



Practical Overview of SPM

Zurich SPM Course

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February 3, 2015



Purpose

- Lay out path and motivation for presentations that follow today and tomorrow
- Familiarise with SPM 12 Graphical User Interface
- Present example dataset for simple block-design single-subject fMRI analysis

Overview of an fMRI Experiment

Planning phase

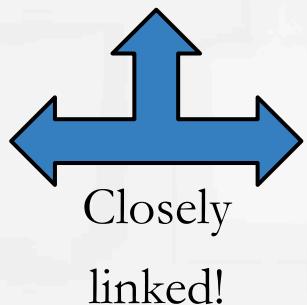
Experimental design:



Event-related designs

Design efficiency

Data acquisition



Data Analysis

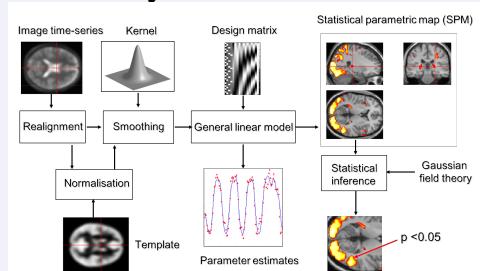
Single subject – first level analysis:

Preprocessing

GLM

Classical inference

Random field theory

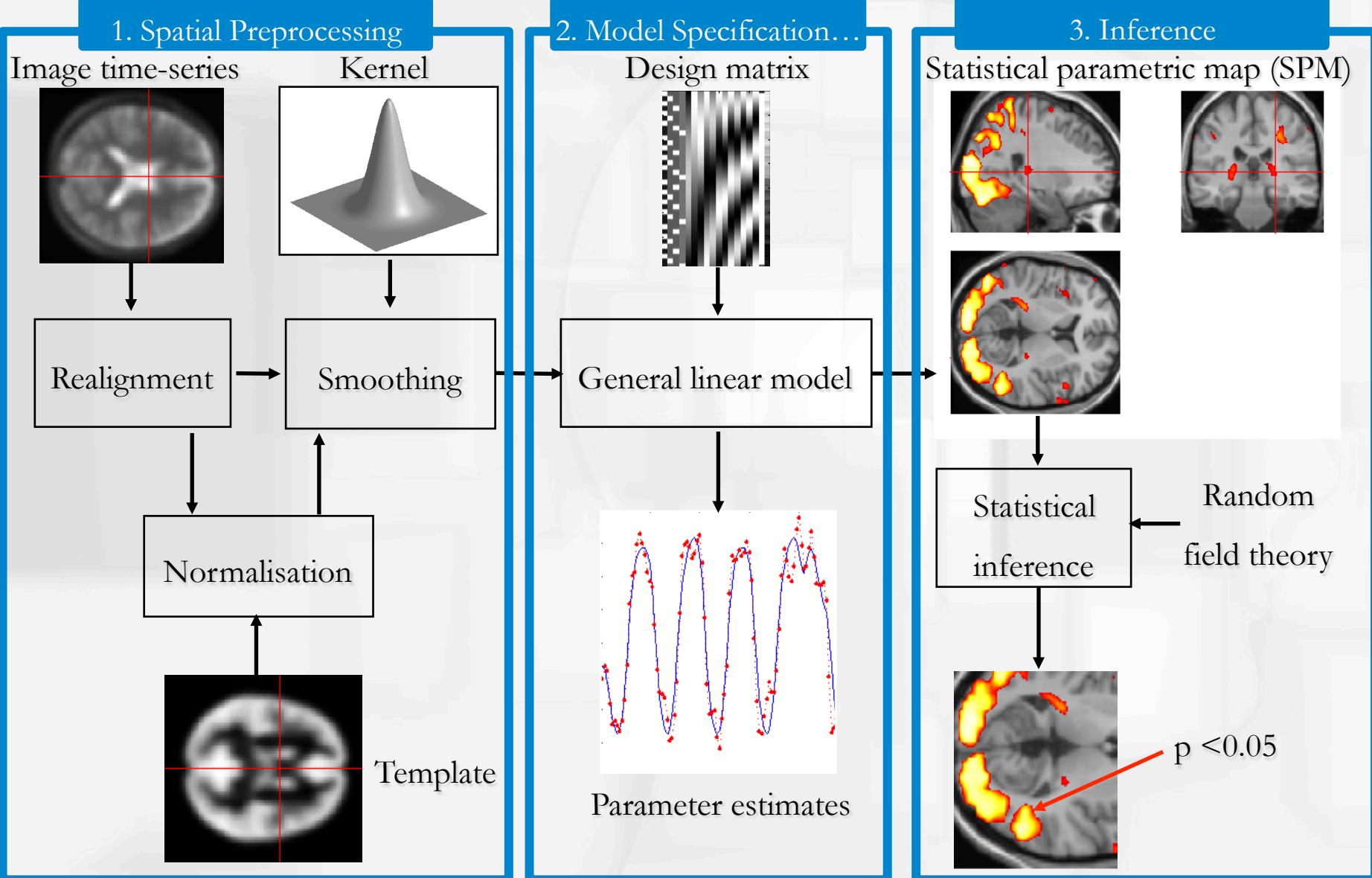


Group – second level analysis:

