MATLAB TUTORIAL
How to Analyze EEG on SPM

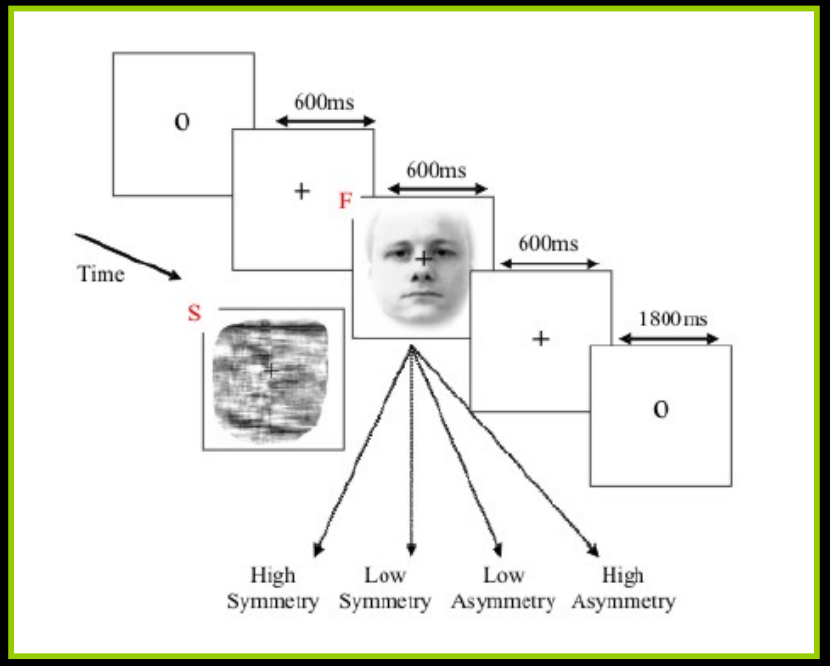
Independent Study in Psychology
Fall 2011

EEG Dataset

Multimodal face-evoked dataset:
http://www.fil.ion.ucl.ac.uk/spm/data/mmfaces/

Paradigm

- Randomized presentation of 86 faces and 86 scrambled faces, both matched for low-level visual properties
- Each face required a four-way, left-right symmetry judgment



EEG Data

- 128-channel ActiveTwo system
  - 32 A (Back)
  - 32 B (Right)
  - 32 C (Front)
  - 32 D (Left)
- One right earlobe electrode and one left earlobe electrode
- Two bipolar channels measured HEOG and VEOG
- Sampled at 2048 Hz

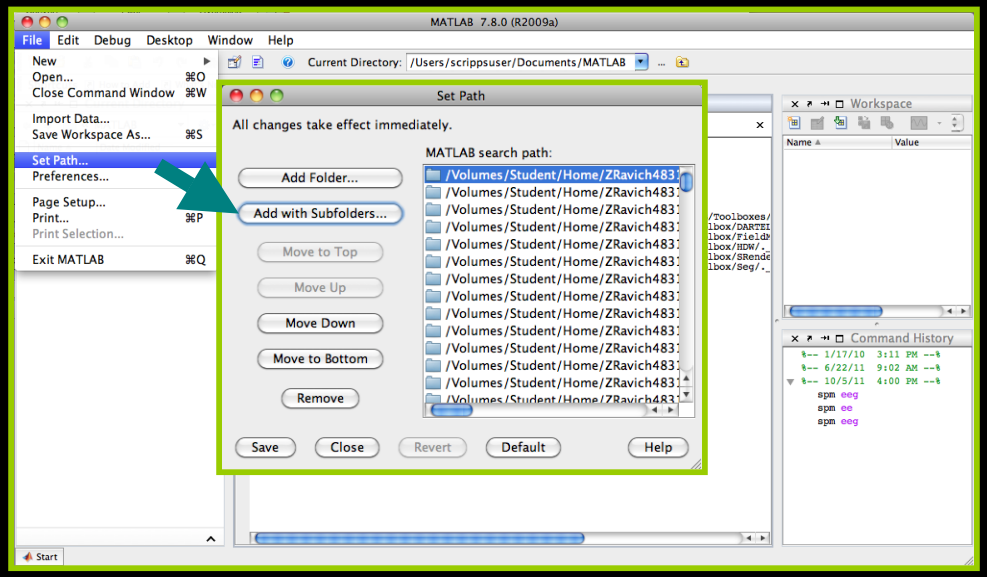
EEG Data Files

- Biosemi raw data files (data acquired in the two runs of the protocol)
  - EEG/faces_run1.bdf
  - EEG/faces_run2.bdf
- Text file (list of condition labels in the same order as the trials appear in the two files - “faces” for presentation of faces and “scrambled” for presentation of scrambled faces)
  - EEG/condition_labels.txt
- ASCII file (electrode locations, fiducials and headshape points measured with a Polhemus digitizer)
  - EEG/electrode_locations_and_headshape.sfp

EEG Data Analysis

Step 1
Getting Started

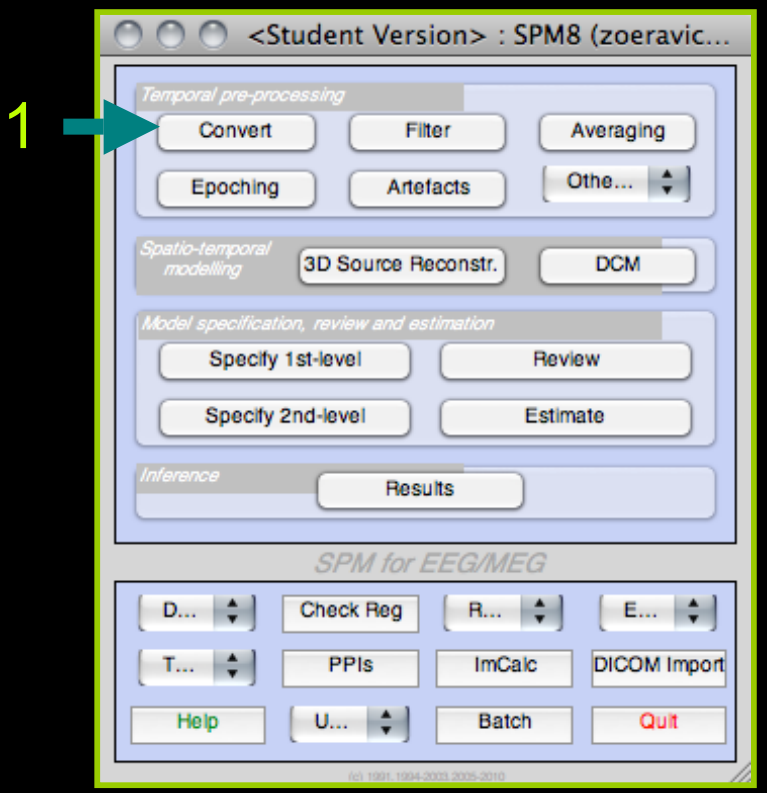
- Open up MATLAB
- Go to "File" → "Set Path" → "Add with Subfolders" → Select the dataset folder (I.e., Home\ZoeRavich4831\MATLAB\Datasets)
  - "Do you want to save this path for future reference?"; Click "No"
- Go to the Command Window and type "spm eeg" to open up the EEG GUI



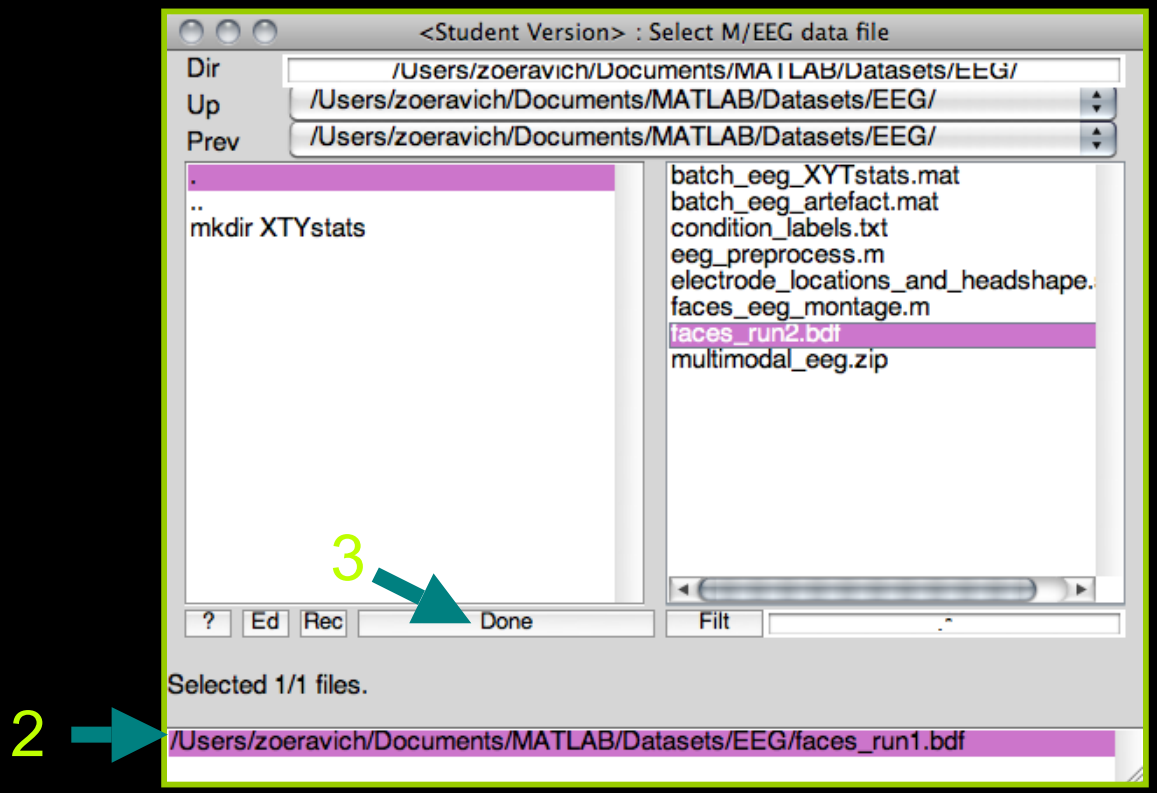
Step 2
Convert

- Press the CONVERT button
  - Select the faces_run1.bdf file
  - "Define settings?"; Click "Just read"
- New files: spm8_faces_run1.mat and spm8_faces_run1.dat
- The "Info" tab will appear
  - "History" tab (lists processing steps that have been applied to the file)
  - "Channels" tab (lists channels in the file and their properties)
  - "Trial" tab (lists the trials or events)
  - "Inv" tab (reviews inverse solutions; if you click on the "EEG" tab, you will see the raw EEG traces)

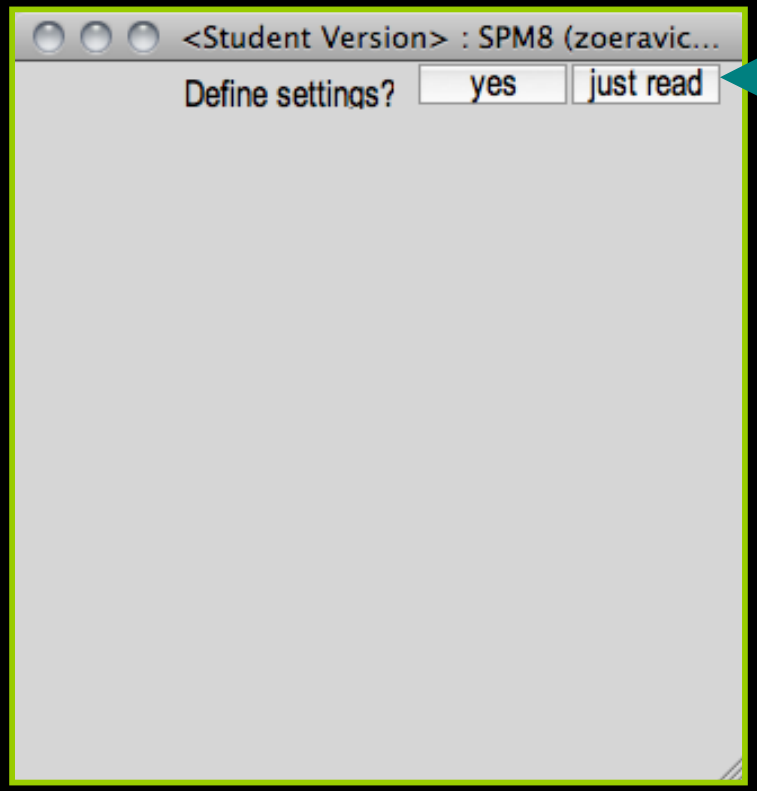
Step 2
Convert



Step 2
Convert

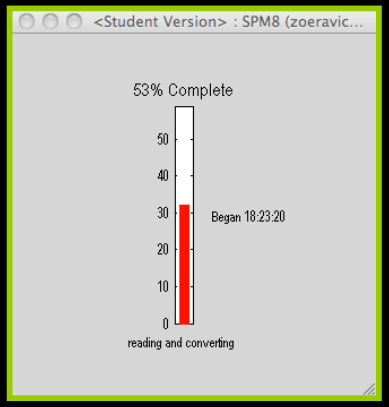


Step 2
Convert

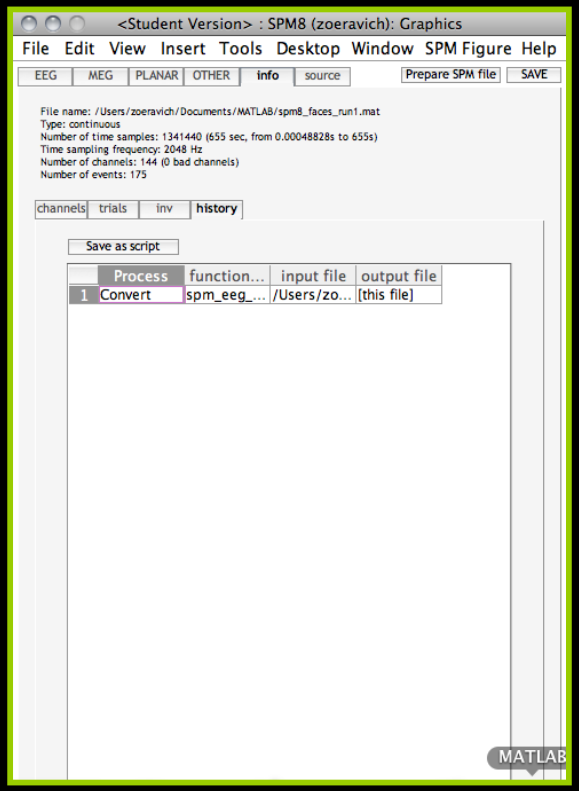


4

Processing…



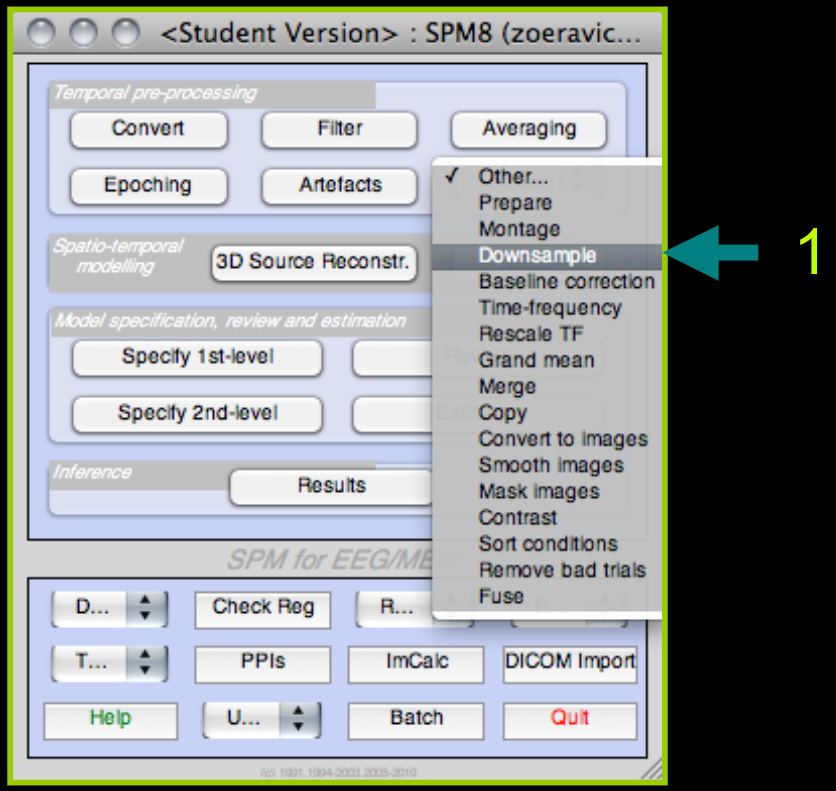
Step 2
Convert



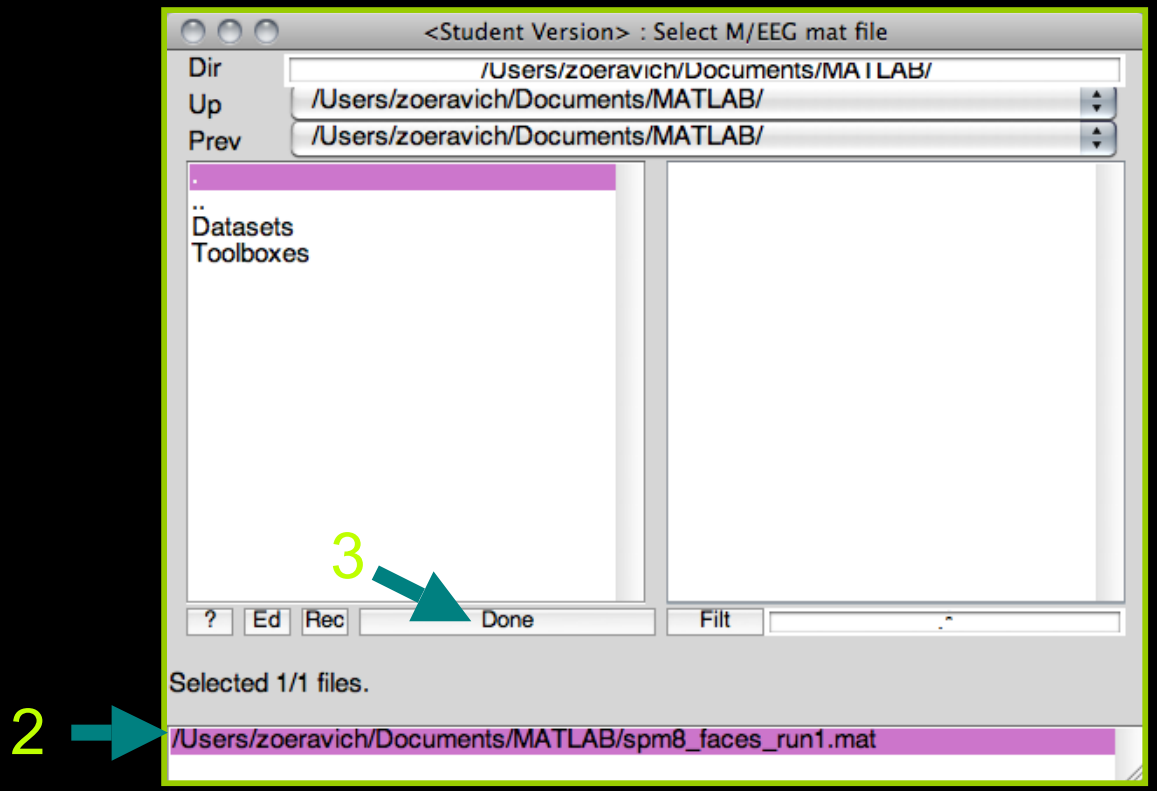
Step 3
Downsample

- Select DOWNSAMPLE from the "Other" drop-down menu
  - Select the spm8_faces_run1.mat file
  - "New sampling rate"; Type "200" (Hz)
- New files: dspm8_faces_run1.mat and dspm8_faces_run1.dat

