# MRes Advanced Brain Imaging

## Revision session

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# General questions

- **How do you map from voxel space to world space?**
- **What are the real world coordinates of the voxel with indices $\begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$ of an image with the following tranformation matrix?**

$$\begin{bmatrix} 1 & 0 & 0 & 25 \\ 0 & 1 & 0 & 57 \\ 0 & 0 & 1 & 45 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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**Which objective functions are used for (1) realignment of functional images and (2) coregistration of a structural and functional image?**

# General questions

**Draw a Venn diagram of these different types of image transformations: (1) rigid body, (2) affine and (3) all possible types of transformation. Give an example of each of these types of trasnformation and/or mention at what stage of the pre-processing each type is used.**

# General questions

**If you resample your images after each preprocessing step, how will the images look different (as compared to when you resampled only after smoothing)?**

# Realignment

**What are some the possible sources of residual errors that are still present after realignment?**

# Realignment

**What can you do to minimize the effects of those residual errors?**

# Normalization

**What are the reasons for normalization?**

# Normalization

**Most spatial normalization procedures involves two steps, affine and non-linear transformation. Why?**

# Normalization

**What alternatives are there if you still want to average results accross subjects without normalising your data?**

# Smoothing

- **What are the main reasons for spatial smoothing ?**

# General questions

**Draw a Venn diagram of: t-test, paired t-test, ANOVA, repeated measures ANOVA, General Linear model.**

# General questions

**If two regressors $X_1$ and $X_2$ are correlated, what do the $\beta$ estimates represent?**

# General questions

**If regressor 1 and 2 are correlated and you orthogonalize 2 with respect to 1 which, if any, $\beta$ will change and why? Explain via geometric perspective.**

# General questions

The General Linear Model described by $Y = X\beta + \varepsilon$. **Define the design matrices (X) of the following**:

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- Paired t-test with 2 conditons (A and B) with 3 subjects

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- ANOVA with three groups of subjects and 3 subjects in each group

# General questions

The General Linear Model described by $Y = X\beta + \varepsilon$. **Define the design matrices (X) of the following**:

- Repeated measures ANOVA for 3 subjects and with three within subject levels

# General questions

The General Linear Model described by $Y = X\beta + \varepsilon$. **Define the design matrices (X) of the following**:

- Regression

# Experimental design

- **List at least 6 parametric factors.**
- **What is the advantage of having a parametric factor with 3 rather than 2 levels?**

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# General questions

In the experiment, you present 4 flashes with the following onset vector.

$$\begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

You assume a simple HRF.

$$\begin{bmatrix} 1 & 3 & 5 & 1 & -2 & 0 \end{bmatrix}$$

**Generate a predictor for your BOLD-response in the experiment.**

# General questions

- An experiment was performed with a TR $= 3$ secs and an SOA $= 3$ secs. **How would you change the experimental parameters and why?**
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# General questions

**Why is it possible to optimize the efficiency of an experimental design even before running the experiment?**

# General questions

**Explain the concept of design efficiency from the perspective of maximal bandpassed energy.**

# General questions

**What would be the most efficient fMRI design and why?**

# Basis functions

**Which experiments make *a priori* optimization of design efficiency difficult?**

# Basis functions

- **Explain the concept of basis functions for modeling the HRF.**

- You have performed a complex working memory experiment. You are not sure about the shape of the activation functions. **Which basis sets might be useful for modeling the hemodynamic response? What are their advantages and disadvantages?**

# Basis functions

- **Explain the concept of basis functions for modeling the HRF.**
- You have performed a complex working memory experiment. You are not sure about the shape of the activation functions. **Which basis sets might be useful for modeling the hemodynamic response? What are their advantages and disadvantages?**

# Basis functions

- **Why would you model your events using the informed basis functions set (i.e. what is the function of the derivatives)?**
- **How can you test whether the informed basis functions set is really sufficient for modeling the HRF?**

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# Basis functions

**What conditions need to be fulfilled in order to perform selective averaging rather then using a convolution model for estimating the averaged response to an event class?**

# General questions

**How does non-sphericity emerge at 1st and 2nd level?**

# General questions

- **What is the meaning of a p-value in classical statistics? E.g. $p < \alpha$ means that:**
- **In the case where $p > \alpha$, does it provide evidence to say that $H_0$ is true?**
- **A t-test is a ratio of?**

