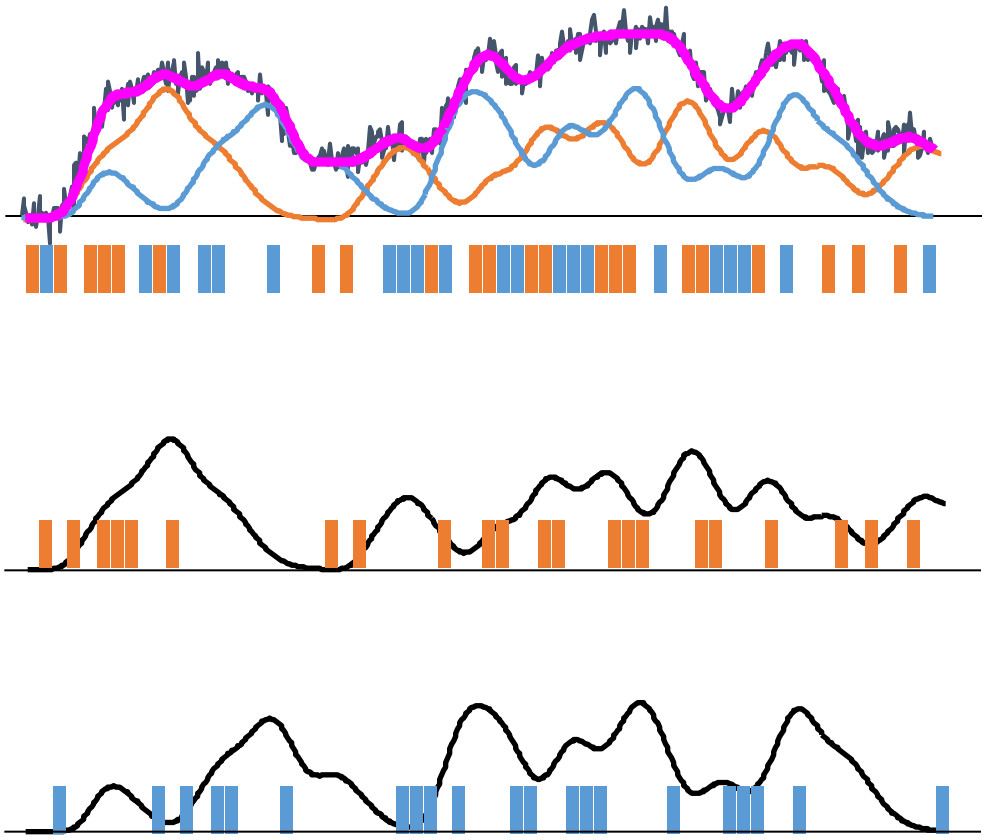
Alternate way to model responses



Alternate way to model responses



Regression – Multiple conditions



Task A

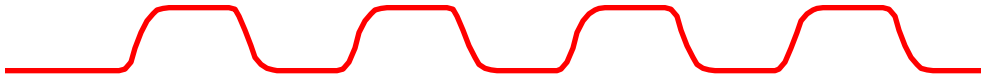
Task B

1. Create stimulus vector for each stimulus/task
2. Convolve with ideal HRF
3. Fit regressors to data

Recap

1. Create stimulus vector (task timing) for each stimulus/task

2. Convolve with ideal HRF → regressors



3. Fit regressors to data

OR

1. Determine task timing
2. Input to AFNI, specifying response function model (e.g. BLOCK, GAM, …)