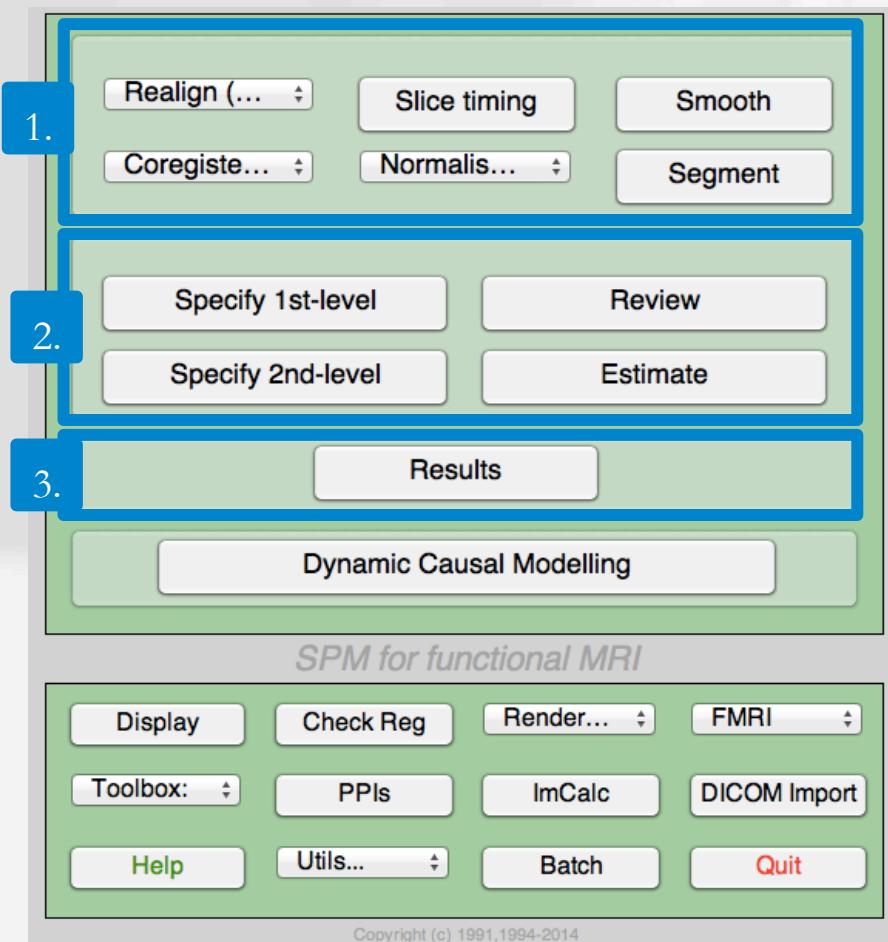
Group statistics

Random effects

Overview of SPM for fMRI

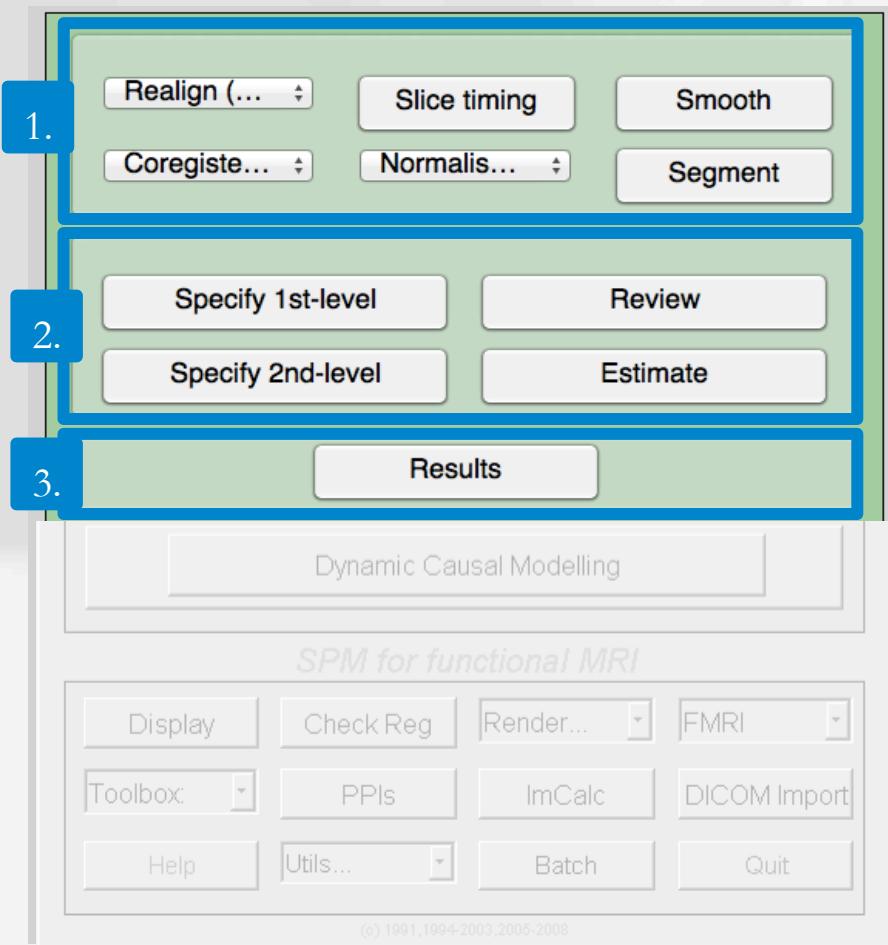


The SPM Graphical User Interface (GUI)



- Spatial Preprocessing
- Model Specification...
- Inference
- DCM
- Tools...(see Practical sessions)

The SPM Graphical User Interface (GUI)



- Spatial Preprocessing
- Model Specification...
- Inference



Single Subject Analysis

Introducing the Dataset (MoAE)

- Mother of All Experiments: Auditory Stimulation
 - TR 7 seconds
 - 6 TR rest
 - 6 TR binaural stimulation
(1 bi-syllabic word per second)
- Chapter 28 of SPM manual

