

SPM: Introduction

Shamil Hadi

Computer Science and Engineering

Oakland University

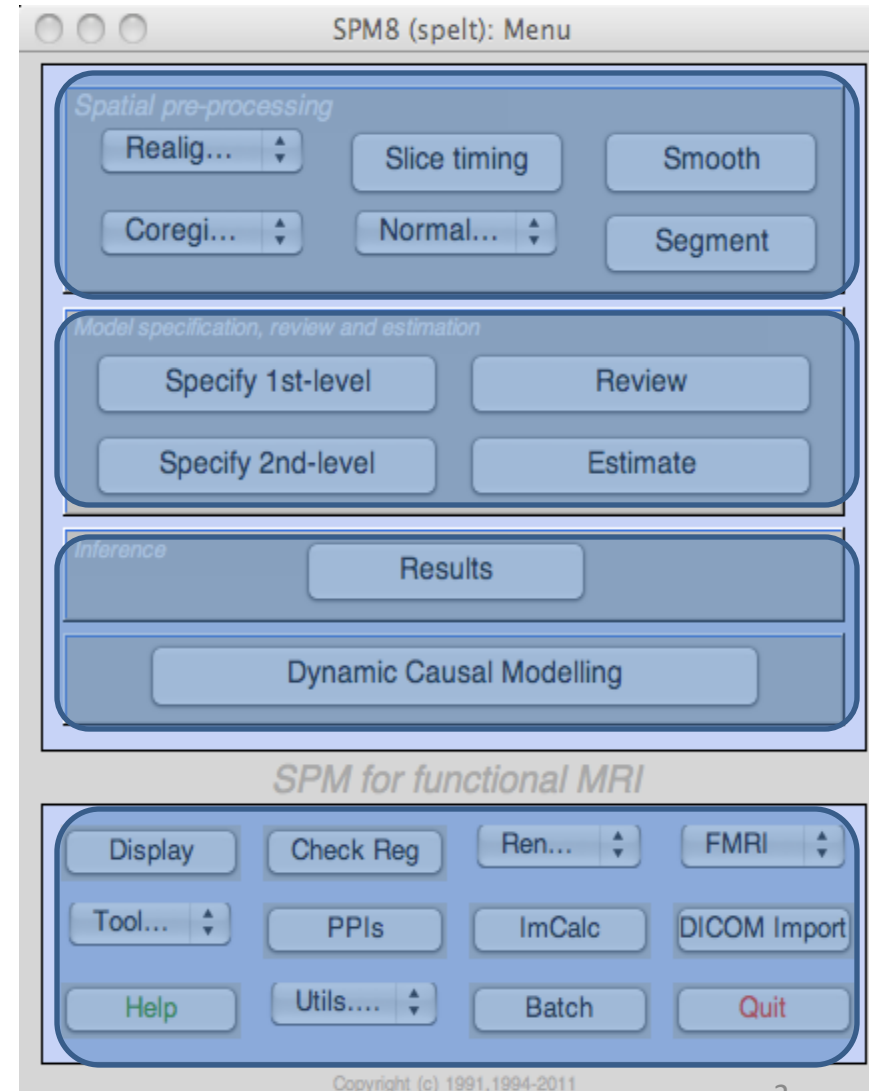
SPM: Overview

❑ C language and MATLAB

❑ Friendly GUI

❑ Main Functions

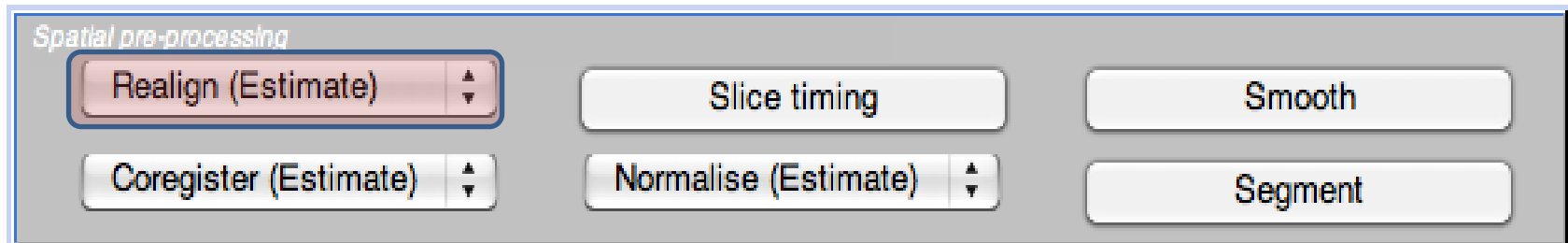
- 1- Spatial pre-processing
- 2- Model specification, review and estimation
- 3- Inference
- 4- Other fMRI tools



Preprocessing: Realignment

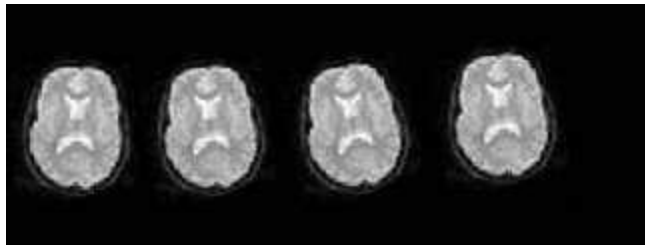
☐ Realignment

- Intra-subject registration
- Align all functional images
- Positioning of the brain in each image is the same

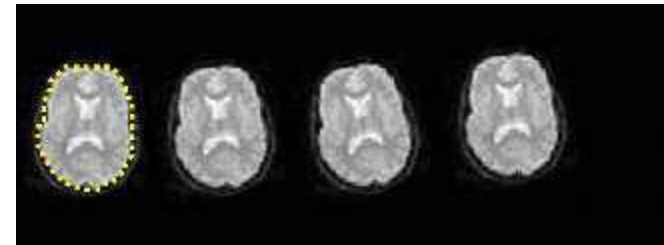


Preprocessing: Realignment

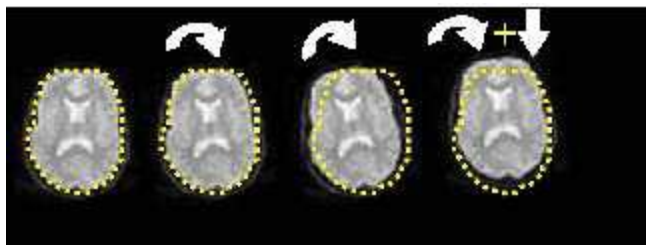
Step 1



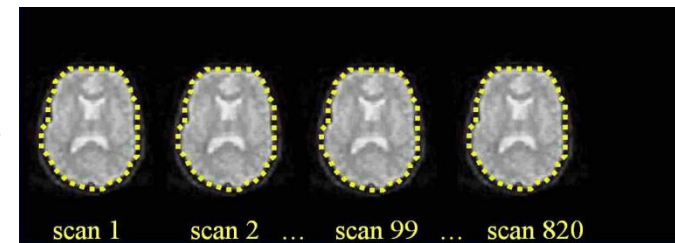
Step 2



Step 3



Step 4



Spatial pre-processing

Realign (Estimate)



Slice timing

Smooth

Coregister (Estimate)



Normalise (Estimate)



Segment

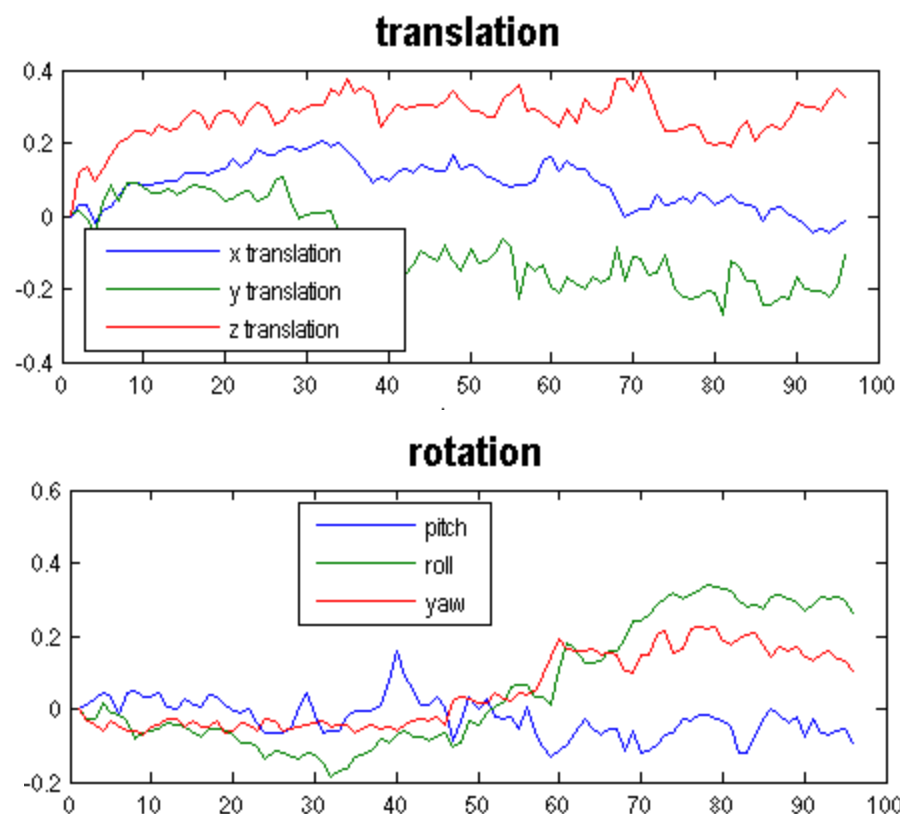
Preprocessing: Realignment

Image realignment

```

1 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_004.img
2 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_005.img
3 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_006.img
4 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_007.img
5 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_008.img
6 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_009.img
7 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_010.img
8 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_011.img
9 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_012.img
10 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_013.img
11 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_014.img
12 F:\Iraqi_Universities\Data\Preprocessing\fm00223\fm00223_015.img
..... etc

```



Spatial pre-processing

Realign (Estimate)

Slice timing

Smooth

Coregister (Estimate)