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# General questions

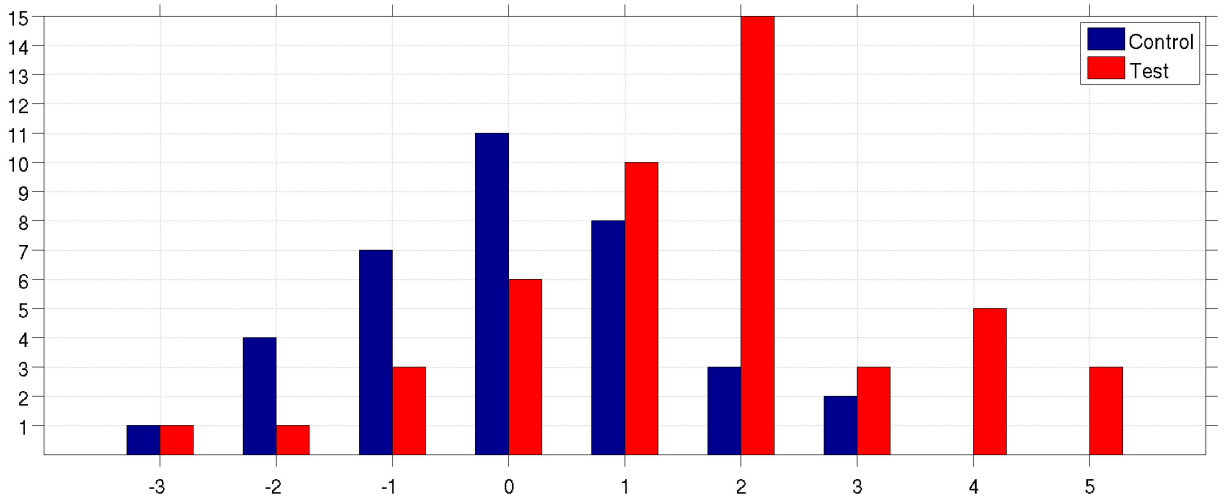
**Does the t-statistic depend on the scaling of the regressors?**

# Inferences

**Define precisely the three levels of inference and their constraints: voxel, cluster and set. What are their advantages and disadvantages?**

# Inferences

Given the following outcomes and a threshold $\mu_1 = 0.5$:

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- True positives or Hits (TP):
- True negatives or Correct Rejections (TN)
- False positives or False alarms (FP):
- False negatives or Missed (FN):

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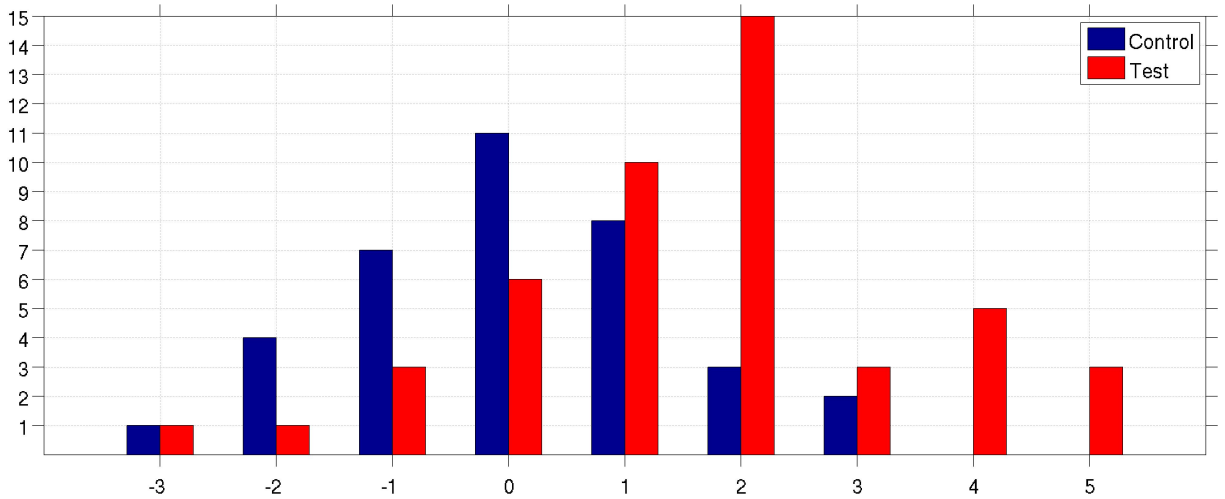


