Group analyses

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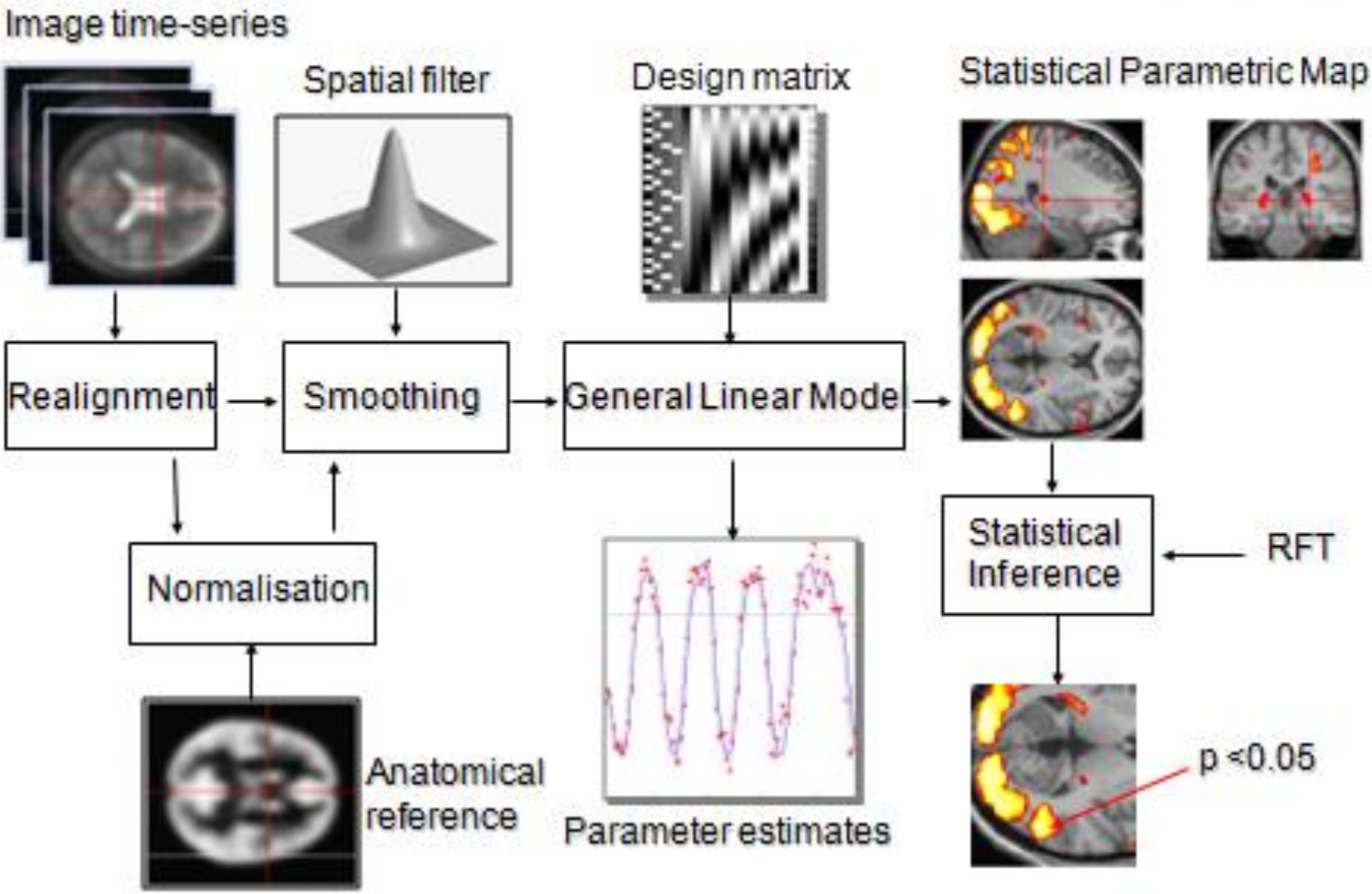


Image time-series
Spatial filter
Design matrix
Statistical Parametric Map
Realignment
Smoothing
General Linear Mode
Normalisation
Statistical Inference
RFT
Anatomical reference
Parameter estimates
p <0.05

