











 What are we looking at?

 • Our data is a time-series capturing changes in blood oxygenation (fMRI signal intensities) in each voxel, tracked over the time of our experiment

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Mass univariate approach $Y = X\beta + \varepsilon$ $\begin{bmatrix} r_1 \\ r_2 \\ \vdots \\ r_n \end{bmatrix} = \begin{bmatrix} 1 & x_{11} & \cdots & x_{1n} \\ 1 & x_{21} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots \\ 1 & x_{nn} & \cdots & x_{nn} \end{bmatrix} \times \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_n \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \\ \downarrow \\ Feeduals$ Observed Data Number of BODD Number of BODD Regressors Model parameters



















The problem with our data
Many types of noise in our data

E.g. HRF temporally smooth rather than discrete, head movement, physiological noise like heart beat/breathing, scanner physics, susceptibility artefacts/dropout, ...

The noise is not identically distributed or independent, but may affect

- some frequencies more than others • Much of this can be avoided by good quality acquisition, and by preprocessing
- However, some of it may remain and has to be dealt with during analysis

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- After fitting the GLM we use the estimated parameters to determine whether there is significant activation present in the voxel.
- Inference is based on the fact that:

 $\hat{\boldsymbol{\beta}} \sim N(\boldsymbol{\beta}, (\mathbf{X}^T \mathbf{V}^{-1} \mathbf{X})^{-1})$

• Use t and F procedures to perform tests on effects of interest.

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- Assuming the errors are normally distributed, F has an approximate F-distribution with (ν_0,ν) degrees of freedom, where:

$$v_0 = \frac{tr([(\mathbf{R} - \mathbf{R}_0)\mathbf{V}])^2}{tr([(\mathbf{R} - \mathbf{R}_0)\mathbf{V}]^2)} \text{ and } v = \frac{tr(\mathbf{R}\mathbf{V})^2}{tr((\mathbf{R}\mathbf{V})^2)}$$

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SPECIFY 1st LEVEL











SPECIFY 1st LEVEL SPM BasicRD File Eck Ver Highlight "Condition" and select "New Condition Cerrent Module: SUB +
 Data & Design
 Subject/Session
 Scans Open the newly created "Condition" option Highlight "Name" and enter the condition's name, e.g. "Listening"
 Highlight "Onsets" and enter the onset times of your condition, e.g. "6:12:84"

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SPECIFY 1st LEVEL ant Dalay Wesley 1941 Spore 1969 SPM will write an SPM.mat file to your directory
SPM will also plot the design matrix in the second sec Graphics window

You can use the REVIEW button to
check your model specification Back functions: 10 Surface of seasons: 1 Totals per seasons: 1 Sufficient Seasons: 1 Righ parts Films: proj Calif. (2016) Ethics destanders: memory sealing Season mans saiding: seasons guilts 52





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