Utilizing Baseline and Differential Information to Improve FMRI Brain Activation

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Outline

1. The FMRI Problem
2. Differential Activation
3. Baseline Information
4. Results
5. Discussion

1. The FMRI Problem

In fMRI, a subject is placed in the MRI machine and volume images of their brain measured

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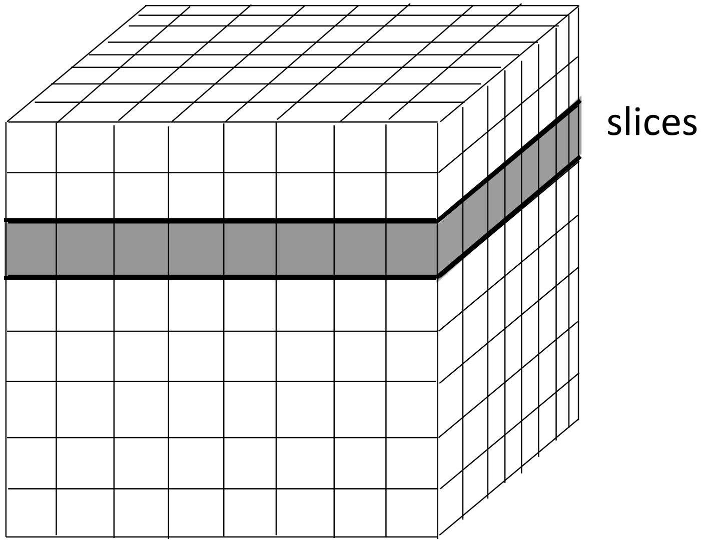
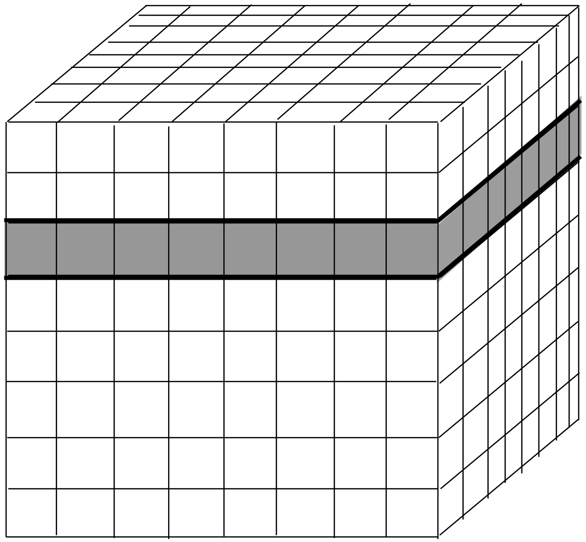
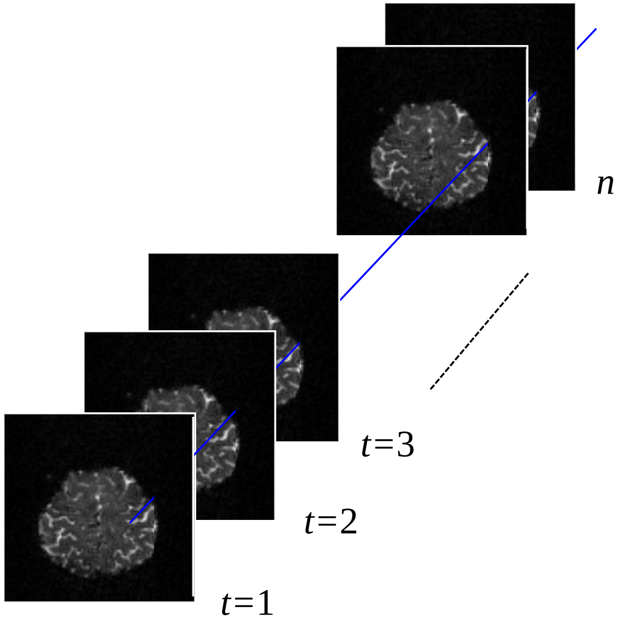


1. The FMRI Problem

… at n time points while they are generally performing a designed cognitive task





2. Differential Activation

We observe n, data points, $(x_1,y_1),\ldots,(x_n,y_n)$ and determine a statistically significant relationship between x (task design) an y (observed voxel value) as $y_t=\beta_0+\beta_1 x_t+\varepsilon_t$, assuming $\varepsilon_i \sim N(0,\sigma^2)$ for $t=1,\ldots,n$.