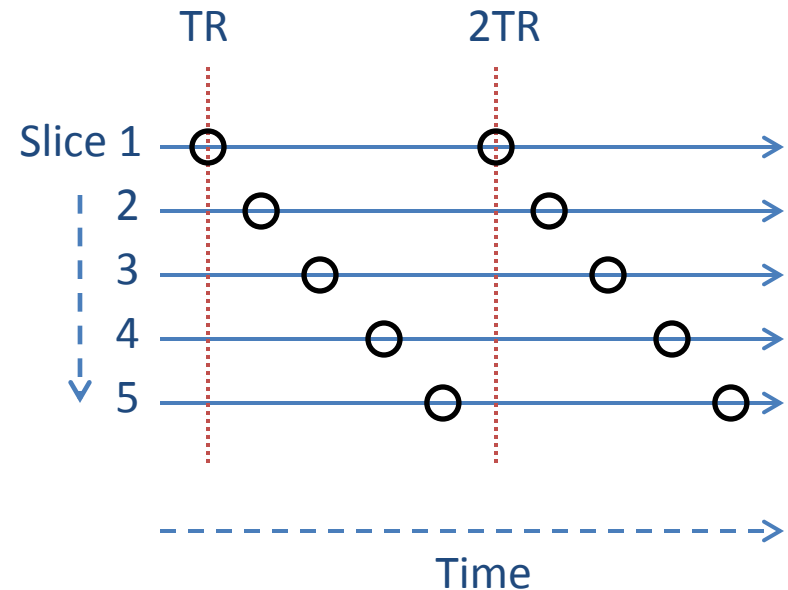
Normalise (Estimate)

Segment

Preprocessing: Slice Timing

❑ Slice timing

- Correcting the time of image acquisition



Spatial pre-processing

Realign (Estimate)



Slice timing

Smooth

Coregister (Estimate)



Normalise (Estimate)



Segment

Preprocessing: Coregistration

□ Coregistration

- Intra-subject
- Differences in signal intensity between the images, e.g., EPI and T1
- Methods
 - Segmentation
 - Mutual information

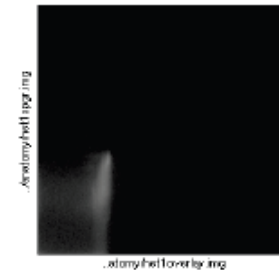
Normalised Mutual Information Coregistration

$$X1 = 1.093^{\circ}X - 0.011^{\circ}Y - 0.008^{\circ}Z - 10.591$$

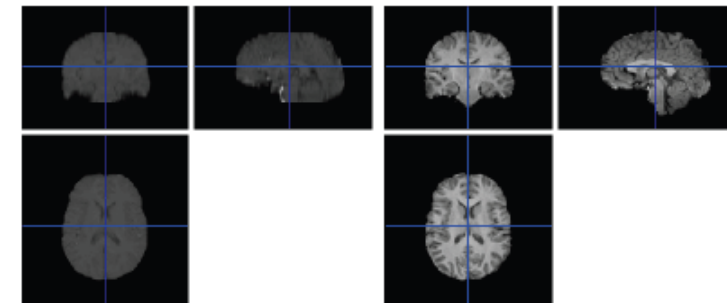
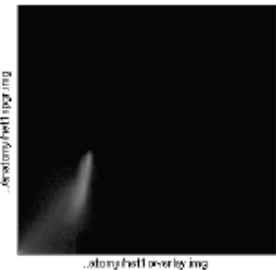
$$Y1 = 0.010^{\circ}X + 1.086^{\circ}Y - 0.190^{\circ}Z + 8.054$$

$$Z1 = 0.001^{\circ}X + 0.020^{\circ}Y + 0.298^{\circ}Z - 7.243$$

Original Joint Histogram



Final Joint Histogram



Spatial pre-processing

Realign (Estimate)



Slice timing

Smooth

Coregister (Estimate)



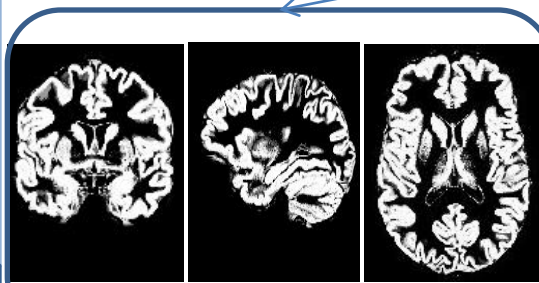
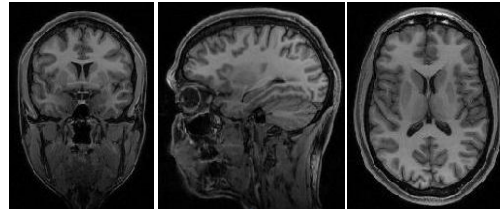
Normalise (Estimate)



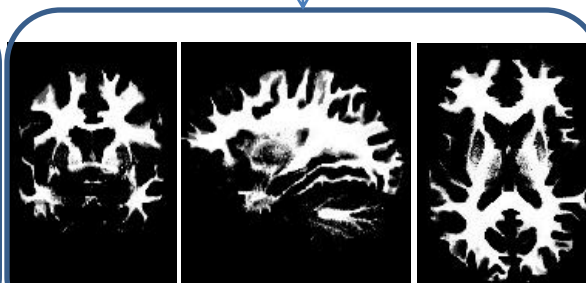
Segment

Preprocessing: Segmentation

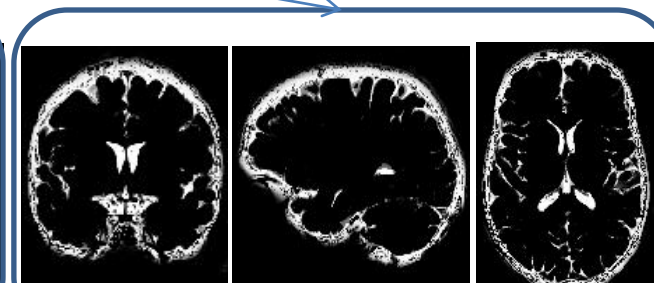
□ Segmentation into GM/WM/CSF



GM



WM



CSF

Spatial pre-processing

Realign (Estimate) ▲▼

Slice timing

Smooth

Coregister (Estimate) ▲▼

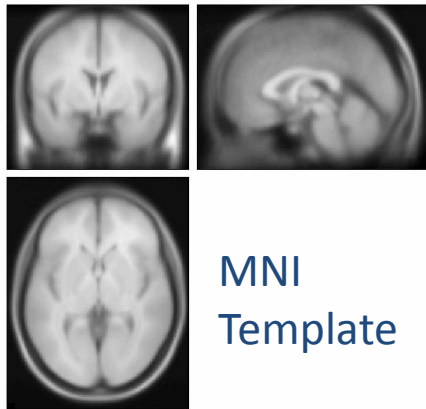
Normalise (Estimate) ▲▼

Segment

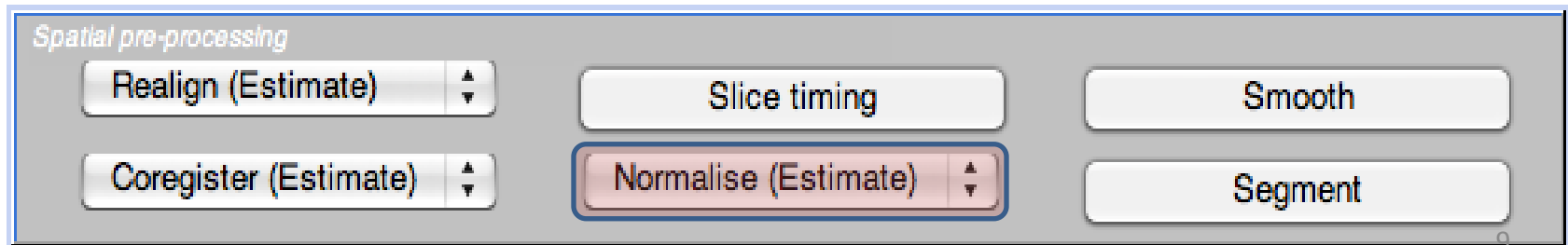
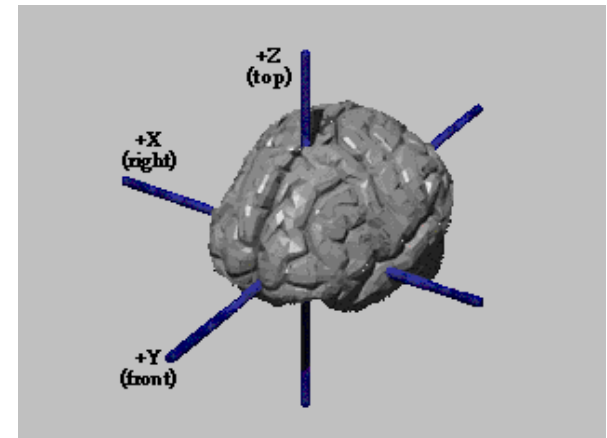
Preprocessing: Normalization

