

fMRI pre-processing

Juergen Dukart

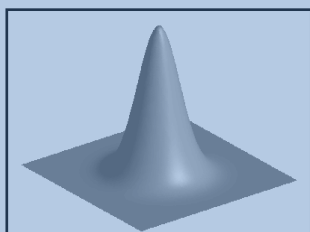
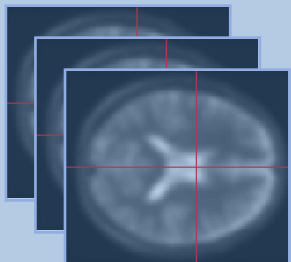
Outline

- Why do we need pre-processing?
- fMRI pre-processing
 - Slice time correction
 - Realignment
 - Unwarping
 - Coregistration
 - Spatial normalisation
 - Smoothing

Overview

fMRI time-series

kernel



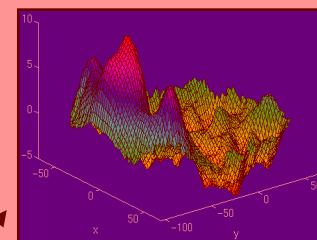
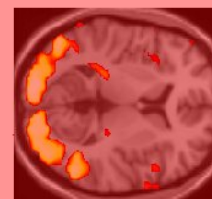
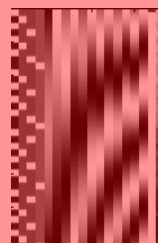
Motion correction

Smoothing

General Linear Model

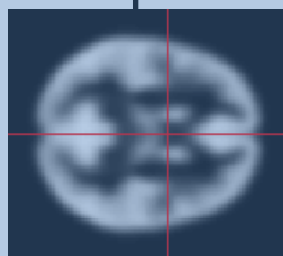
Design matrix

Statistical Parametric Map

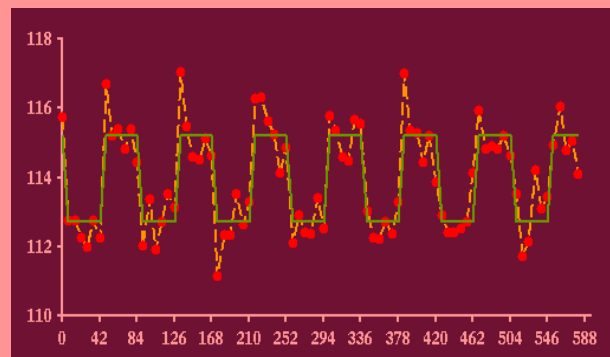


(Co-registration and) Spatial normalisation

Parameter Estimates

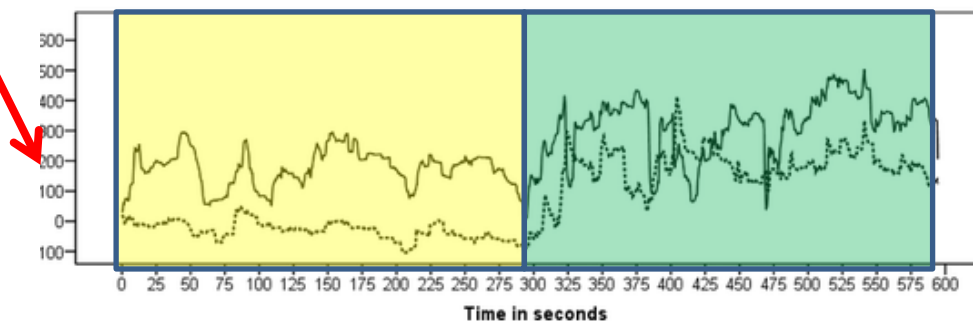
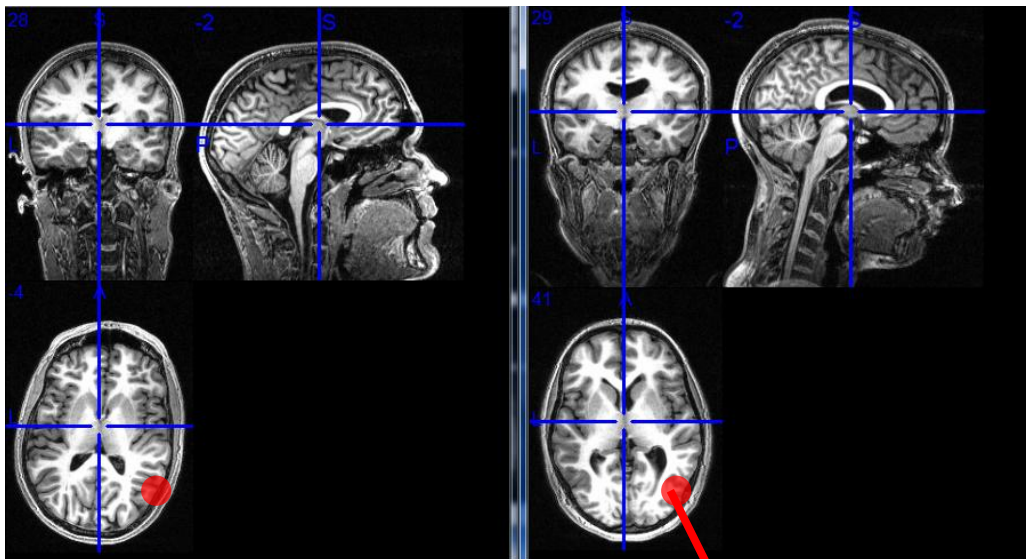