In each voxel

$$W=(X'X)^{-1}$$

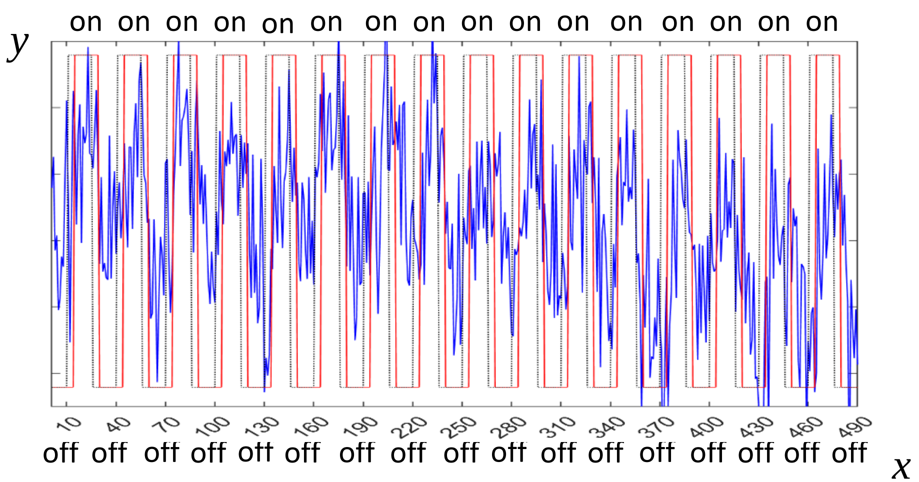
$$\hat{\beta}=(X'X)^{-1}X'y \qquad t=\frac{\hat{\beta}_1}{SE(\hat{\beta}_1)}$$

$$W=\begin{pmatrix} w_{11} & w_{12} \\ w_{21} & w_{22} \end{pmatrix}$$

$$SE(\hat{\beta}_1)=s\sqrt{w_{22}}$$

2. Differential Activation

The practice in fMRI brain imaging is to determine brain activation within a voxel by way of a statistically significant increase in the BOLD signal.



[1.7701,0.1205,0.0098,12.3427]