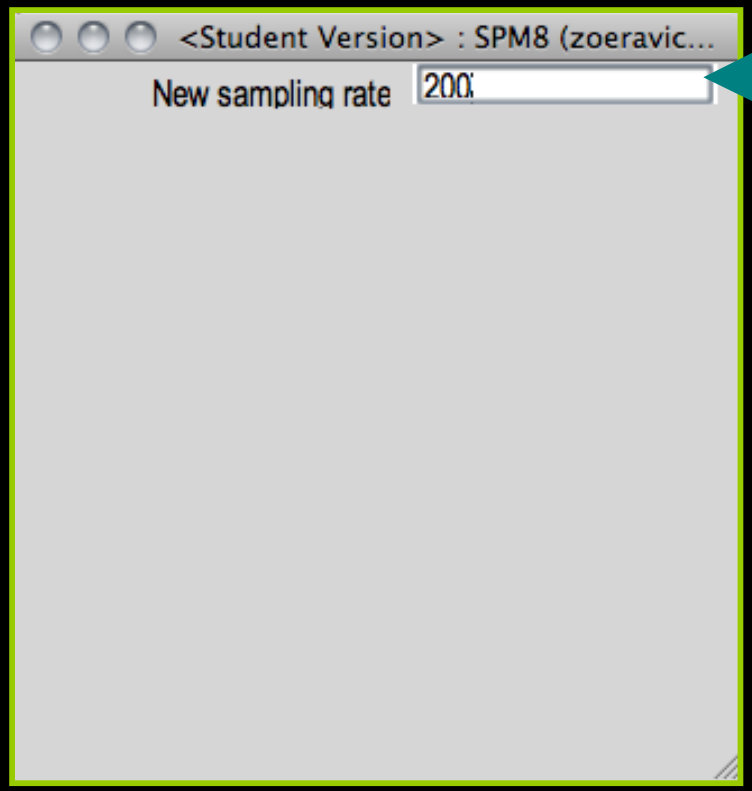
Step 3
Downsample



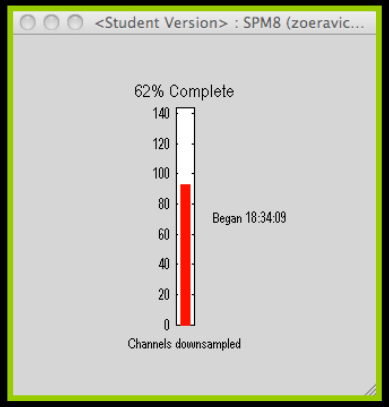
Step 3
Downsample



Step 3
Downsample



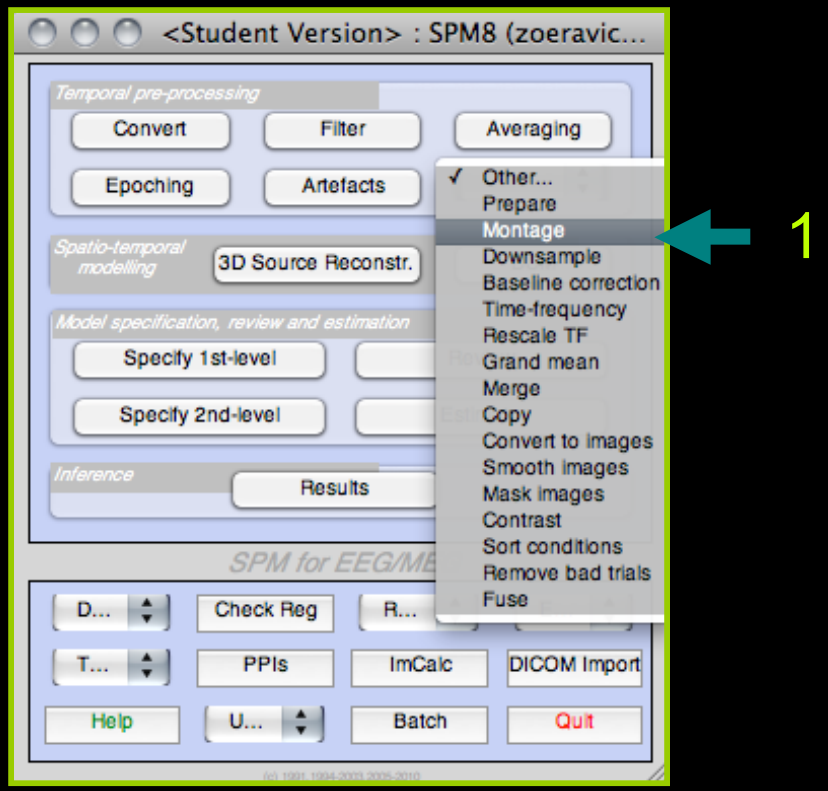
Processing…



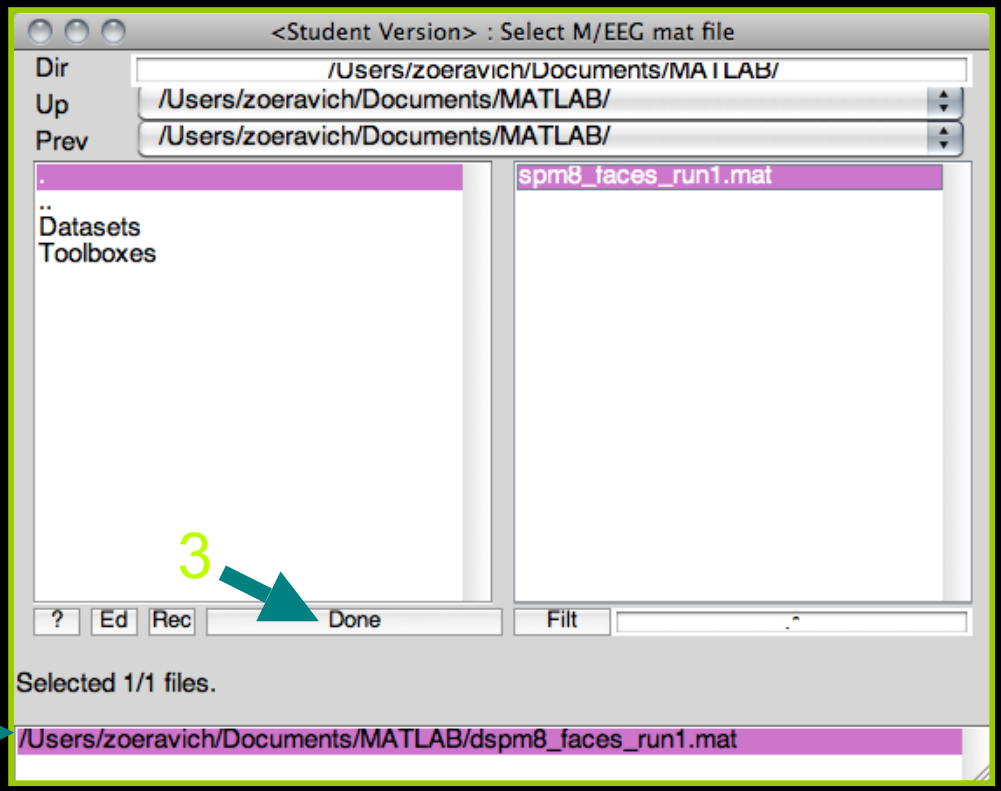
Step 4
Montage

- Select MONTAGE from the "Other" drop-down menu
  - Select the dspm8_faces_run1.mat file
  - "How to specify the montage?"; Click "File"
  - Select the generated faces_eeg_montage.mat file
  - "Keep the other channels?"; Click "No"
- New files: Mdspm8_faces_run1.mat and Mdspm8_faces_run1.dat

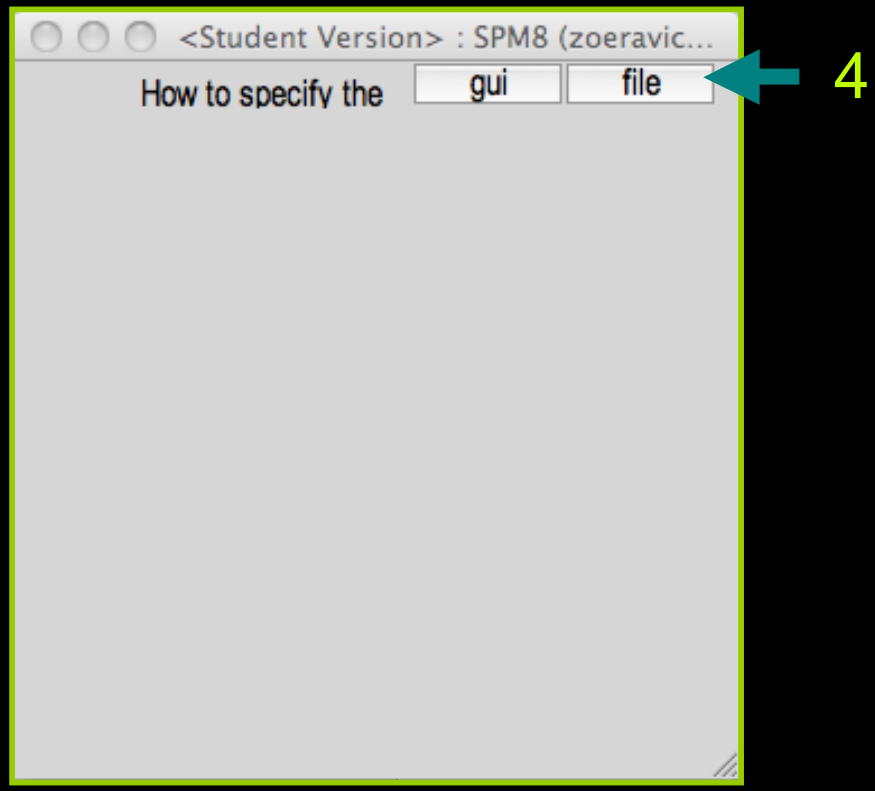
Step 4
Montage



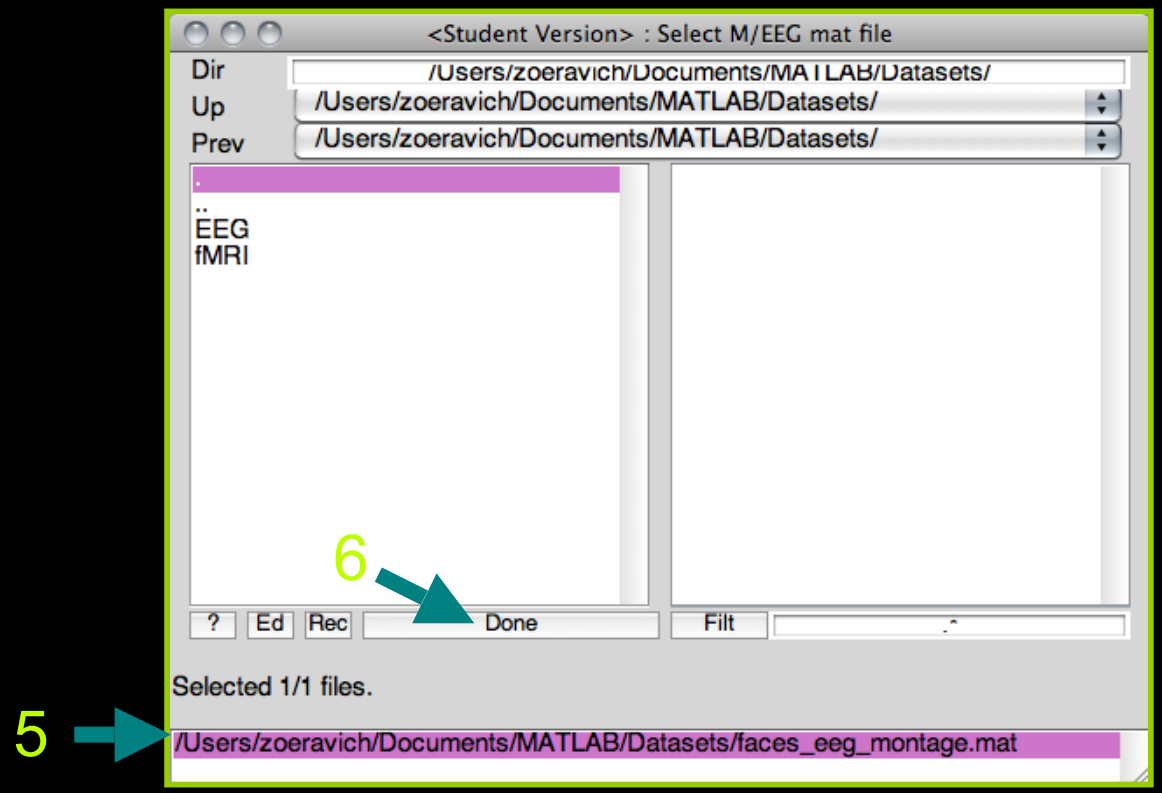
Step 4
Montage



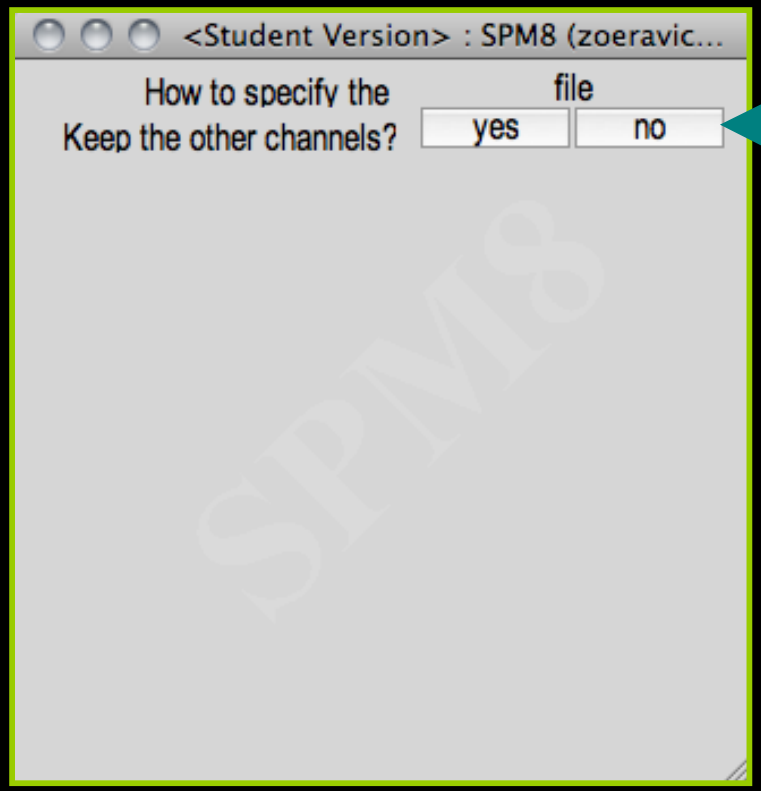
Step 4
Montage



Step 4
Montage

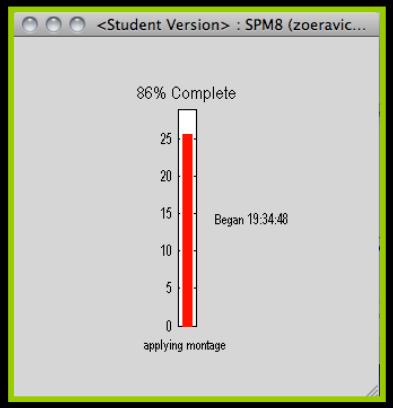


Step 4
Montage



7

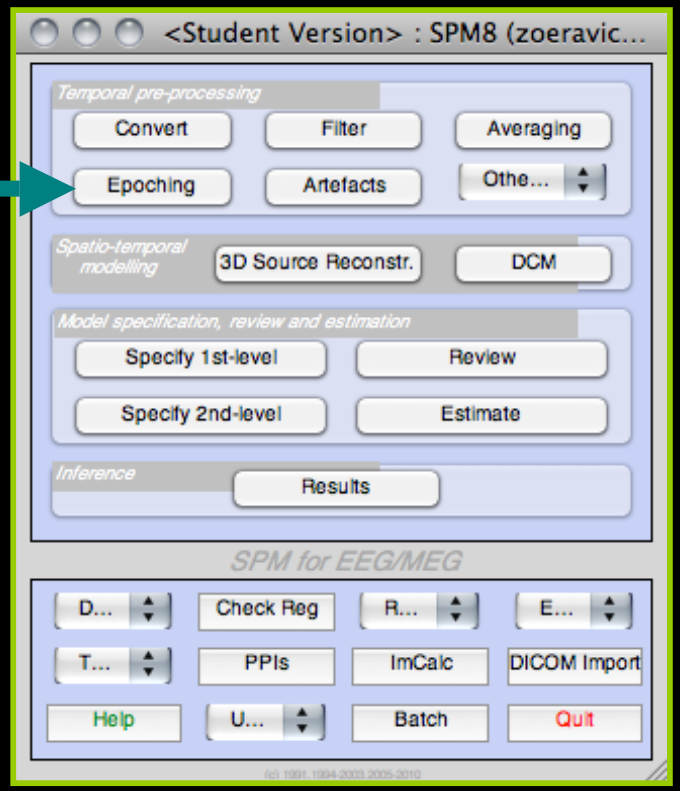
Processing…



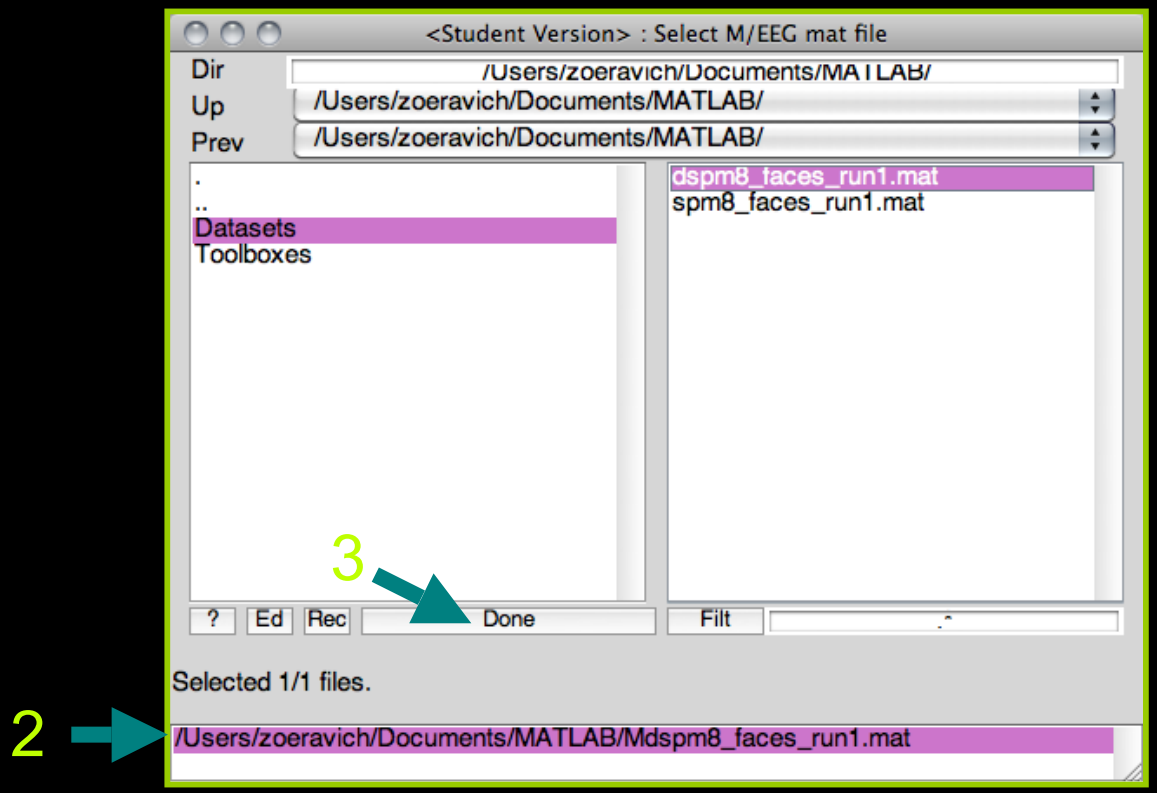
Step 5
Epoch

- Press the EPOCH button
  - Select the Mdspm8_faces_run1.mat file
  - "Start of trial in PST [ms]"; Type "-200"
  - "End of trial in PST [ms]"; Type "600"
- Select the event with type "STATUS" and value 1 appears 172 time in the GUI that pops up and press OK
  - "Review individual trials?"; Click "No"
  - "Save trial definitions?"; Click "No"
- New files: eMdspm8_faces_run1.mat and eMdspm8_faces_run1.dat