❑ Spatial Normalization

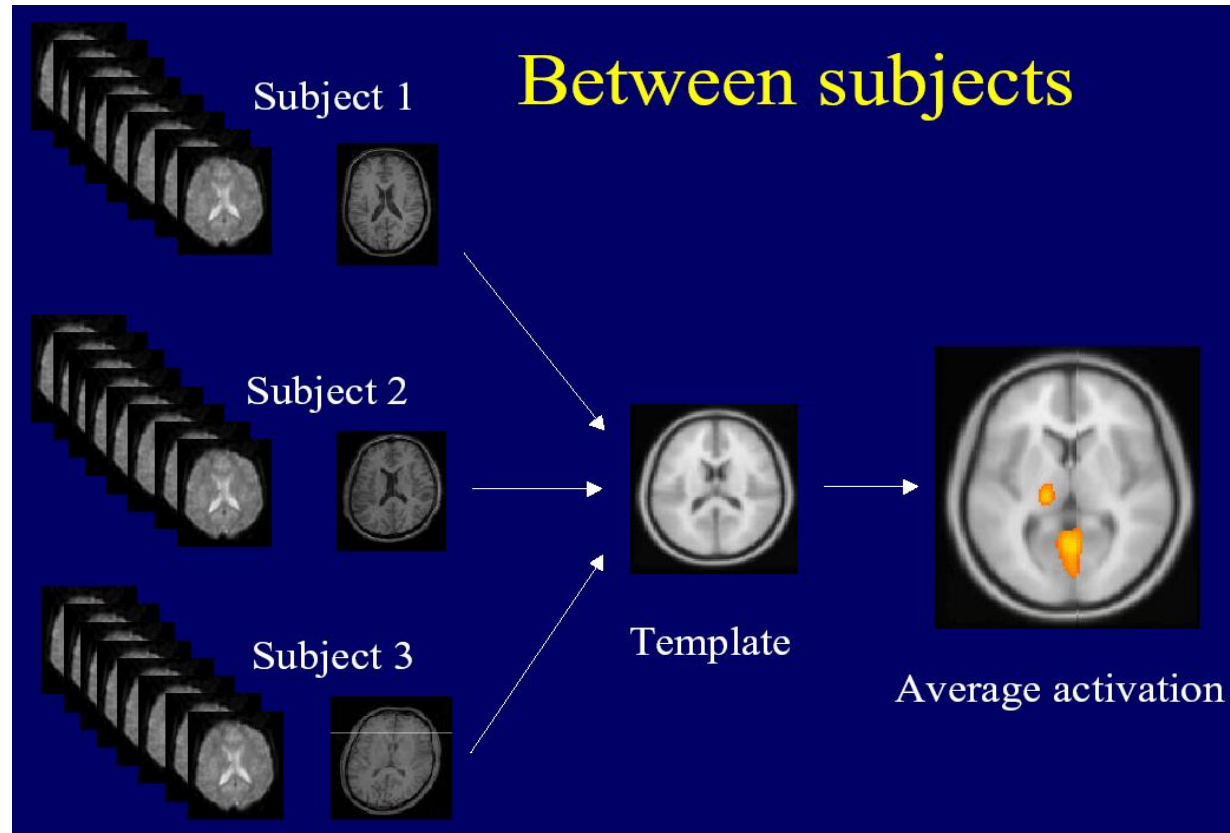
- Inter-subject registration
- Register anatomy images to standard space
 - Montreal Neurological Institution (MNI)
 - Talairach



Talairach
Template



Preprocessing: Normalization



Spatial pre-processing

Realign (Estimate)



Slice timing

Smooth

Coregister (Estimate)

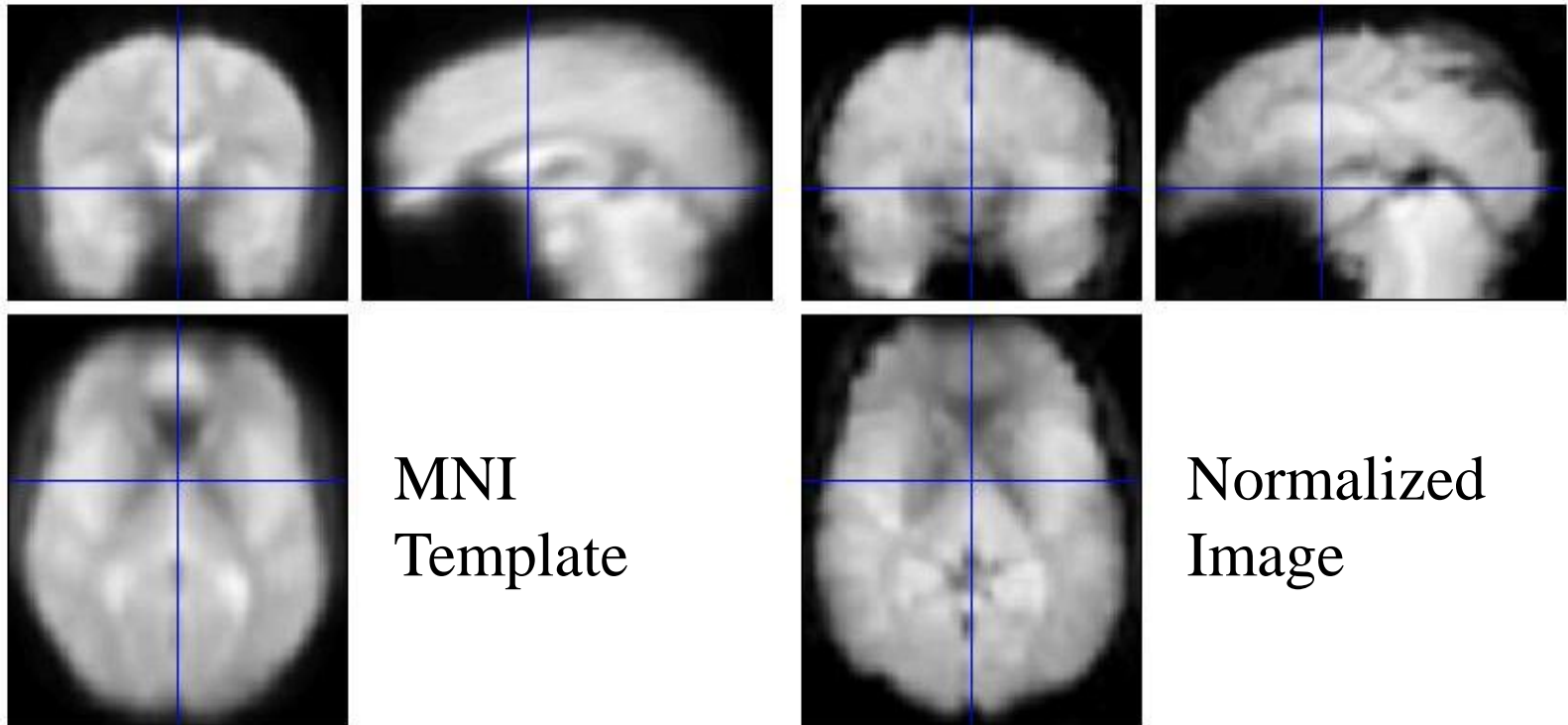


Normalise (Estimate)



Segment

Preprocessing: Normalization



Spatial pre-processing

Realign (Estimate)



Slice timing

Smooth

Coregister (Estimate)

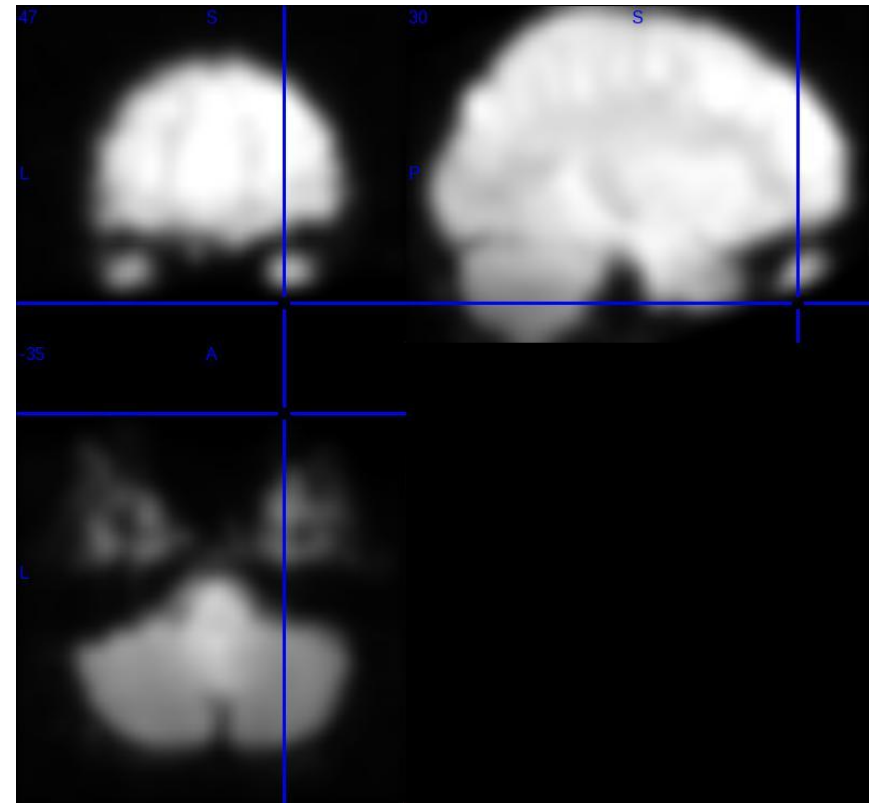
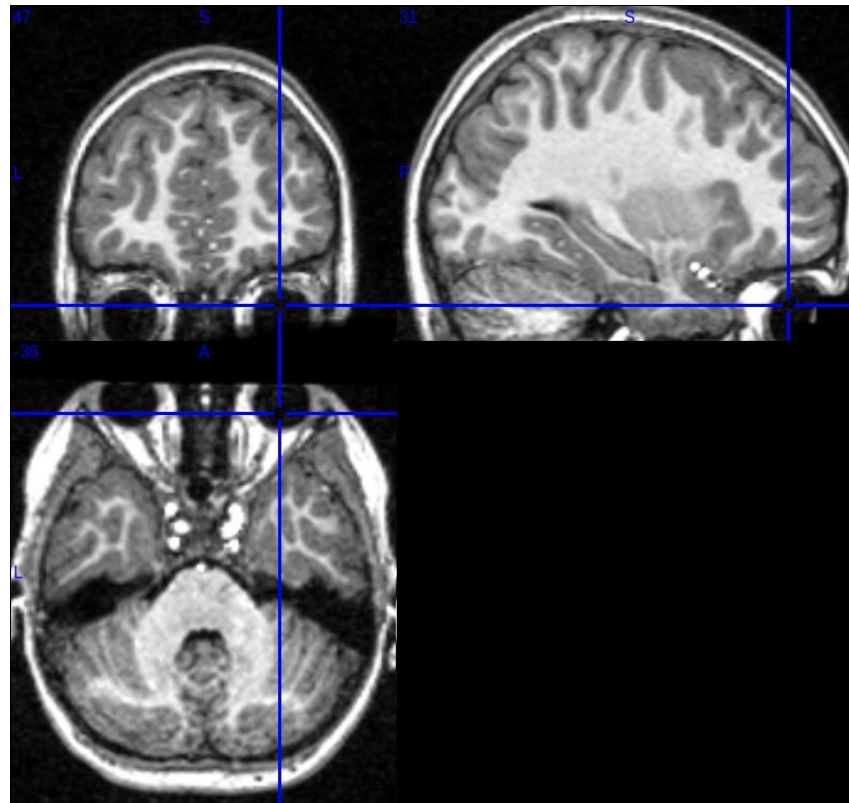