GROUP ANALYSIS

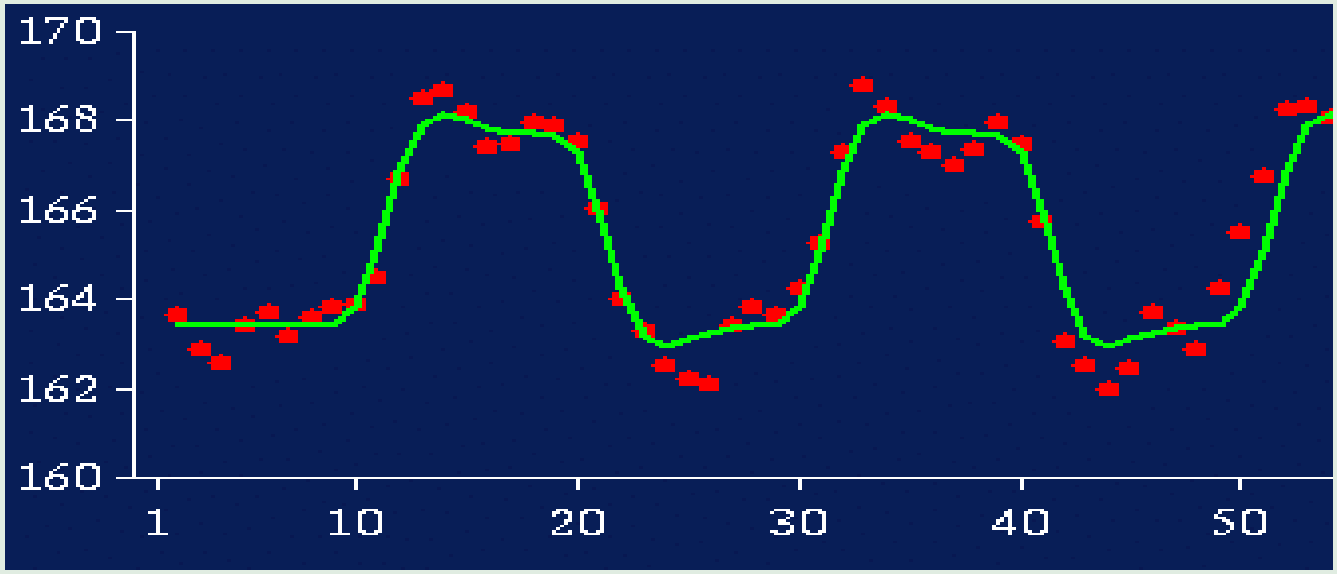
- Fixed Effects Analysis (FFX)
- Random Effects Analysis (RFX)
- Multiple Groups/Conditions

GROUP ANALYSIS

- **Fixed Effects Analysis (FFX)**
- Random Effects Analysis (RFX)
- Multiple Groups/Conditions

