

# Retrieving the HRF in resting state fMRI: methodology and applications

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## HRF retrieval

We assume that resting-state brain dynamics is driven by spontaneous events which can be seen as a point process. A linear time invariant system is used to model the relationship between the spontaneous neural event and BOLD response, i.e. the BOLD signal  $y(t)$ , is modeled as the convolution of neural state  $x(t)$  and HRF  $h(t)$ :

$$y(t) = s(t) \otimes h(t) + c + \varepsilon(t)$$

The timing set  $S$  of resting state BOLD spikes is detected as a point process:

$$S\{i\} = t^i, y(t^i) \geq \mu \& y(t^i) \geq y(t^i - \tau) \& y(t^i) \geq y(t^i + \tau)$$

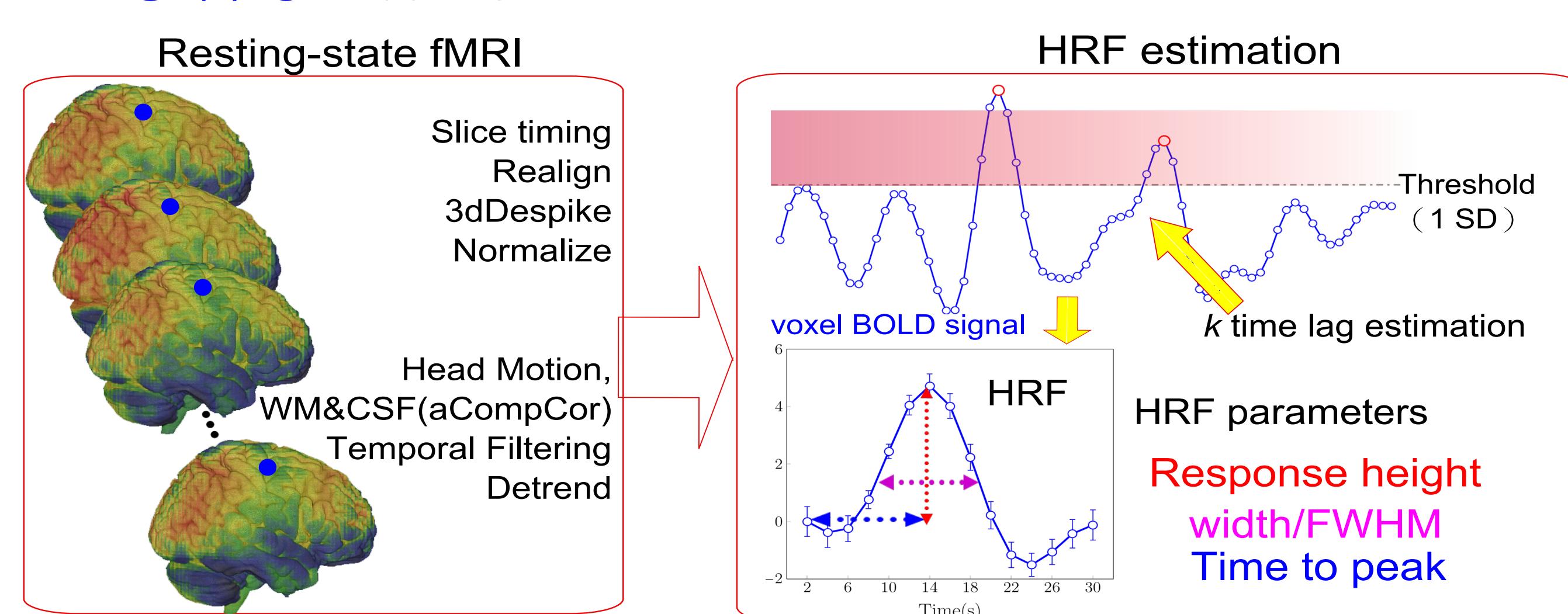
The peak of BOLD signal lags behind the peak of neural activation ( $k$  seconds). we choose the one for which the noise squared error:

$$|y(t) - \hat{s}(t) \otimes h(t)|^2$$

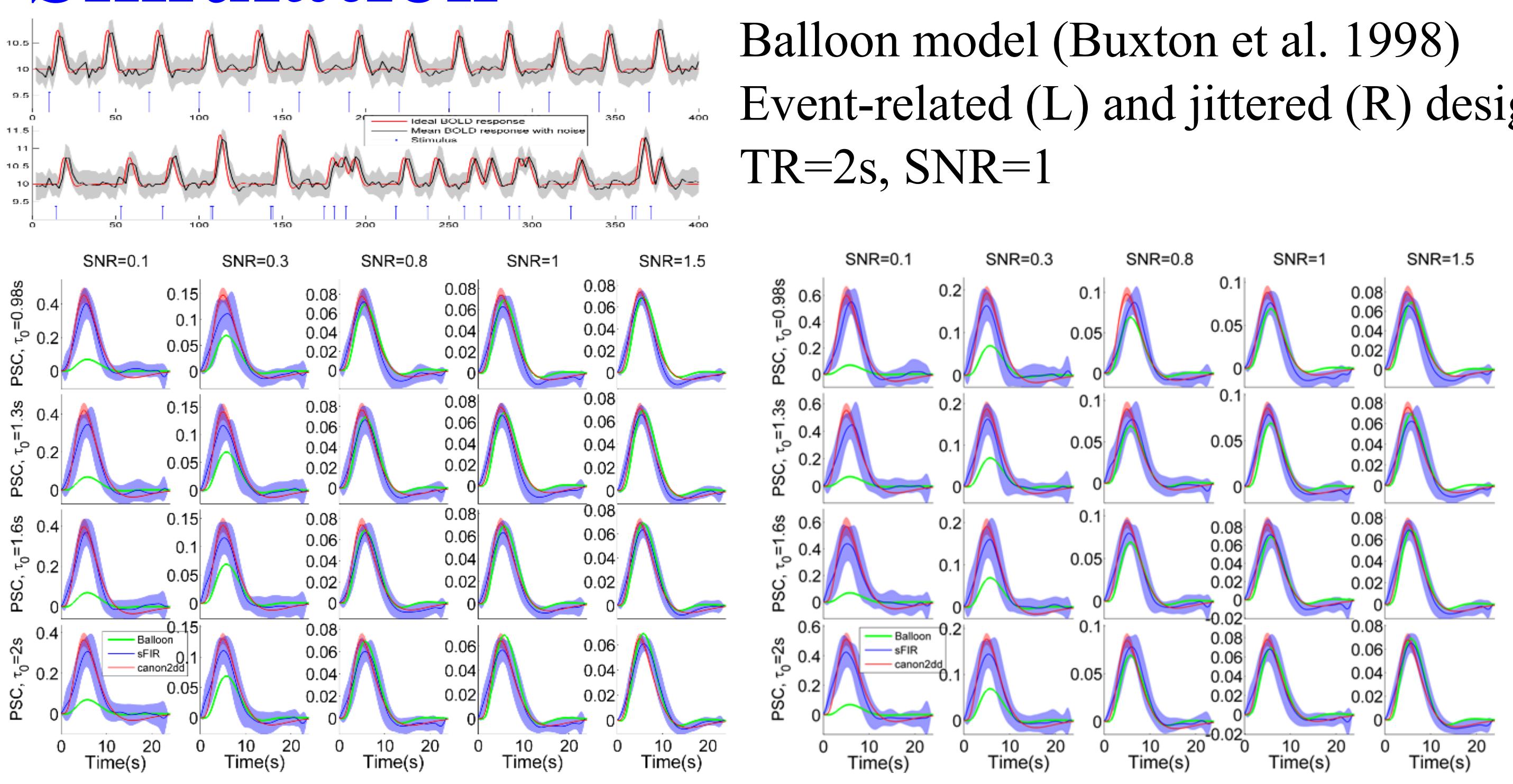
is smallest, indicating the spontaneous event onset. AR(p) noise model.