Normalise (Estimate)



Segment

Preprocessing: Normalization



Spatial pre-processing

Realign (Estimate)



Slice timing

Smooth

Coregister (Estimate)



Normalise (Estimate)

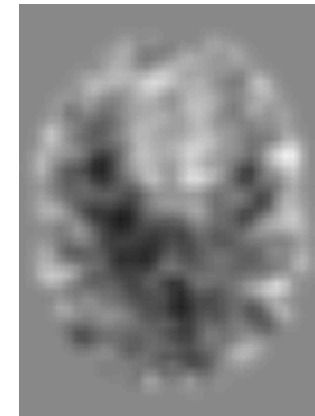
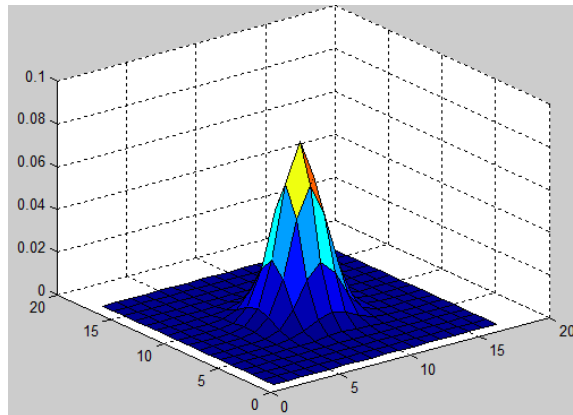


Segment

Preprocessing: Spatial Smoothing

□ Spatial Smoothing

- Inter-subject analyses
- Bluer fMRI data



Spatial pre-processing

Realign (Estimate)



Slice timing

Smooth

Coregister (Estimate)



Normalise (Estimate)



Segment

Preprocessing: Spatial Smoothing

% Gaussian Filter for smoothing image data

% Shamil Hadi

% Oakland University

% September 12, 2012

% \$Id: Gaussian_Filter Shamil \$

```
clear all;
```

```
clc;
```

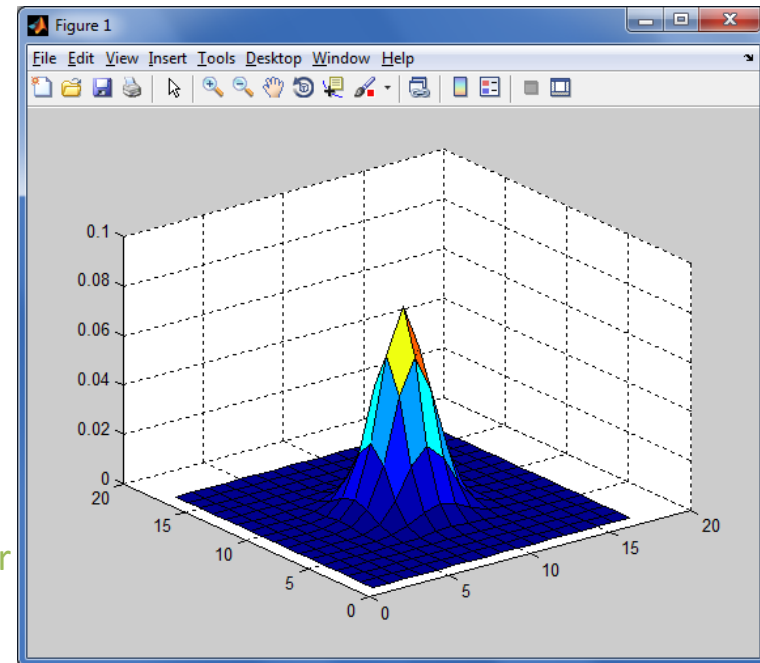
```
[X, Y] = meshgrid(-8:8, -8:8); % specifying the range
```

```
sigma = 1;
```

```
Gaussian = 1/(2*pi*sigma^2)*exp(-(X.^2 + Y.^2)/(2*sigma^2));
```

```
Gaussian = Gaussian./sum(Gaussian(:)); % normalizing the filter
```

```
figure, surf(Gaussian);
```



Spatial pre-processing

Realign (Estimate)



Slice timing

Smooth

Coregister (Estimate)

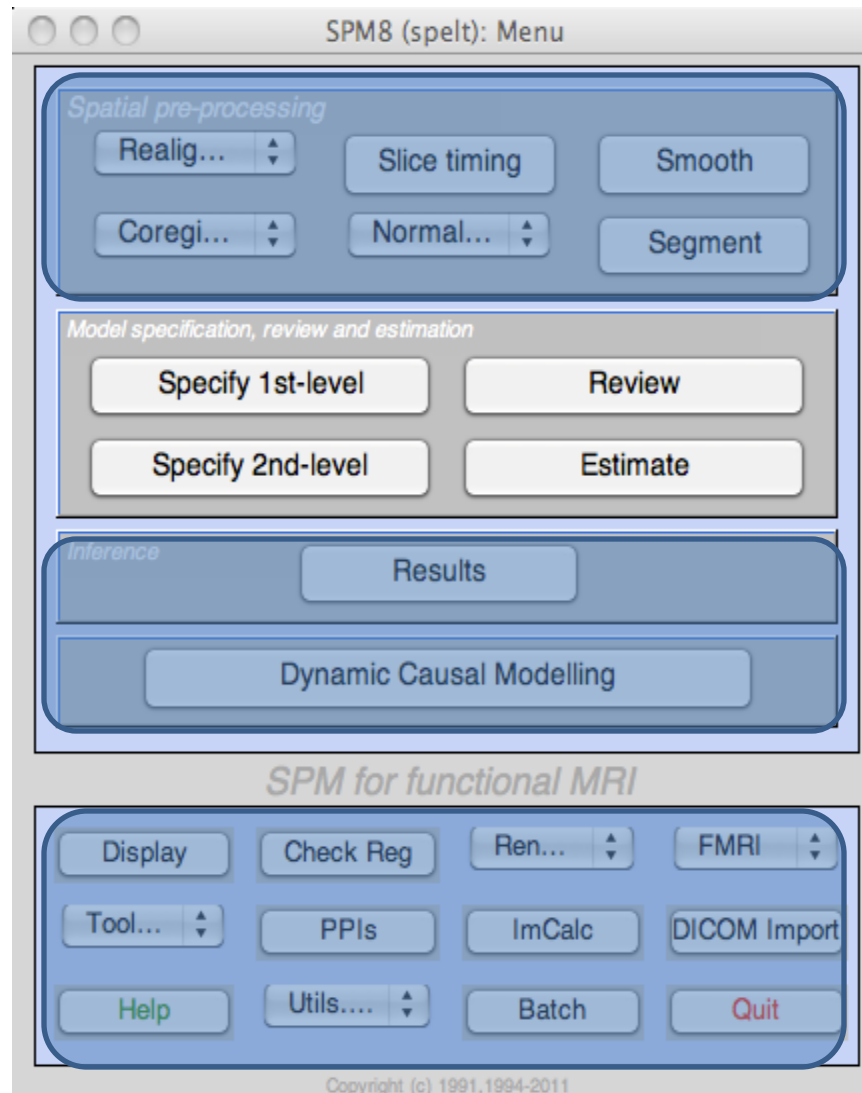


Normalise (Estimate)