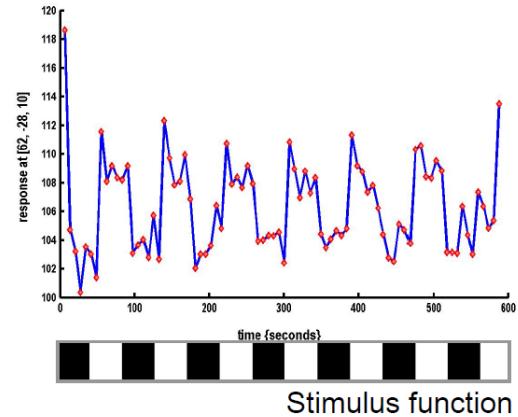
A very simple fMRI experiment

One session

Passive word
listening
versus rest

7 cycles of
rest and listening

Blocks of 6 scans
with 7 sec TR

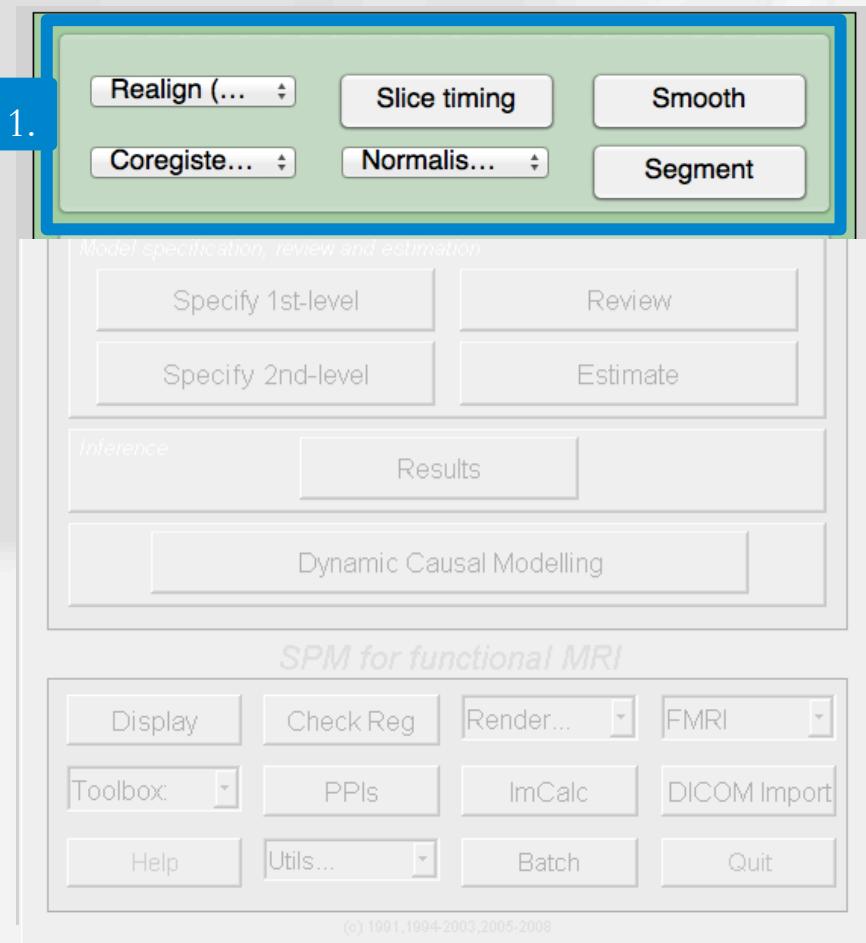


Question: Is there a change in the BOLD response
between listening and rest?

Other talks

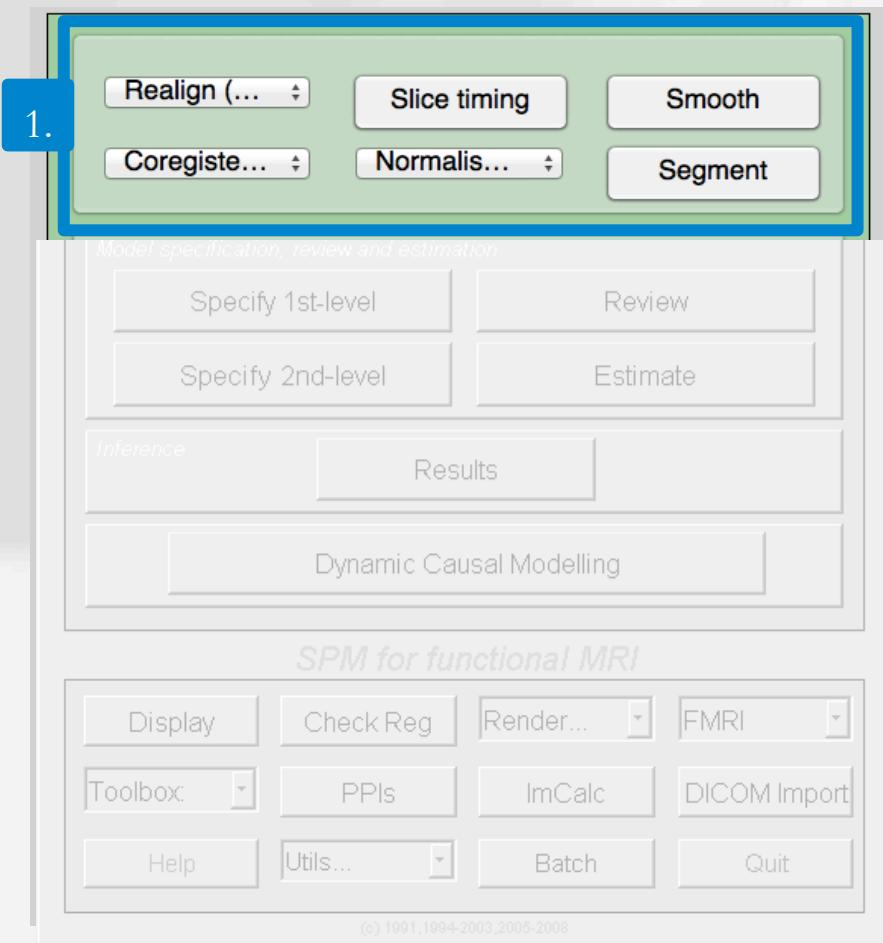
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- **The General Linear Model for fMRI**
(Frederike Petzschner)
- **Statistical inference and design efficiency** (Jakob Heinze)
- **Multiple comparison correction in SPMs**
(Justin Chumbley)
- **Experimental design** (Sandra Iglesias)
- **Event-related fMRI** (Christian Ruff)
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The SPM Graphical User Interface (GUI)



- Spatial Preprocessing
- Model Specification...
- Inference
- DCM
- Tools...