HRF modeled as canonical with 2 derivatives or FIR

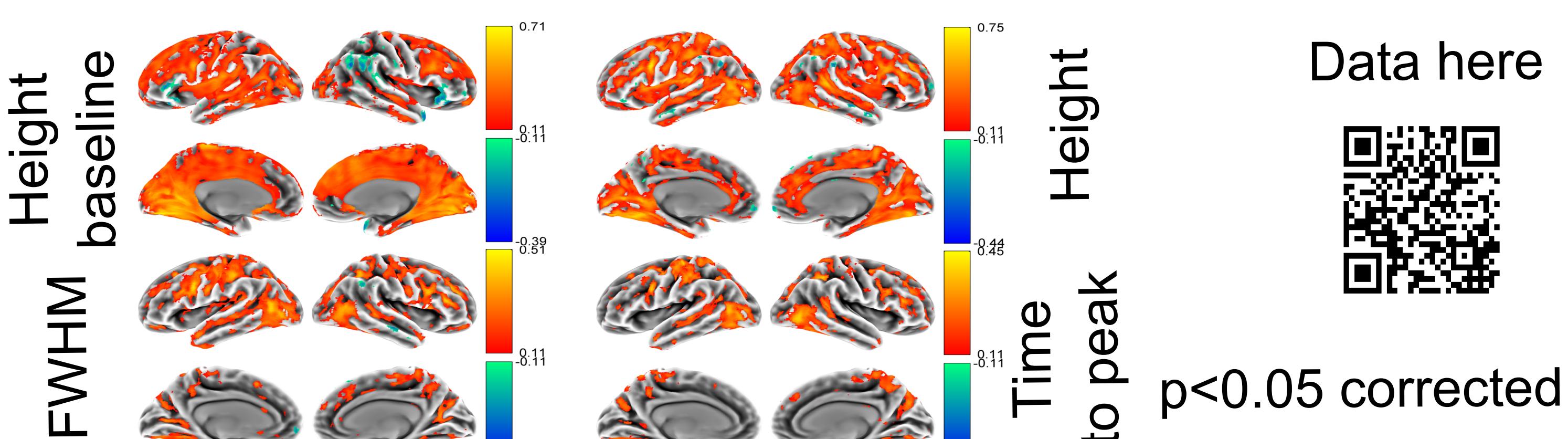
## Flowchart



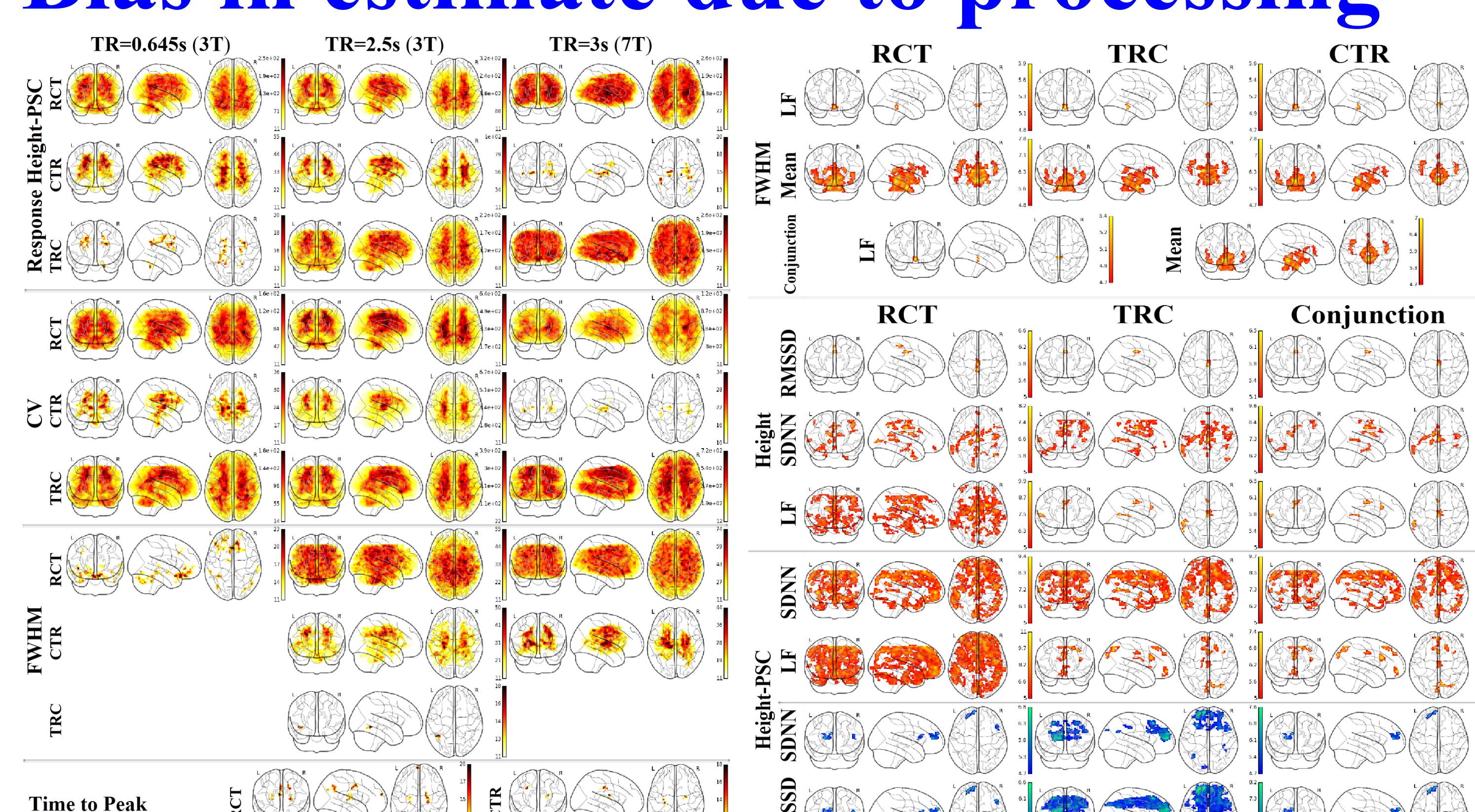
## Simulation



## Correlation with