$$\hat{\beta} = (X'X)^{-1}X'y$$

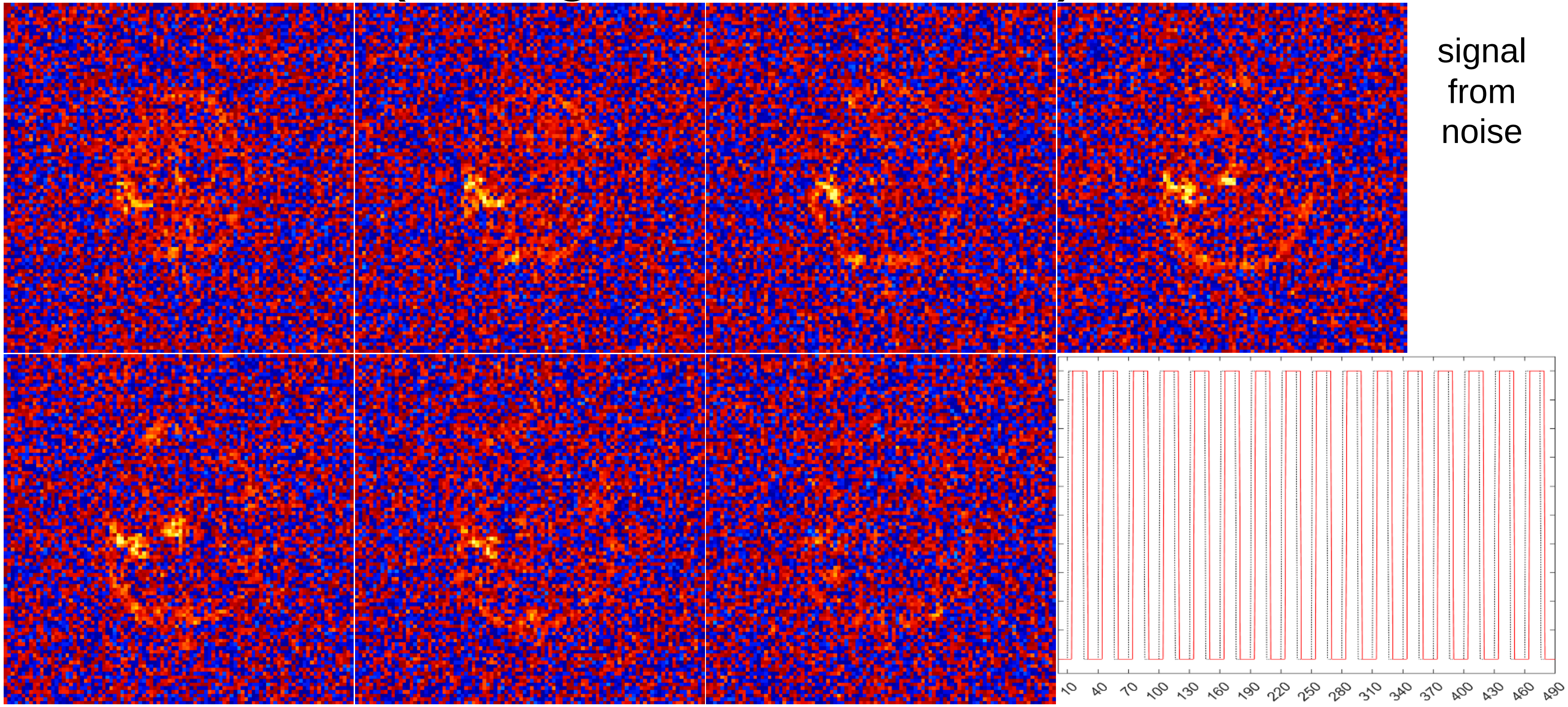
β_1 coefficient

$$t = \frac{\hat{\beta}_1}{SE(\hat{\beta}_1)}$$

t statistic

2. Differential Activation

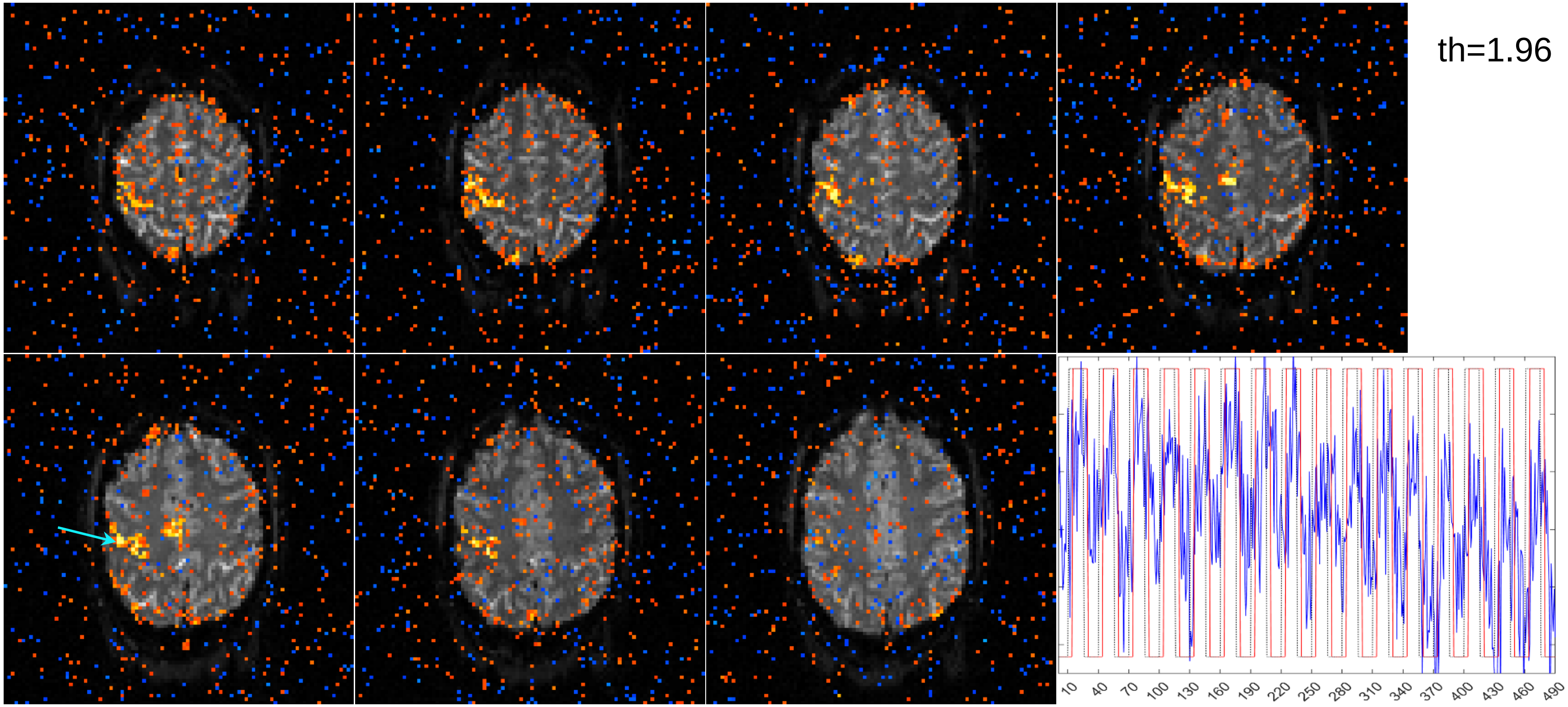
Every voxel has a *t*-statistic describing the degree of activation (change from baseline) in it.