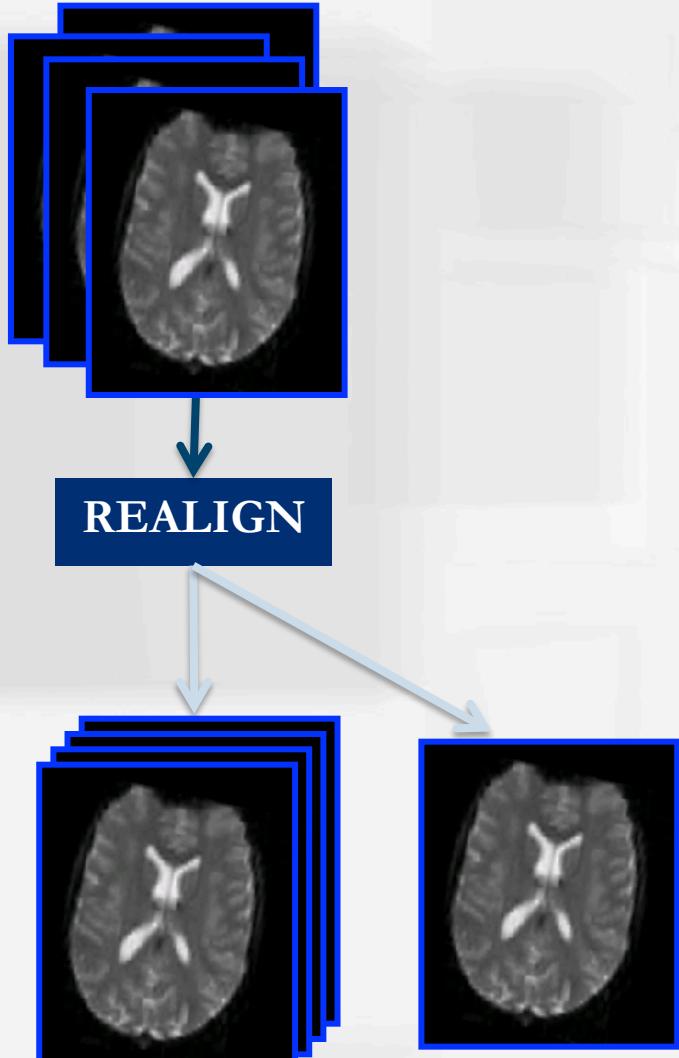
The SPM Graphical User Interface (GUI)



- Spatial Preprocessing
 - Realignment
 - Co-registration
 - Unified Segmentation & Normalization
 - Smoothing...

Spatial Preprocessing

fMRI time-series



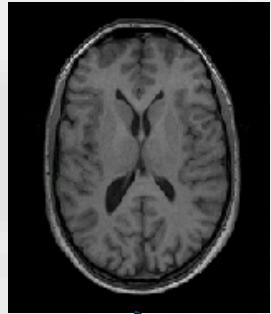
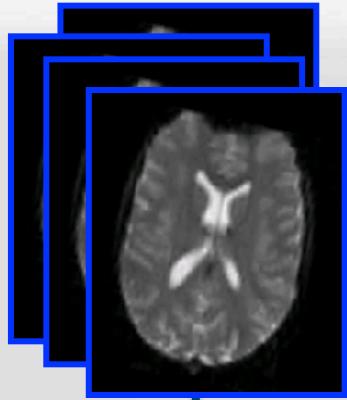
Motion corrected

Mean functional

Spatial Preprocessing

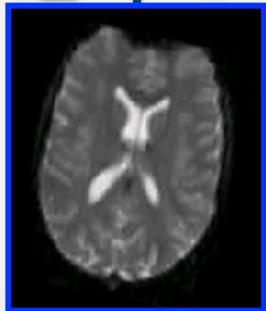
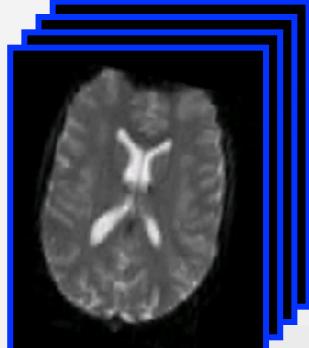
fMRI time-series

Anatomical MRI



REALIGN

COREG



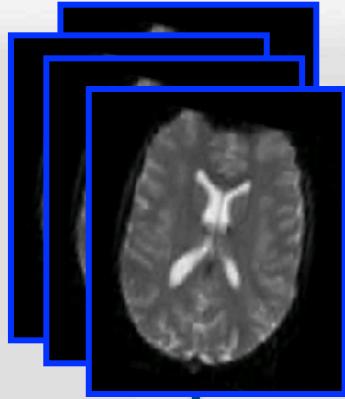
Motion corrected

Mean functional
(Headers changed)

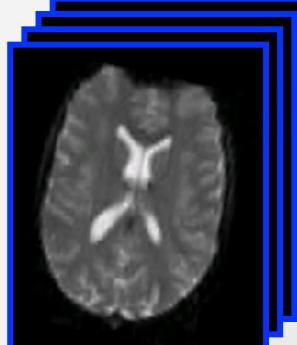
$$\begin{pmatrix} m_{11} & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & 1 \end{pmatrix}$$

Spatial Preprocessing

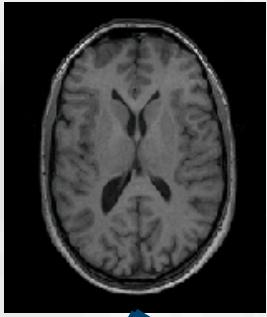
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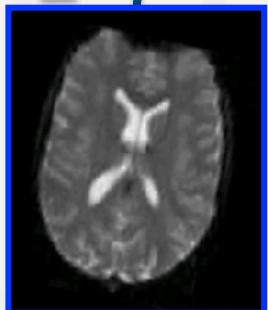
REALIGN



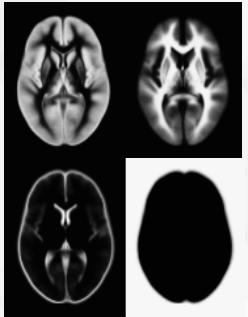
Anatomical MRI



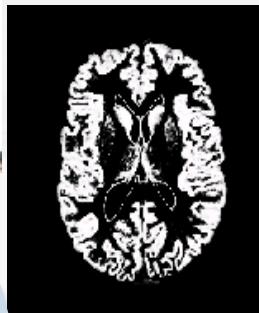
COREG



TPMs



SEGMENT

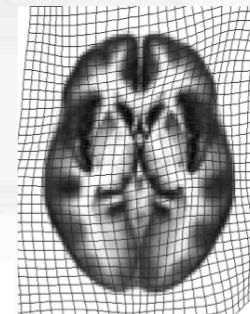


Input →

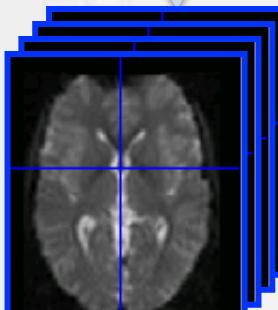
Output →

Deformation
field

(y_s*.nii)