Subject 1

For voxel v in the brain

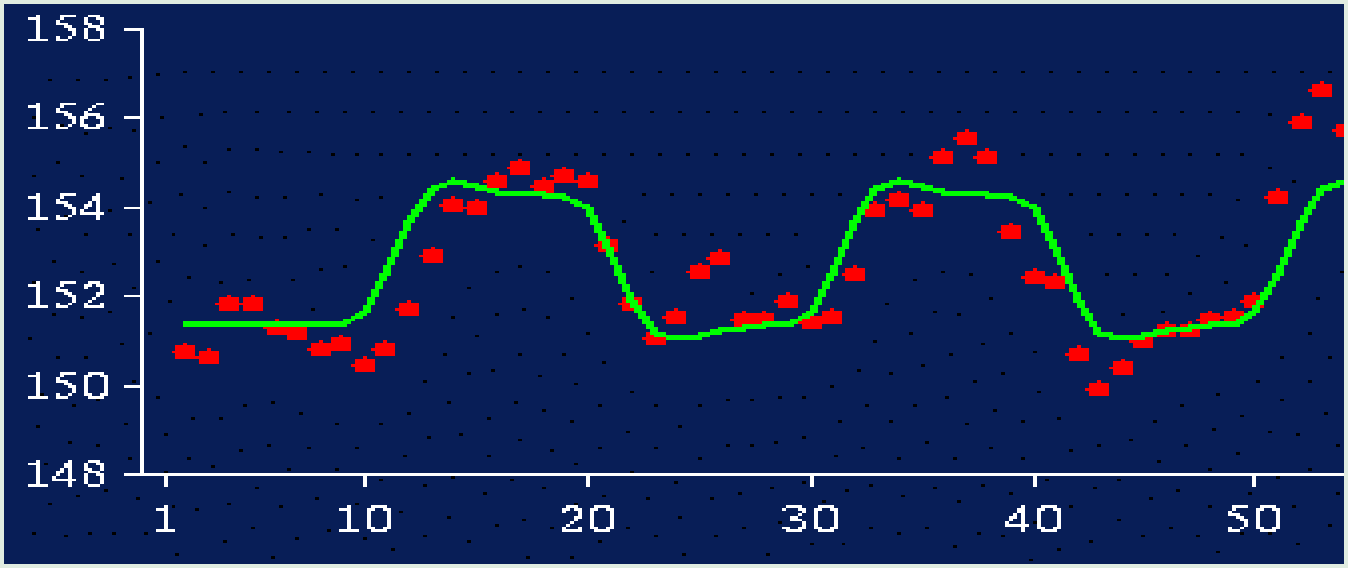


Effect size, c ~ 4

Within subject variability, s_w~0.9

Subject 3

For voxel v in the brain

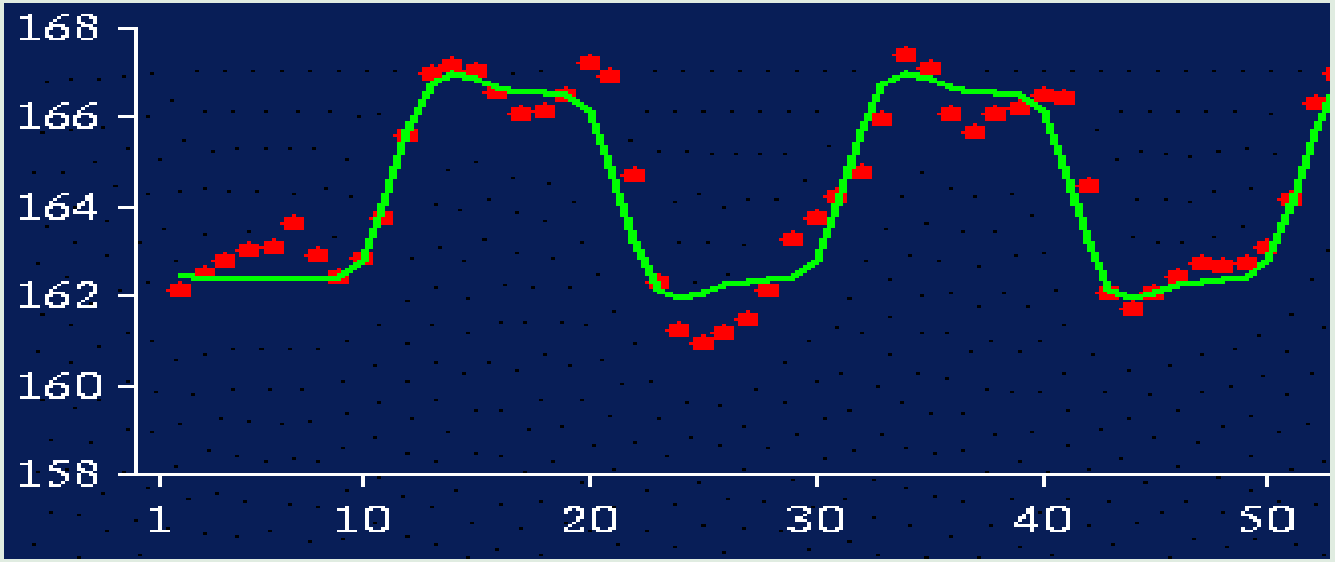


Effect size, c ~ 2

Within subject variability, s_w~1.5

Subject 12

For voxel v in the brain



Effect size, c ~ 4

Within subject variability, s_w~1.1

Fixed Effects Analysis

Time series are effectively concatenated – as though we had one subject with N=50x12=600 scans.

s_w = [0.9, 1.2, 1.5, 0.5, 0.4, 0.7, 0.8, 2.1, 1.8, 0.8, 0.7, 1.1]