Standard template

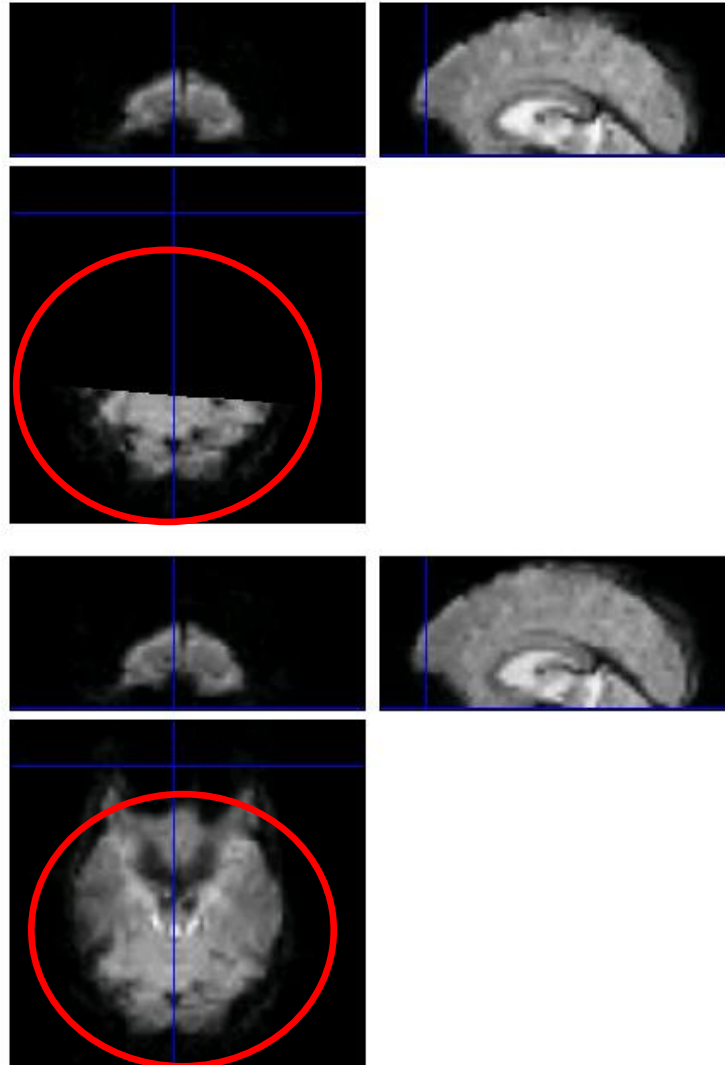


Why do we need pre-processing?

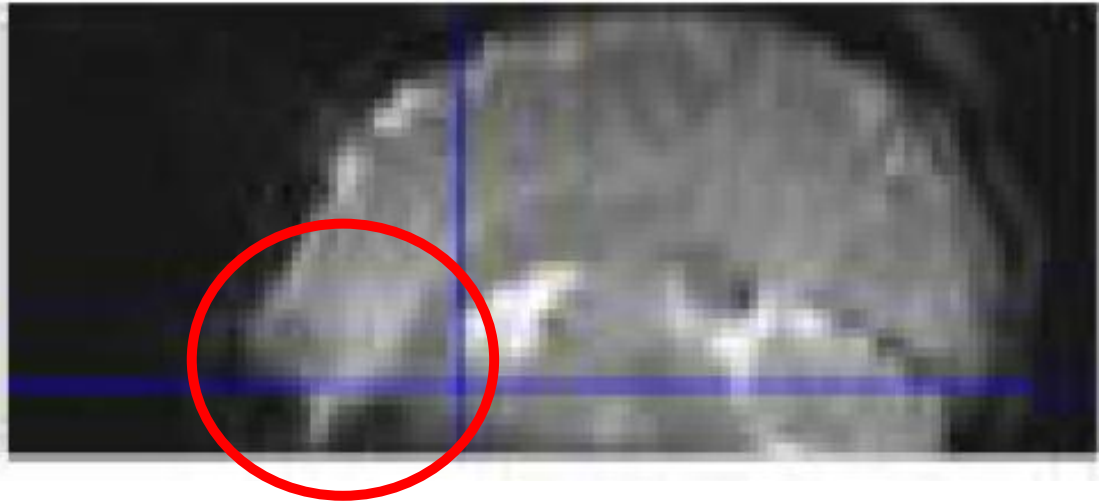
What do we want?