signal from noise

2. Differential Activation

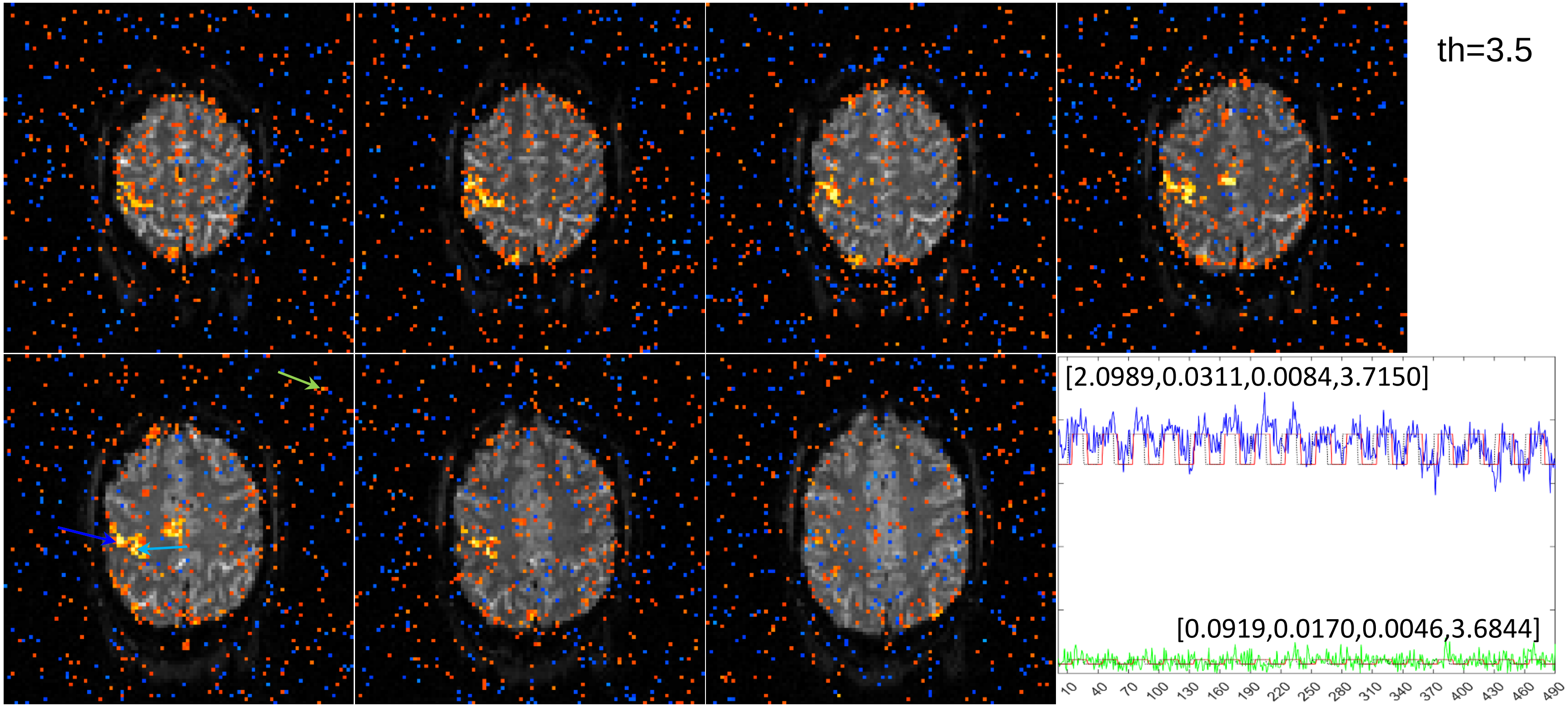
We threshold to separate true (biological) signal from noise (random variation/signal not of interest).