Mean effect, m=2.67
Average within subject variability (stand dev), s_w =1.04

Standard Error Mean (SEM_W) = s_w /sqrt(N)=0.04

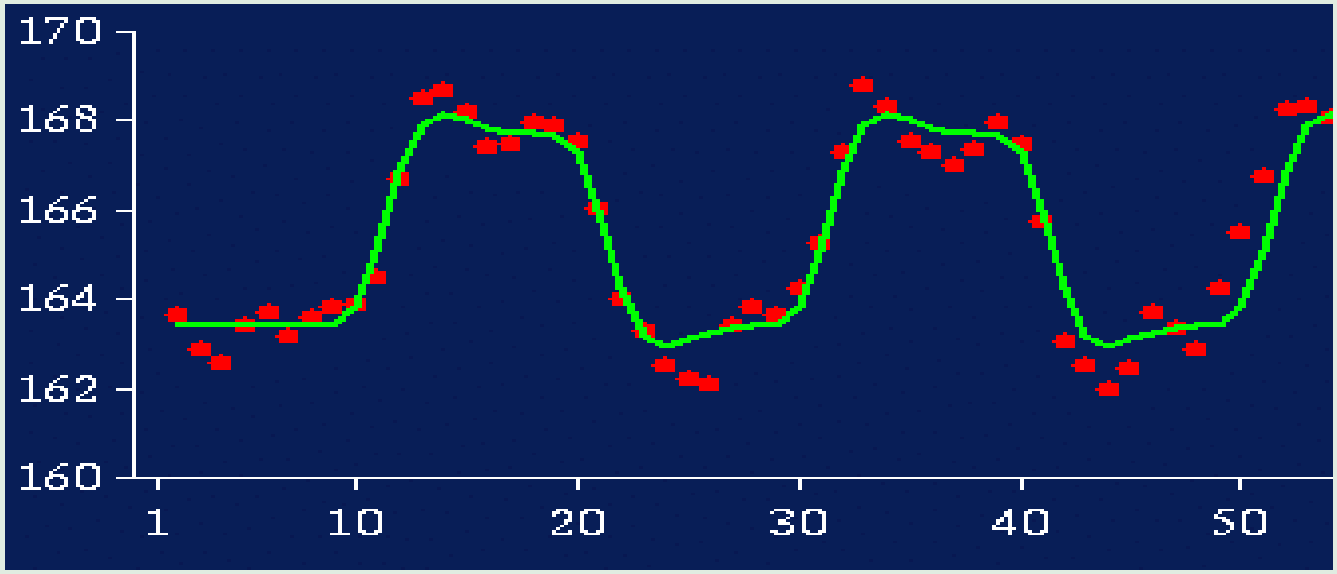
Is effect significant at voxel v?
$t=m/SEM_W=62.7$
$p=10^{-51}$

GROUP ANALYSIS

- Fixed Effects Analysis (FFX)
- **Random Effects Analysis (RFX)**
- Multiple Conditions