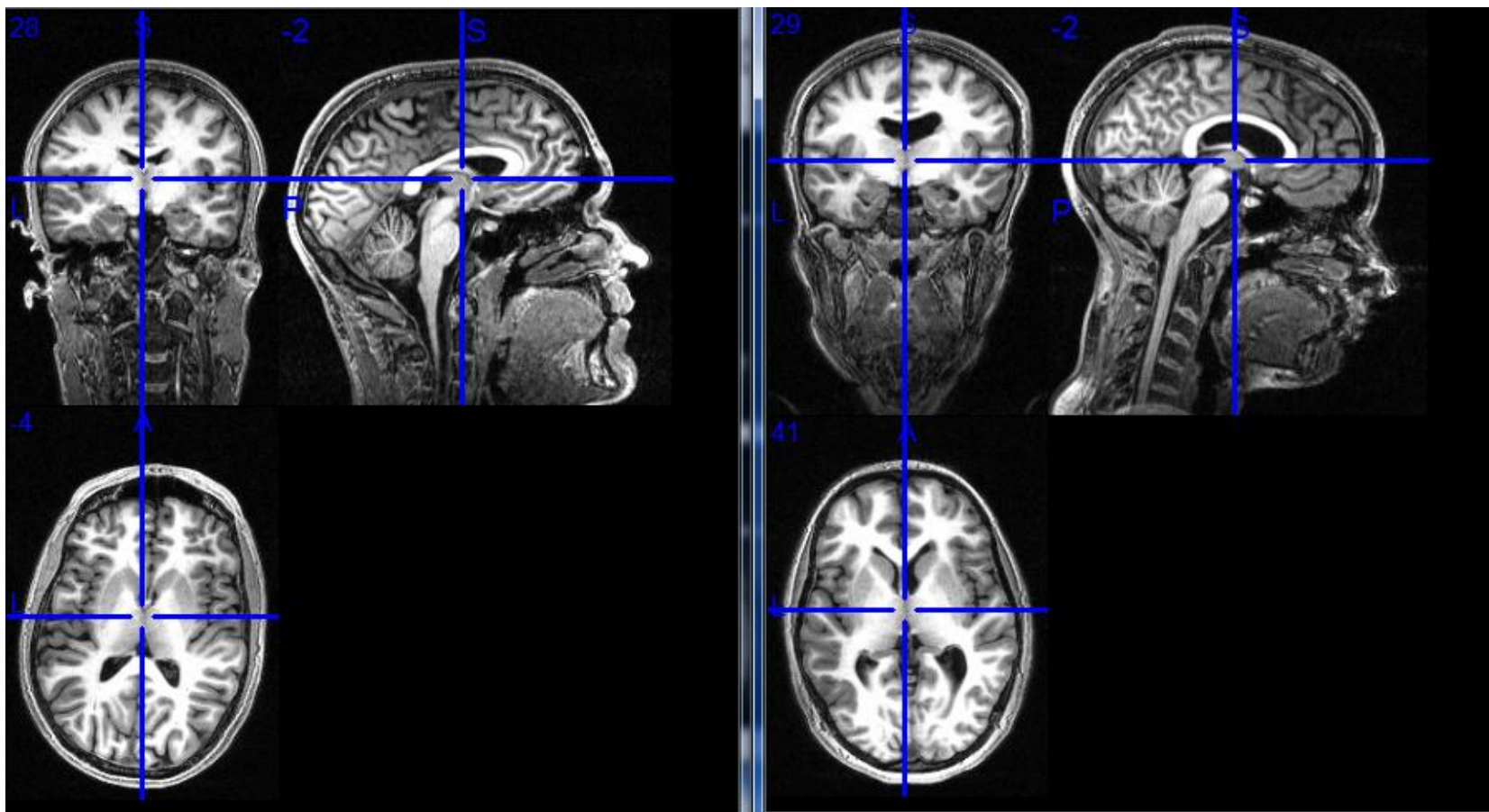
Movement



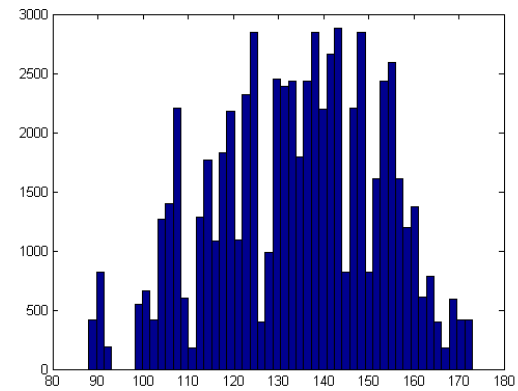
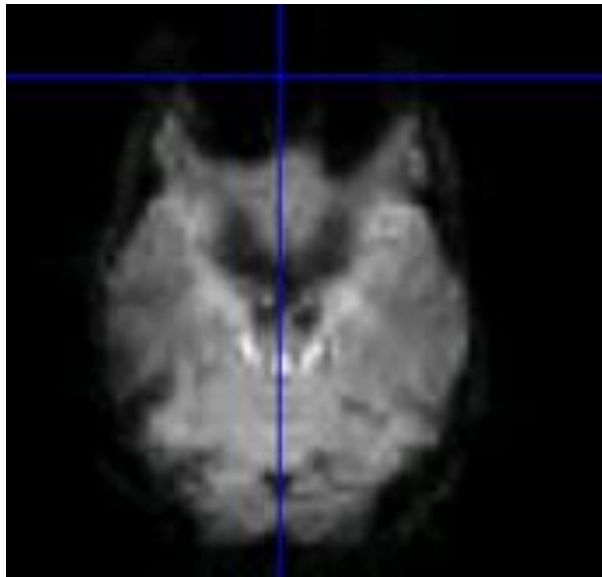
Distortions



Inter-subject variability



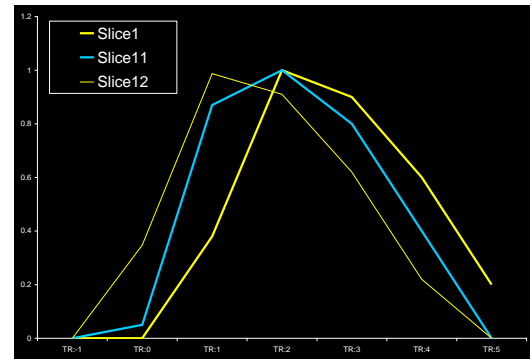
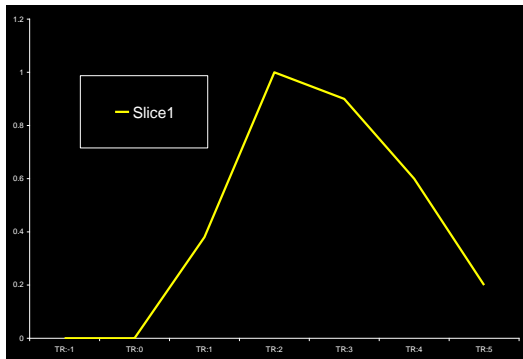
Non-gaussian distribution