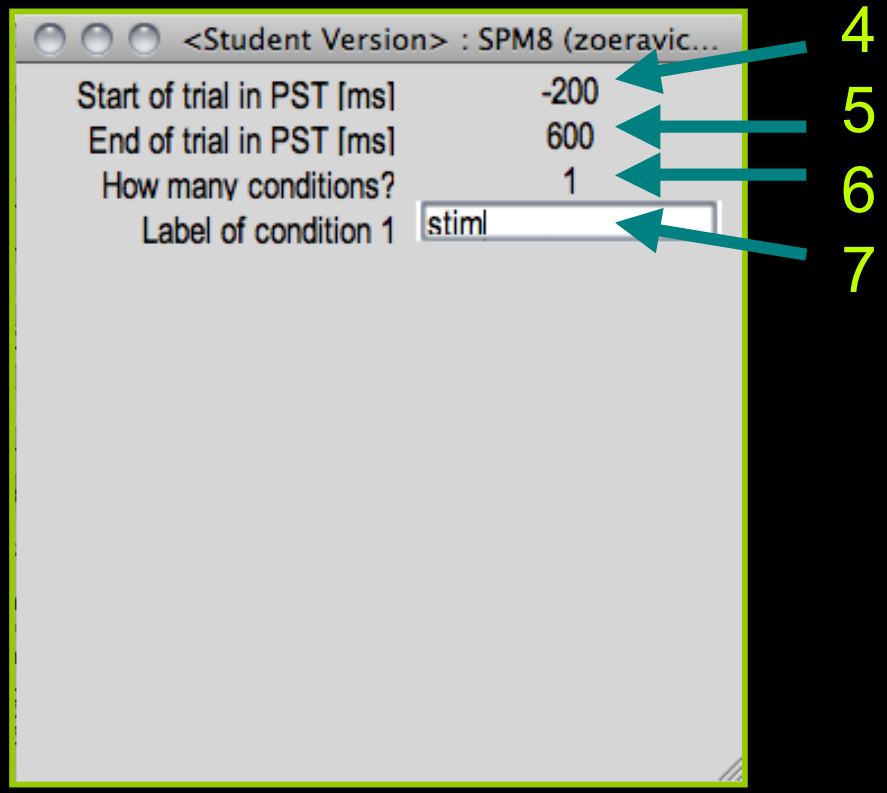
Step 5
Epoch


1
<Student Version> : SPM8 (zoeravic...
Temporal pre-processing
Convert
Filter
Averaging
Epoching
Artefacts
Othe...
Spatio-temporal modelling
3D Source Reconstr.
DCM
Model specification, review and estimation
Specify 1st-level
Review
Specify 2nd-level
Estimate
Inference
Results
SPM for EEG/MEG
D...
Check Reg
R...
E...
T...
PPIs
ImCalc
DICOM Import
Help
U...
Batch
Quit

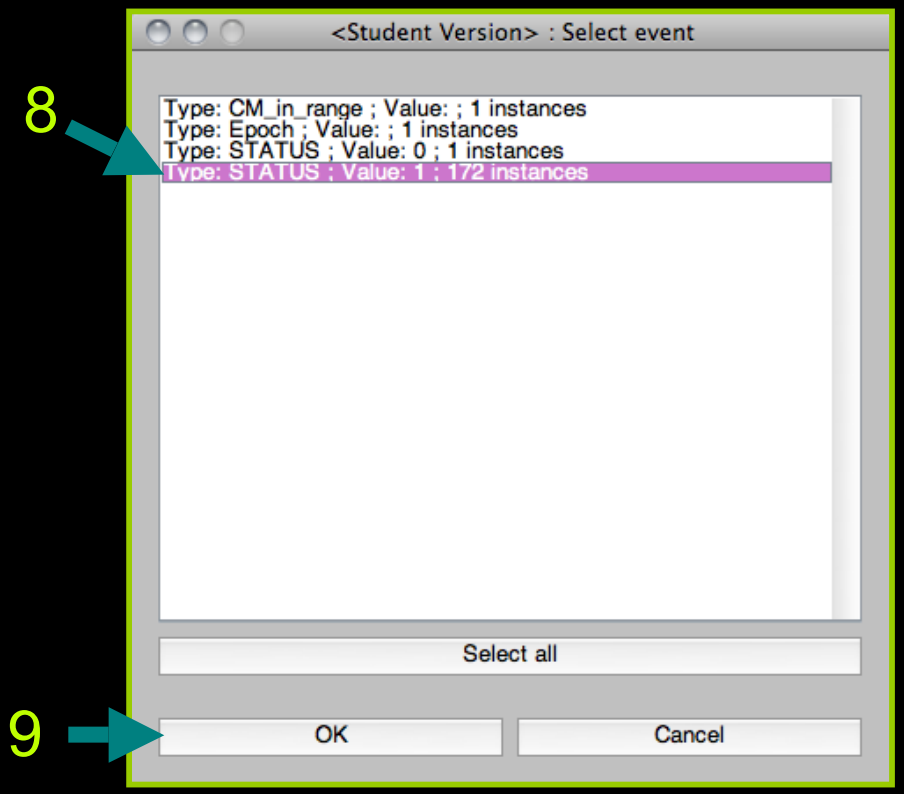
Step 5
Epoch


<Student Version> : Select M/EEG mat file
Dir
/Users/zoeravich/Documents/MATLAB/
Up
/Users/zoeravich/Documents/MATLAB/
Prev
/Users/zoeravich/Documents/MATLAB/
.
..
Datasets
Toolboxes
dspm8_faces_run1.mat
spm8_faces_run1.mat
3
?
Ed
Rec
Done
Filt
Selected 1/1 files.
2
/Users/zoeravich/Documents/MATLAB/Mdspm8_faces_run1.mat

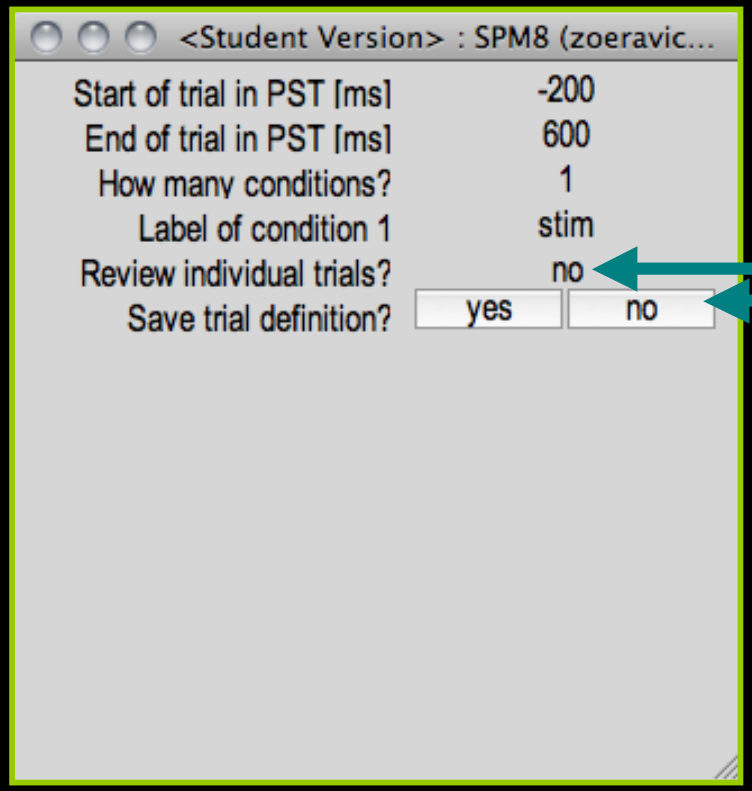
Step 5
Epoch


<Student Version> : SPM8 (zoeravic...
Start of trial in PST [ms]
-200
End of trial in PST [ms]
600
How many conditions?
1
Label of condition 1
stim
4
5
6
7

Step 5
Epoch

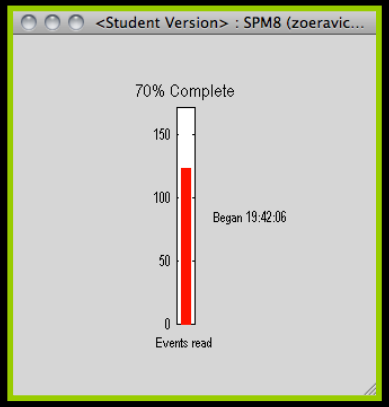

8
9
<Student Version> : Select event
Type: CM_in_range ; Value: ; 1 instances
Type: Epoch ; Value: ; 1 instances
Type: STATUS ; Value: 0 ; 1 instances
Type: STATUS ; Value: 1 ; 172 instances
Select all
OK
Cancel

Step 5
Epoch



10 & 11

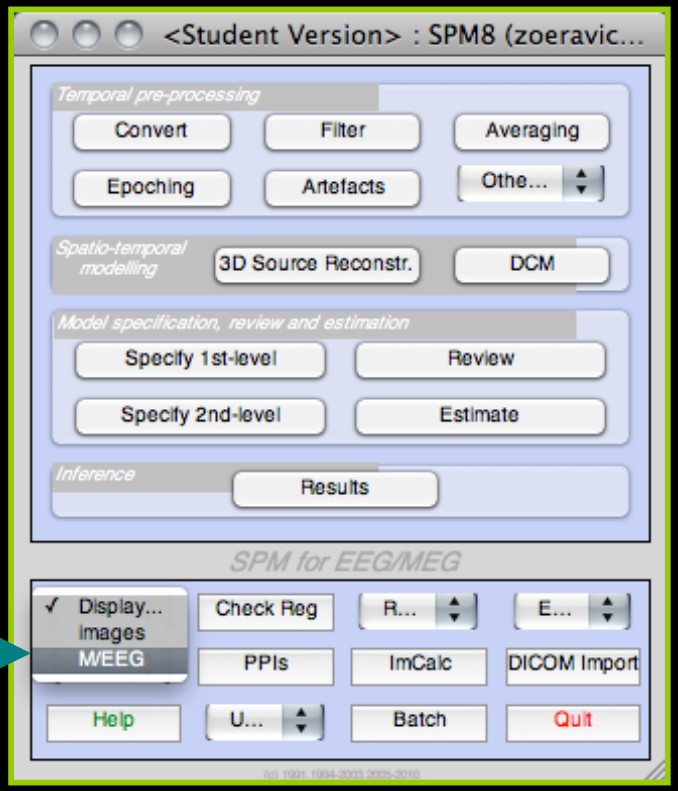
Processing…



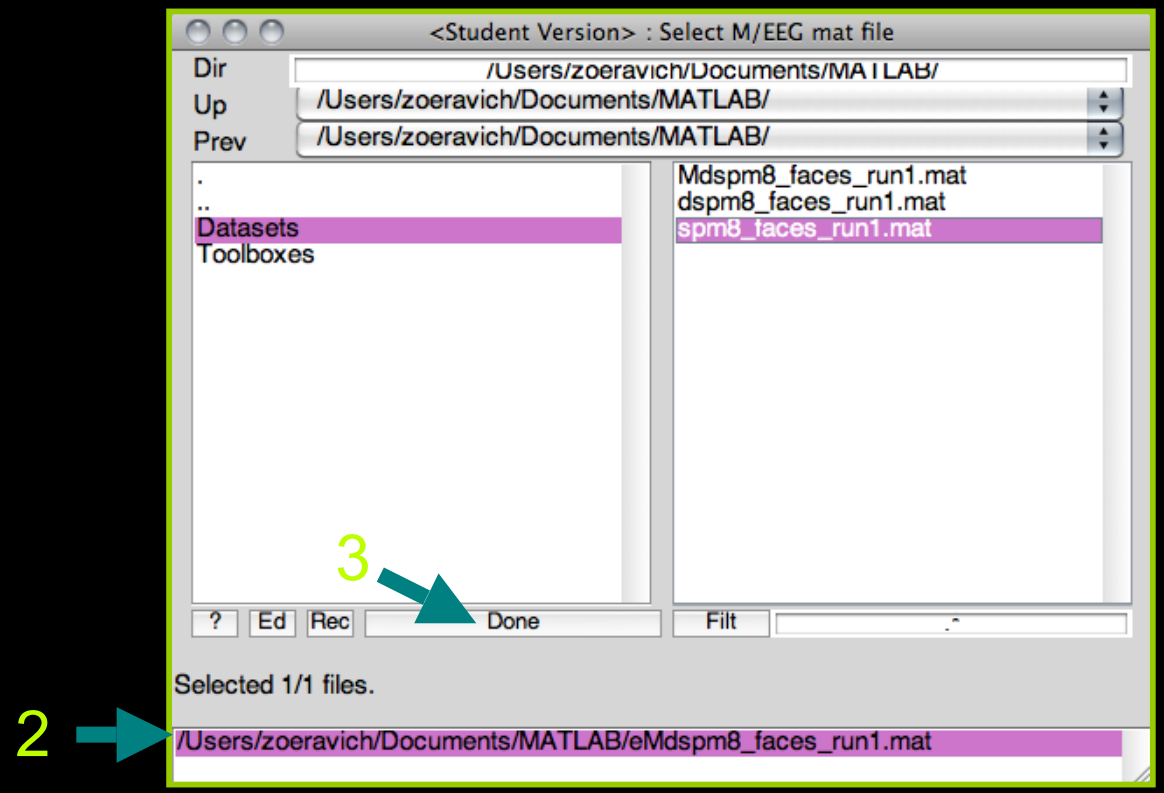
Step 6
Reassignment of Trial Labels

- Open the eMdspm8_faces_run1.mat file in the reviewing tool
  - Switch to the "Trials" tab, which should present a table with 172 rows
- Open conditions_labels.txt and select/copy (Ctrl-A/Ctrl-C) all of the rows
  - Place the cursor in the first row and first column under the "Trials" tab and paste the copied labels (Ctrl-V)
  - Press "Update" and then "SAVE"