NORM
WRITE



Motion corrected

Mean functional

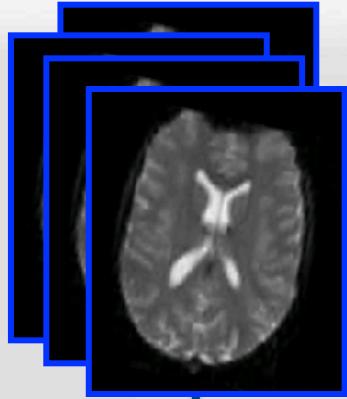
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MNI Space

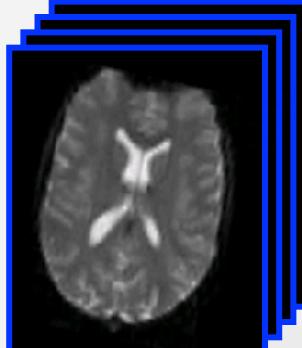
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Spatial Preprocessing

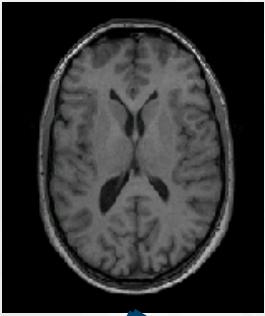
fMRI time-series



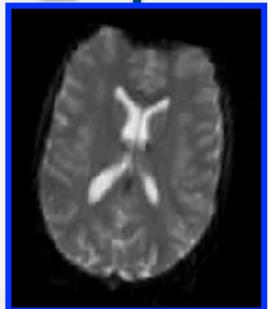
REALIGN



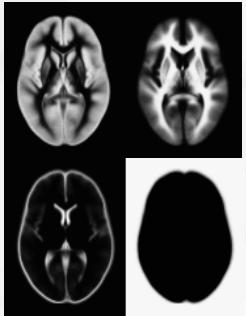
Anatomical MRI



COREG



TPMs

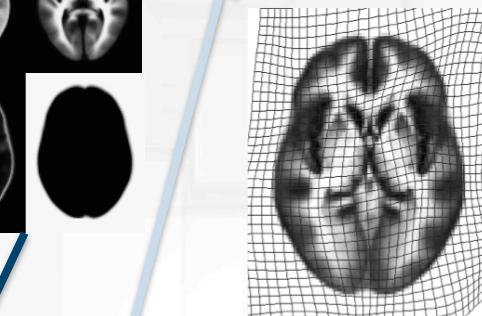


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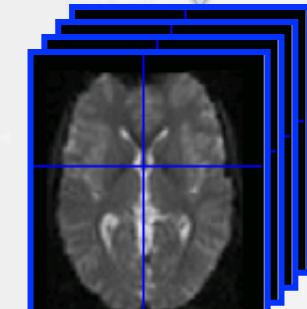


Deformation
field

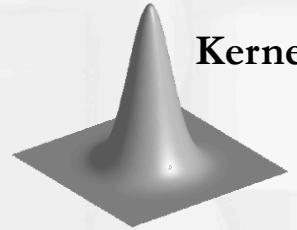
(y_s*.nii)



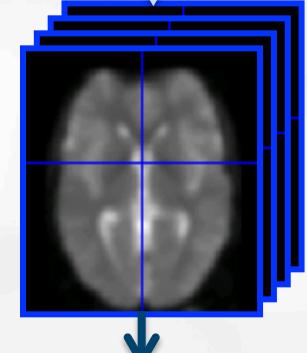
NORM
WRITE



Kernel



SMOOTH



Motion corrected

Mean functional

(Headers changed)

MNI Space

GLM

$$\begin{pmatrix} m_{11} & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & 1 \end{pmatrix}$$

Other talks: Spatial (Pre)processing

- **Preprocessing (Lars Kasper)**

- The General Linear Model

(Frederike Petzschner)



- Statistical inference and

efficiency (Jakob Heinze)

- Multiple comparison correction in SPMs

(Justin Chumbley)

- Experimental design (Sandra Iglesias)

- Event-related fMRI (Christian Ruff)

- Resting state fMRI (David Cole)

- Group analyses (Guillaume Flandin)

- Advanced issues in fMRI statistics

(Tom Nichols)



- **Voxel-based morphometry (Ged Ridgway)**

- Multivariate analyses (Sudhir R. Raman)