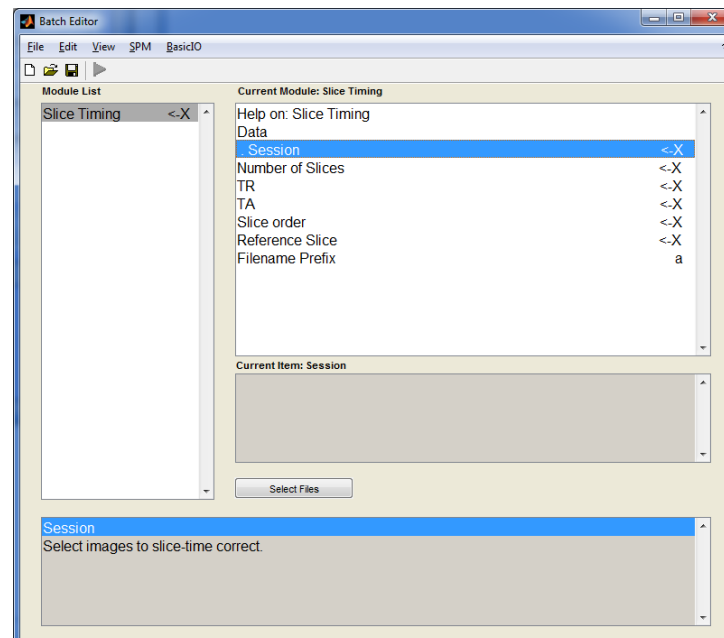
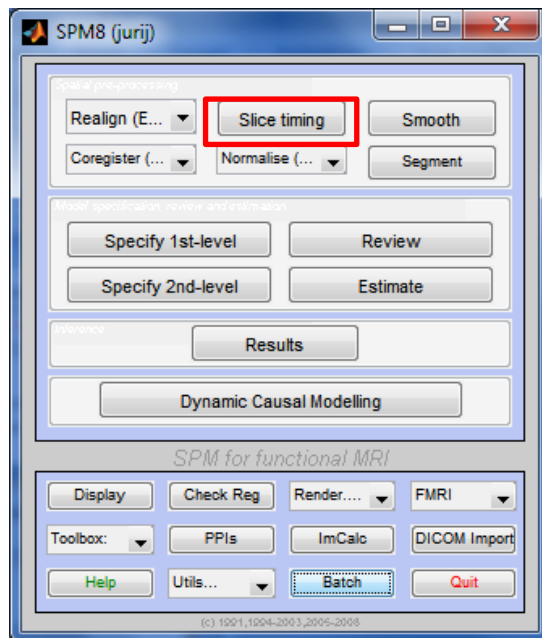
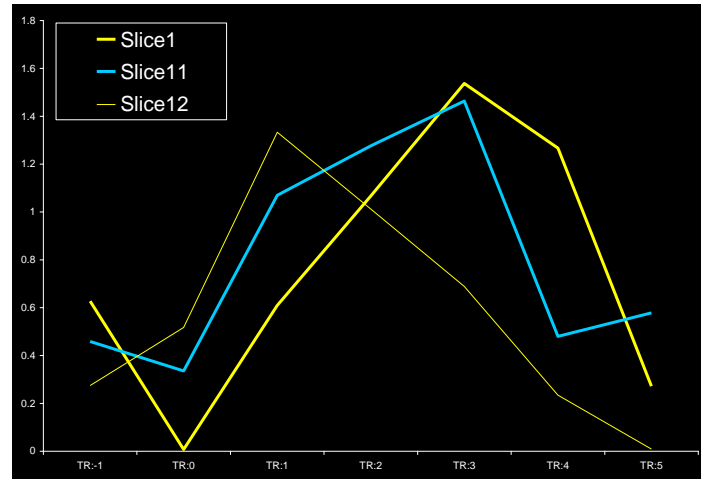
fMRI pre-processing

- Slice timing correction (optional)
- Realignment (Motion correction)
- Unwarping (Distortion correction, optional)
- Co-registration
 - Link functional scans to anatomical scan
- Spatial normalisation (unified segmentation)
 - Fitting images to a standard brain
- Smoothing
 - Increases signal-to-noise ratio and approximates a Gaussian distribution

Slice timing (optional)



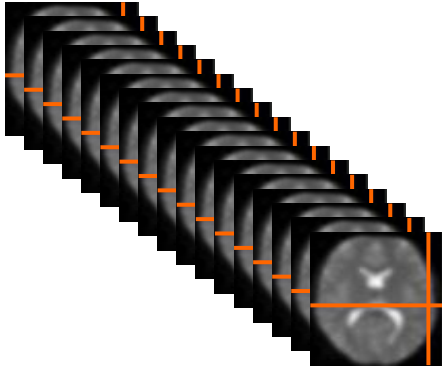
Slice timing (optional)