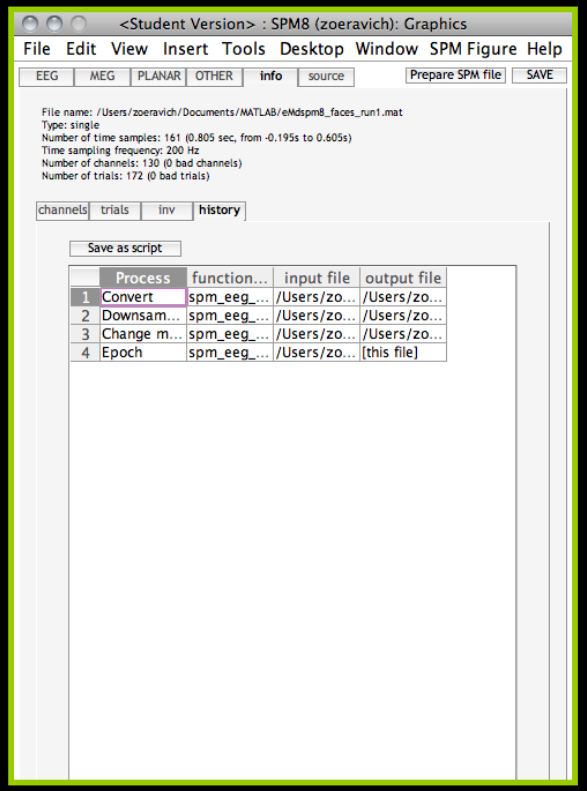
Step 6
Reassignment of Trial Labels



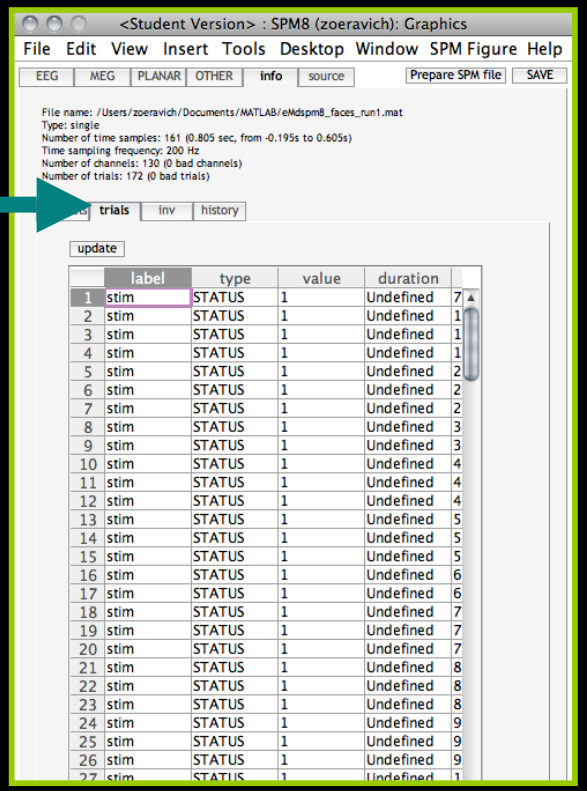
Step 6
Reassignment of Trial Labels



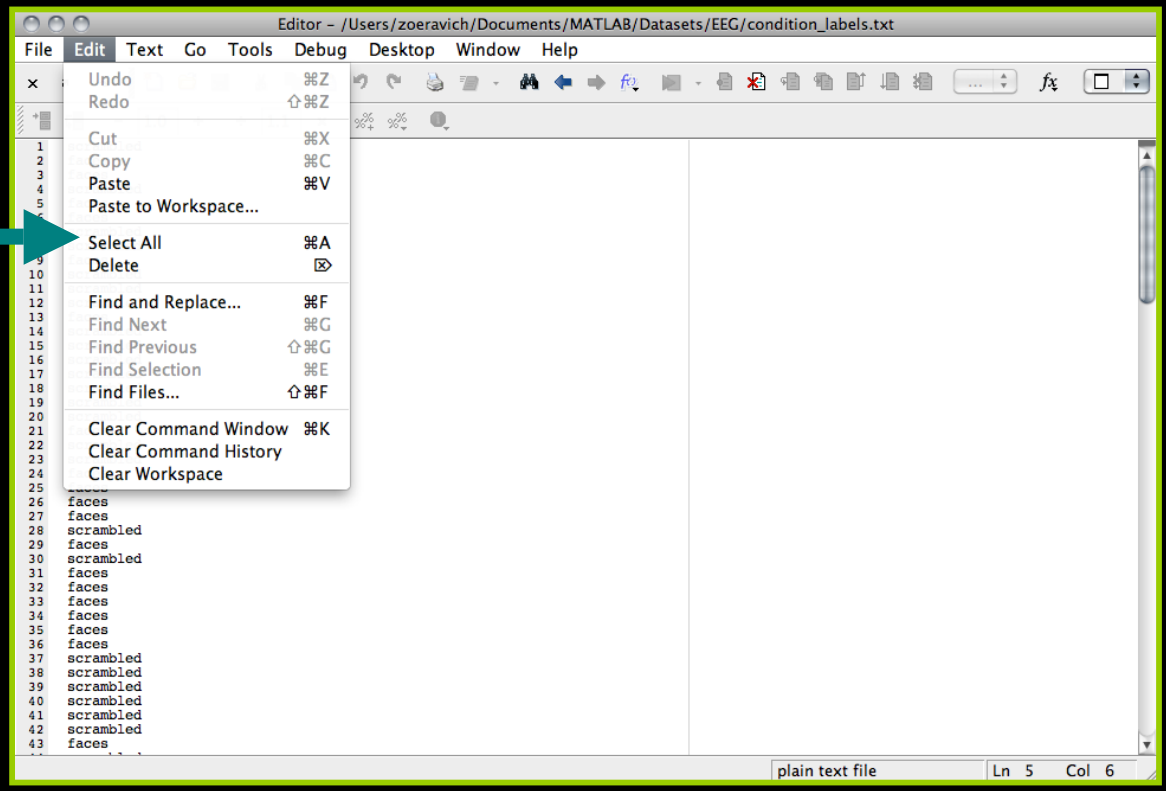
Step 6
Reassignment of Trial Labels



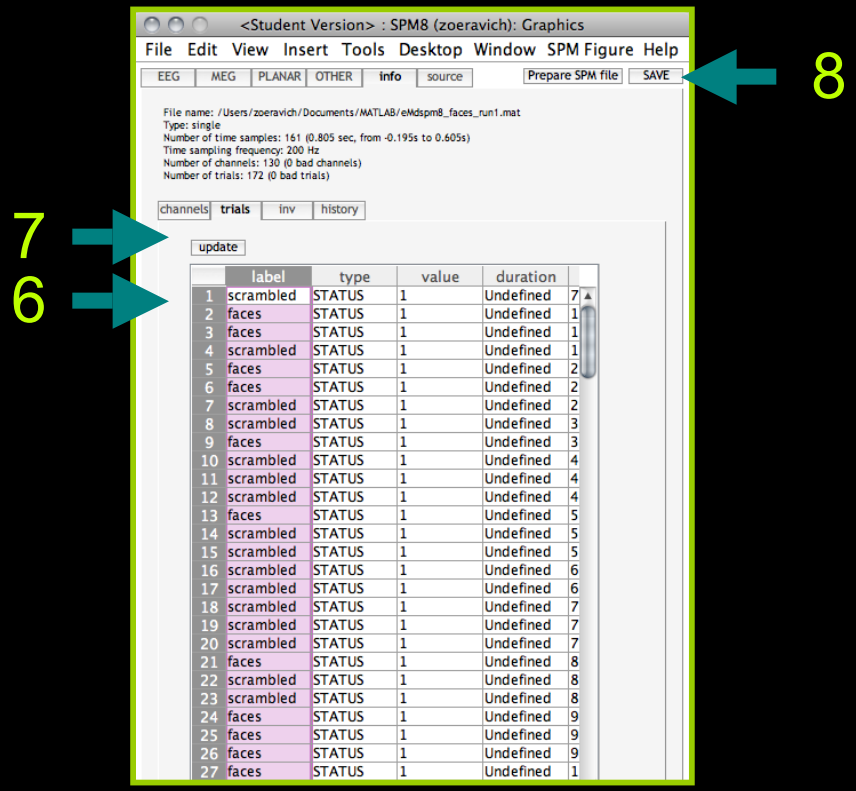
4



Step 6
Reassignment of Trial Labels



Step 6
Reassignment of Trial Labels

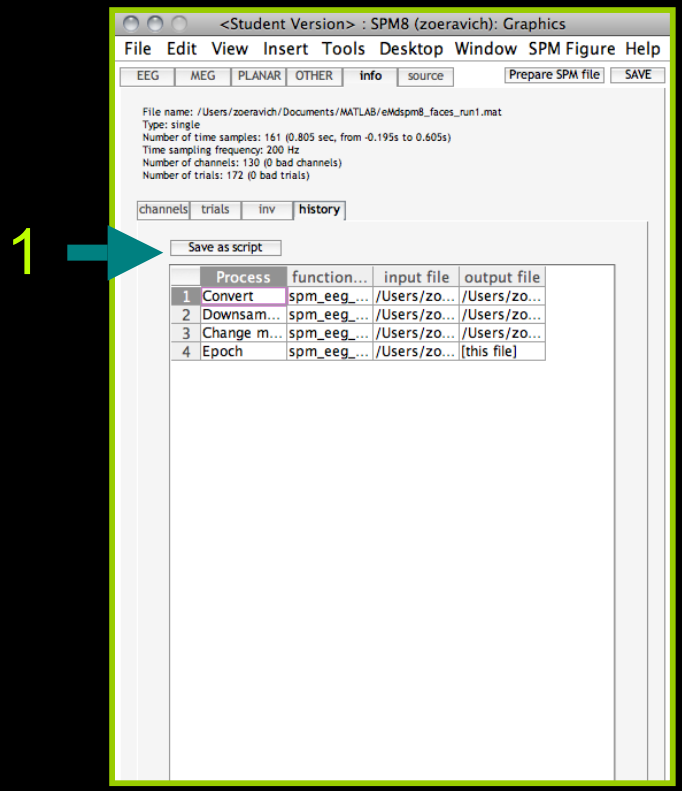


	label	type	value	duration	
1	scrambled	STATUS	1	Undefined	7
2	faces	STATUS	1	Undefined	1
3	faces	STATUS	1	Undefined	1
4	scrambled	STATUS	1	Undefined	1
5	faces	STATUS	1	Undefined	2
6	faces	STATUS	1	Undefined	2
7	scrambled	STATUS	1	Undefined	2
8	scrambled	STATUS	1	Undefined	3
9	faces	STATUS	1	Undefined	3
10	scrambled	STATUS	1	Undefined	4
11	scrambled	STATUS	1	Undefined	4
12	scrambled	STATUS	1	Undefined	4
13	faces	STATUS	1	Undefined	5
14	scrambled	STATUS	1	Undefined	5
15	scrambled	STATUS	1	Undefined	5
16	scrambled	STATUS	1	Undefined	6
17	scrambled	STATUS	1	Undefined	6
18	scrambled	STATUS	1	Undefined	7
19	scrambled	STATUS	1	Undefined	7
20	scrambled	STATUS	1	Undefined	7
21	faces	STATUS	1	Undefined	8
22	scrambled	STATUS	1	Undefined	8
23	scrambled	STATUS	1	Undefined	8
24	faces	STATUS	1	Undefined	9
25	faces	STATUS	1	Undefined	9
26	faces	STATUS	1	Undefined	9
27	faces	STATUS	1	Undefined	1

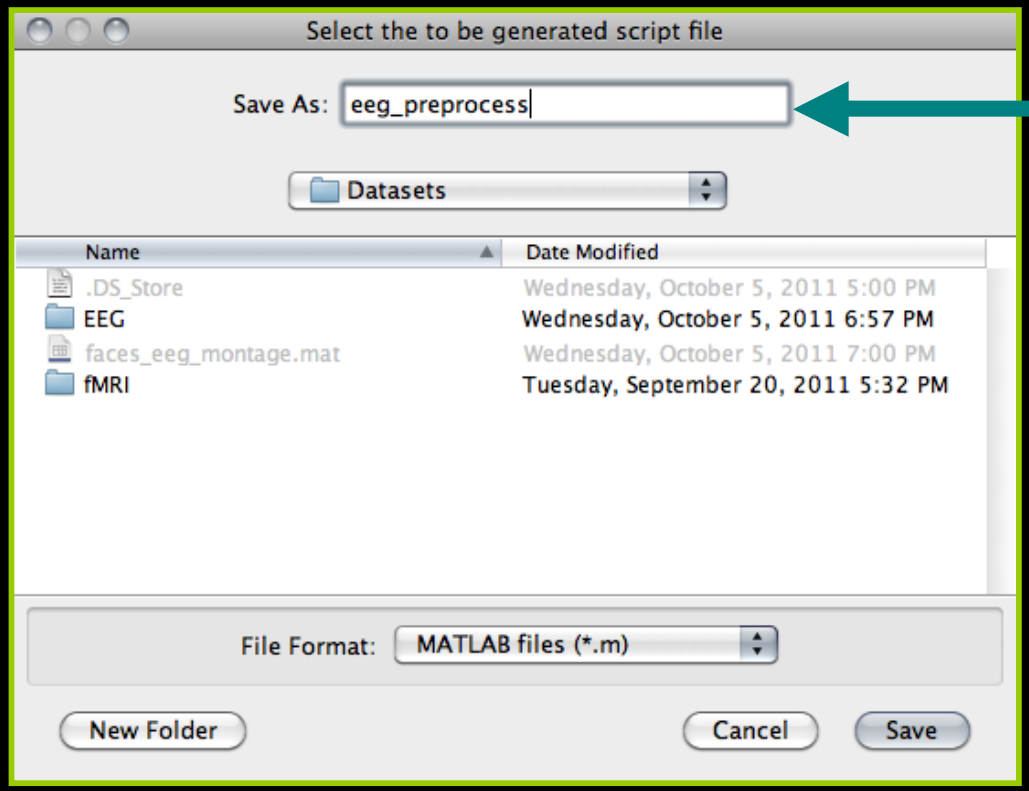
Step 7
Scripting the Second File

- Open the eMdspm8_faces_run1.mat file in the reviewing tool
  - Go to the "History" tab and press the "Save as script" button
  - Name the script eeg_preprocess.m in the dialogue box that appears
  - Select OK in the next dialogue box to save all the steps
- Open eeg_preprocess.m
  - Use the "Find & Replace" function to replace all occurrences of "run1" with "run2"
  - Then, delete the line starting with S.timewindow
  - Press the "Run" button to save the changes and run the script
- Type D = conditions(D, [], importdata('condition_labels.txt')); D.save;
  - This updates the trial labels using information imported from the condition_labels.txt
- New files: eMdspm8_faces_run2.mat and eMdspm8_faces_run2.dat