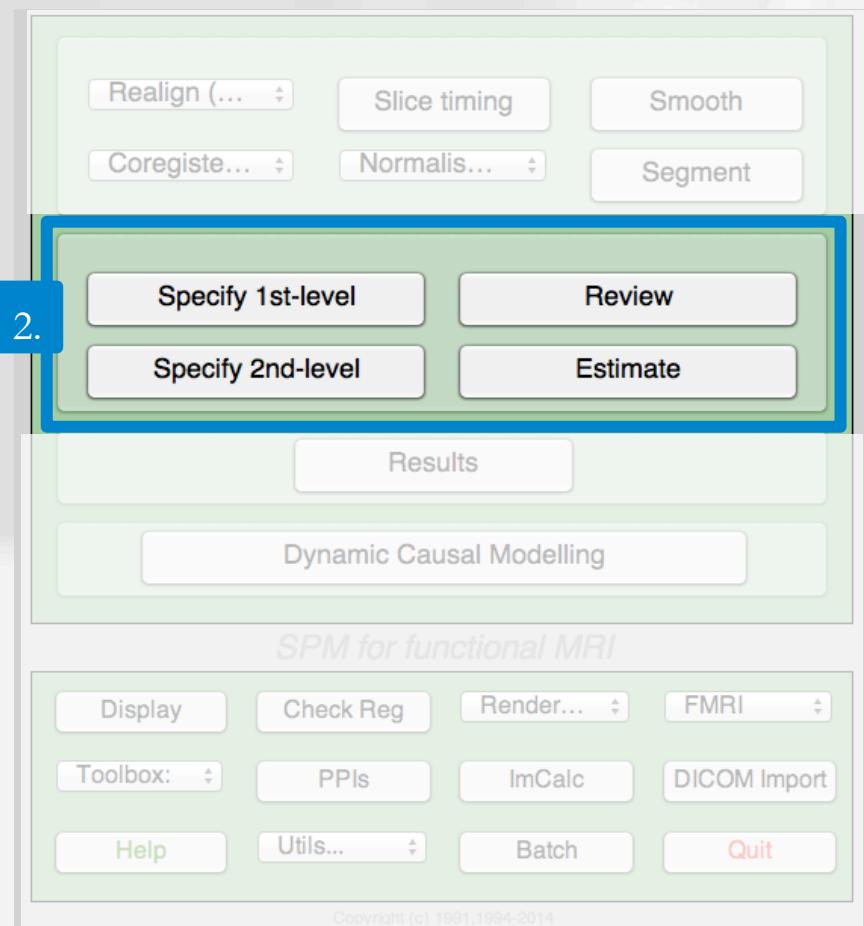
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- Basics of DCM (Hanneke den Ouden)

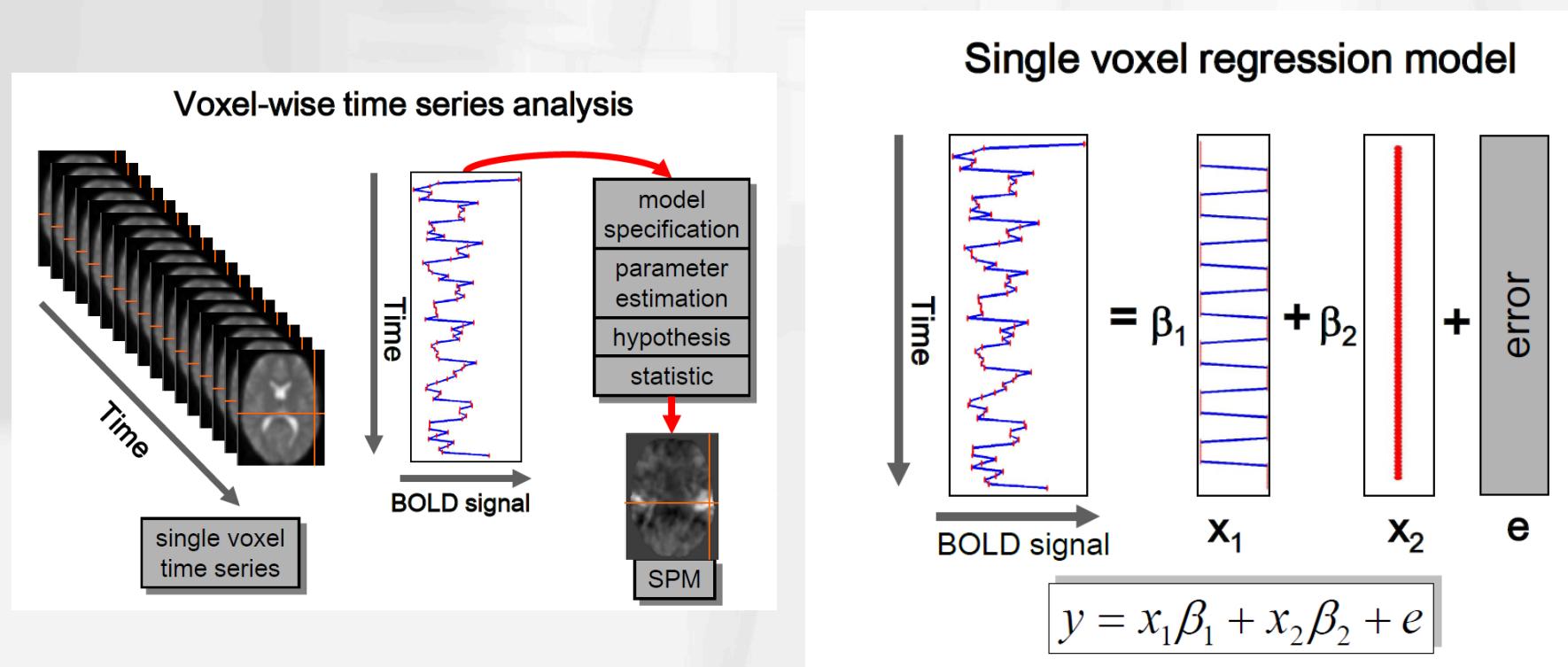
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The SPM Graphical User Interface (GUI)