Subject 1

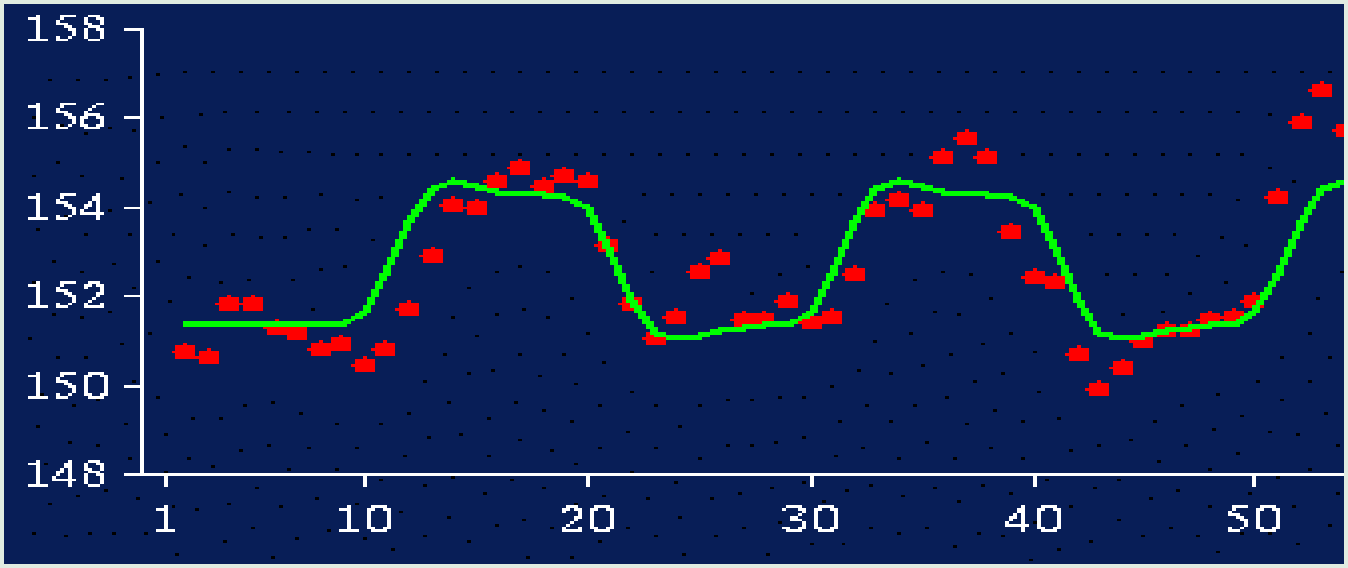
For voxel v in the brain



Effect size, c ~ 4

Subject 3

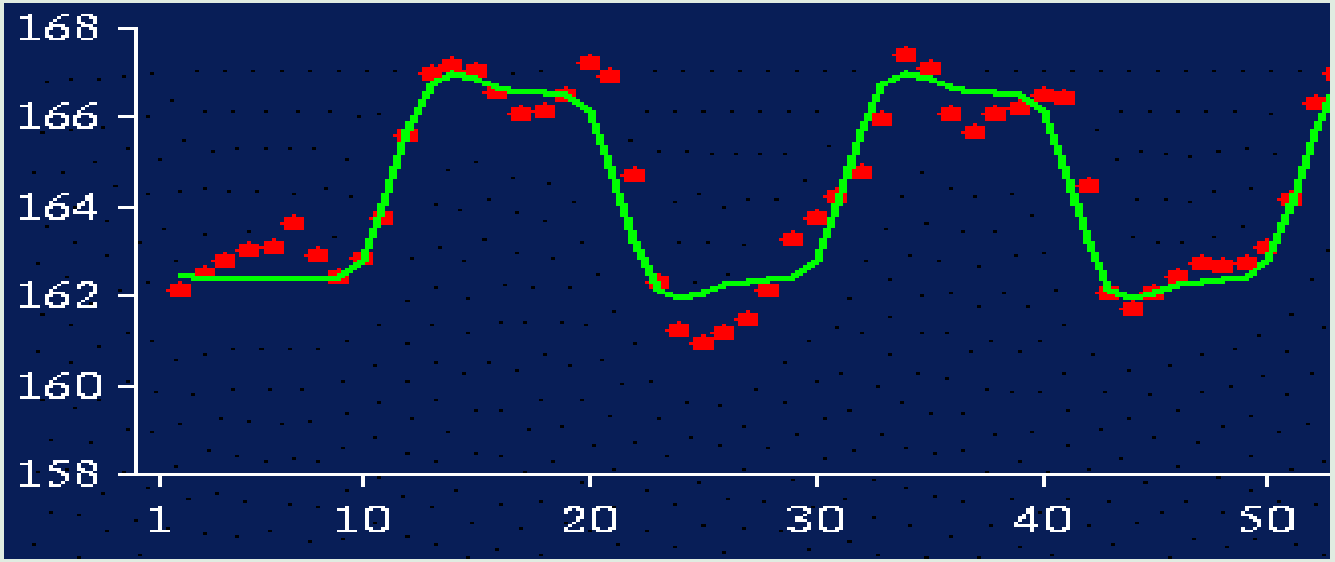
For voxel v in the brain



Effect size, c ~ 2

Subject 12

For voxel v in the brain



Effect size, c ~ 4

Whole Group

For group of N=12 subjects effect sizes are

c = [4, 3, 2, 1, 1, 2, 3, 3, 3, 2, 4, 4]

Group effect (mean), m=2.67
Between subject variability (stand dev), s_b =1.07
Standard Error Mean (SEM) = s_b /sqrt(N)=0.31

Is effect significant at voxel v?
t=m/SEM=8.61
$p=10^{-6}$

Random Effects Analysis (RFX)

For group of N=12 subjects effect sizes are

c= [3, 4, 2, 1, 1, 2, 3, 3, 3, 2, 4, 4]

Group effect (mean), m=2.67
Between subject variability (stand dev), s_b =1.07

This is called a Random Effects Analysis because we are comparing the group effect to the between-subject variability.

Summary Statistic Approach

For group of N=12 subjects effect sizes are

c = [3, 4, 2, 1, 1, 2, 3, 3, 3, 2, 4, 4]

Group effect (mean), m=2.67
Between subject variability (stand dev), s_b =1.07

This is also known as a summary statistic approach because we are summarising the response of each subject by a single summary statistic – their effect size.

RFX versus FFX

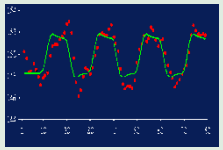
With Fixed Effects Analysis (FFX) we compare the group effect to the within-subject variability. It is not an inference about the sample from which the subjects were drawn.

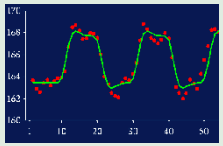
With Random Effects Analysis (RFX) we compare the group effect to the between-subject variability. It is an inference about the sample from which the subjects were drawn. If you had a new subject from that population, you could be confident they would also show the effect.