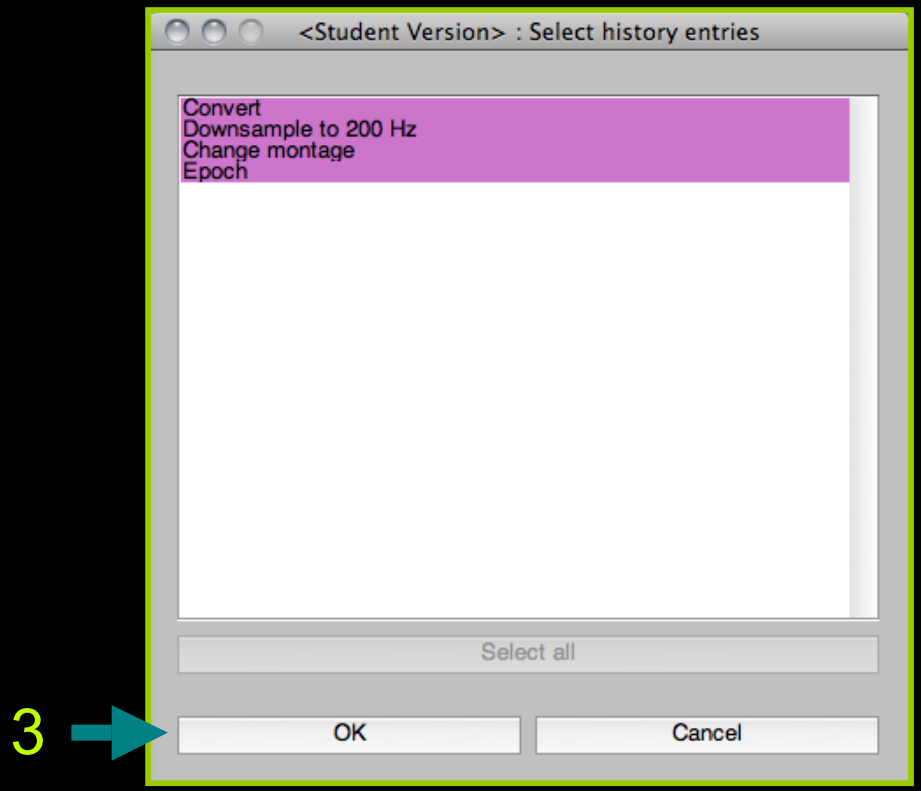
Step 7
Scripting the Second File



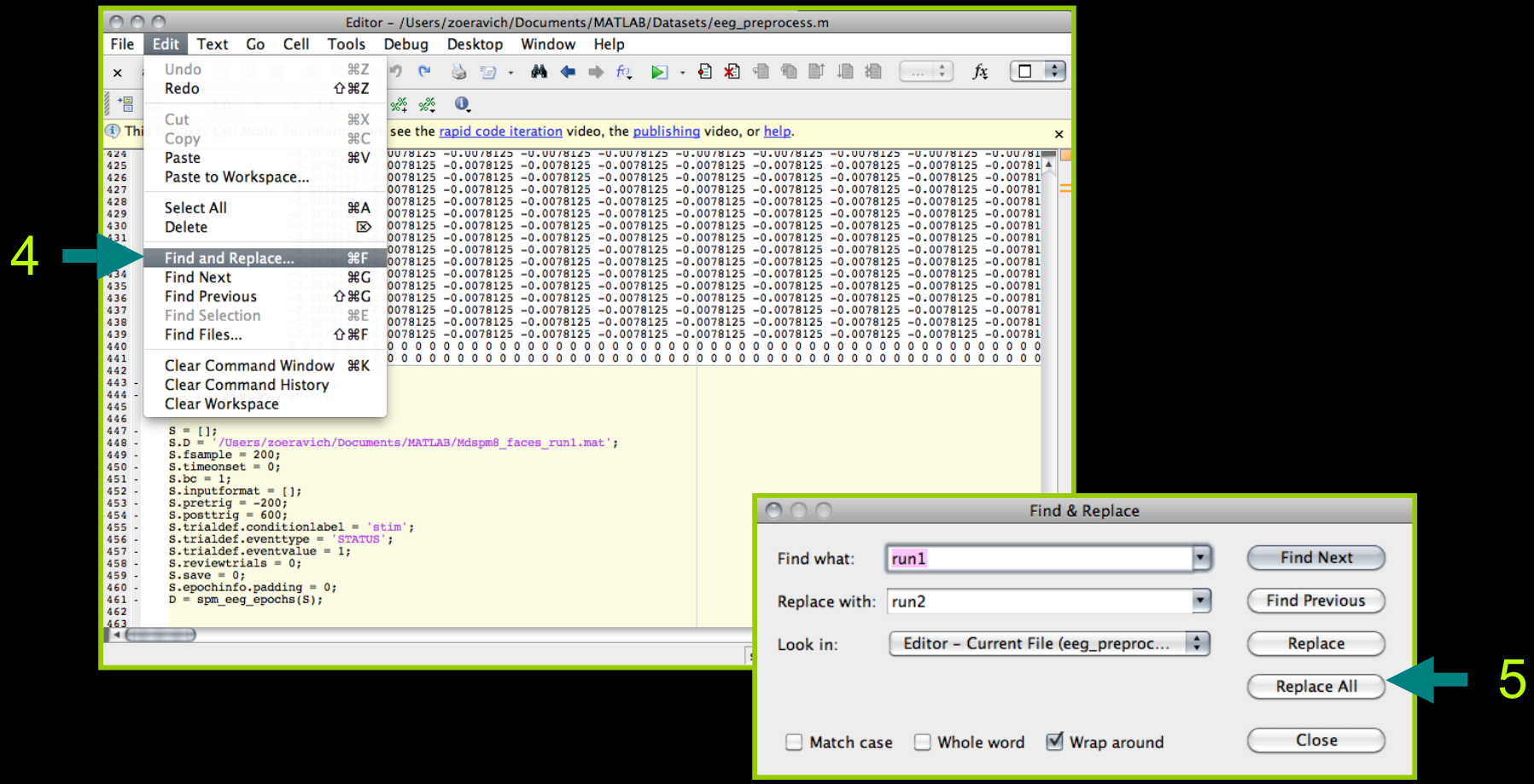
Step 7
Scripting the Second File



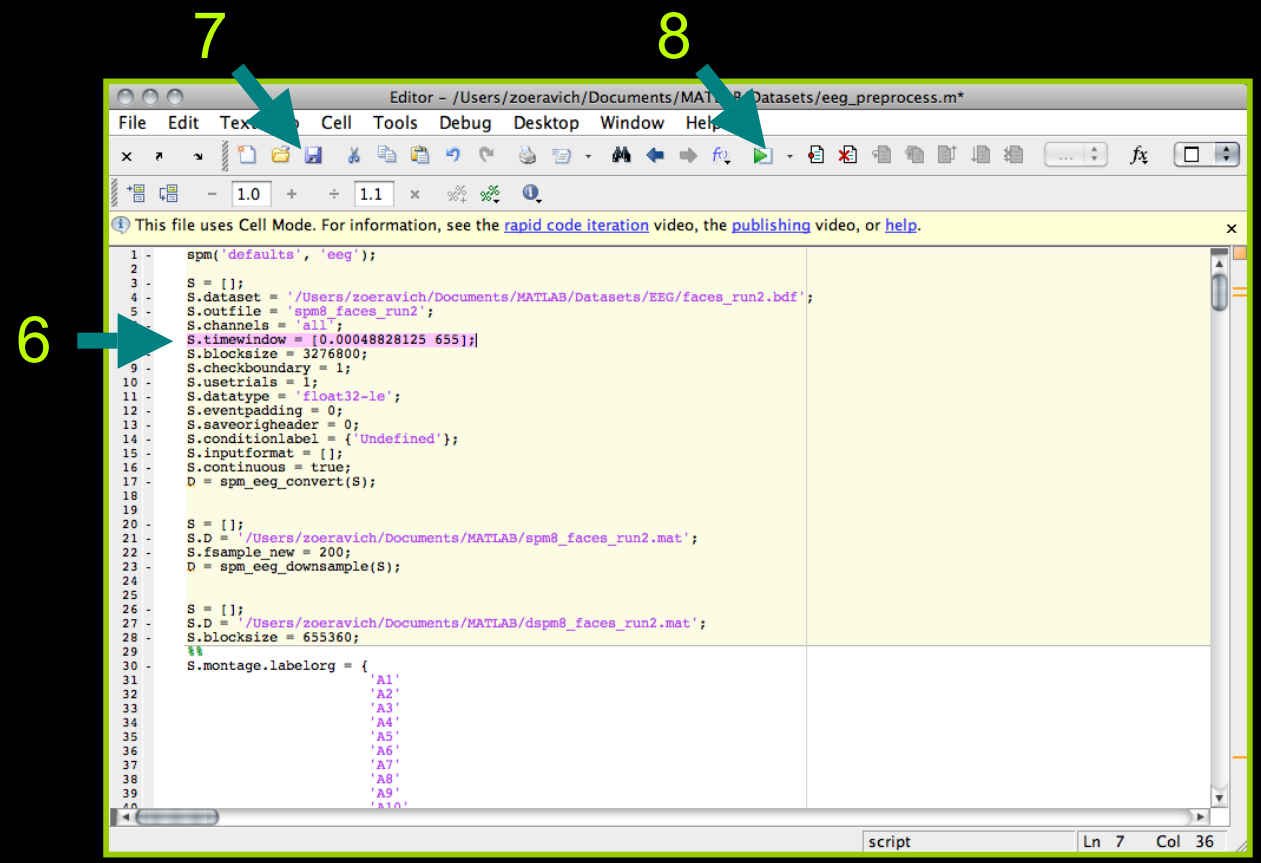
Step 7
Scripting the Second File



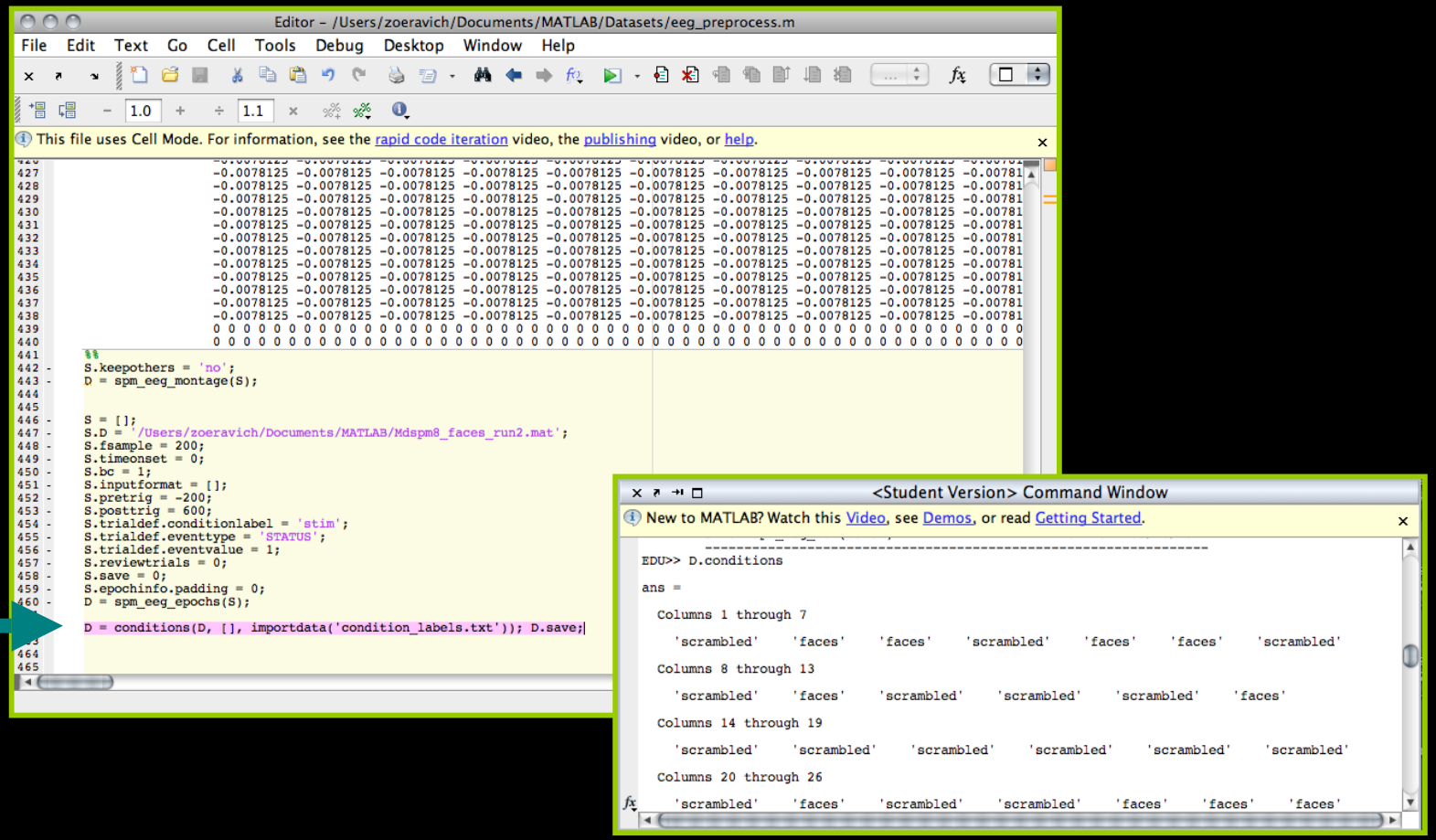
Step 7
Scripting the Second File



Step 7
Scripting the Second File



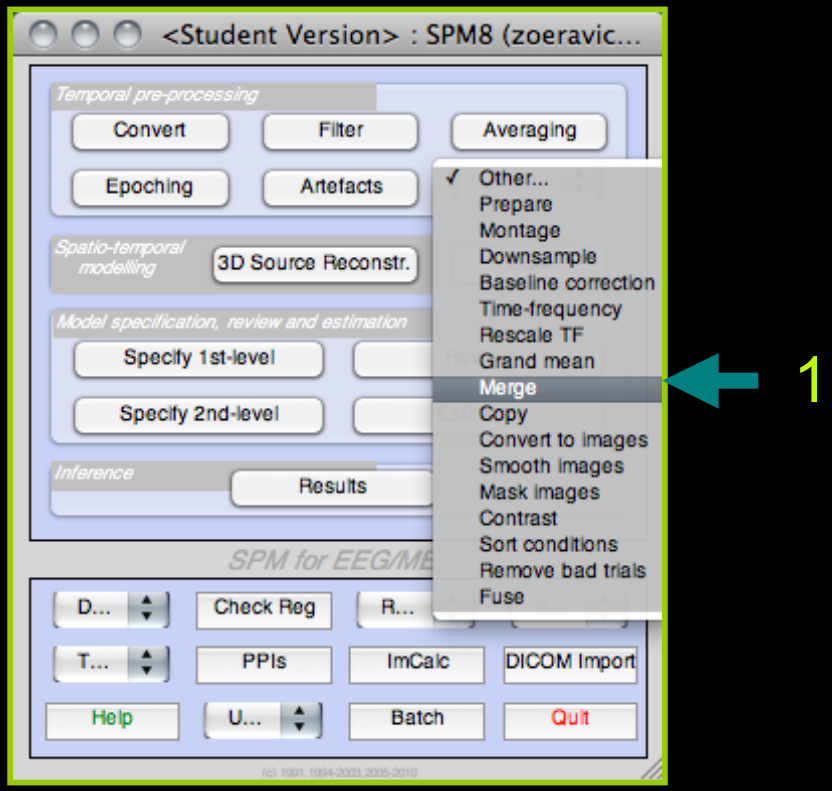
Step 7
Scripting the Second File



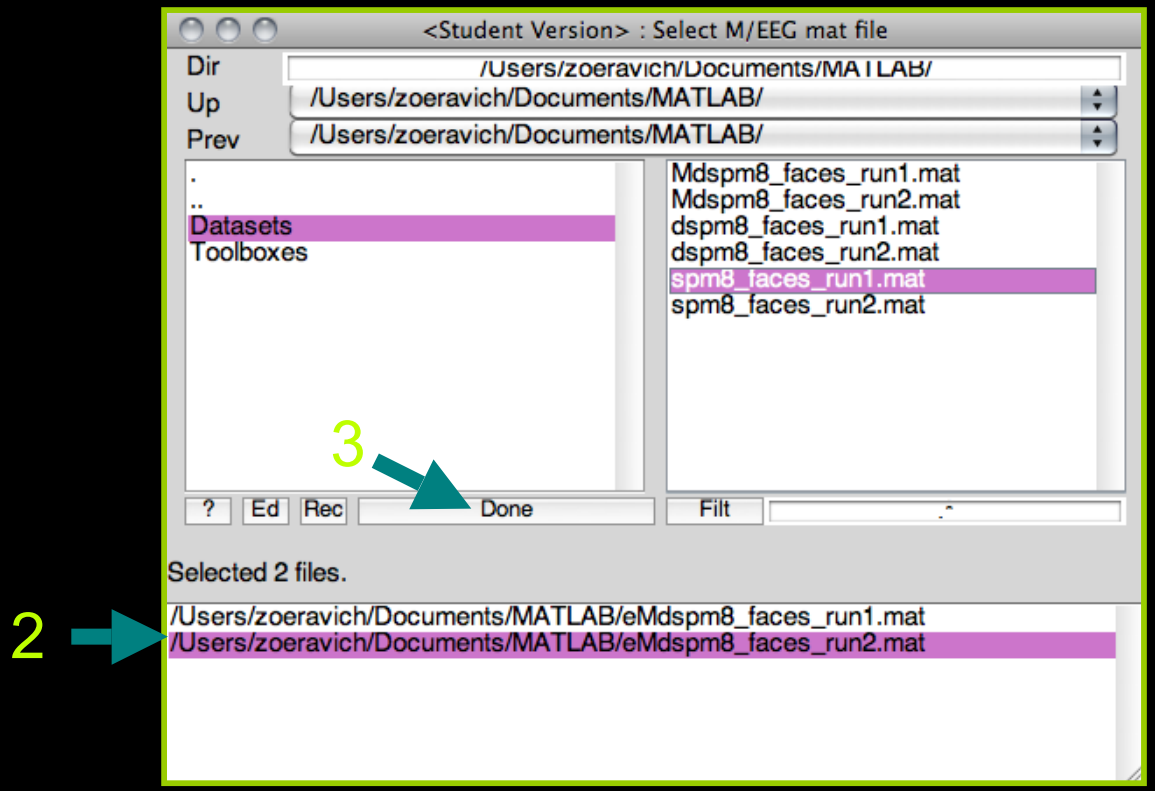
Step 8
Merge

- Select MERGE from the "Other" drop-down menu
  - Select the eMspm8_faces_run1.mat and eMdspm8_faces_run2.mat files
  - Press "Done"
  - "What to do with condition labels?"; Click "Leave as they are"
- New files: ceMdspm8_races_run1.mat and ceMdspm8_races_run1.dat

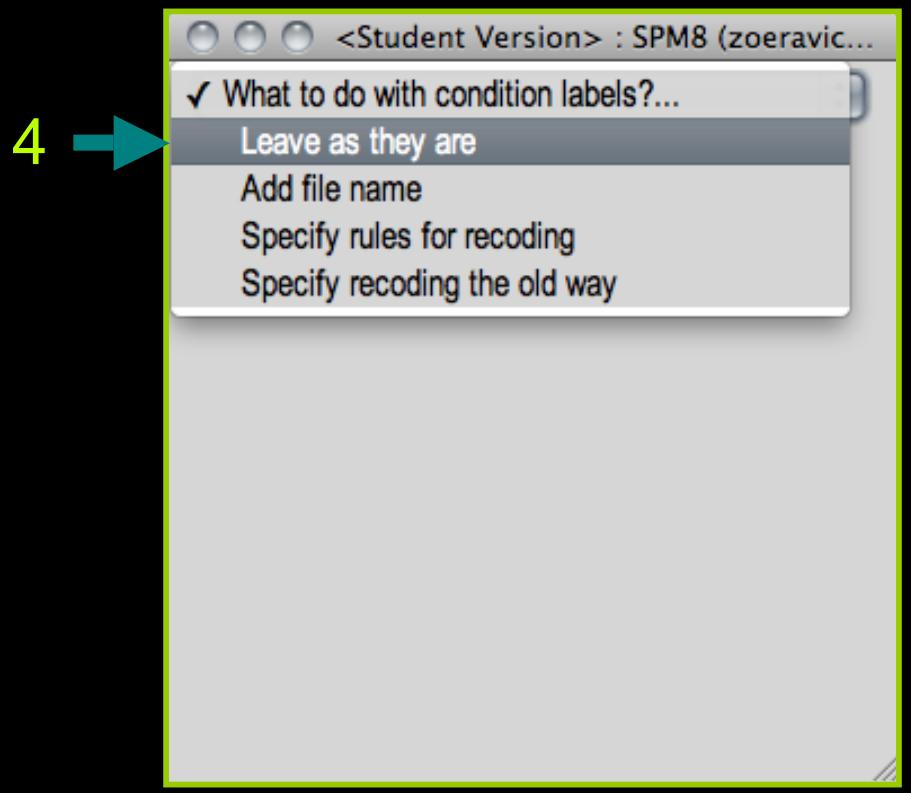
Step 8
Merge


<Student Version> : SPM8 (zoeravic...
Temporal pre-processing
Convert
Filter
Averaging
Epoching
Artefacts
Other...
Prepare
Montage
Downsample
Baseline correction
Time-frequency
Rescale TF
Grand mean
Merge
Copy
Convert to images
Smooth images
Mask images
Contrast
Sort conditions
Remove bad trials
Fuse
Spatio-temporal modelling
3D Source Reconstr.
Model specification, review and estimation
Specify 1st-level
Specify 2nd-level
Inference
Results
SPM for EEG/ME
D...
Check Reg
R...
T...
PPIs
ImCalc
DICOM Import
Help
U...
Batch
Quit
1

Step 8
Merge


<Student Version> : Select M/EEG mat file
Dir
/Users/zoeravich/Documents/MATLAB/
Up
/Users/zoeravich/Documents/MATLAB/
Prev
/Users/zoeravich/Documents/MATLAB/
.
..
Datasets
Toolboxes
Mdspm8_faces_run1.mat
Mdspm8_faces_run2.mat
dspm8_faces_run1.mat
dspm8_faces_run2.mat
spm8_faces_run1.mat
spm8_faces_run2.mat
3
?
Ed
Rec
Done
Filt
Selected 2 files.
2
/Users/zoeravich/Documents/MATLAB/eMdspm8_faces_run1.mat
/Users/zoeravich/Documents/MATLAB/eMdspm8_faces_run2.mat

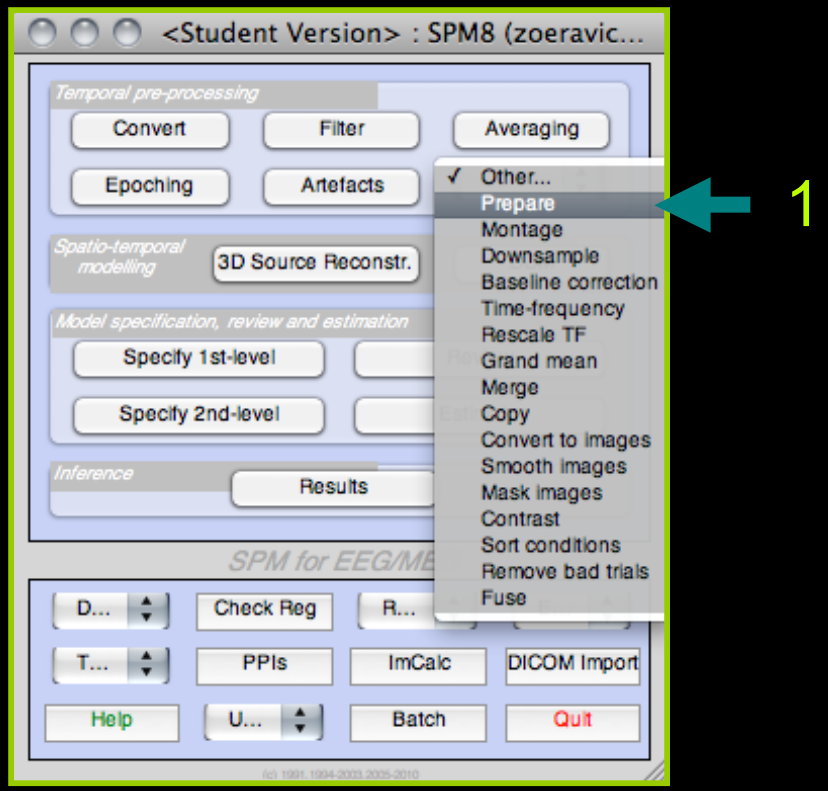
Step 8
Merge


4
<Student Version> : SPM8 (zoeravic...
✓ What to do with condition labels?...
Leave as they are
Add file name
Specify rules for recoding
Specify recoding the old way

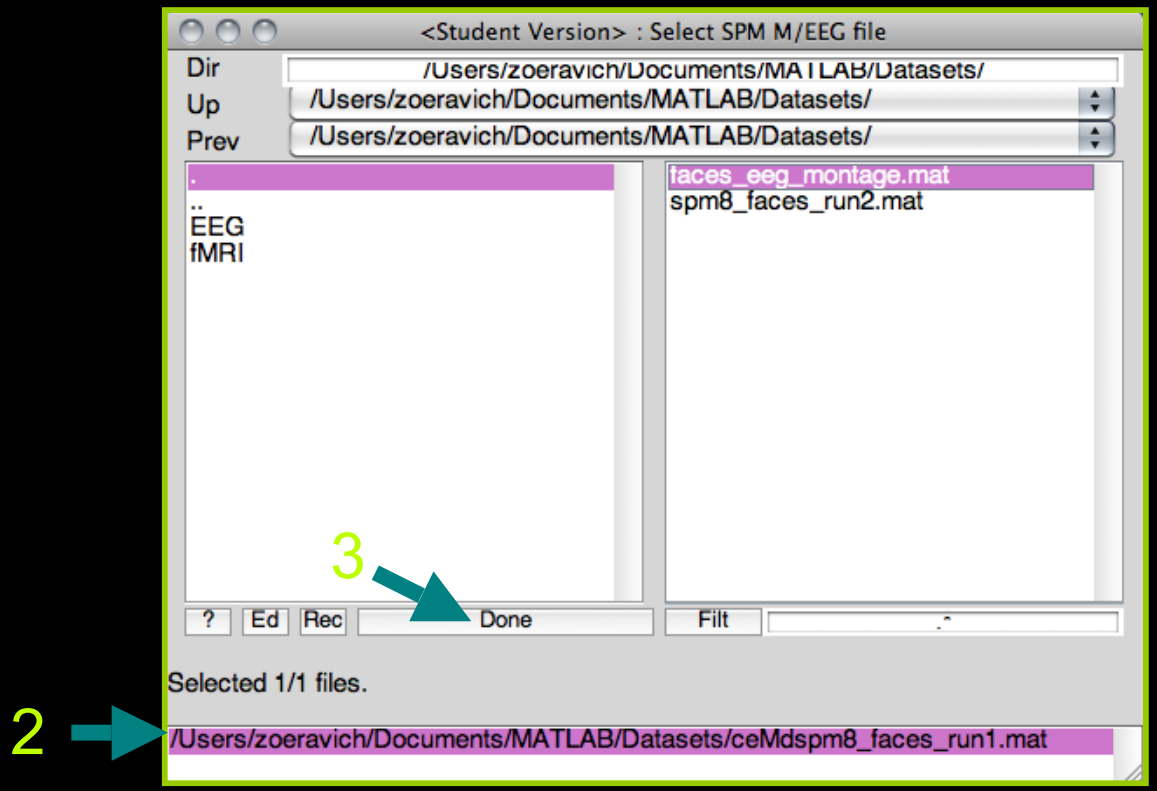
Step 9
Prepare

- Select PREPARE from the "Other" drop-down menu button
  - Select the ceMdspm8_faces_run1.mat file
  - In the "Sensors" submenu, choose "Load EEG sensors"/"Convert locations file"; Choose the electrode_locations_and_headshape.sfp file
  - In the "2D Projection" submenu, select "Project 3D (EEG)"
  - After a 2D channel layout appears, select "Apply" from the "2D Projection" submenu and "Save" from the "File" submenu