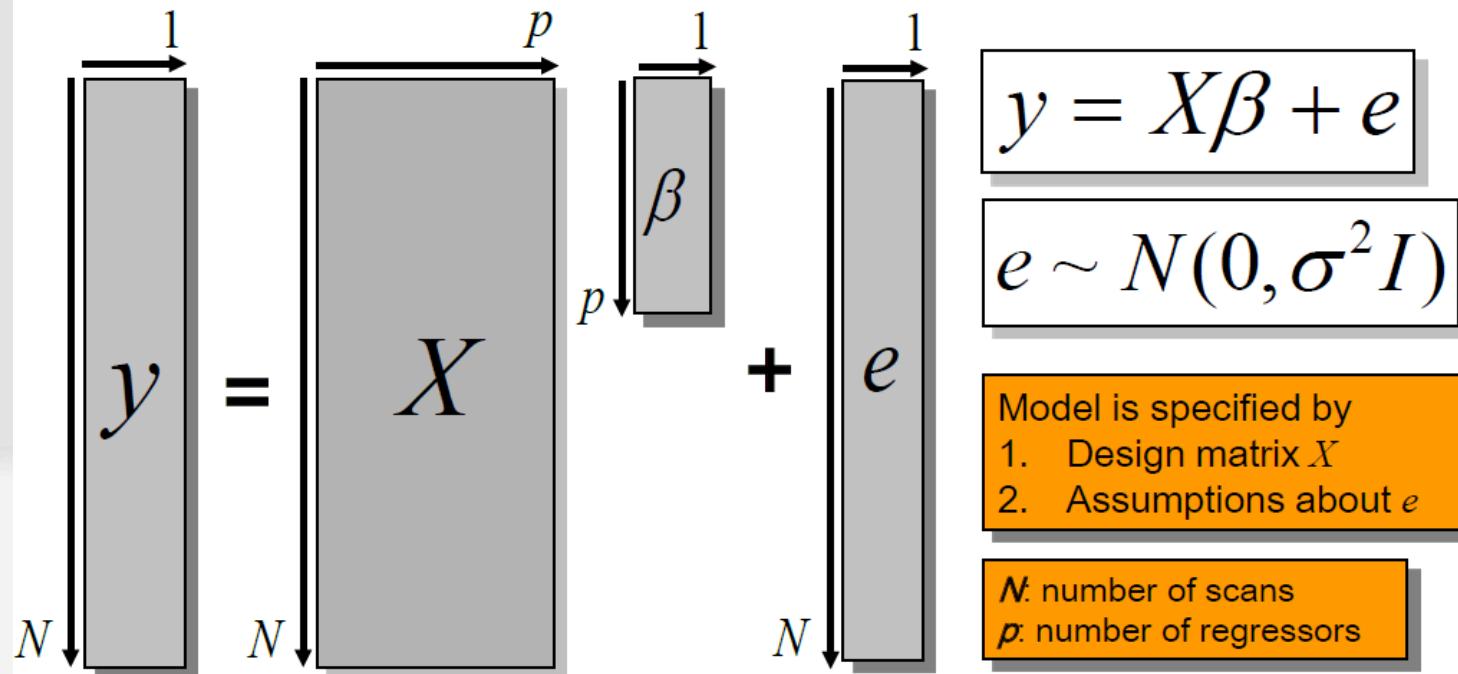
- Model Specification
 - Specify 1st level
 - Review
 - Estimate

Model Specification: The General Linear Model



The Design Matrix

Mass-univariate analysis: voxel-wise GLM



The design matrix embodies all available knowledge about experimentally controlled factors and potential confounds.

Other talks: Model Specification

- Preprocessing (Lars Kasper)
- **The General Linear Model for fMRI (Frederike Petzschner)**



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- Resting state fMRI (David



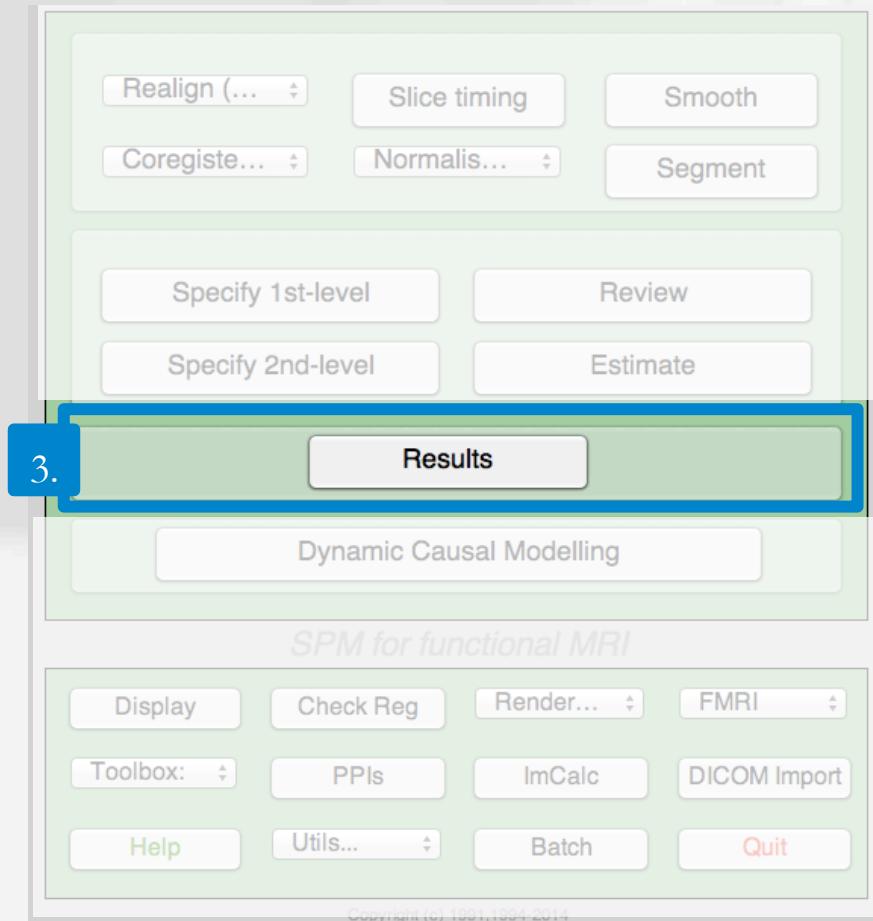
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- Basics of DCM (J. W. M. den Ouden)
- Advanced DCM (Klaas E. Stephan)



The SPM Graphical User Interface (GUI)



■ Inference

- Contrast Manager
- Results Table
- Plot
- Overlays

Statistical Inference



■ T-test

■ F-Test

To test an hypothesis, we construct a “test statistic”.

- “Null hypothesis” $H_0 = \text{“there is no effect”} \Rightarrow c^T \beta = 0$

This is what we want to disprove.

\Leftrightarrow The “alternative hypothesis” H_1 represents the outcome of interest.

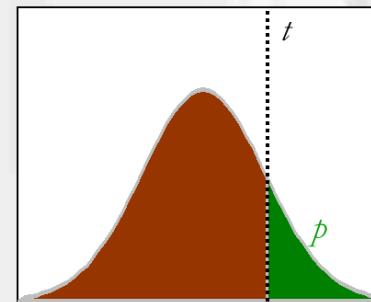
- A p -value summarises evidence against H_0 .