[1.7701,0.1205,0.0098,12.3427]

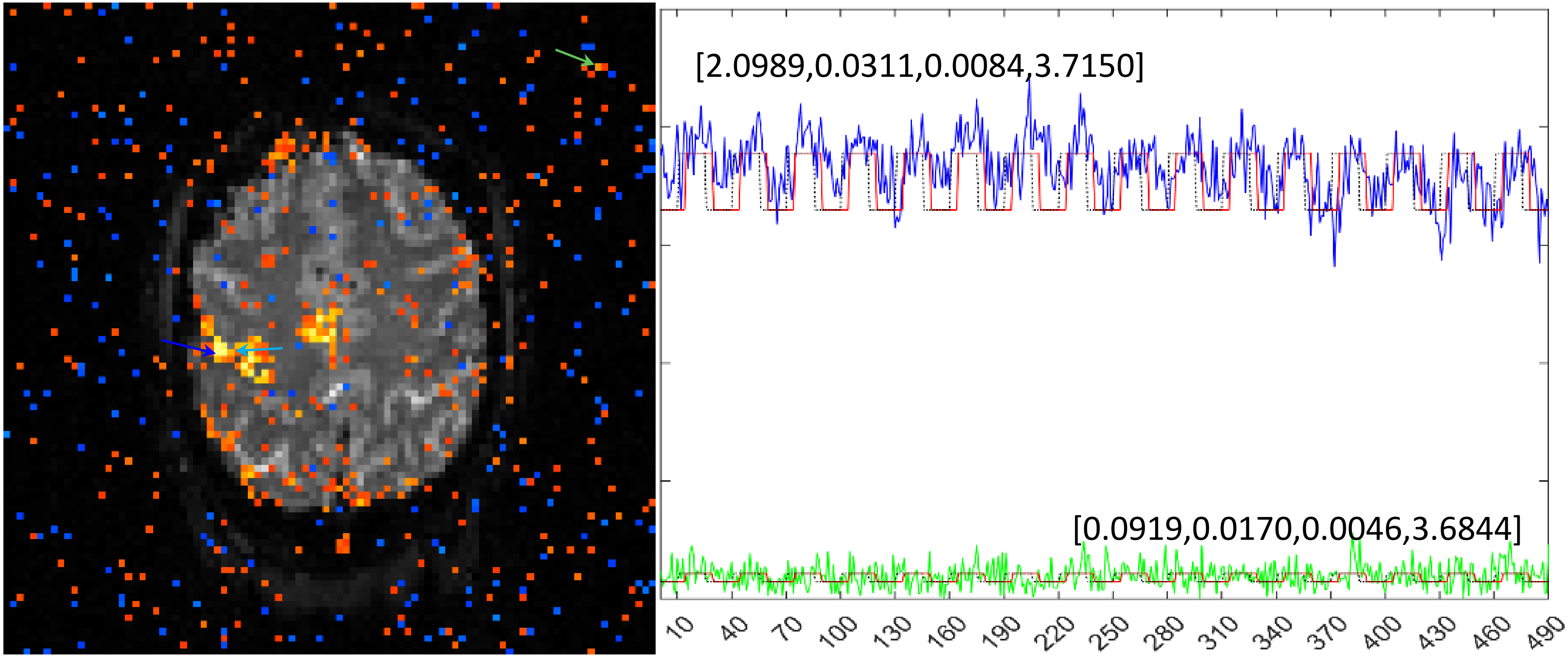
2. Differential Activation

But there are often many voxels above threshold or a high threshold may eliminate good voxels.