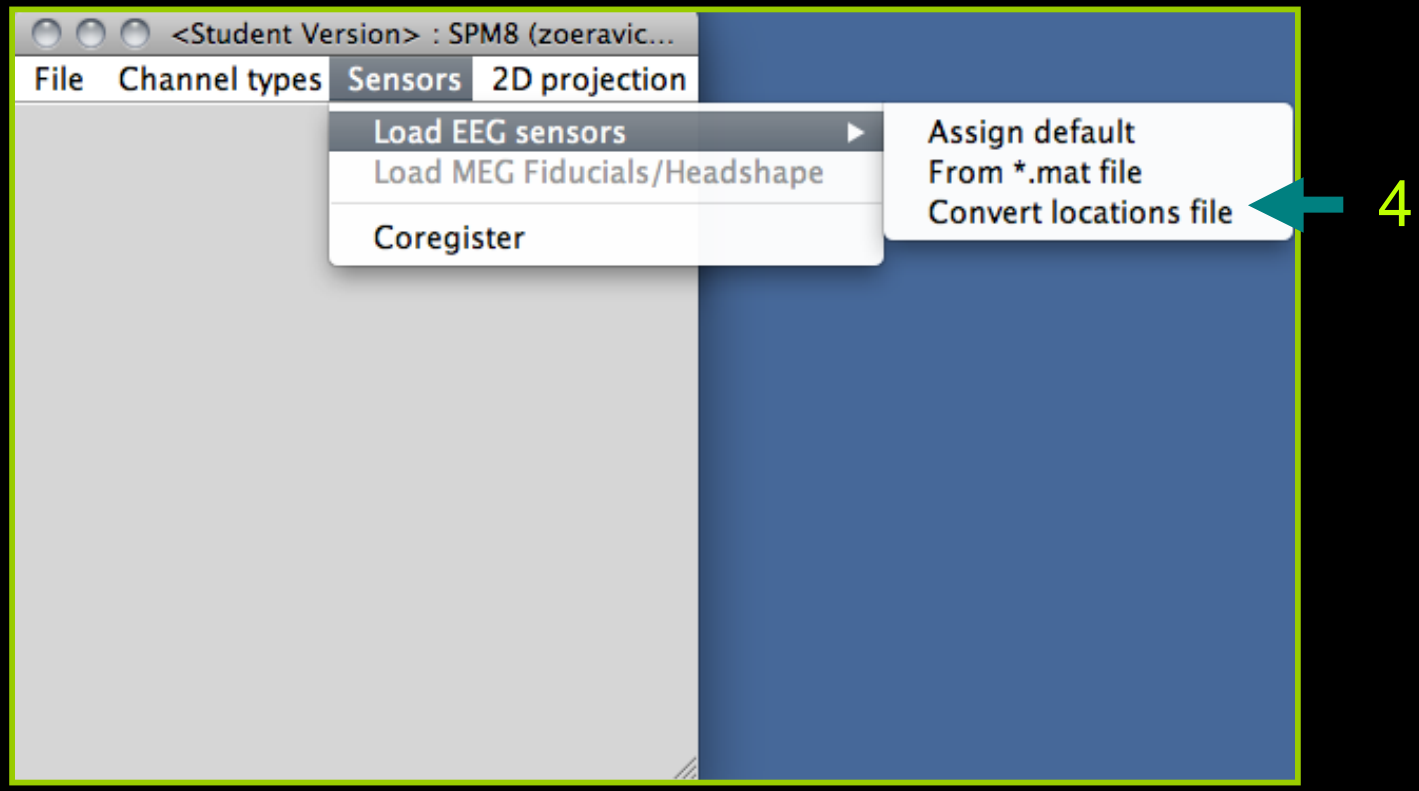
Step 9
Prepare



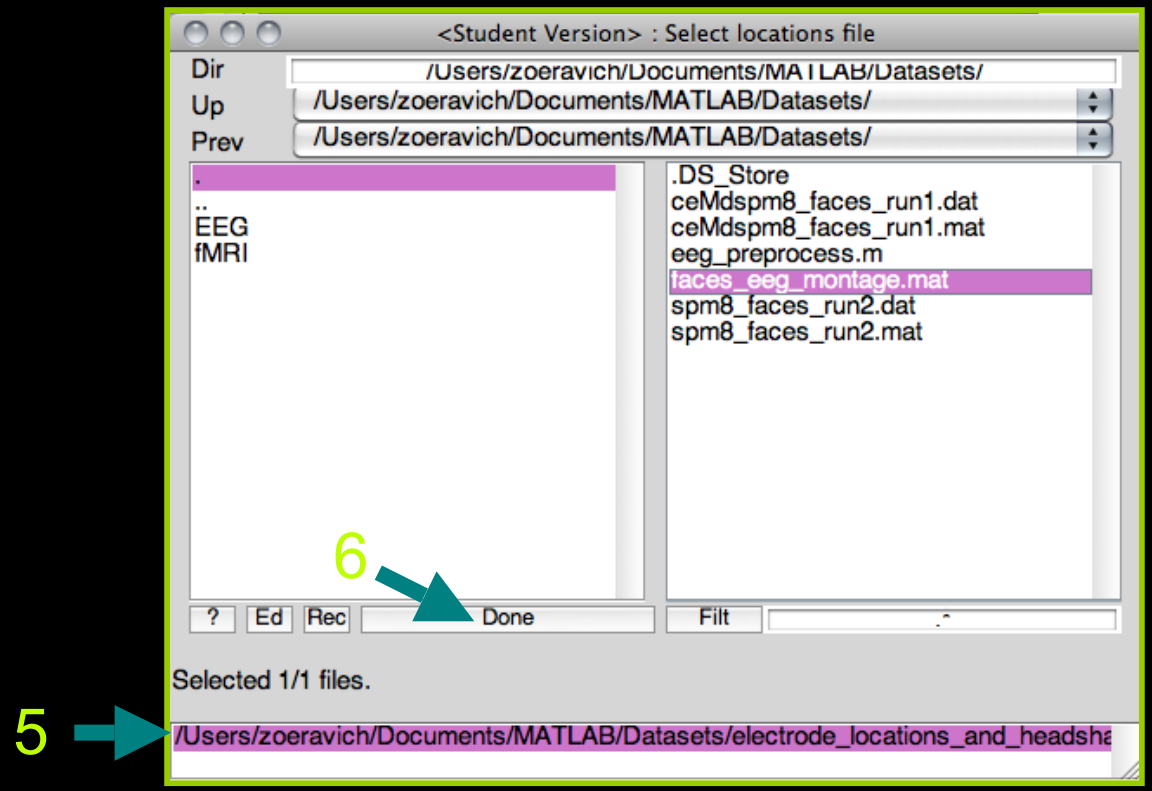
Step 9
Prepare



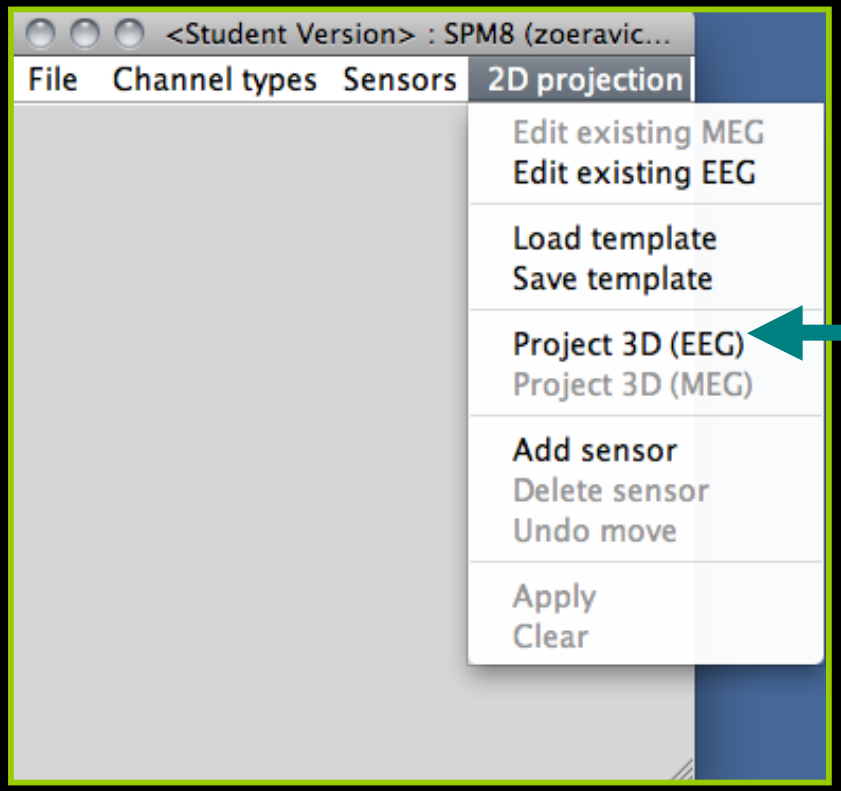
Step 9
Prepare

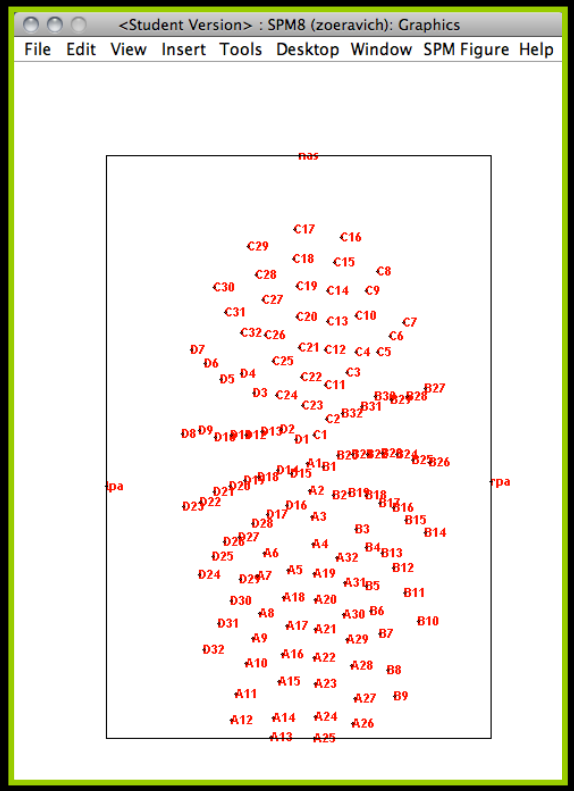


Step 9
Prepare

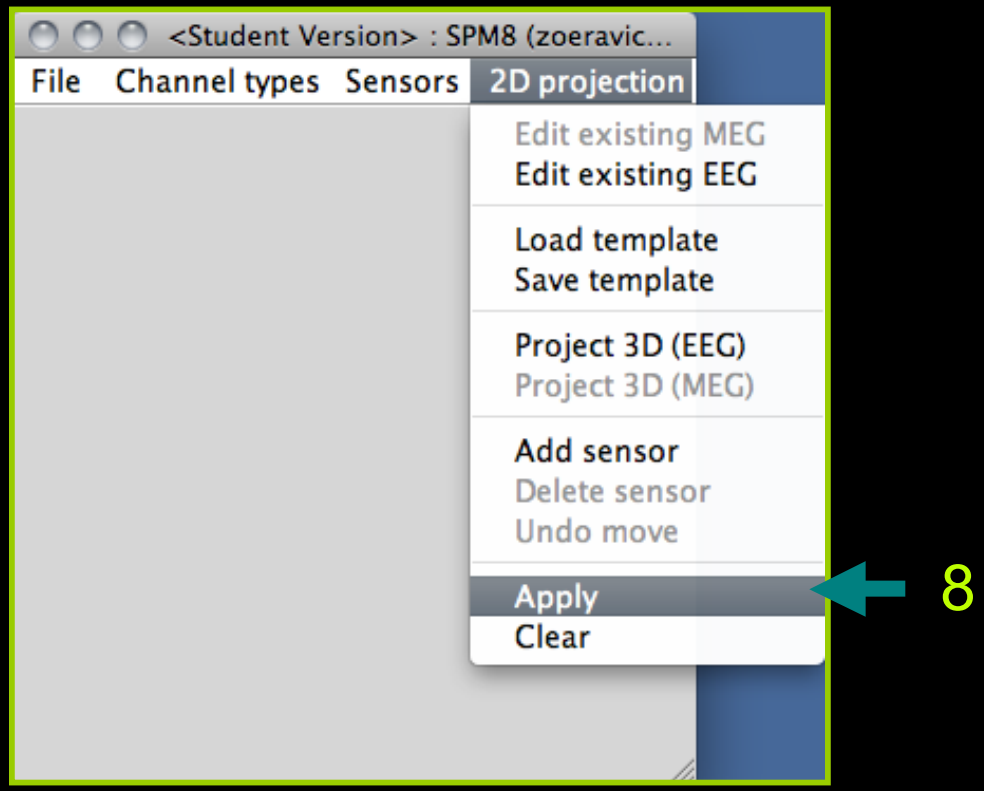


Step 9
Prepare

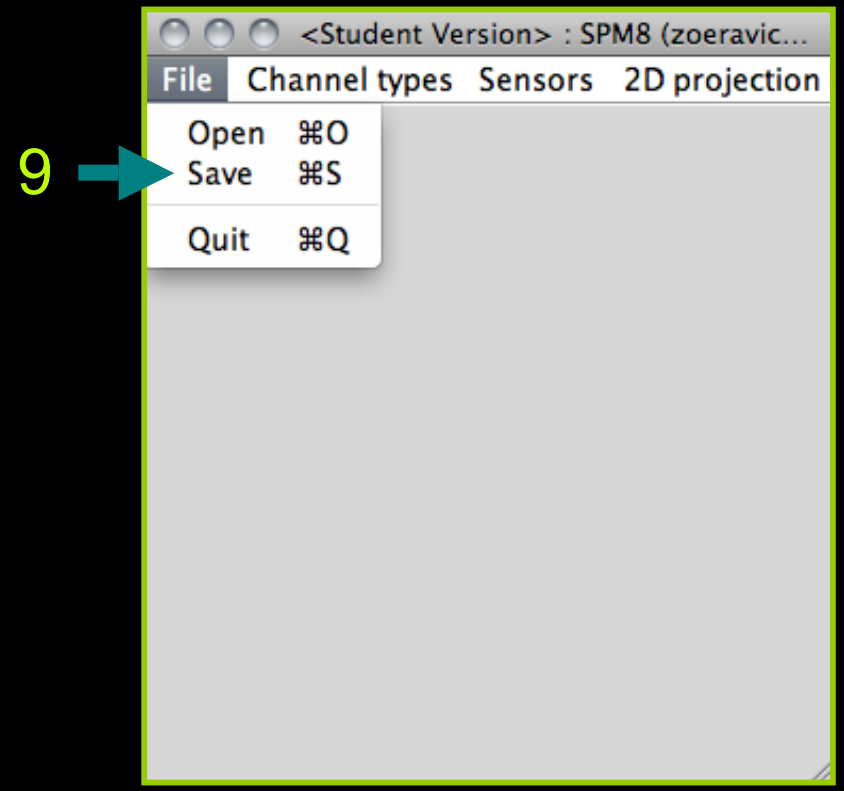




Step 9
Prepare



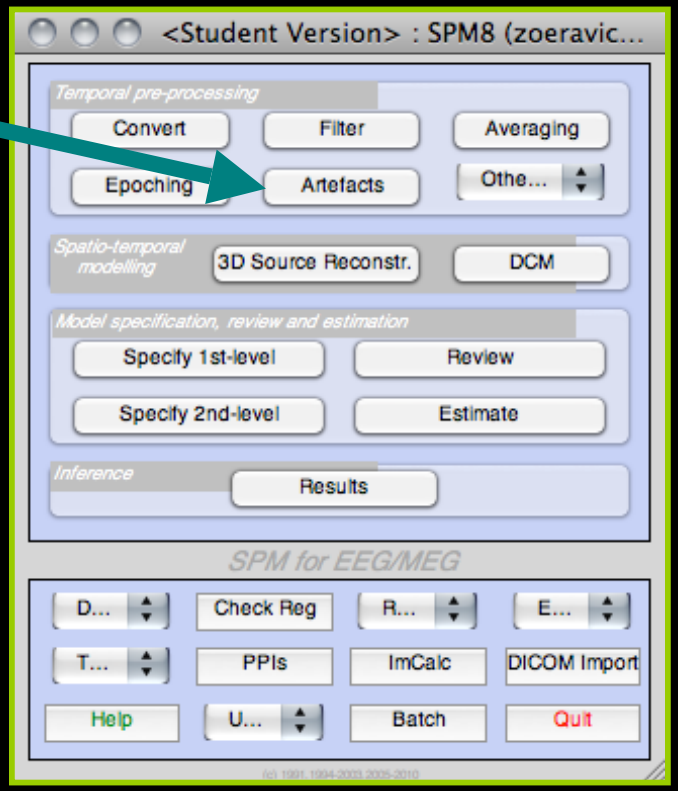
Step 9
Prepare



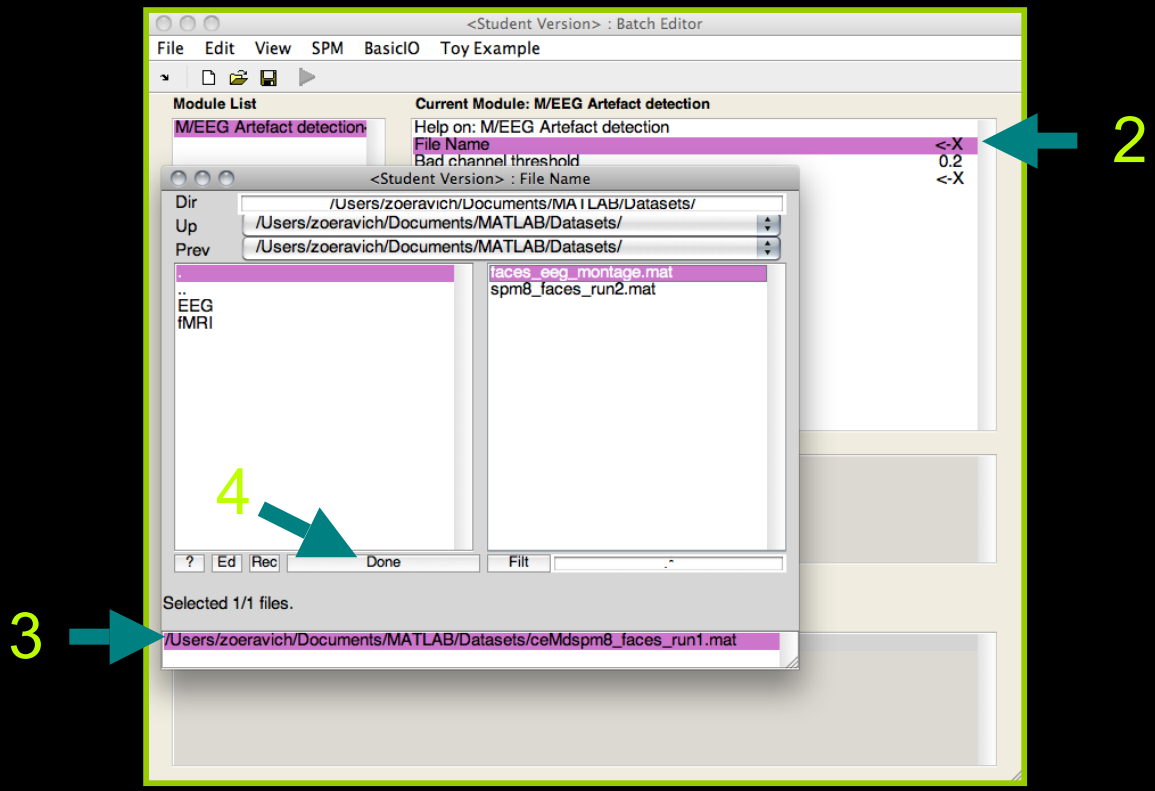
Step 10
Artefact Rejection

- Press the ARTEFACTS button
  - Select the ceMdspm8_faces_run1.mat file as the "File name"
  - "How to look for artefacts"; Click on "Detection algorithm" and select "Threshold channels"
  - "Threshold"; Type 200 (μV)
  - Run the batch by pressing the green button at the top of the window
- New files: aceMdspm8_races_run1.mat and aceMdspm8_races_run1.dat