This is the probability of observing t , or a more extreme value, under the null hypothesis:

$$p(T \geq t | H_0)$$

- The conclusion about the hypothesis:

We reject H_0 in favour of H_1 if $t > u_a$



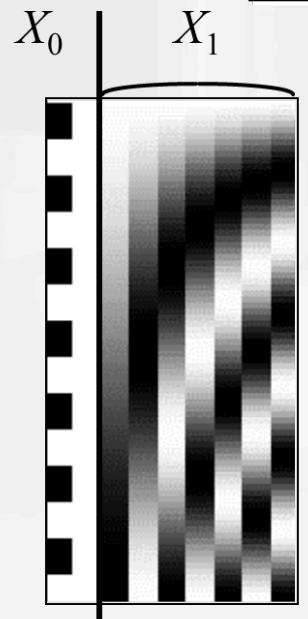
Statistical Inference



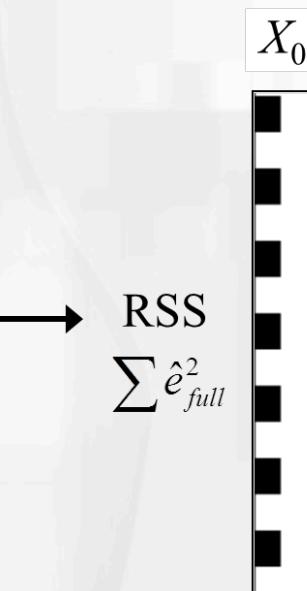
- T-test
- F-Test

Model comparison: Full vs. reduced model

Null Hypothesis H_0 : True model is X_0 (reduced model)



Full model ($X_0 + X_1$)?



Or reduced model (X_0)?

F-statistic: ratio of unexplained variance under X_0 and total unexplained variance under the full model

$$F \propto \frac{RSS_0 - RSS}{\sum \hat{e}_{reduced}^2}$$



Other talks: Inference

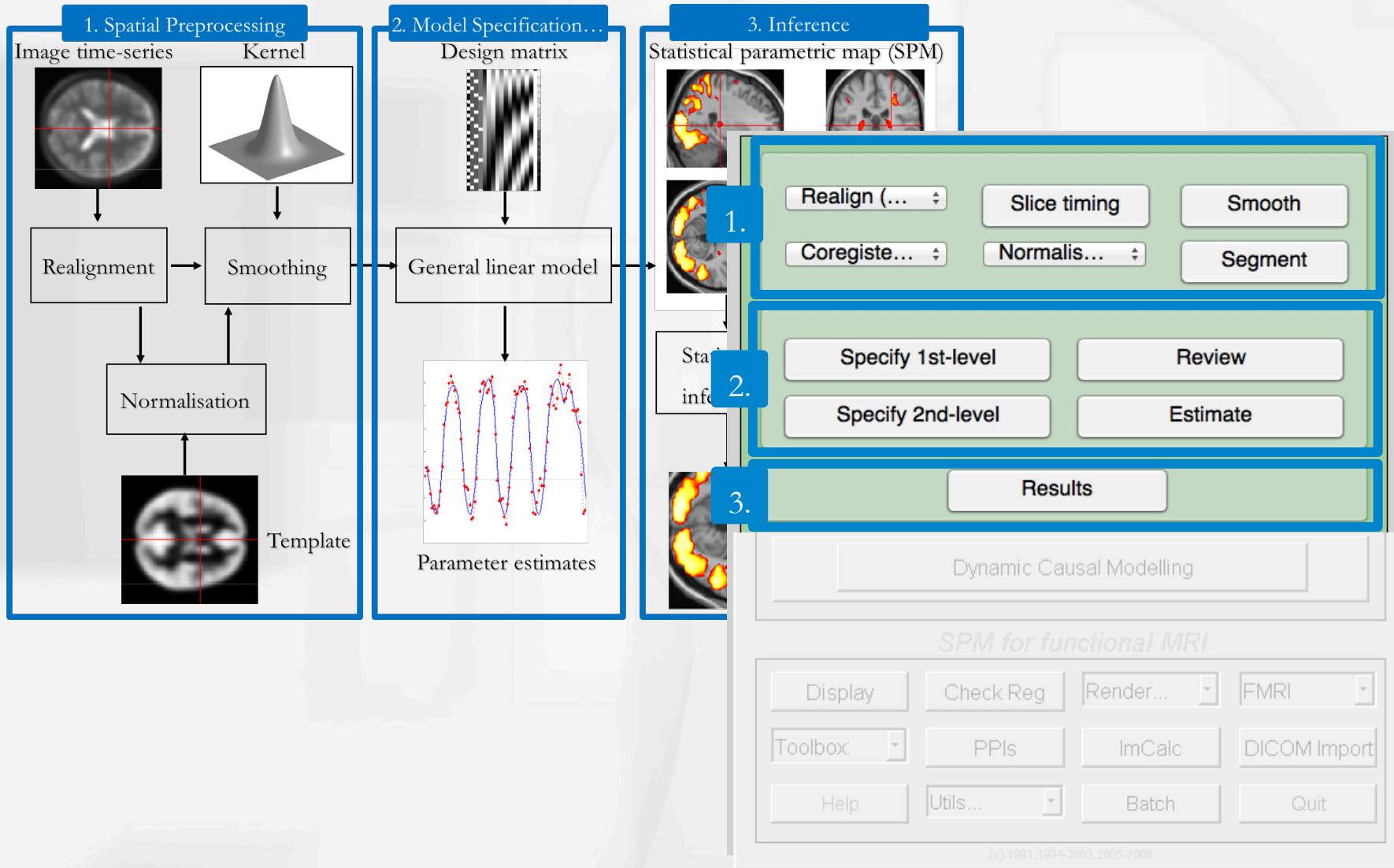
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- Event-related fMRI (Curtis Hart)
- Resting state fMRI (David Cole)



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Summary



Buttons I haven't touched (upon)

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- The General Linear Model for fMRI (Frederike Petzschner)
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Thank you...

- ...and:
 - TNU Zurich,
 - in particular: Klaas
 - Lars Kasper
 - Everyone I borrowed slides from ☺