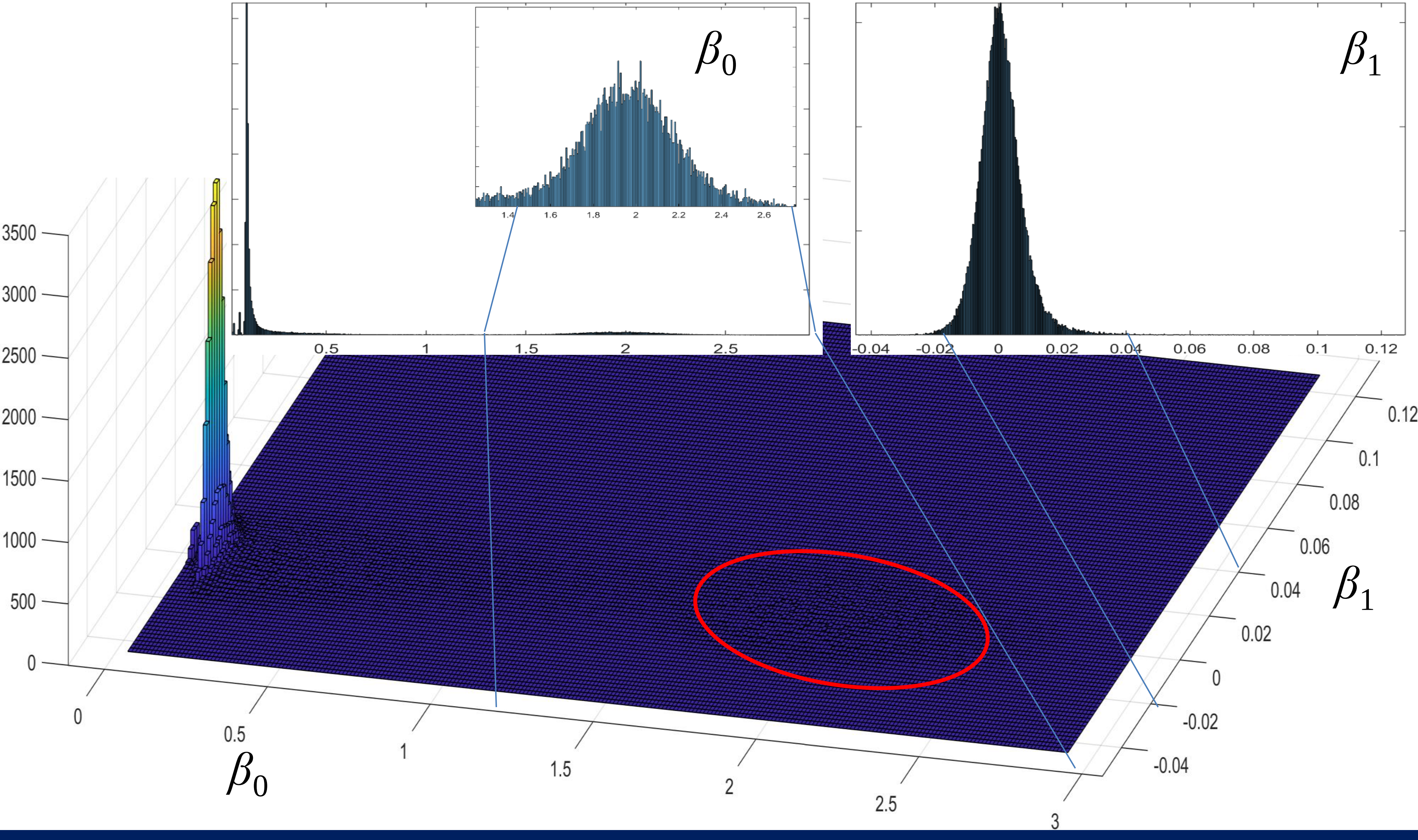
3. Baseline Information

We can have two voxels that have the same activation level, but different baselines, β_0.