CBF



## Bias in estimate due to processing

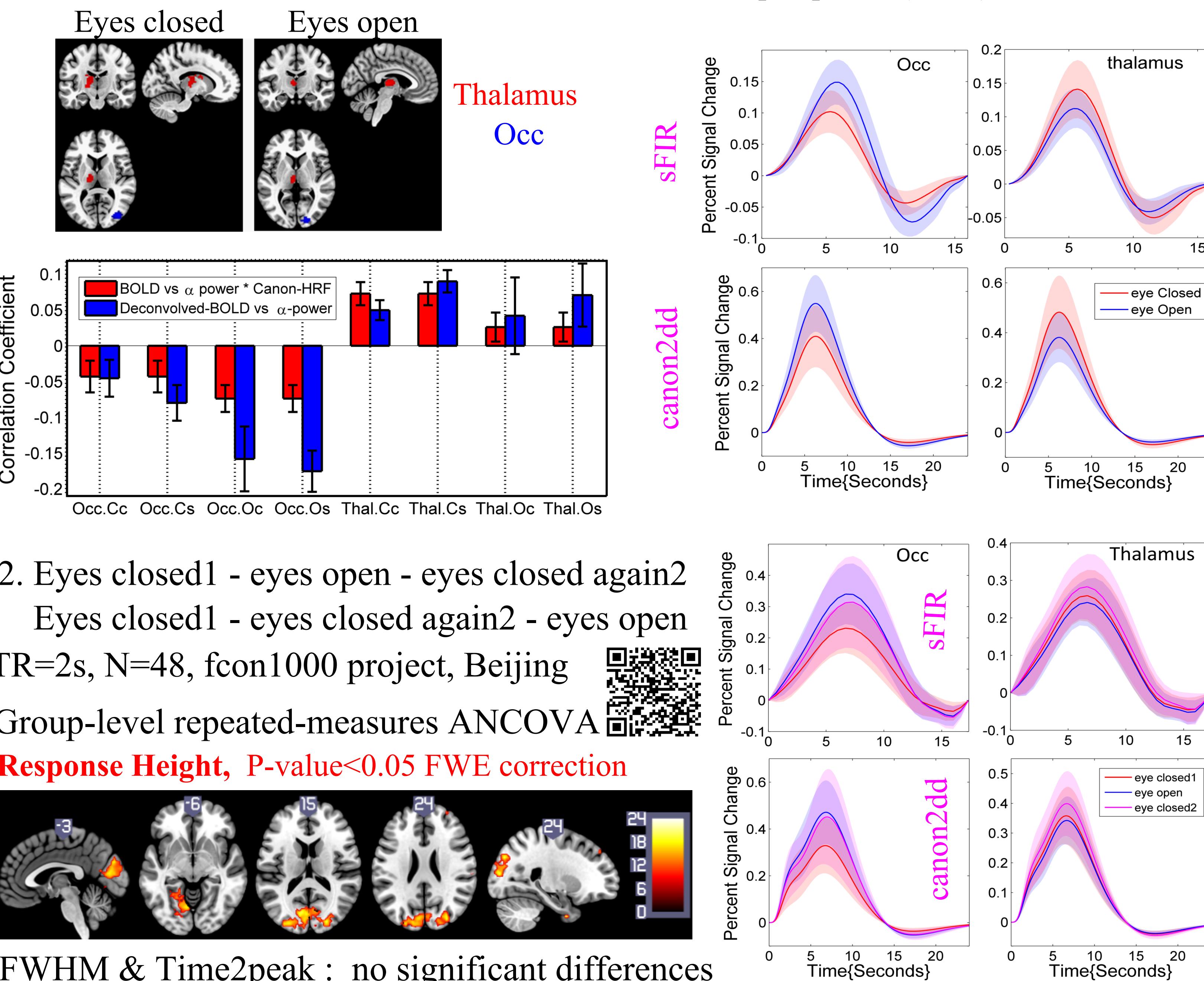


Autonomic system fluctuations and their correction influence HRF estimate.  
 $p < 0.05$  corrected