Segment

Model Specification

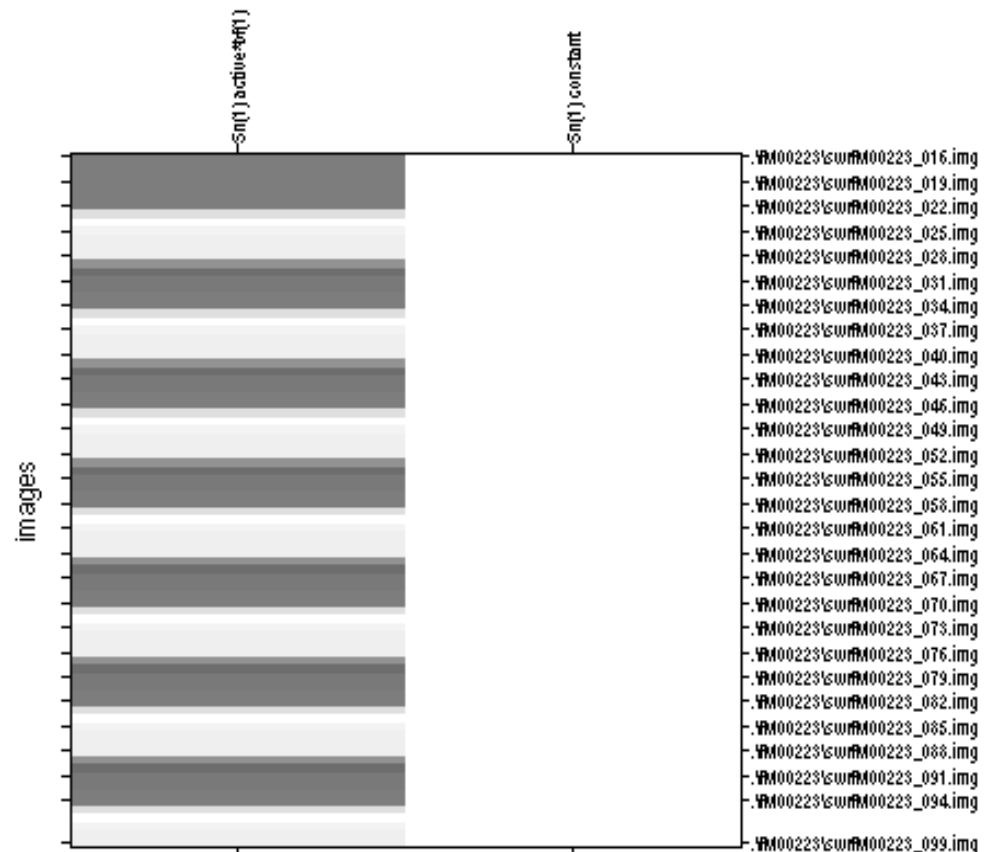


Model Specification

☐ Specify 1st-level

- Specify GLM design matrix, and data file

Statistical analysis: Design



Model specification, review and estimation

Specify 1st-level

Review

Specify 2nd-level

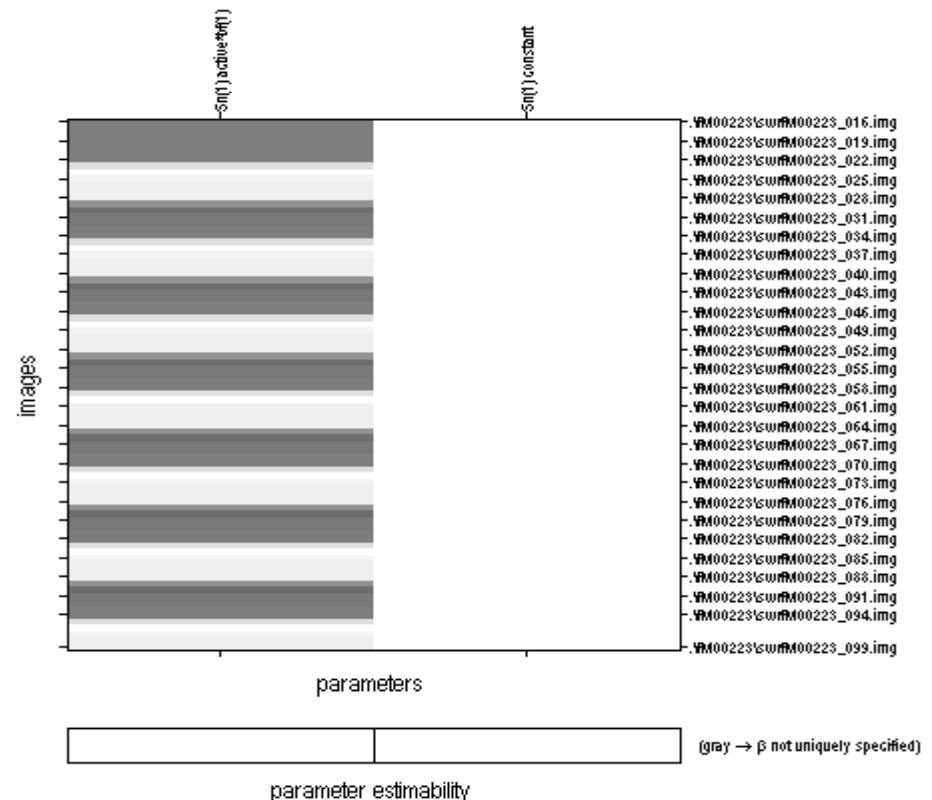
Estimate

Model Specification

Review

➤ Check the work

Statistical analysis: Design



Model specification, review and estimation

Specify 1st-level

Review

Specify 2nd-level

Estimate

Design description...

Basis functions : hrf
 Number of sessions : 1
 Trials per session : 1
 Interscan interval : 7.00 {s}
 High pass Filter : Cutoff: 128 {s}
 Global calculation : mean voxel value
 Grand mean scaling : session specific
 Global normalisation : None

Model Specification

☐ Specify 2nd-level

➤ Statistical test, e.g., one sample t -test

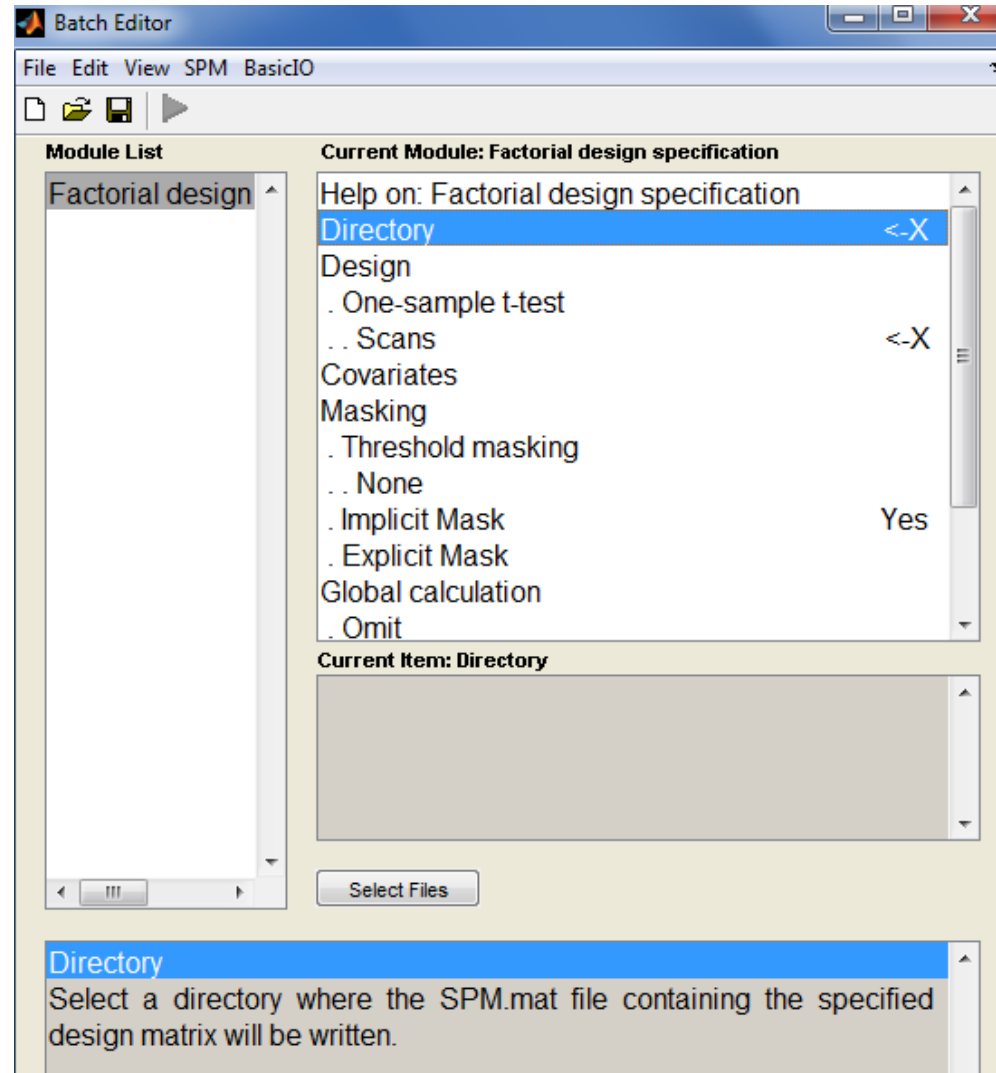
Model specification, review and estimation

Specify 1st-level

Review

Specify 2nd-level

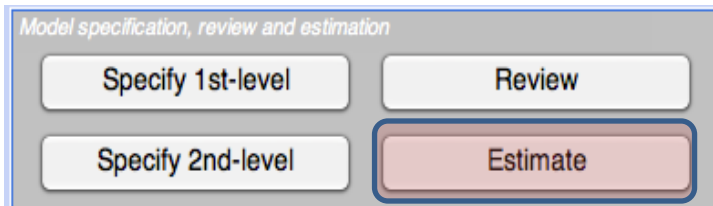
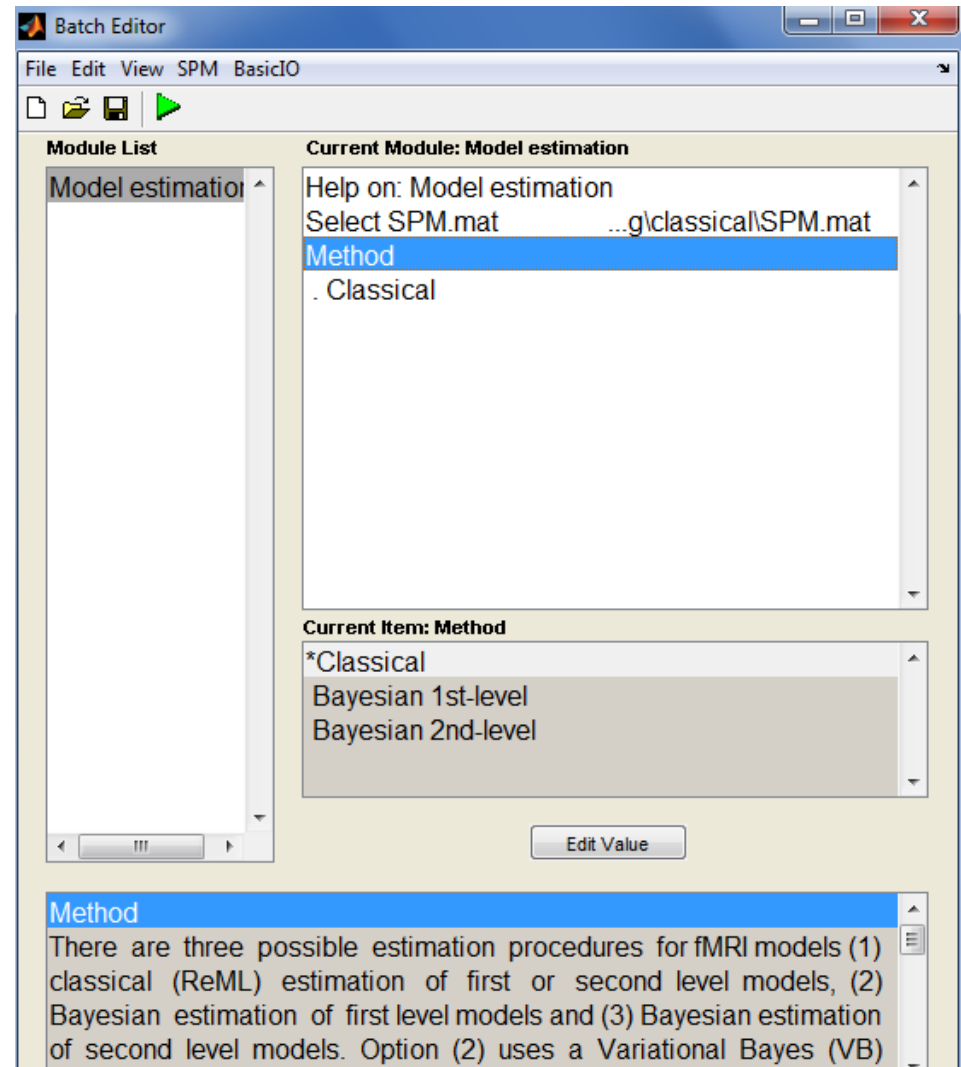
Estimate