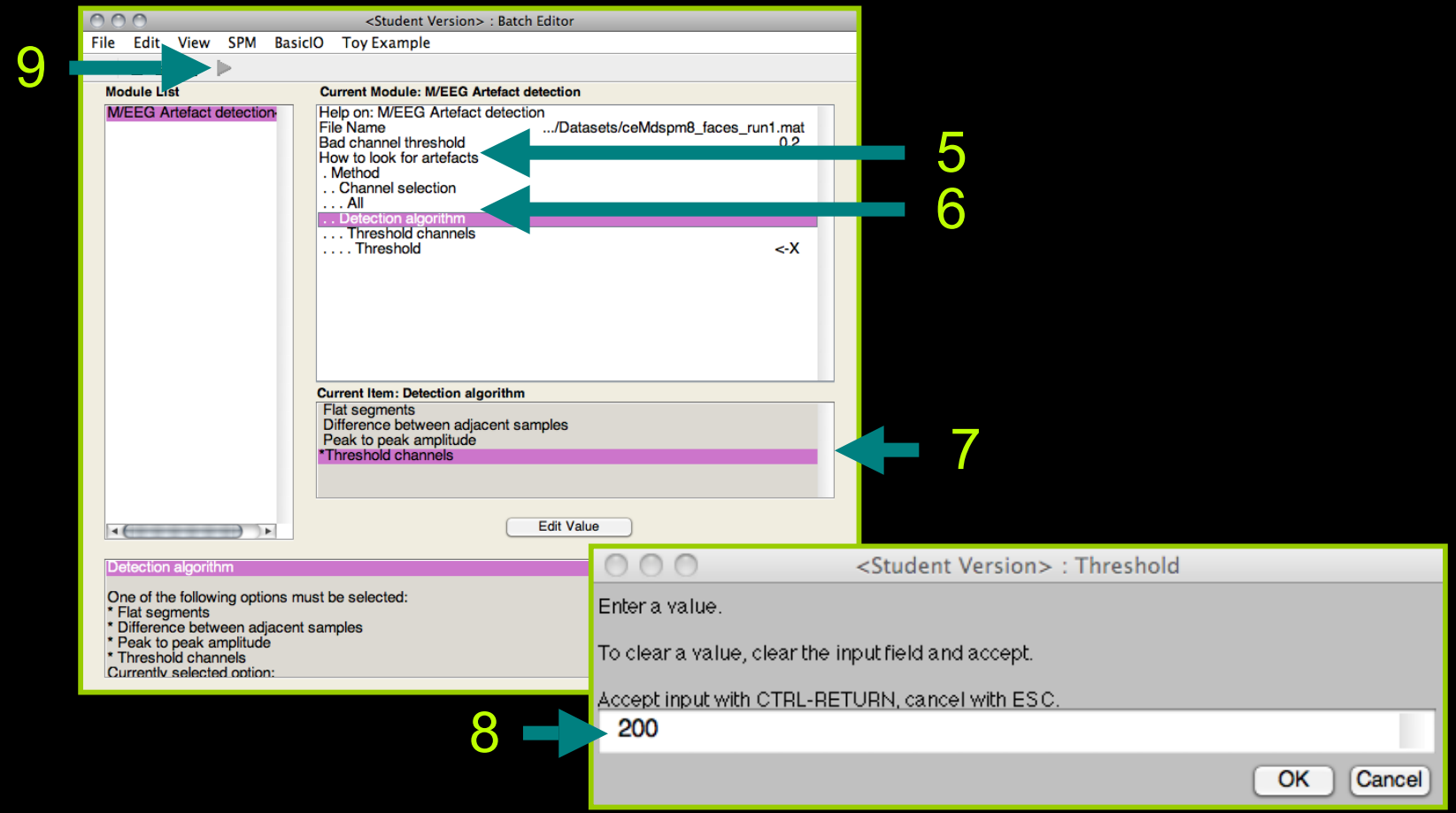
Step 10
Artefact Rejection



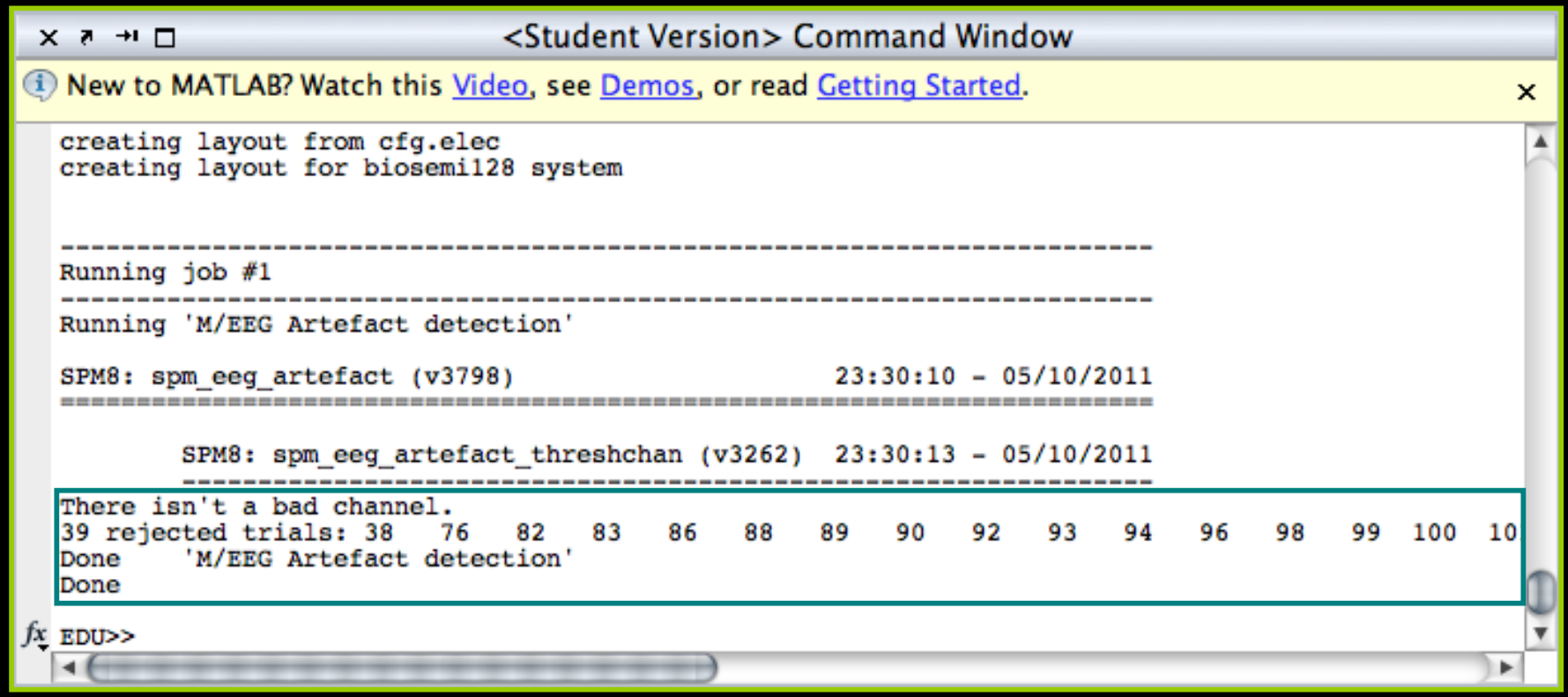
Step 10
Artefact Rejection



Step 10
Artefact Rejection



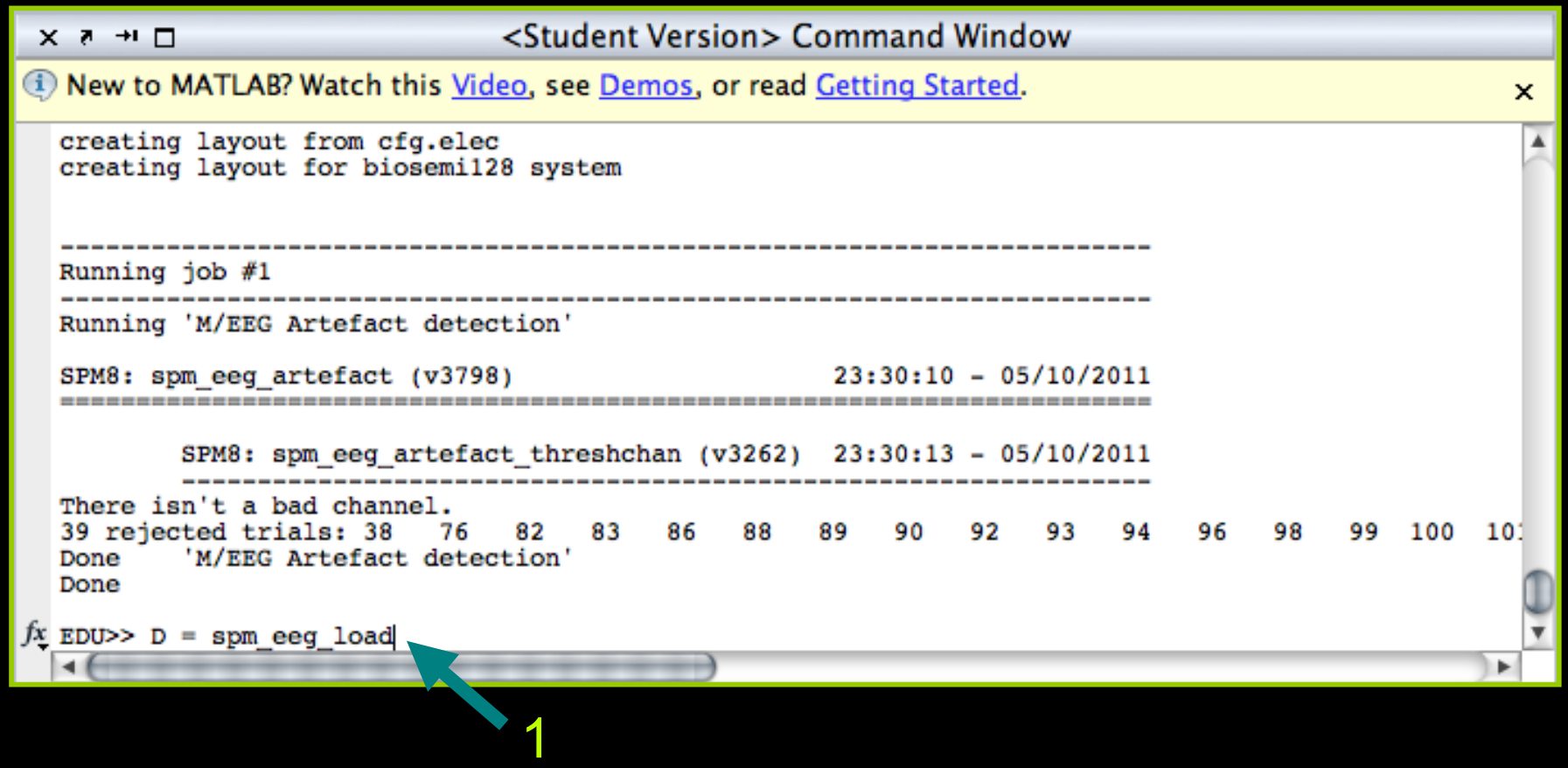
Step 10
Artefact Rejection



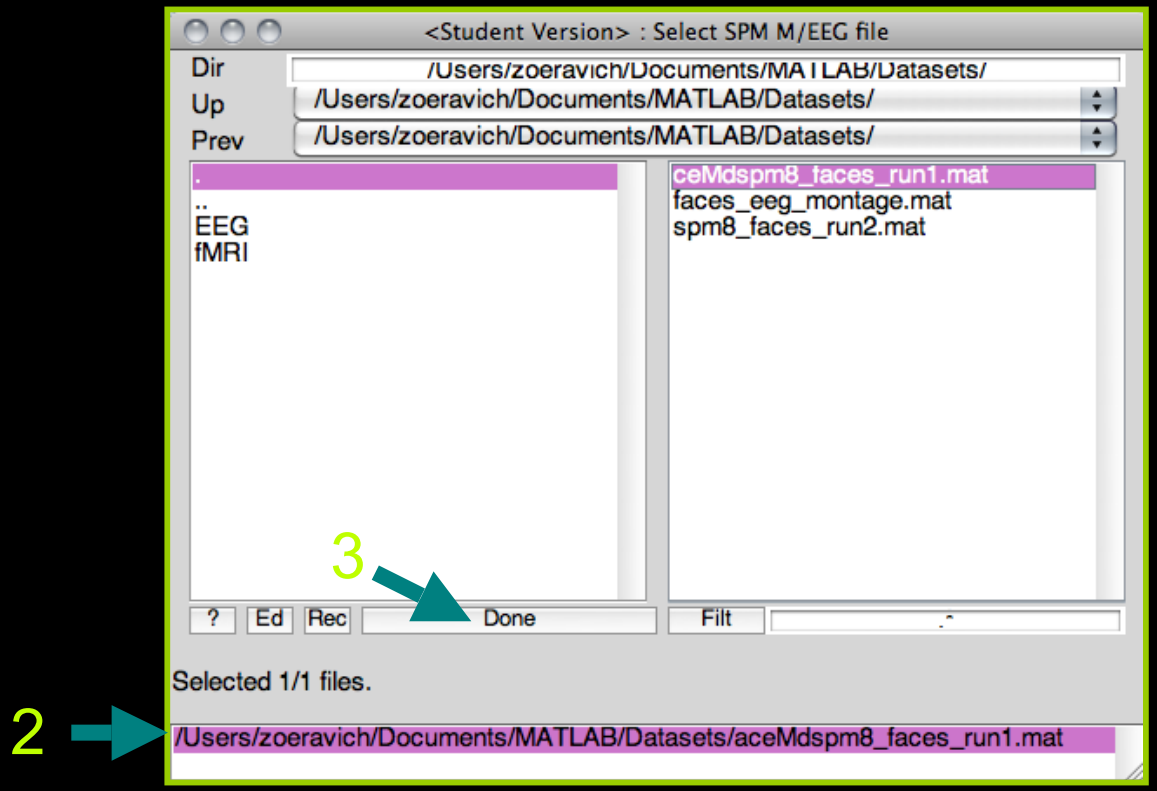
Step 11
Exploring the M/EEG Object

- Review the preprocessed dataset by typing D = spm_eeg_load and then selecting the aceMdspm8_races_run1.mat file
  - This reveals the data values, the list of condition labels, a vector of rejected and retained trials, the order and the names of the channels, as well as the size of the data matrix
- Review the full list of methods performing operations with the object by typing methods('meeg')

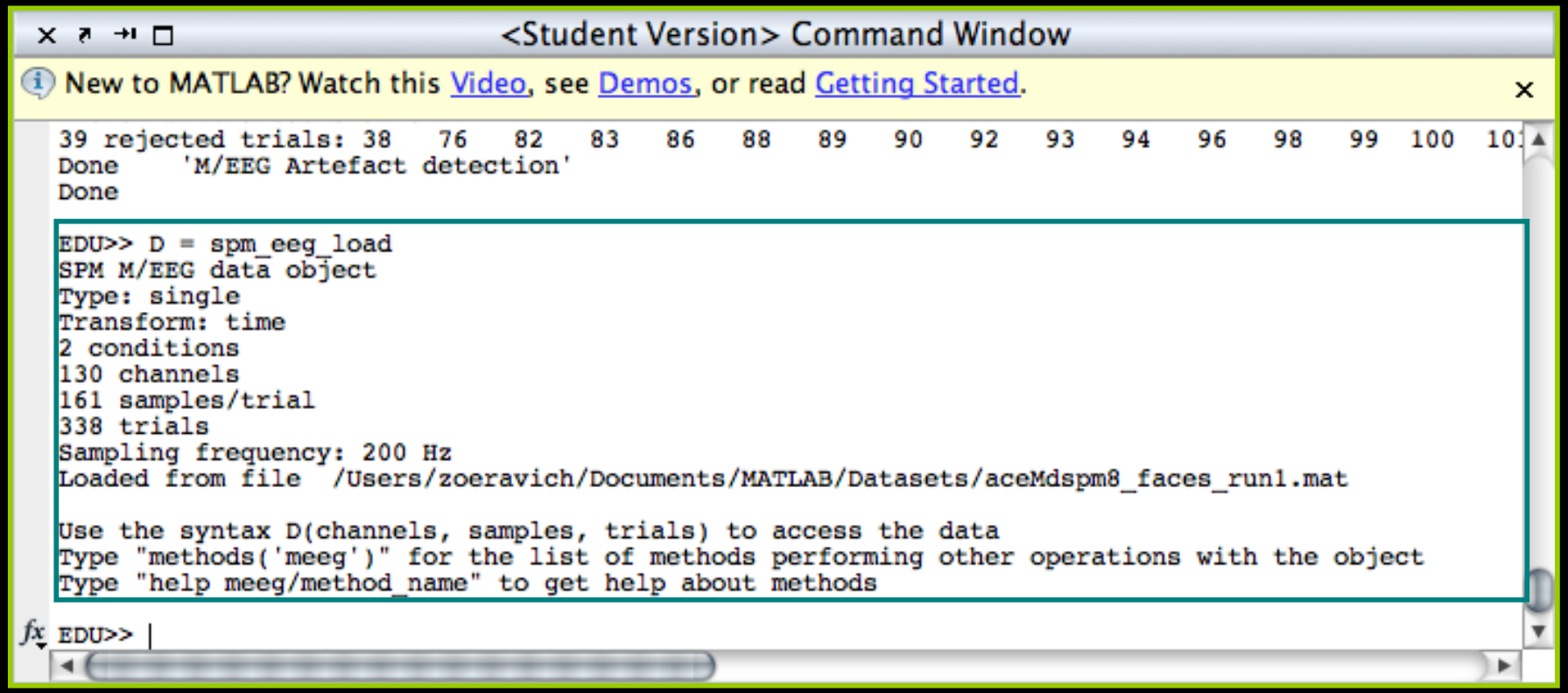
Step 11
Exploring the M/EEG Object



Step 11
Exploring the M/EEG Object



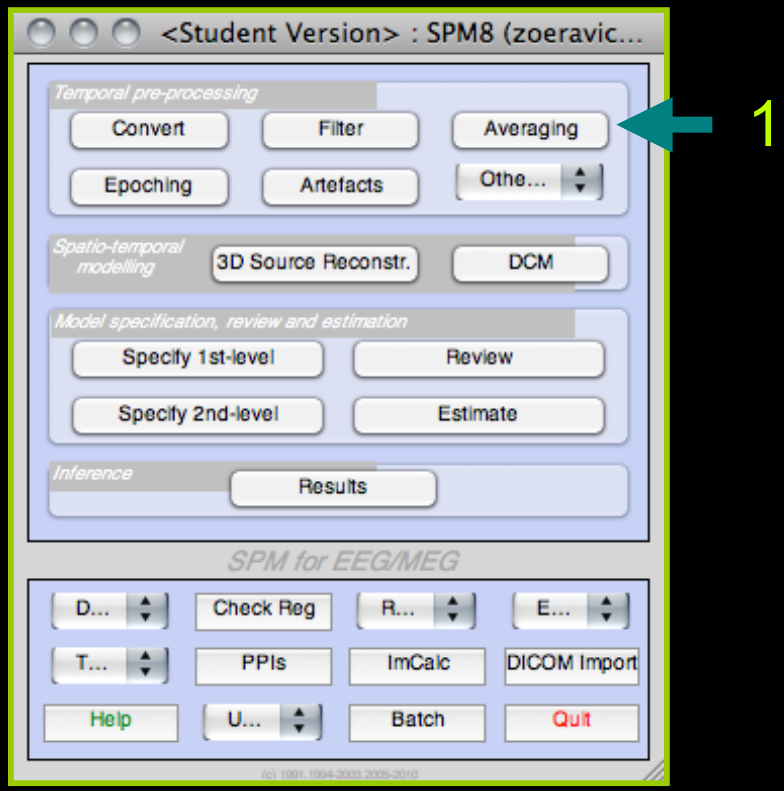
Step 11
Exploring the M/EEG Object



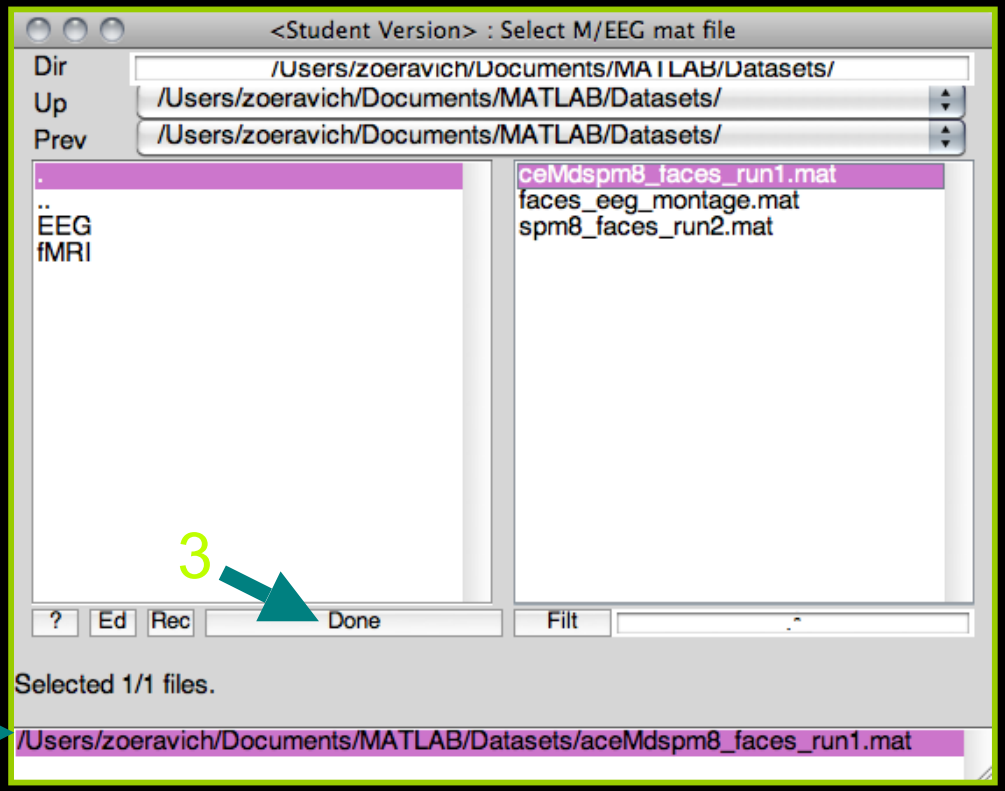
Step 12
Basic ERPs

- Press the AVERAGING button
  - Select the aceMdspm8_faces_run1.mat file
  - "Use robust averaging?"; Click "Yes"
  - "Save weights"; Click "Yes"
  - "Compute weights by condition"; Click "No"
  - "Offset of the weighting function"; Hit "Enter"
- New datasets: maceMdspm8_faces_run1.{mat,dat} and WaceMdspm8_faces_run1.{mat, dat}
- Select CONTRAST from the "Other" drop-down menu button
  - Select the maceMdspm8_faces_run1.mat file
  - "Difference"; Type [1 -1]
  - "Add another"; Click "Yes"
  - "Mean"; Type [1/2 1/2]
  - "Add another"; Click "No"
  - "Weight by num replications"; Click "No"
- New datasets: wmaceMdspm8_faces_run1.{mat,dat}