## Eyes Closed vs. Open

1. Simultaneous EEG-fMRI, Eyes closed - eyes open

Correlation between BOLD & canonical HRF convolved alpha power (GLM)



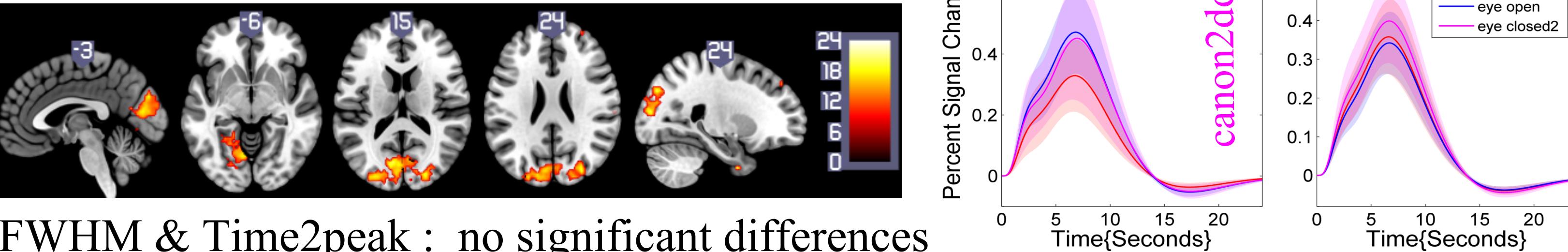
2. Eyes closed1 - eyes open - eyes closed again2