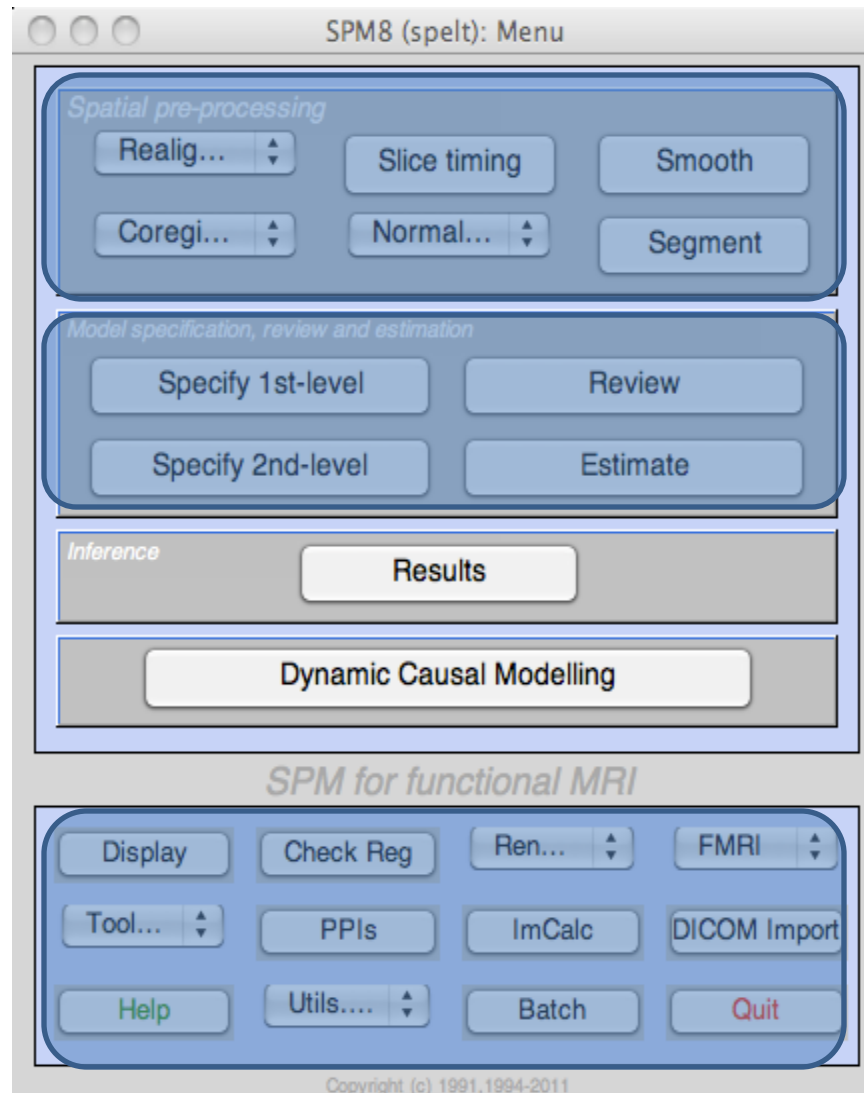
Model Specification

□ Estimate

➤ Estimation of GLM parameters

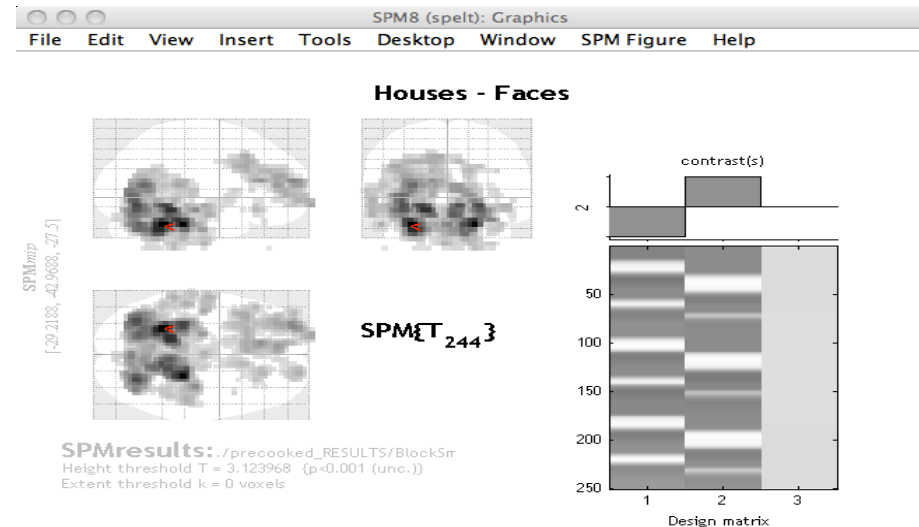
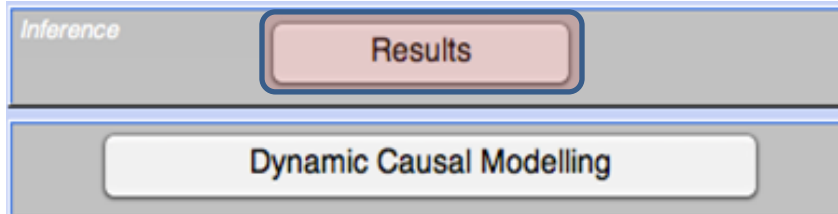
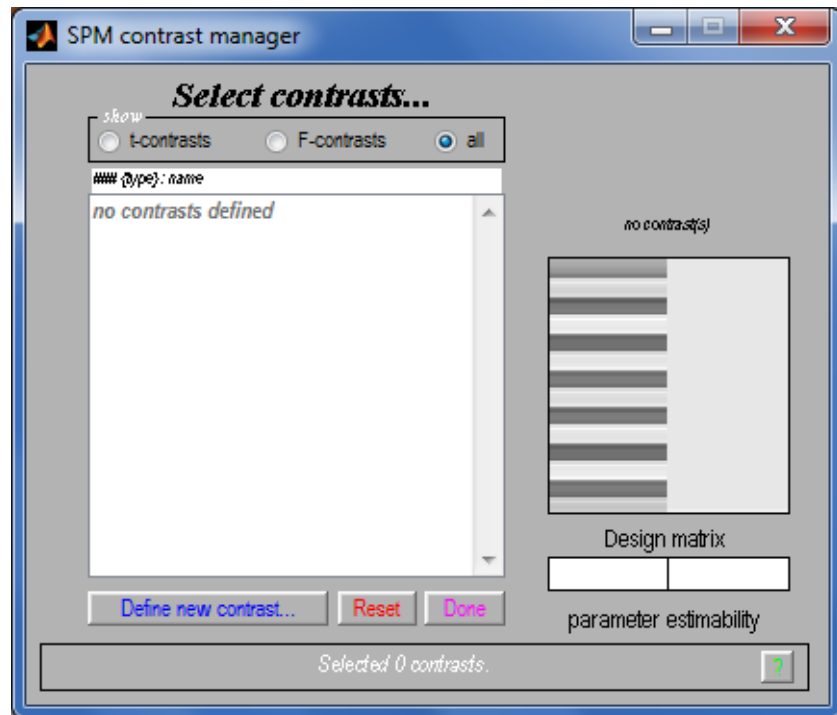