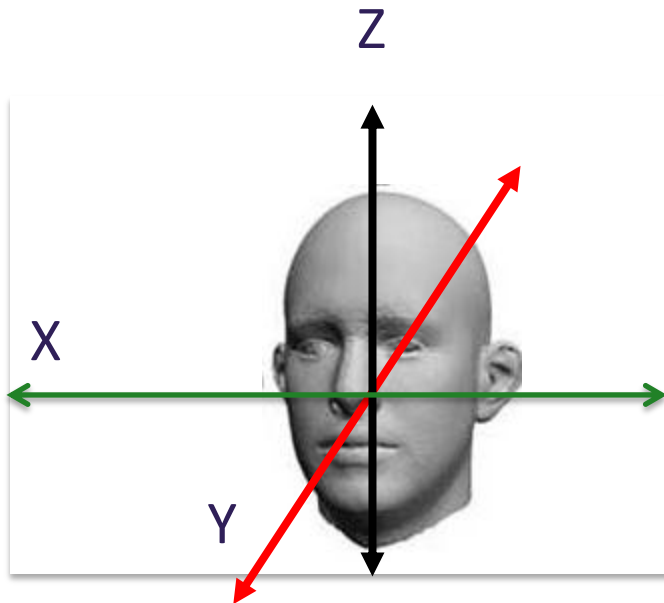
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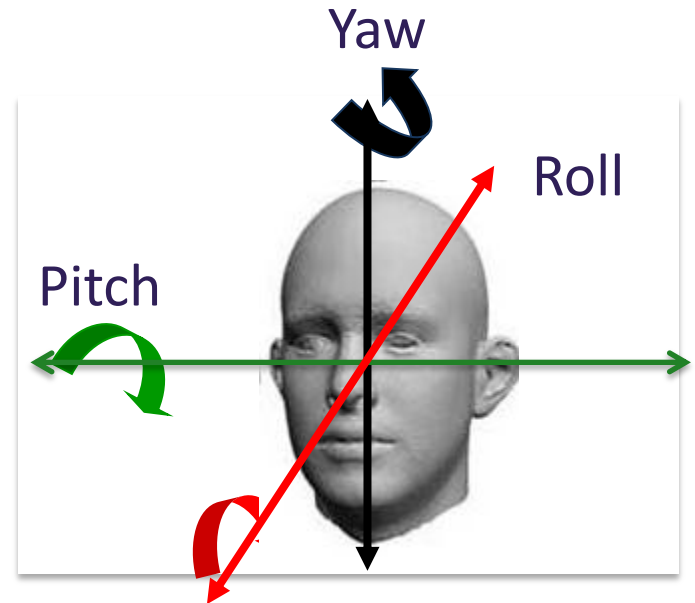
Realignment (motion correction)



Translation



Rotation

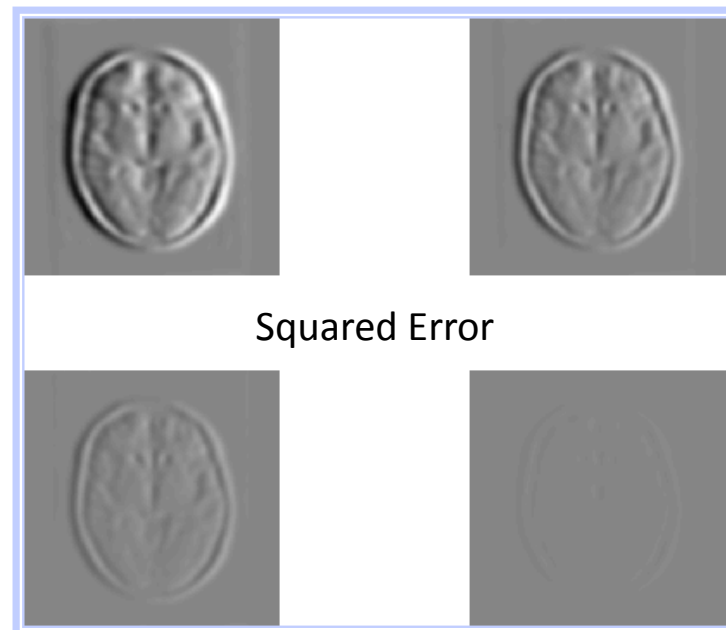


Realignment (motion correction)

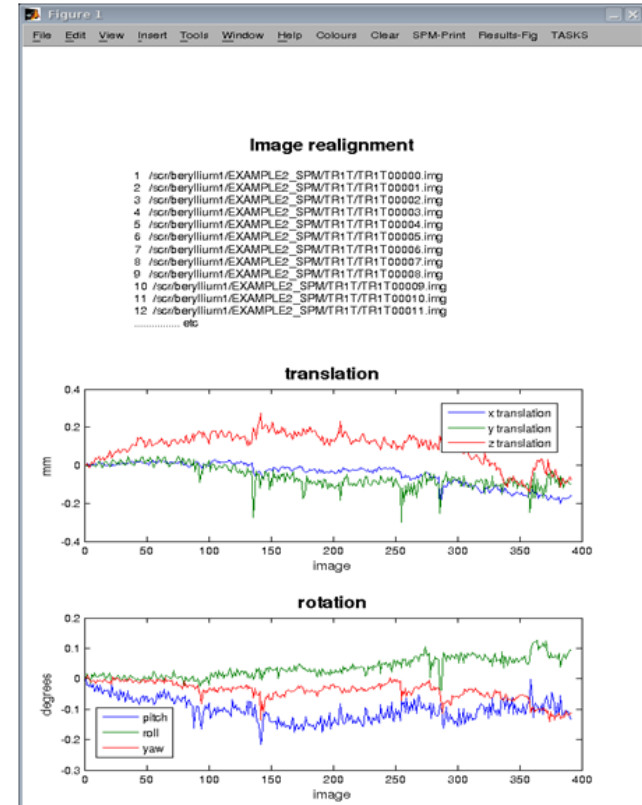
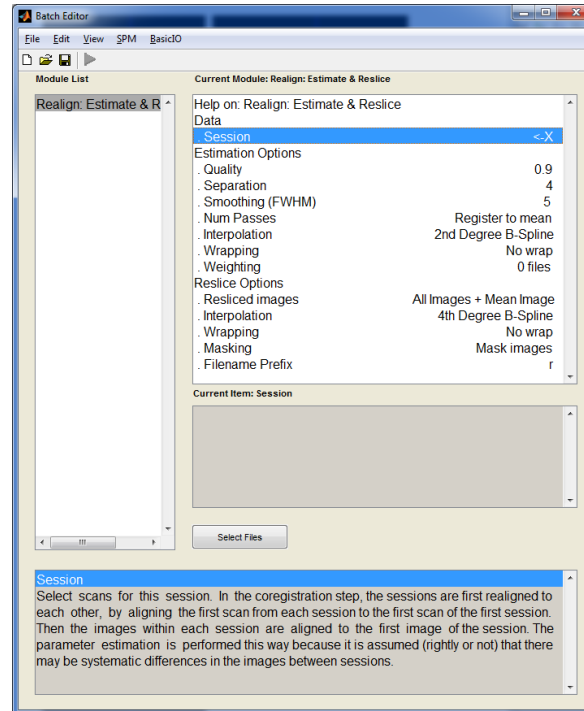
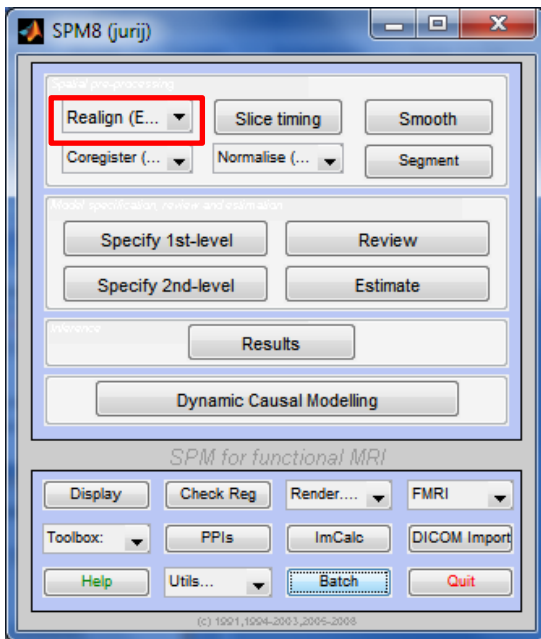
Rigid body transformations parameterised by:

Translations	Pitch about X axis	Roll about Y axis	Yaw about Z axis
$\begin{pmatrix} 1 & 0 & 0 & X_{\text{trans}} \\ 0 & 1 & 0 & Y_{\text{trans}} \\ 0 & 0 & 1 & Z_{\text{trans}} \\ 0 & 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(\Phi) & \sin(\Phi) & 0 \\ 0 & -\sin(\Phi) & \cos(\Phi) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} \cos(\Theta) & 0 & \sin(\Theta) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(\Theta) & 0 & \cos(\Theta) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} \cos(\Omega) & \sin(\Omega) & 0 & 0 \\ -\sin(\Omega) & \cos(\Omega) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Minimizing the squared difference (error) between the images



Realignment (motion correction)

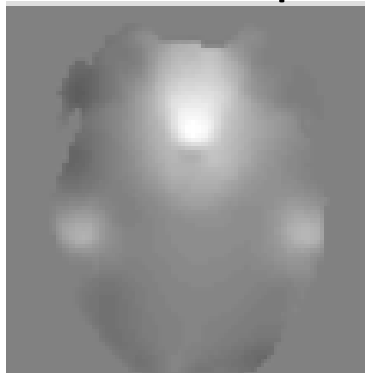


fMRI pre-processing

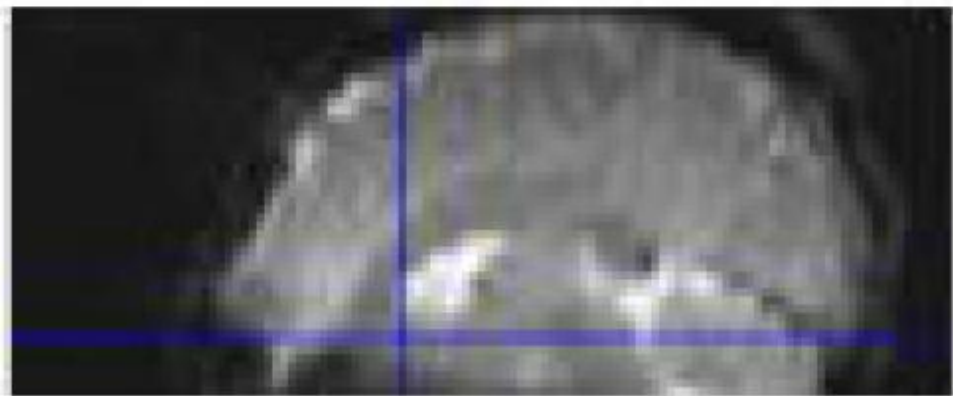
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Distortion correction (unwarp)