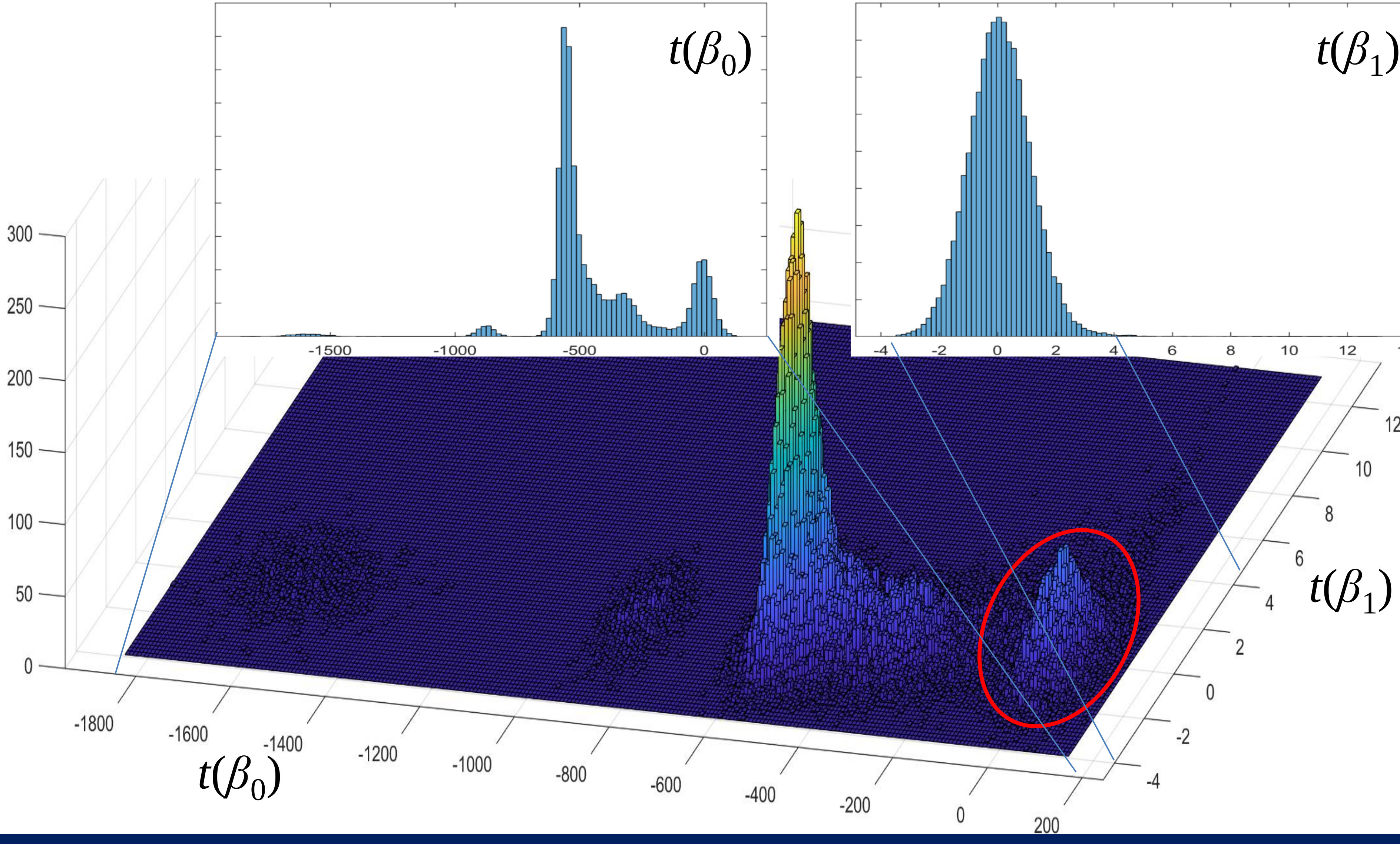
4. Results

Regression Coefficients



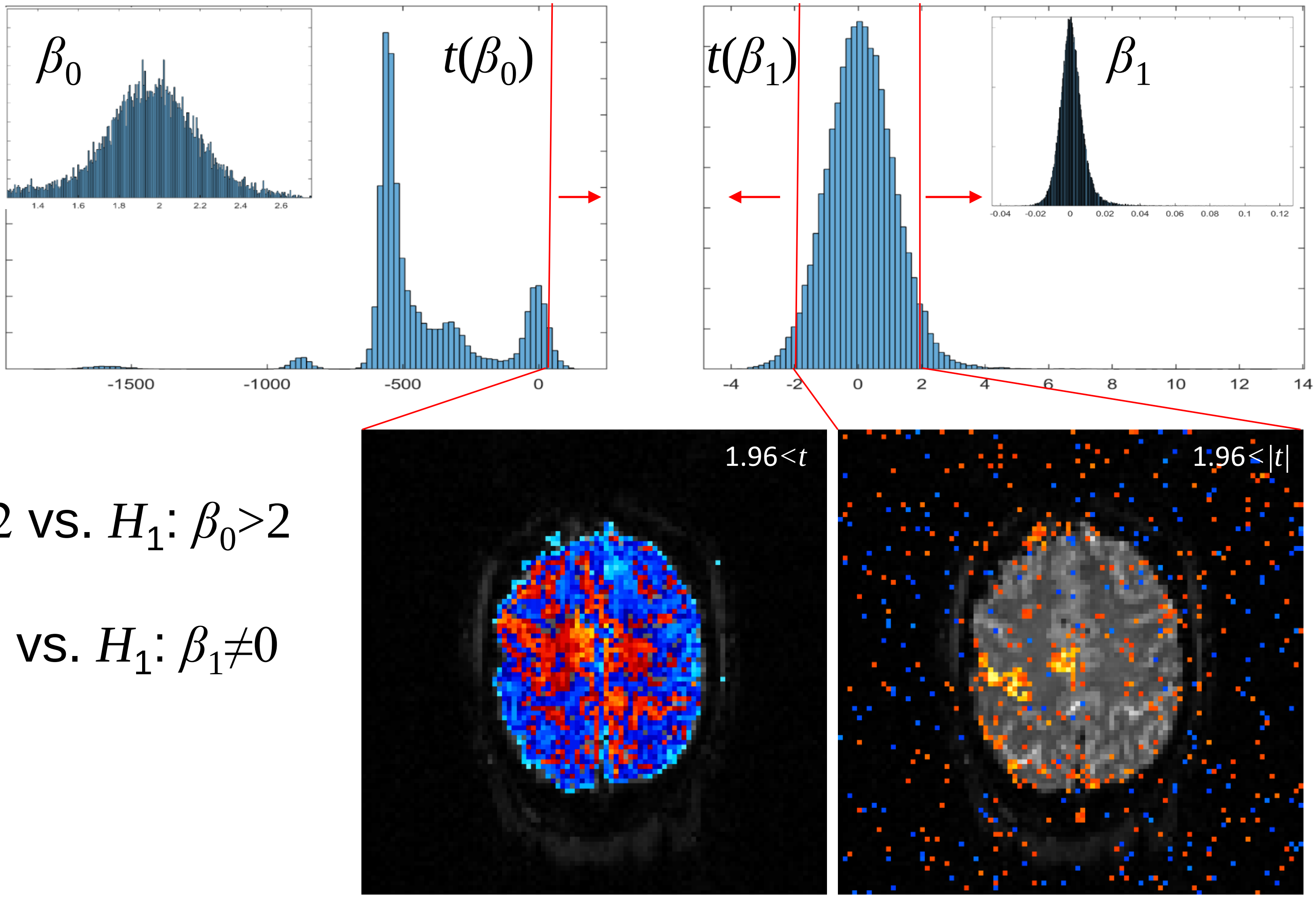
4. Results

t-statistics



4. Results

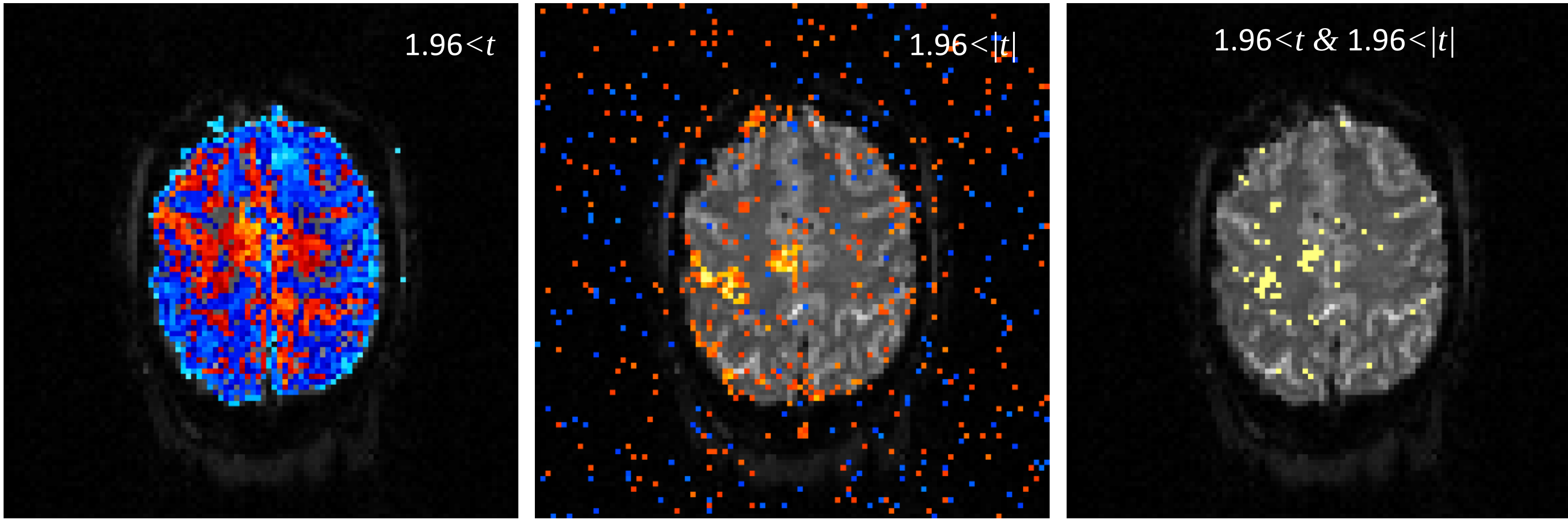
t-statistic selection



H_0: $\beta_0 \leq 2$ vs. H_1: $\beta_0 > 2$
and also
H_0: $\beta_1 = 0$ vs. H_1: $\beta_1 \neq 0$

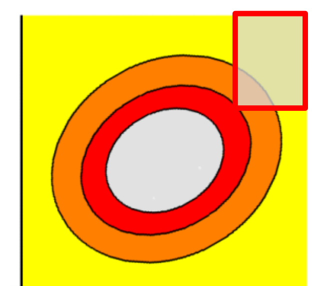
4. Results

t-statistic selection



$t(\beta_0)$ $t(\beta_1)$

$t(\beta_1)$



$t(\beta_0)$

Need to utilize bivariate t-distribution and wedge of distribution for significance.

5. Discussion

Baseline anatomical information was explored along with differential functional information to determine brain activation.

Utilizing the baseline signal intensity which is an strong indicator of tissue type can assist in detecting activation in gray matter tissue and reduce false positives.

Thank You!

Questions?

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