Inference



Inference

- ❑ Results button
 - Contrast Manager



Statistics: p-values adjusted for search volume

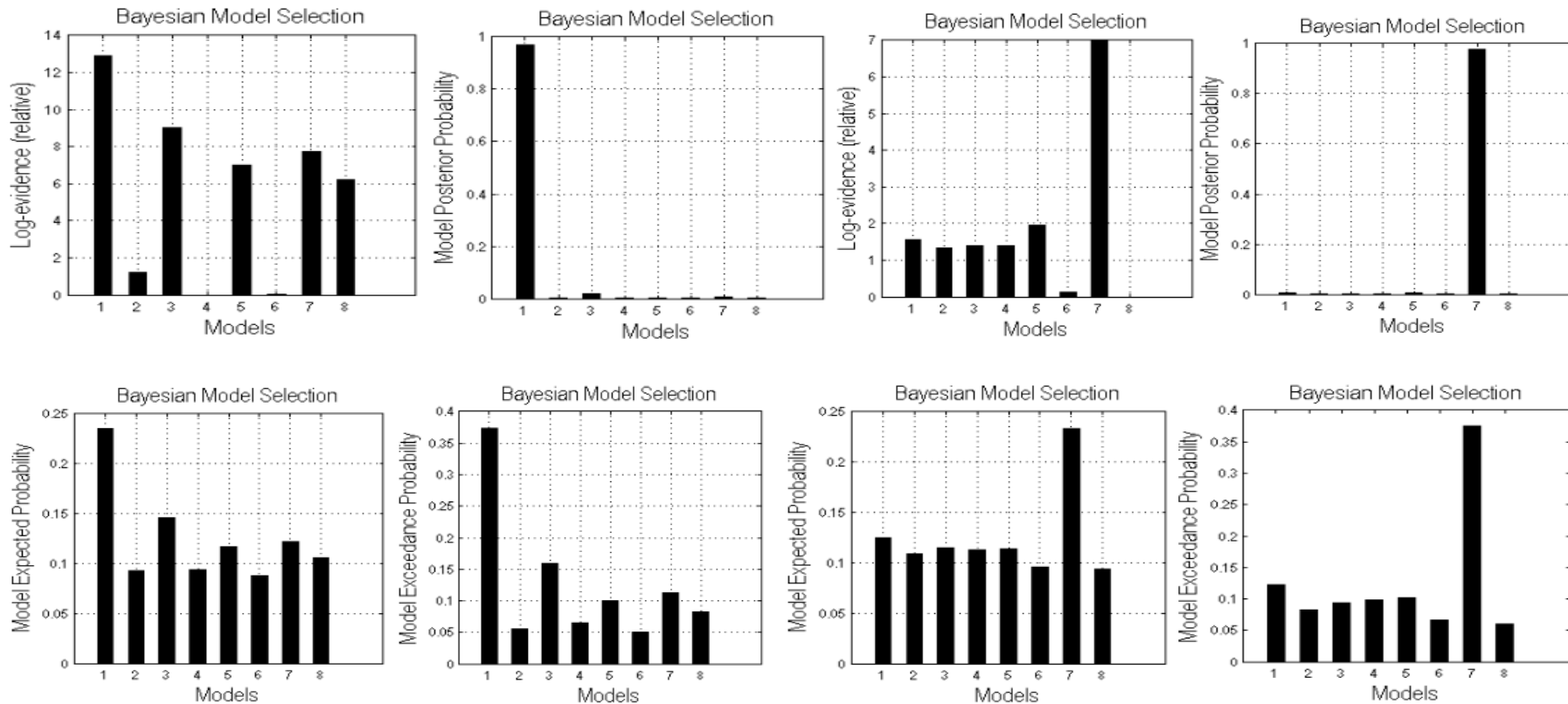
set-level		cluster-level				peak-level						mm mm mm		
p	C	P _{FWE-corr}	Q _{FDR-corr}	k _E	P _{uncorr}	P _{FWE-corr}	Q _{FDR-corr}	T	(Z _g)	P _{uncorr}				
0.004	17	0.000	0.000	2506	0.000	0.000	0.000	9.19	Inf	0.000		-29	-43	-28
						0.000	0.000	8.66	Inf	0.000		22	-29	-28
						0.000	0.000	8.09	7.60	0.000		-19	-40	-12
						0.000	0.000	5.90	5.70	0.000		-29	60	18
		0.000	0.000	704	0.000	0.001	0.001	5.57	5.40	0.000		-12	39	18
						0.003	0.003	5.21	5.16	0.000		-9	46	12
		0.000	0.000	67	0.000	0.015	0.009	4.94	4.82	0.000		-46	-12	-8
		0.000	0.000	78	0.000	0.028	0.013	4.81	4.70	0.000		-60	-9	-18
		0.000	0.000	20	0.012	0.038	0.016	4.74	4.63	0.000		19	64	-2
		0.381	0.128	10	0.060	0.875	0.340	3.63	3.58	0.000		5	50	-2
	0.088	0.028	20	0.012	0.188	0.145	0.042	4.42	4.33	0.000		-50	29	-12
					0.088	0.188	0.052	4.34	4.26	0.000		-33	29	-12
	0.050	0.018	24	0.005	0.991	0.644	0.24	3.30	3.20	0.000		-22	39	-2
	0.001	0.000	57	0.000	0.249	0.069	0.25	4.25	4.17	0.000		43	-40	-28
					0.512	0.136	3.98	3.91	3.91	0.000		-5	-9	-12
		0.953	0.433	2	0.382	0.766	0.259	3.75	3.69	0.000		-19	12	8
		0.896	0.433	3	0.284	0.830	0.307	3.69	3.63	0.000		-12	5	-2
	0.953	0.433	2	0.382	0.965	0.771	0.259	3.75	3.69	0.000		40	12	28
	0.953	0.433	2	0.382	0.966	0.965	0.497	3.46	3.42	0.000		-53	26	8
	0.953	0.433	2	0.382	0.972	0.966	0.497	3.46	3.42	0.000		29	29	-12
	0.953	0.433	2	0.382	0.994	0.972	0.519	3.44	3.40	0.000		5	15	8
						0.994	0.684	3.30	3.27	0.001		19	29	-2

table shows 3 local maxima more than 8.0mm apart

Height threshold: T = 3.12, p = 0.001 (1,000)
 Extent threshold: k = 0 voxels, p = 1,000 (1,000)
 Expected voxels per cluster, <k> = 2.82
 Expected number of clusters, <c> = 7.9
 FWEp: 4.678, FDRp: 4.383, FWEc: 57, FDRc: 20

Degrees of freedom = [1.0, 244.0]
 FWHM = 11.5 11.9 10.6 mm mm mm; 3.3 3.5 2.1 [voxels]
 Volume: 1229379 = 20808 voxels = 714.5 resels
 Voxel size: 3.4 3.4 5.0 mm mm mm; (resel = 24.51 voxels)
 Page 1

Inference

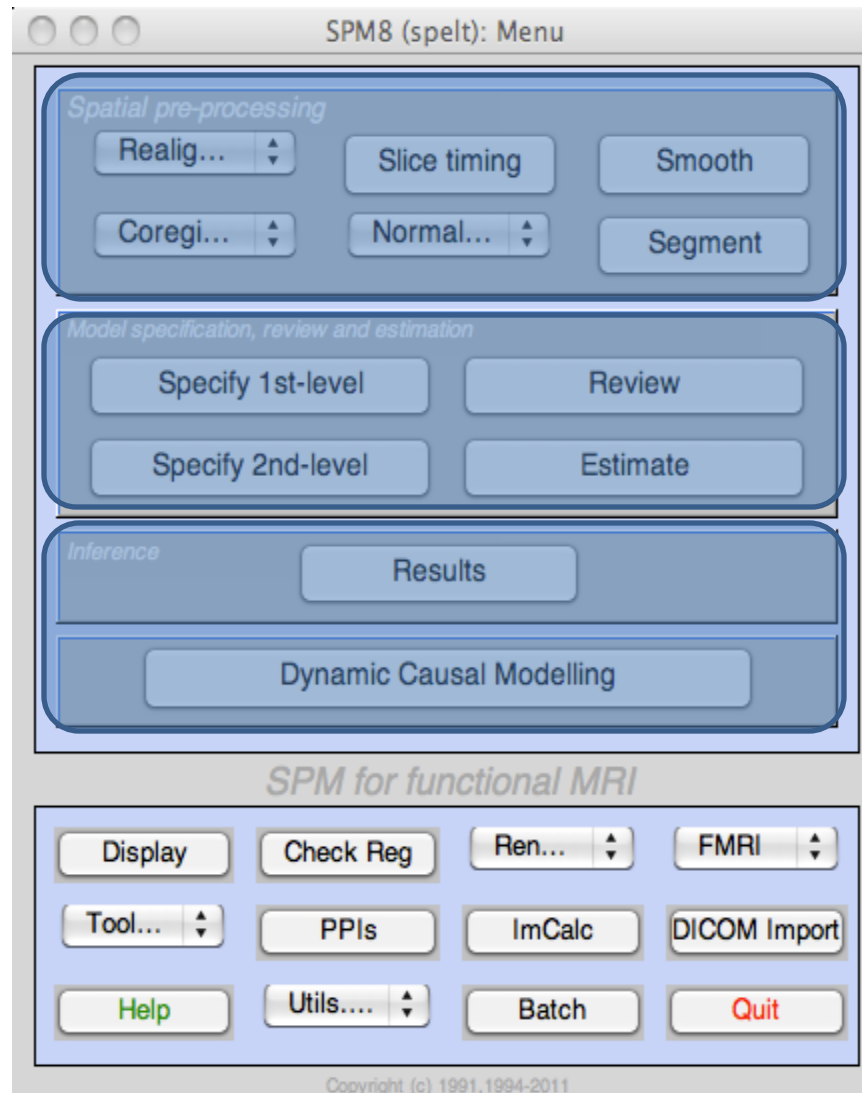


Inference

Results

Dynamic Causal Modelling

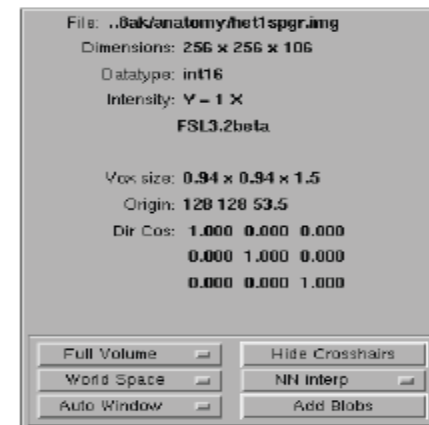
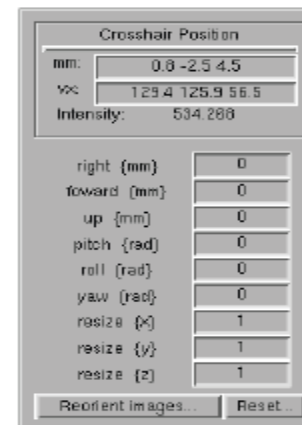
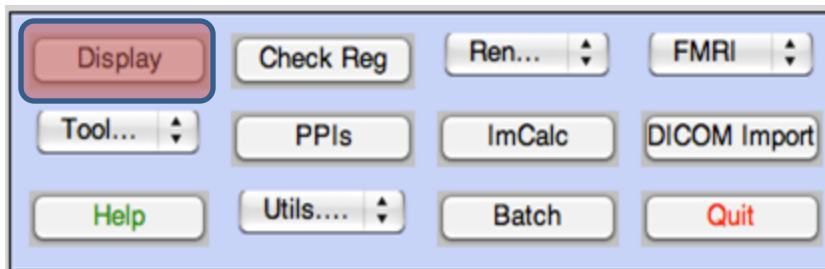
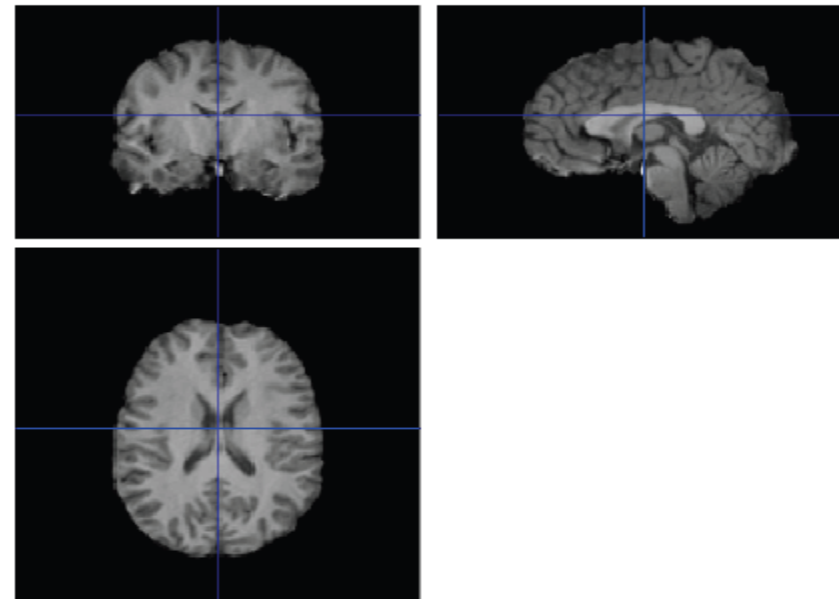
Other Tools