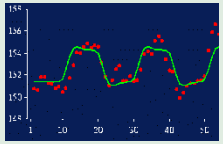
RFX: Summary Statistic

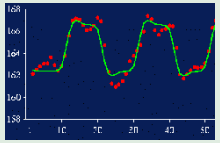
First level

Data

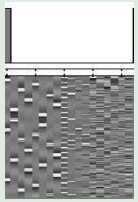


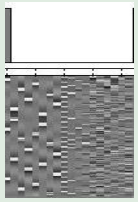


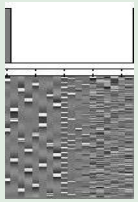


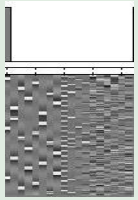


Design Matrix

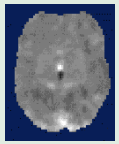


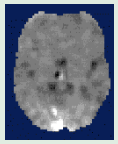


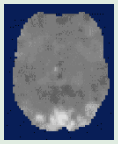


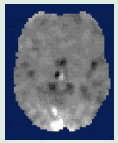


Contrast Images









RFX: Summary Statistic

First level

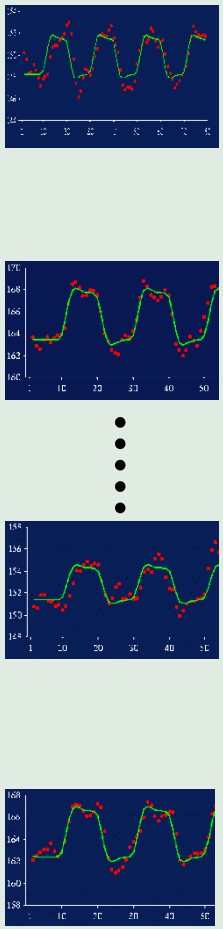
Second level

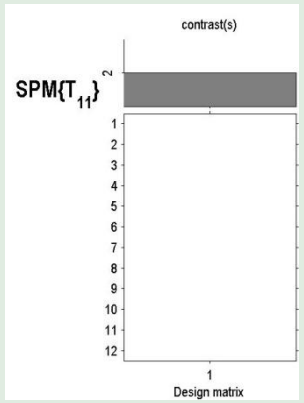
$$t = \frac{c^T \hat{\alpha}}{\sqrt{V\hat{a}r(c^T \hat{\alpha})}}$$

Data

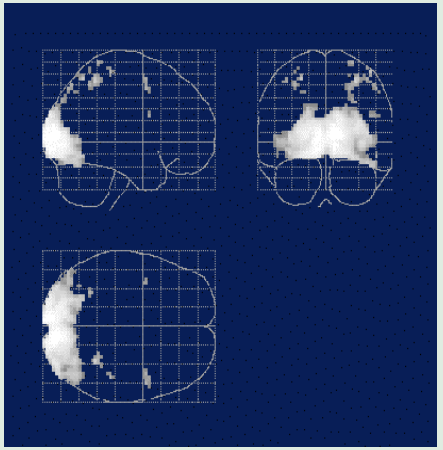
Design Matrix

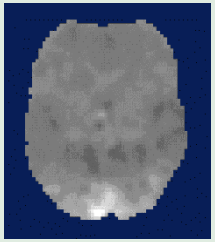
Contrast Images





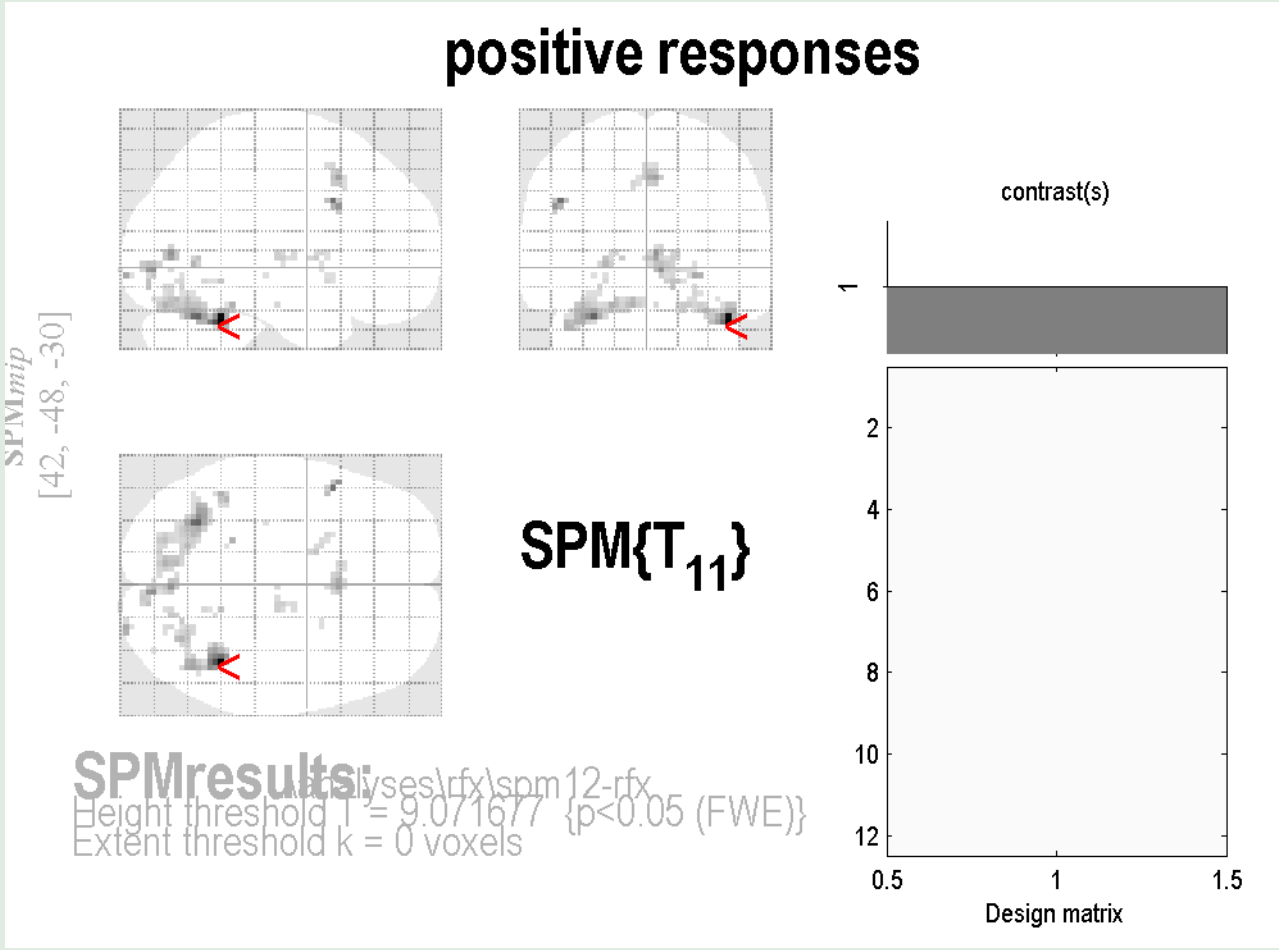
SPM(t)