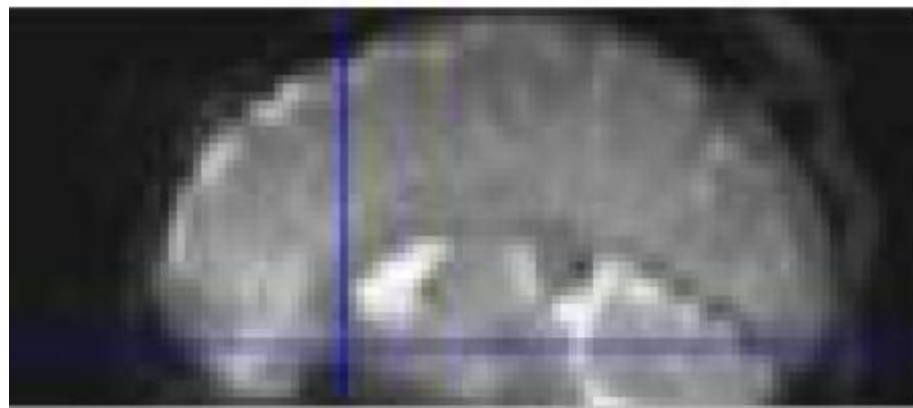
Fieldmap



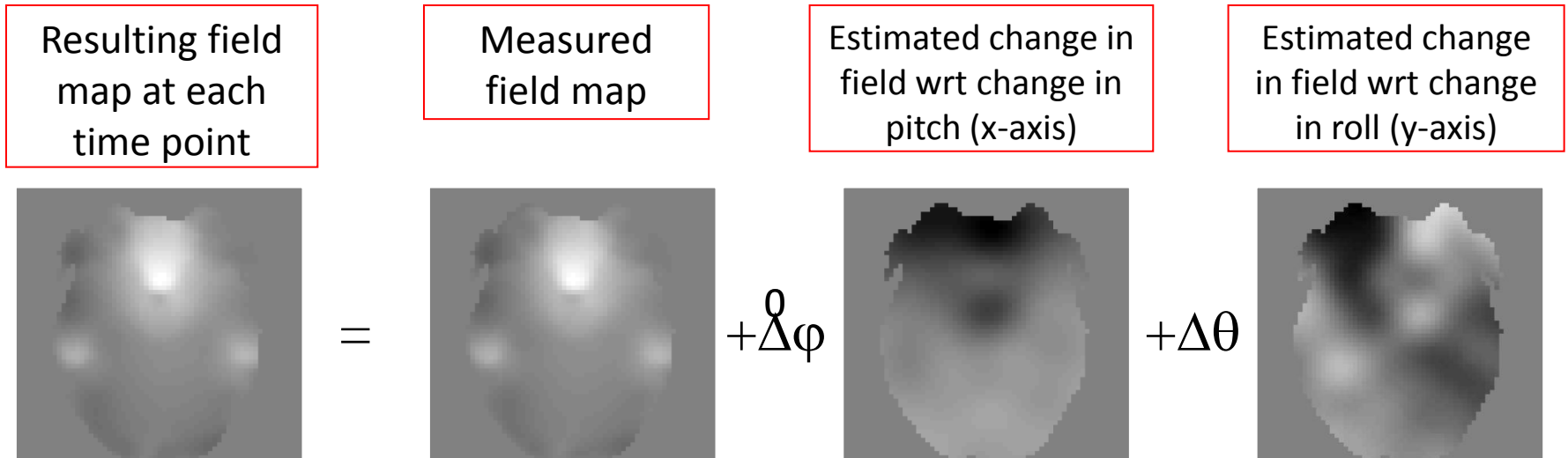
Raw EPI



Undistorted EPI



Unwarp can estimate changes in distortion from movement



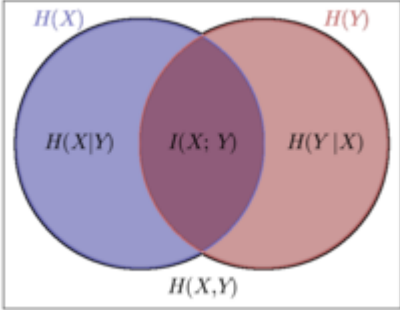
- distortions in a reference image (FieldMap)
- subject motion parameters (that we obtain in realignment)
- change in deformation field with subject movement (estimated via iteration)

