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?**

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

General questions

- **What is an objective function when comparing 2 images?**
- **Why are there different objective functions?**

General questions

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 ?**
- **What is the matched filter theorem?**
- **If we expect your signal to be of Gaussian shape with a kernel of 8 mm FWHM, which smoothing kernel would you use?**

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 β estimates represent?

General questions

If regressor 1 and 2 are correlated and you orthogonalize 2 with respect to 1 which, if any, β 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**:

- Two-sample t-test with 3 subjects in group A and B

General questions

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

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

General questions

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

- 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?**
- **What is the disadvantage of having an odd number of levels in a parametric design (assuming the levels are equally spaced)?**

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?**
- **What are the assumptions inherent in using convolution for modeling the BOLD response?**

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?

General questions

If you assume only two event classes A and B and you shorten the SOA of the events: **Which of the following contrast (common effect of A and B, difference between A amd B) will increase in efficiency and which one will decrease? How can you design the study to optimize the efficiency of both effects?**

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

- **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?**

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

- **What is the iid assumption?**
- **What is heteroscedasticity?**
- **What are the two assumptions underlying sphericity? Define them precisely by referring to the properties of the error covariance matrix.**

General questions

- **Which two sources of variability need to be considered in group studies?**
- **When is the summary statistic approach (in)valid (i.e. which requirements need to be fulfilled?)**

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?**

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

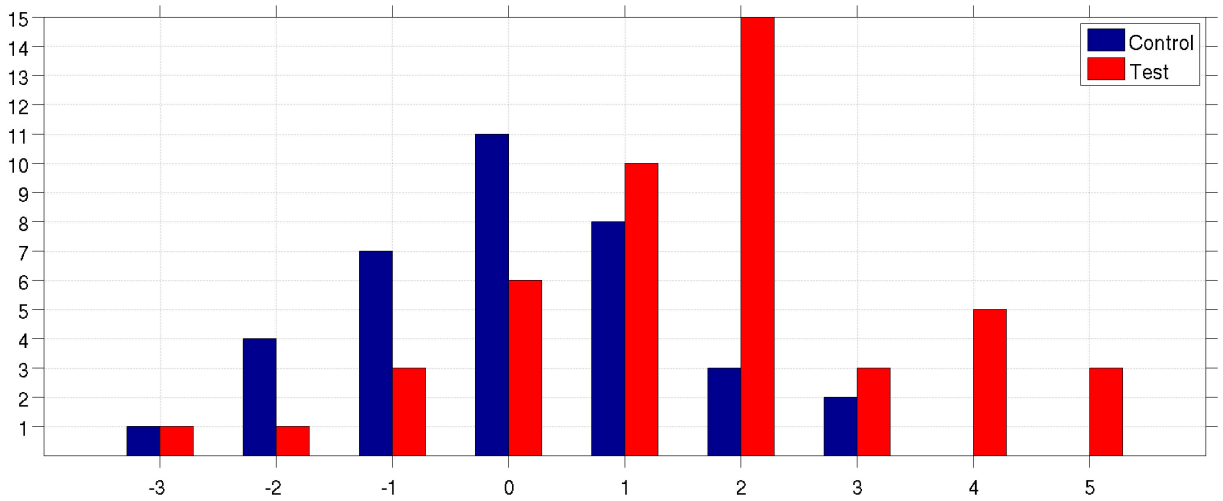
How can you obtain p- and t-values from a uni-dimensional F-test?

Inferences

Explain the extra-sum of square principle for the F-testing

Inferences

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

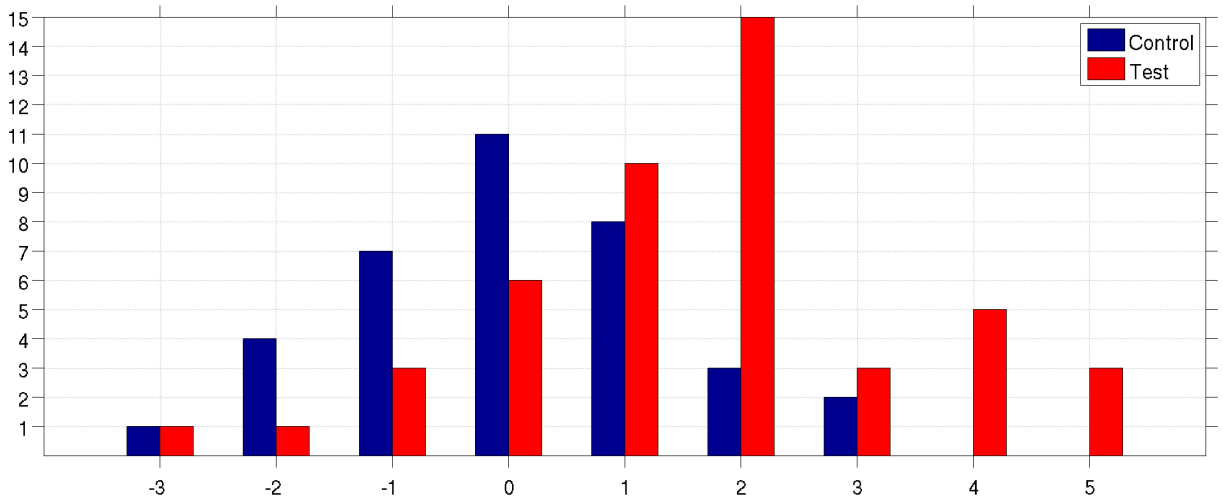


Compute:

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

Inferences

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



Compute:

- Sensitivity or Power:
- Specificity:
- False discovery rate:
- False positive rate - Type I error:

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?

False discovery rate

Explain the procedure to determine all significant voxels within a volume according to false discovery rate.