Eyes closed1 - eyes closed again2 - eyes open

TR=2s, N=48, fcon1000 project, Beijing

Group-level repeated-measures ANCOVA

**Response Height, P-value < 0.05 FWE correction**



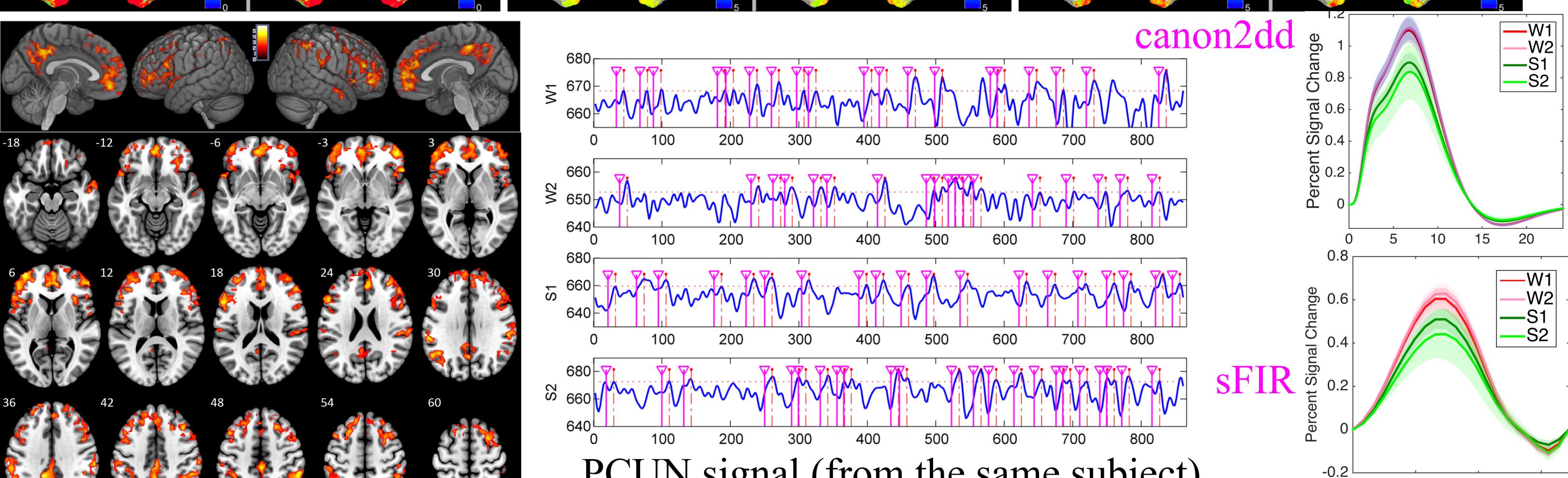
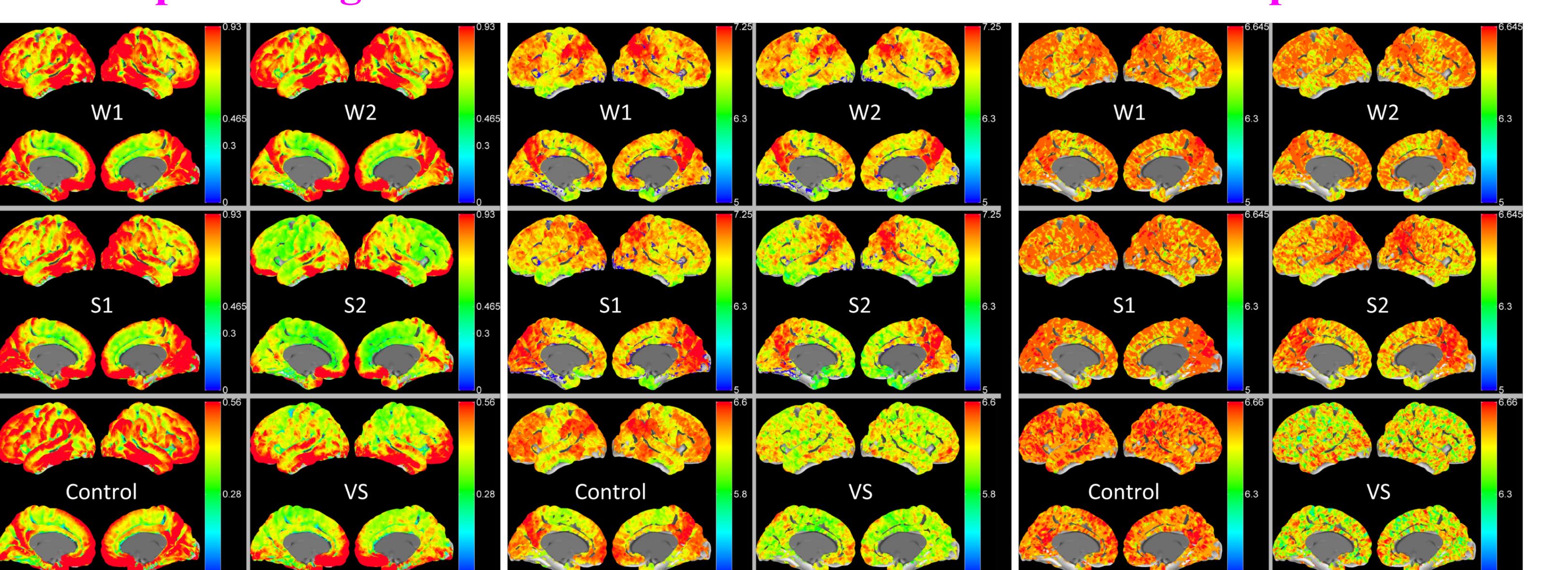
FWHM & Time2peak : no significant differences

## Propofol-induced loss of consciousness

TR=2.46s, 21 subjects. Wake (W1), mild sedation (S1), deep sedation (S2), and recovery of consciousness (W2).

Median Map (canon2dd)

Reponse height      FWHM      Time to peak



T-contrast (W1 S1 S2 W2): [1.5 -0.5 -1.5 0.5], Response Height (conjunction map of canon2dd & sFIR), P-value < 0.05 topo-FDR correction, FWHM, Time to peak - no significant differences

This procedure allows deconvolution of HRF in rs-fMRI, improving lag-based directed connectivity estimation

## References

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- Wu G., Marinazzo D. (2016) Sensitivity of the resting state hemodynamic response function estimation to autonomic nervous system fluctuations, Phil Trans Roy Soc A 374 20150190; DOI: 10.1098/rsta.2015.0190
- Wu G., Marinazzo D. <https://peerj.com/preprints/1317/>