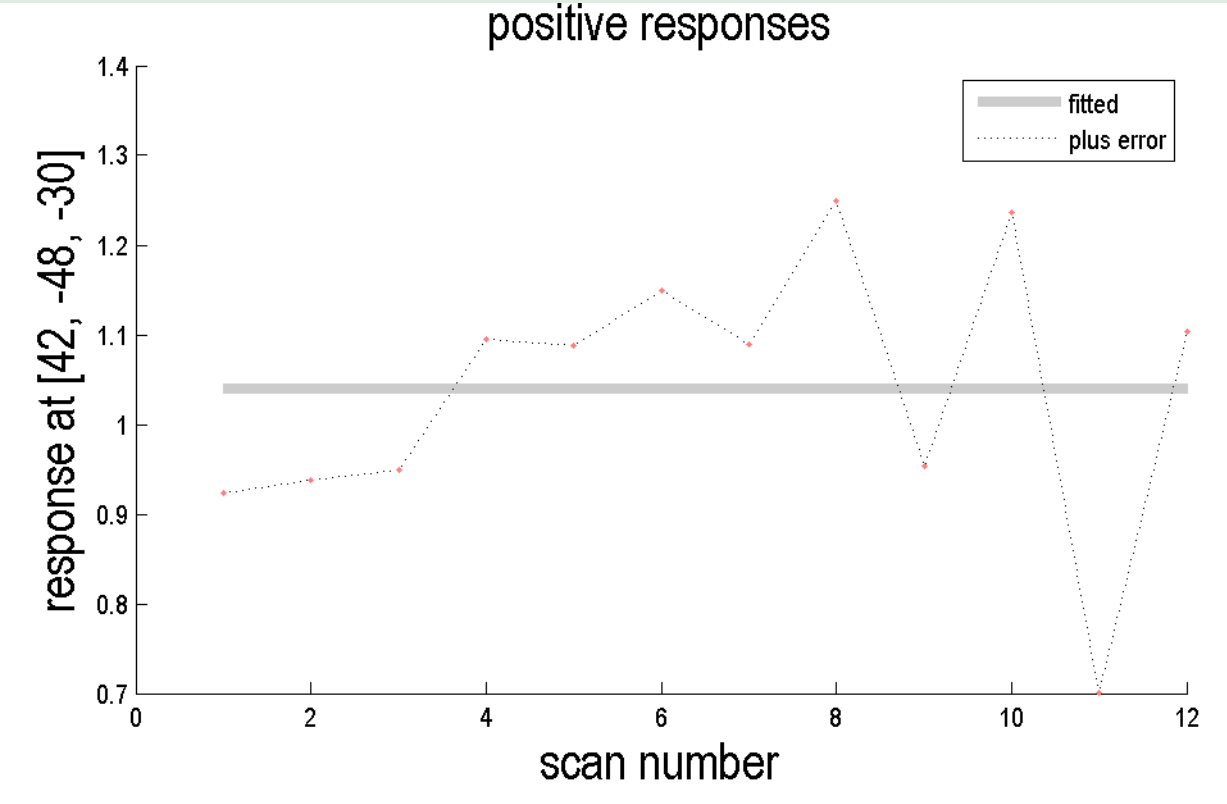


One-sample
t-test @ 2nd level

Face data


positive responses
SPM{T11}
contrast(s)
Design matrix
SPMmip
[42, -48, -30]
SPMresults:
Height threshold T = 9.071677 {p<0.05 (FWE)}
Extent threshold k = 0 voxels