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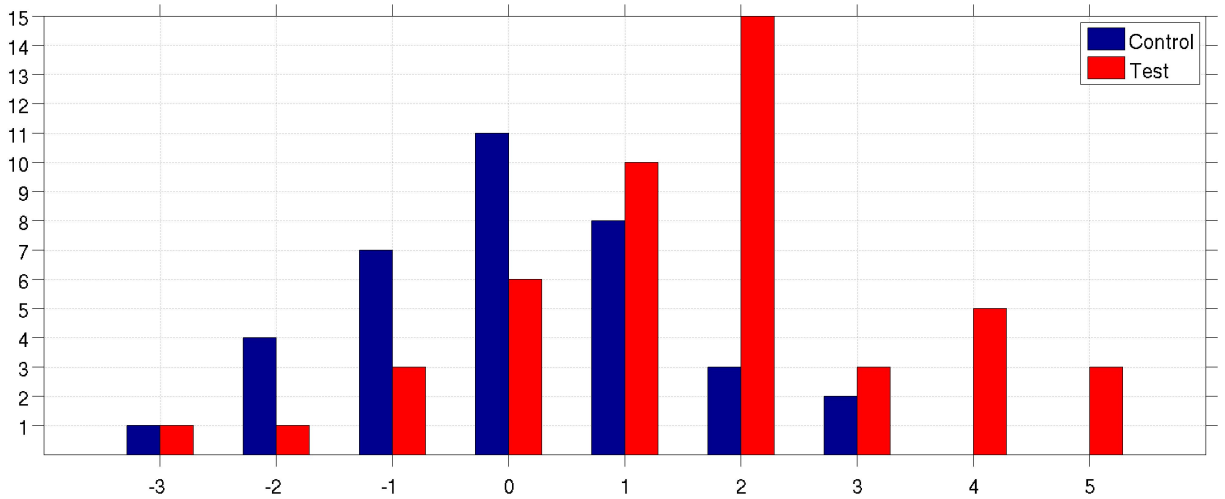


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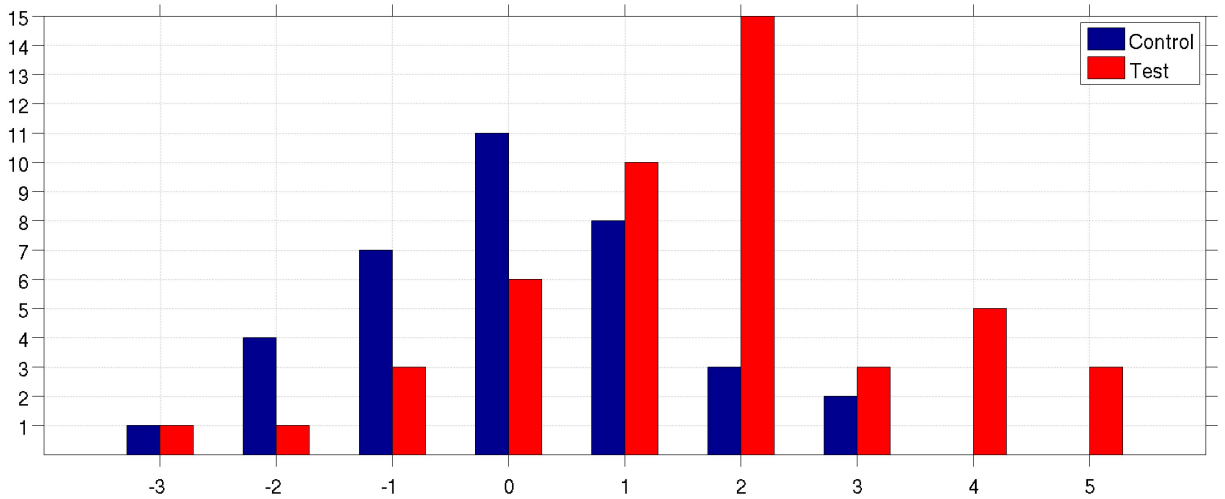


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# Inferences

In 5 Parkinson patients and 5 Alzheimer patients, the following activation measurements have been obtained

| | | | | | |
|---|---|---|---|---|---|
| *Parkinson* | 5 | 7 | 9 | 4 | 3 |
| *Alzheimer* | 1 | 4 | 2 | 2 | 3 |

**Using non-parametric statistics, you want to investigate whether the means are different between the 2 samples at a significance of p<0.05. Describe the main steps of the procedure.**

# Family wise error

Suppose you have a statistical parametric map with 100 000 voxels. But you have smoothed your data with a ridiculously large FWHM (e.g 1 meter!). You are looking for activation with $\alpha = 0.05$.

**What threshold would a Bonferonni correction give you? Why is that not threshold not appropriate? What would a better threshold be?**

# Family wise error

The SPM results page gives you the following values for the estimated smoothness of your data: FWHM $=$ 12.6 11.9 10.9 (in mm). Yet you have smoothed your data with a [8 8 8] mm FWHM Gaussian kernel.

**Is that an error? What could be the differences due to?**