Other Tools

Display

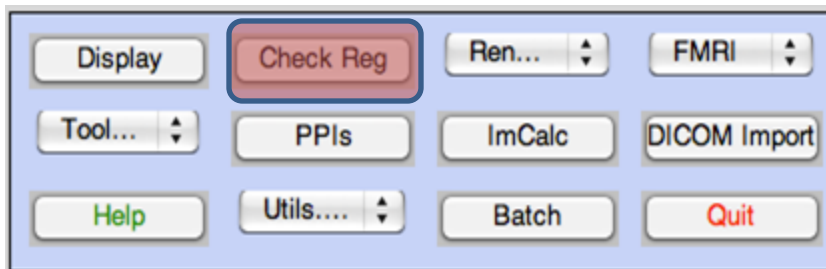
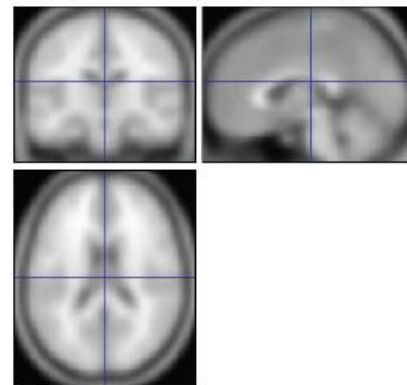
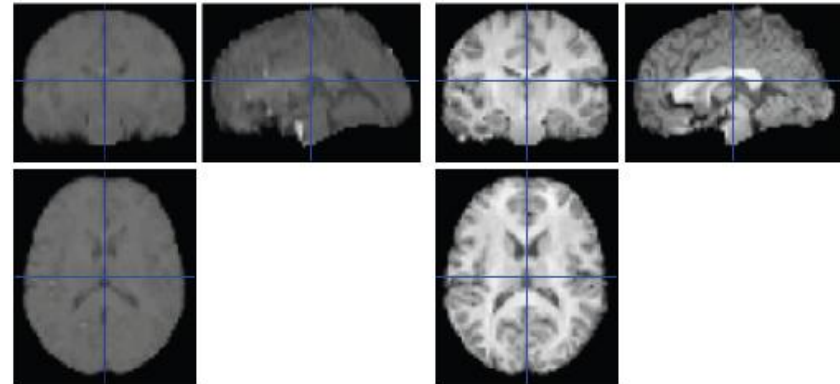
- Change world space and/or origin
- Displays image with orthogonal sections



Other Tools

☐ Check Reg.

- Displaying more than one image
- alignment of images
- All images will be displayed in the space of the first image (MNI)



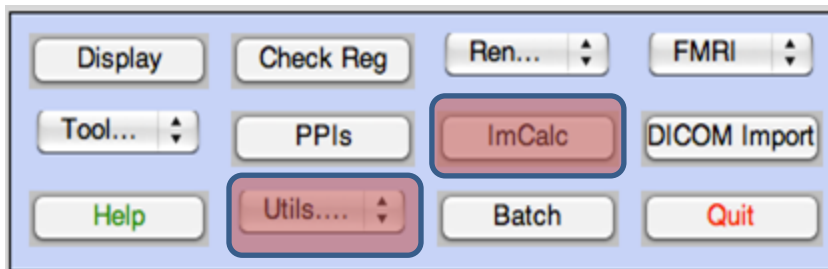
Other Tools

❑ ImCalc

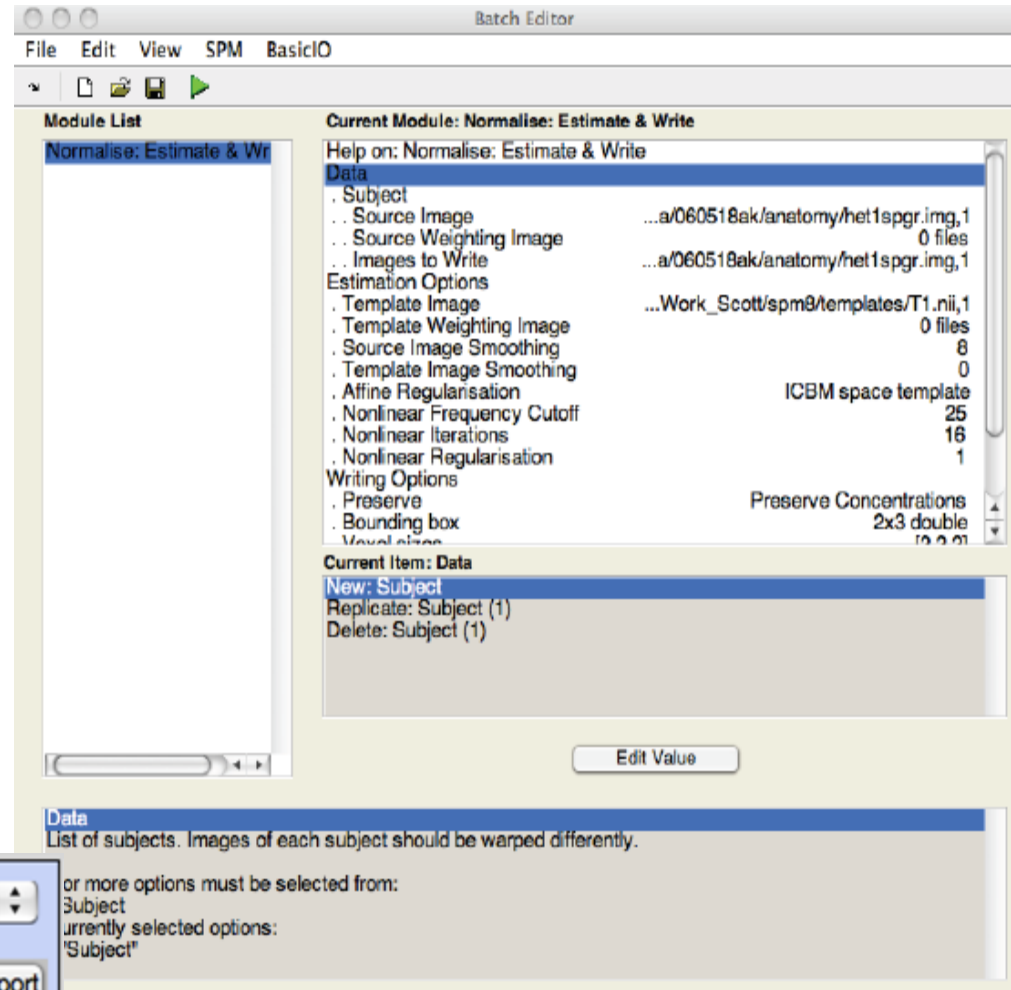
- Image calculator
- Give one or more images, perform MATLAB arithmetic such as mean value

❑ Utils

- Delete files
- Change directory
- Results are written to current directory



Batch Editor



Resources

☐ SPMweb site: <http://www.fil.ion.ucl.ac.uk/spm/>

- SPM: Introduction
- Free : SPM2, SPM5, SPM8
- Courses are available around the world
- Forum list

☐ MRlcro

- MRlcro: <http://www.cabiatl.com/micro/>
- Complementary with SPM
- Easy to learn

Alternative

- ❑ FSL: <http://www.fmrib.ox.ac.uk/fsl>
 - Open source, you can change the code for your requirement
 - Can be used for fMRI and DTI
 - Free

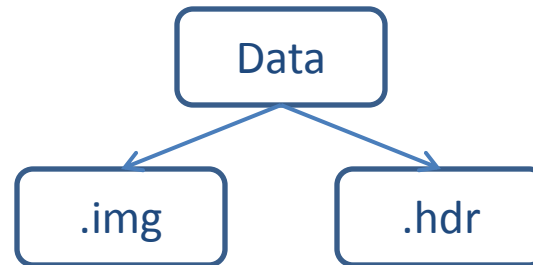
- ❑ AFNI: <http://afni.nimh.nih.gov>
 - Open source, you can change the code for your requirement
 - Free

- ❑ BrainVoyager: <http://www.brainvoyager.com>
 - Closed source, you are not able to change the code
 - Great visualization
 - Not free, ~\$5k

Image Format

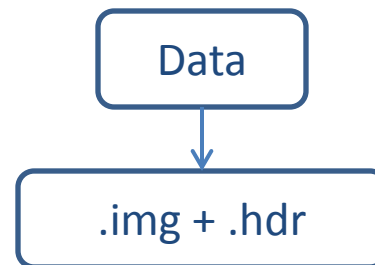
□ Data format

➤ Analyzing format



➤ NIFTI format

- Transformation of the world space is coded in NIFTI header



Important Issue

❑ Is Left Right?

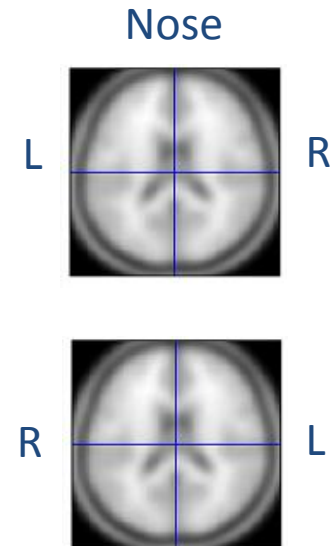
➤ Neurological

- Standing behind a subject
- Right is right side of the subject

➤ Radiological

- Standing in front of a subject
- Right is left side of the subject

➤ Neurological convention has been always used in SPM



Thank You!

smhadi@oakland.edu
Hadi.shamil@IEEE.com