Face data


positive responses
fitted
plus error
response at [42, -48, -30]
scan number
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0
2
4
6
8
10
12

GROUP ANALYSIS

- Fixed Effects Analysis (FFX)
- Random Effects Analysis (RFX)
- **Multiple Groups/Conditions**

Two Groups

Group 1	Group 2
Sub1	Sub13
Sub2	Sub14
...	...
Sub12	Sub24

Enter one contrast image per subject into a two-sample t-test design.

Two Groups

Group 1	Group 2
Sub1	Sub13
Sub2	Sub14
...	...
Sub12	Sub24

Test for effect of group using an F-Contrast: [1 -1]

Multiple Groups

Group 1	Group 2	Group 3
Sub1	Sub13	Sub25
Sub2	Sub14	Sub26
...	...	...
Sub12	Sub24	Sub36

Enter one contrast image per subject into a one-way ANOVA.

Multiple Groups

Group 1	Group 2	Group 3
Sub1	Sub13	Sub25
Sub2	Sub14	Sub26
...	...	...
Sub12	Sub24	Sub36

Test for effect of group using an F-Contrast:

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

https://en.wikibooks.org/wiki/SPM/Group_Analysis

SPM/Group Analysis

< SPM

Group Analysis [edit]

For fMRI or EEG data group analysis is also referred to as second level analysis as the first level of regards fitting General Linear Models to data from each subject. The second level then assesses the variability of the effects over a group of subjects or between groups. SPM relies on the summary statistic approach in which first level analyses produce contrast images, summarising the effects for each subject. These images then enter as data into second level models. For VBM there is no first level. You simply enter your processed anatomical images directly.

It is recommended that group analysis be implemented in SPM using what is called the *"partitioned error"* approach. This requires setting up a second level design matrix to test for each effect of interest.

If you have more than one experimental factor the analysis involves many steps as there are many effects to test for (due to the combinatorial nature of factorial designs). We therefore now provide excerpts from emails on the SPM list to guide your analysis. The answers have been edited for consistency.

Example 1: Two Factors [edit]

A 2-by-2 design with one within-subject and one between-subject factor.

Question:

My experimental set-up looks like this: 2 groups (between-subject factor), with each 2 conditions (time, a pre and post scan). I have 8 subjects in the first group and 14 in the second.

Ideally, I would set-up a 2x2 Mixed ANOVA to model the main effects and interaction effects. I'm assuming it's using the Flexible Factorial? Could you help on how to precisely specify this? And could you help with the contrasts or refer to good literature on this? I find a lot of things online, but none or very limited to a 2x2 mixed ANOVA. I assume I can also add covariates?

What would be the best way to do this? I'm doing VBM analysis in SPM right now, but I guess it's the same approach when using PET or fMRI.

Answer:

What you would do is create two contrast images per subject at the first level:

- c_1=[1 1] Overall/average effect (post plus pre)
- c_2=[1 -1] Difference between condition (post minus pre)

To see where effect c_i (where i can be *1* to *2*) is different between groups create a two sample t-test design (at the "second level") and enter the c_i con images for group 1 (ie. 8 con images), the c_i con images for group 2 (ie. 14 con images) and enter a [1 -1] F-contrast.

To test for an effect over all subjects, create a one sample t-test design, enter the c_i con images for both groups, and use a [1] F-contrast.

So you need four different models at the second level and one contrast in each. This gives you the four things you typically test for in a 2 by 2 design.

You may see a difference (eg. in structure for VBM data) between groups irrespective of time ([1 -1] contrast at 2nd level and [1 1] contrast at first). And you may see that this difference changes over time ([1 -1] at 2nd level and [1 -1] at first, the interaction).

You may wish to mask the latter by the former, and yes, you can enter covariates in the 2nd level designs.

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You may wish to mask the latter by the former, and yes, you can enter covariates in the 2nd level designs.

Summary

Group Inference usually proceeds with RFX analysis, not FFX. Group effects are compared to between rather than within subject variability.

Use t-tests/ANOVAs at second level for inference about single/multiple groups (or single/multiple experimental conditions).