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Co-registration

Normalized mutual information



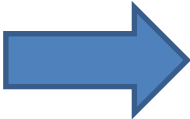
Visual Image

Thermal Image

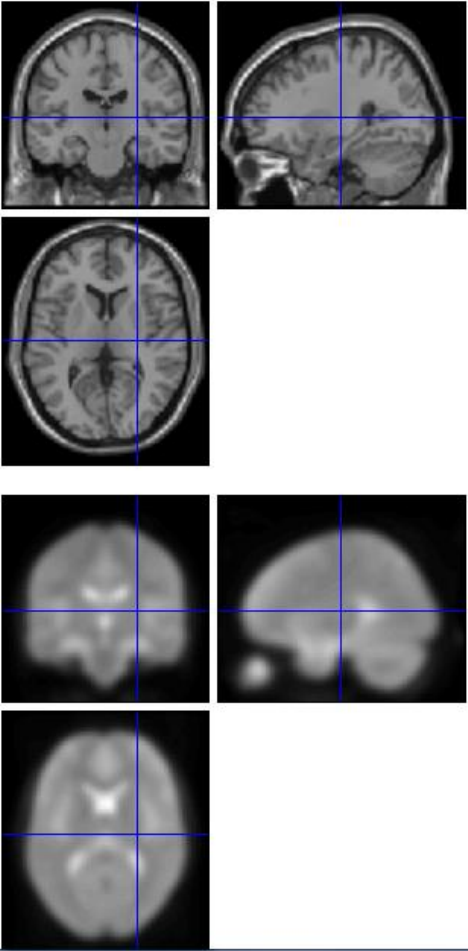


Chess Image after Registration

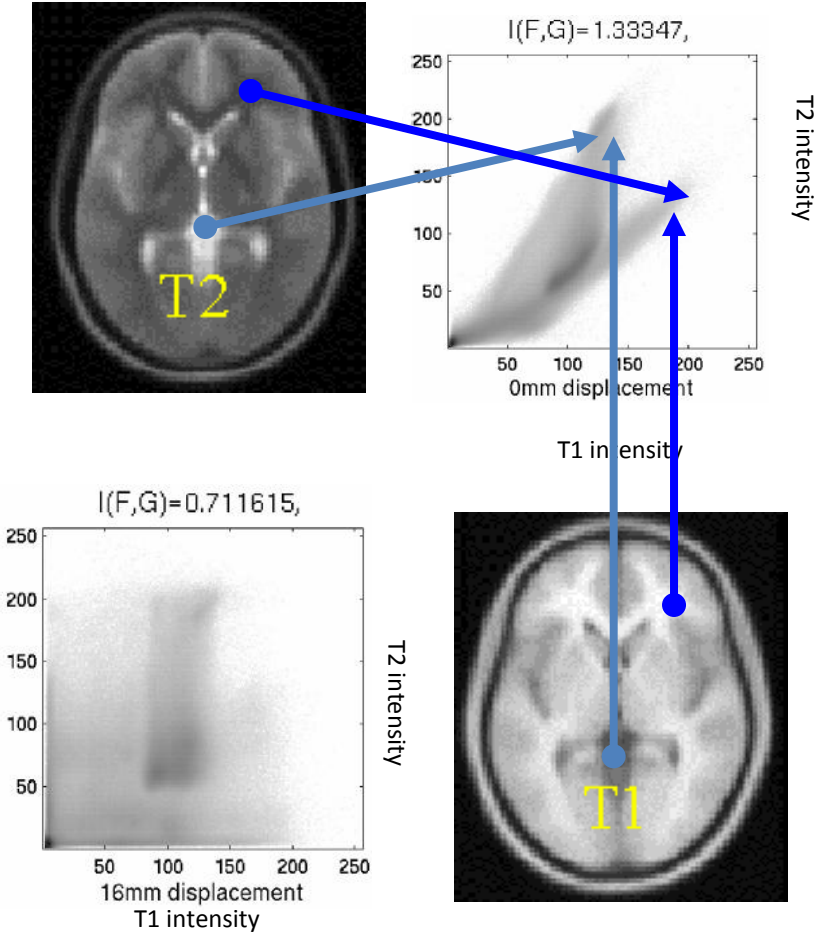
Image after Fusion



functional and structural images in the same space



Co-registration



Spatial normalization

Normalizes structural images to a standard brain template (standard space)

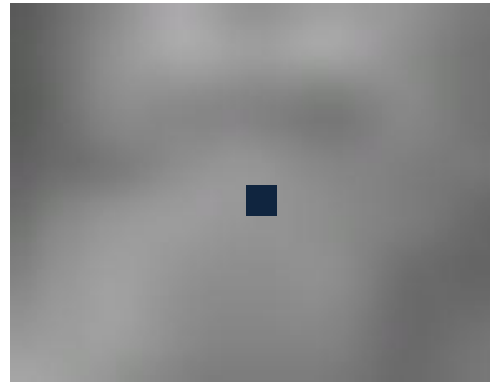
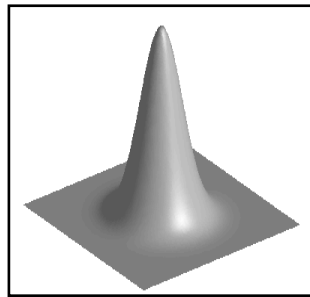
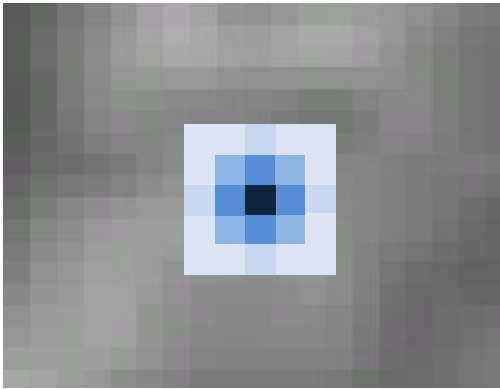
→ The obtained transformation (warping) parameters can be applied on co-registered fMRI data

→ Improved spatial normalization based on high resolution structural information

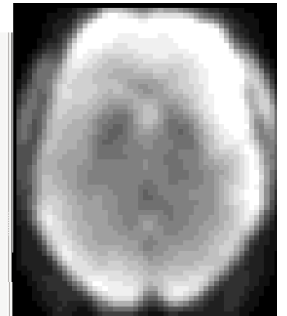
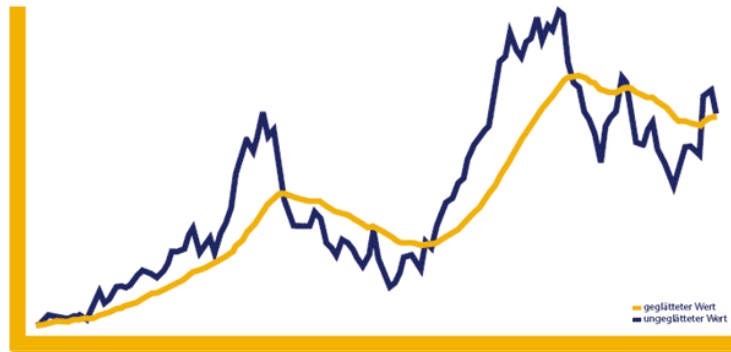
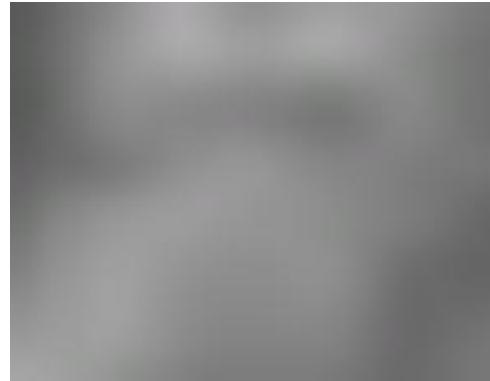
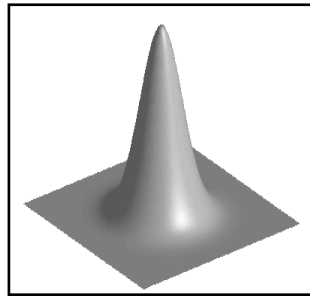
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Smoothing



Smoothing



Thank you for attention