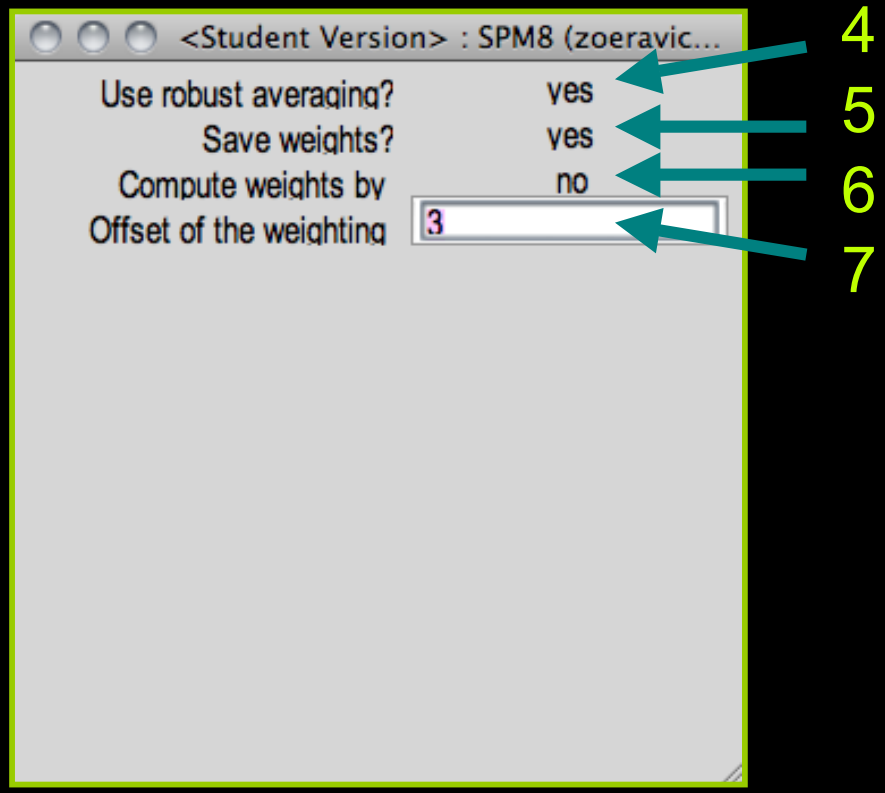
Step 12
Basic ERPs



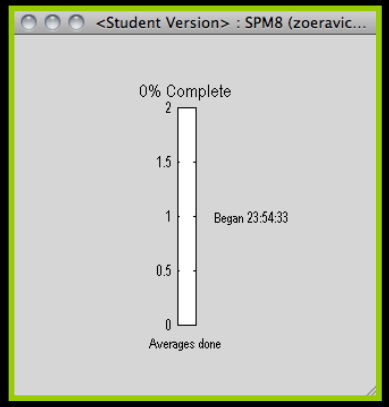
Step 12
Basic ERPs



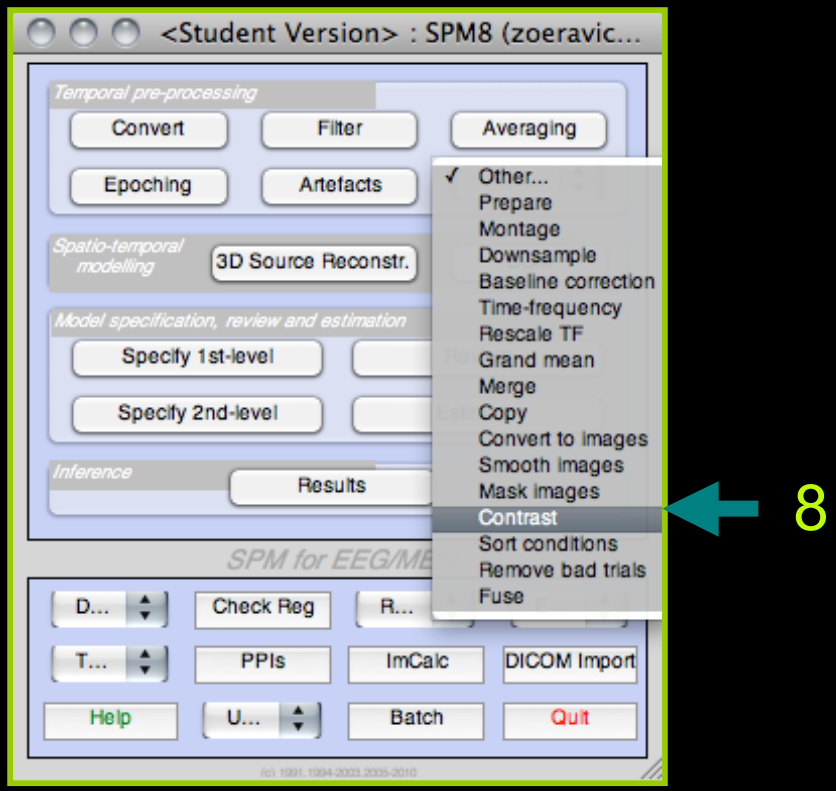
Step 12
Basic ERPs



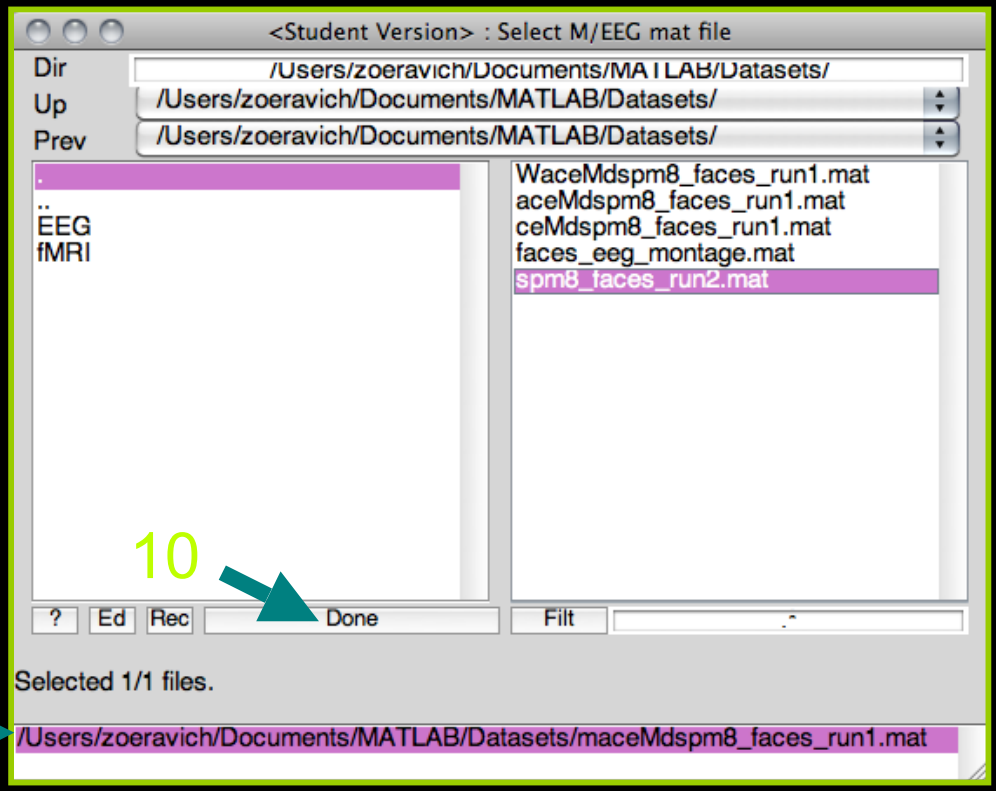
Processing…



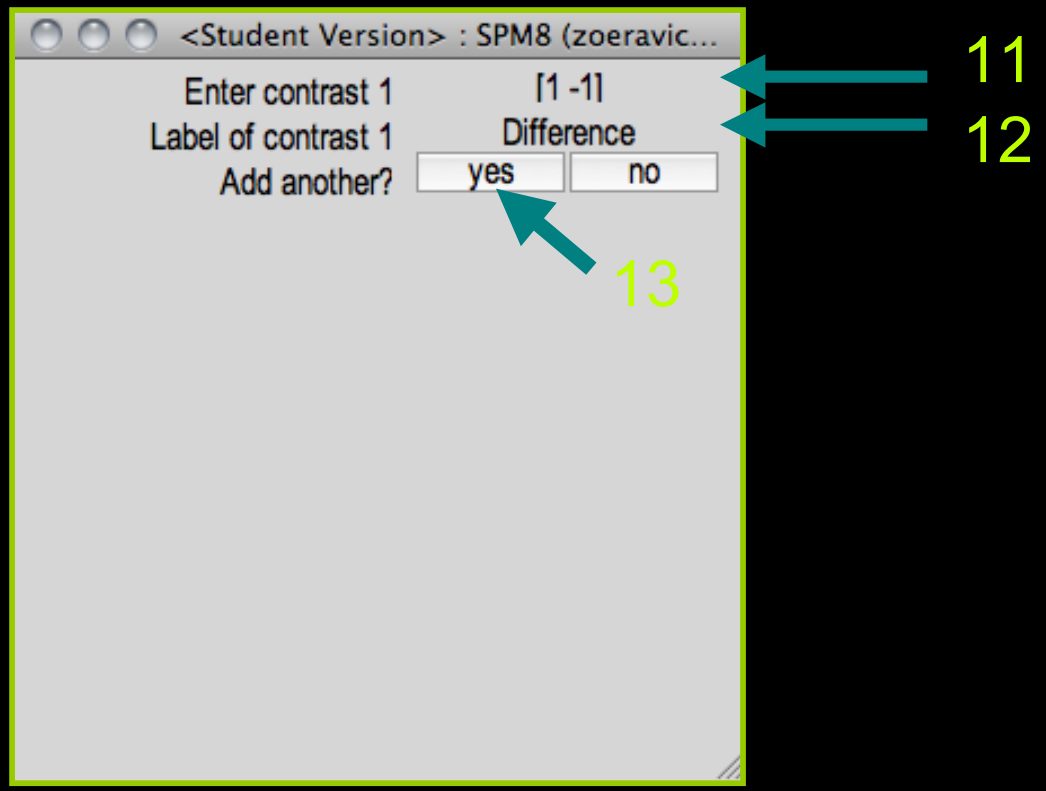
Step 12
Basic ERPs



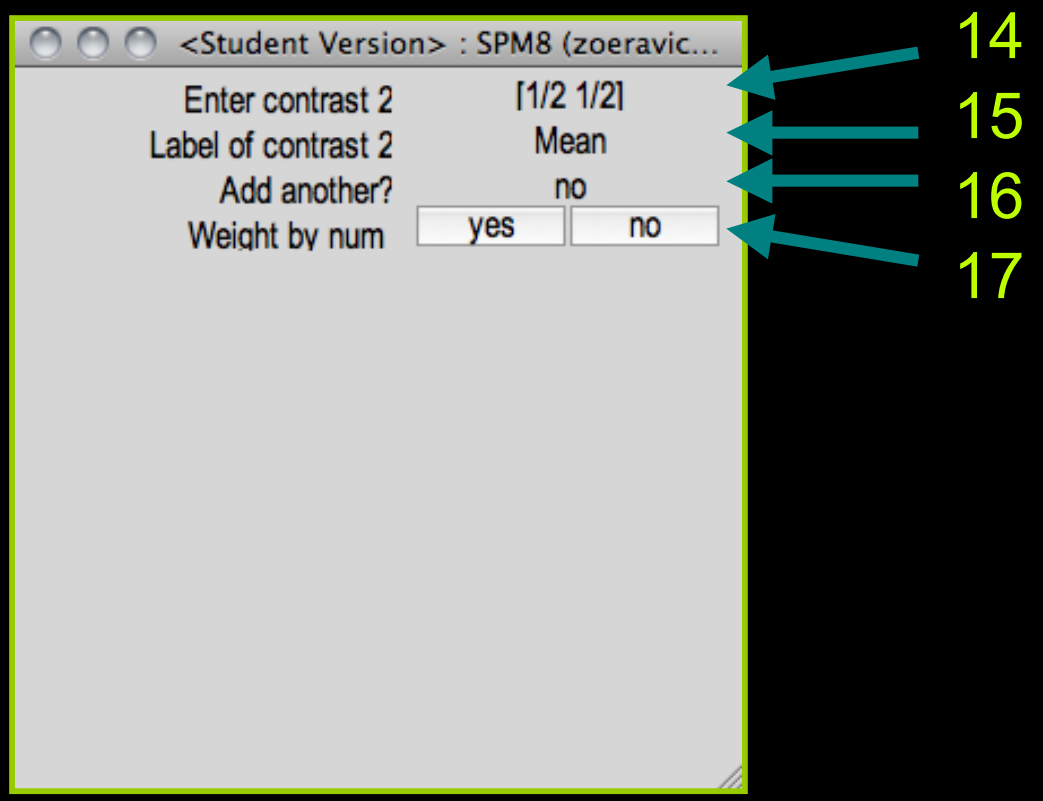
Step 12
Basic ERPs



Step 12
Basic ERPs



Step 12
Basic ERPs



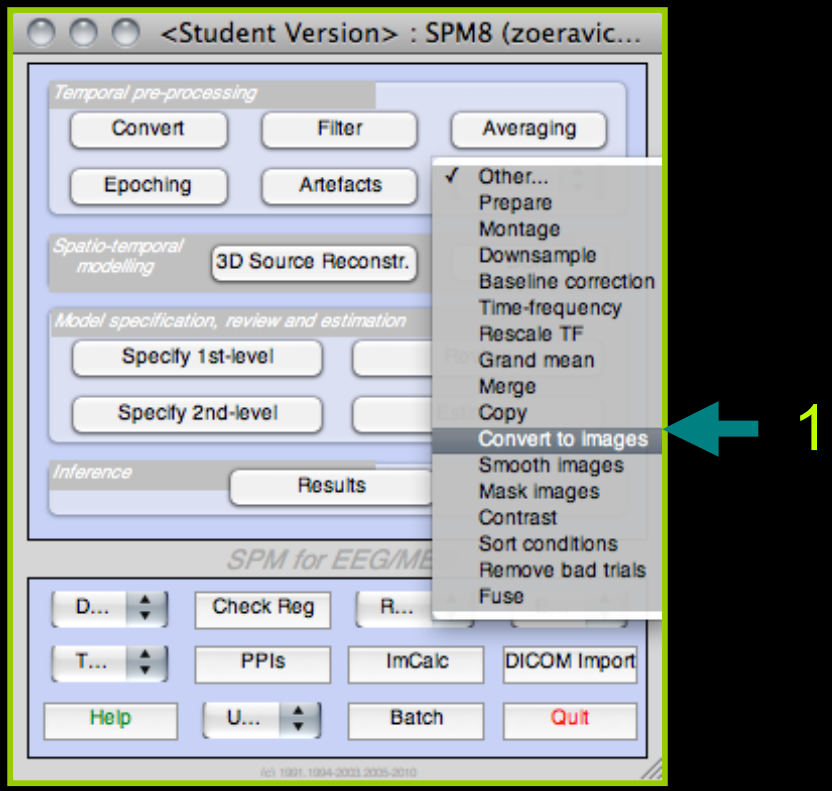
Step 13
3D SPMs

- Select CONVERT TO IMAGES from the "Other" drop-down menu button
  - Select the aceMdspm8_faces_run1.mat file
  - "Output image dimensions"; Type "32"
  - "Interpolate bad channels or"; Click "Interpolate"
- New directory: aceMdspm8_faces_run1
- Select SMOOTH IMAGES from the "Other" drop-down menu button
  - Select the files within the aceMdspm8_faces_run1 directory
  - "FWHM"; Type "9 9 20"
  - "Implicit masking"; Click "Yes"
  - Run the batch by pressing the green button at the top of the window

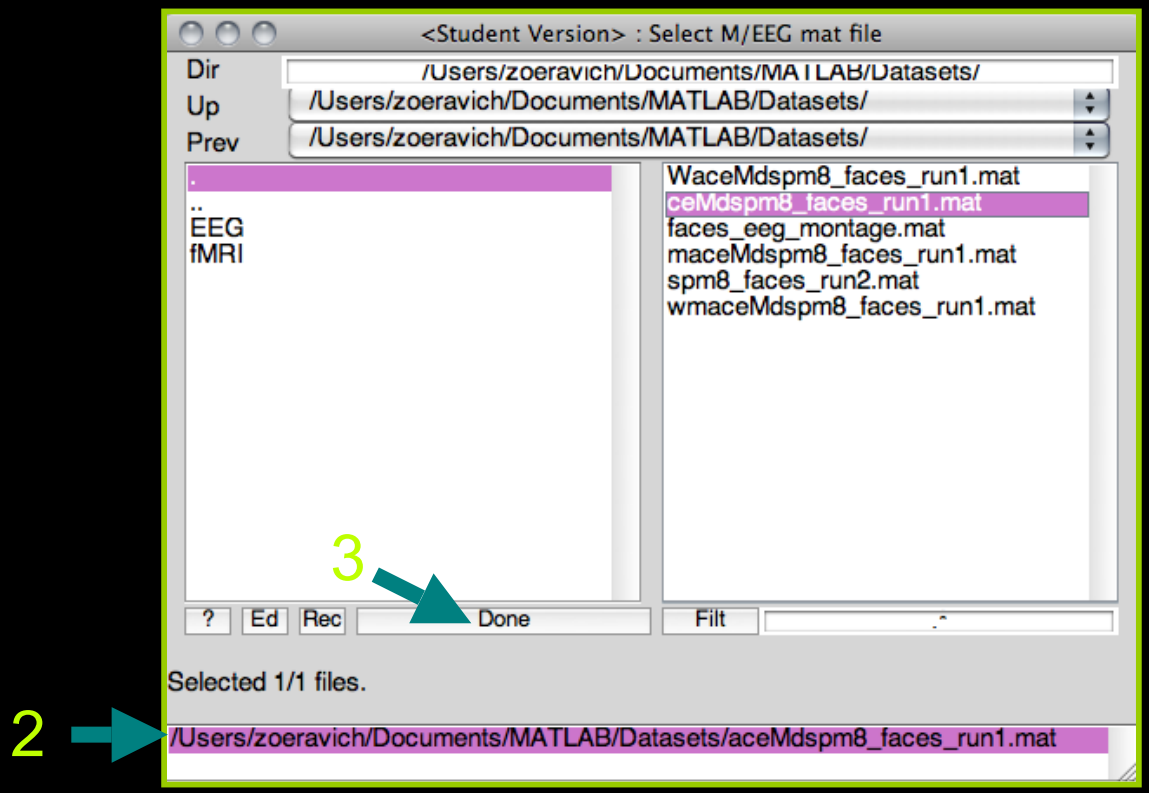
Step 13
3D SPMs Continued

- Create the new directory mkdir_XYTstats
- Press the SPECIFY 2ND LEVEL button
  - "Directory"; Select the mkdir_XYTstats directory
  - "Design"; Click "Two-sample t-test"
  - "Group 1 scans"; Select all images in the subdirectory type_faces
  - "Group 2 scans"; Select all images in the subdirectory type_scrambled
  - Run the batch by pressing the green button at the top of the window
- Press the ESTIMATE button
  - Select the aceMdspm8_faces_run1.mat file
- Press the RESULTS button
  - Define a new F-contrast as [1 -1]
  - Keep the default contrast options the same
  - "Data Type"; Click "Scalp-Time"
  - Press "Whole brain"

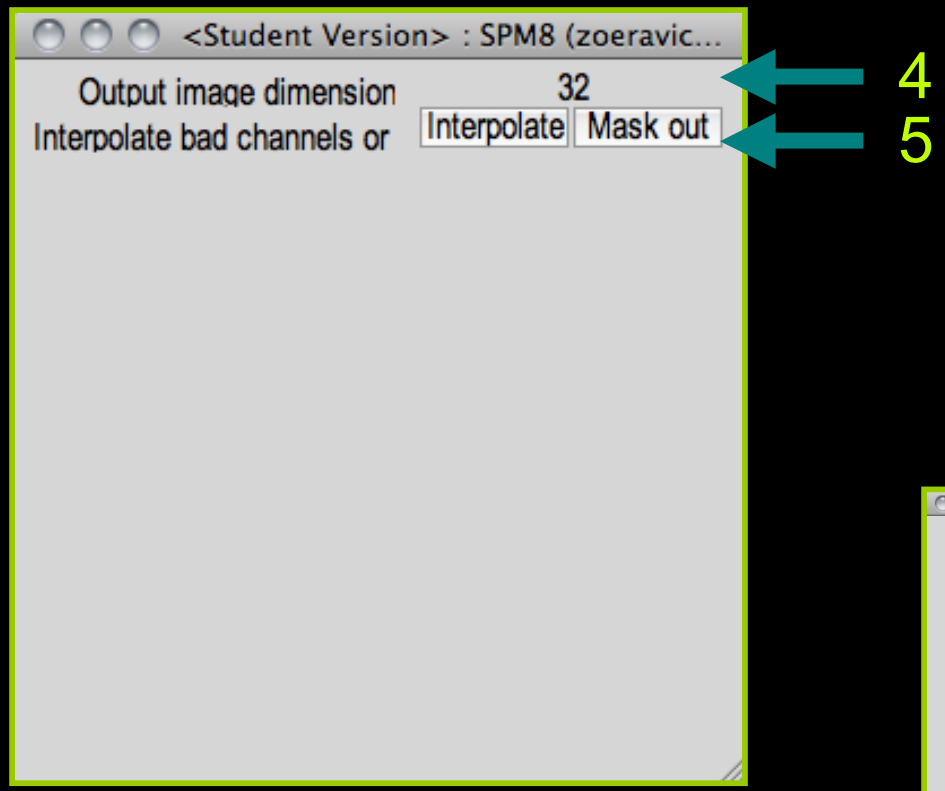
Step 13
3D SPMs



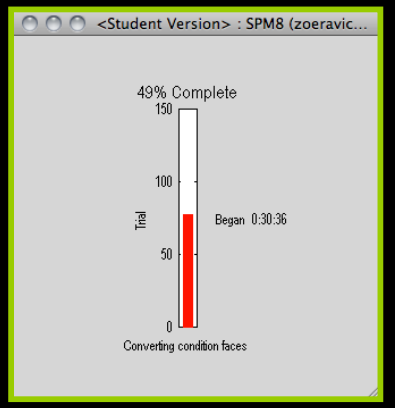
Step 13
3D SPMs



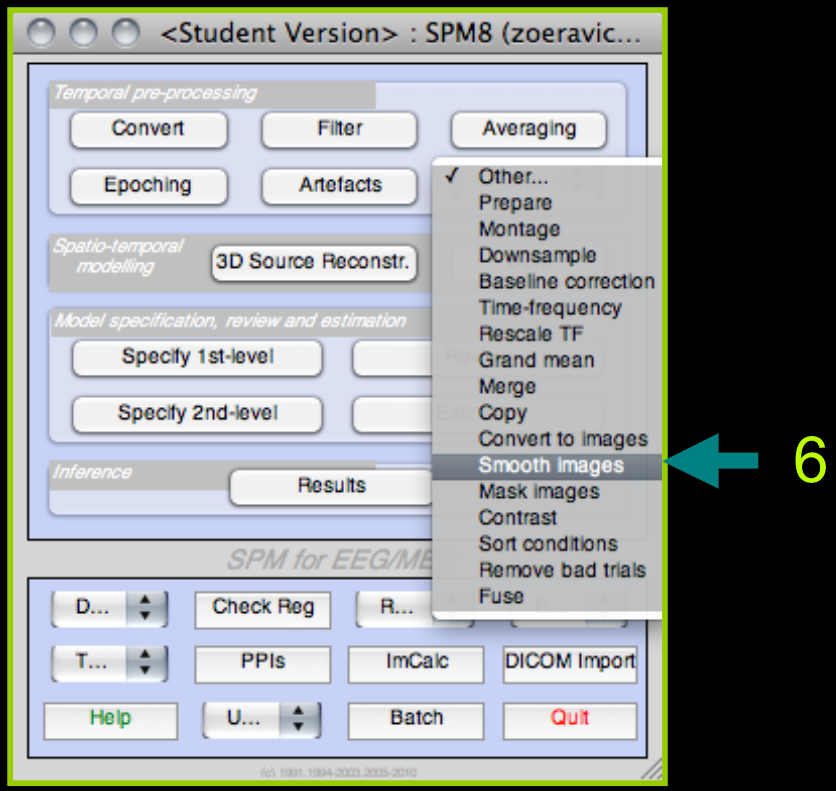
Step 13
3D SPMs



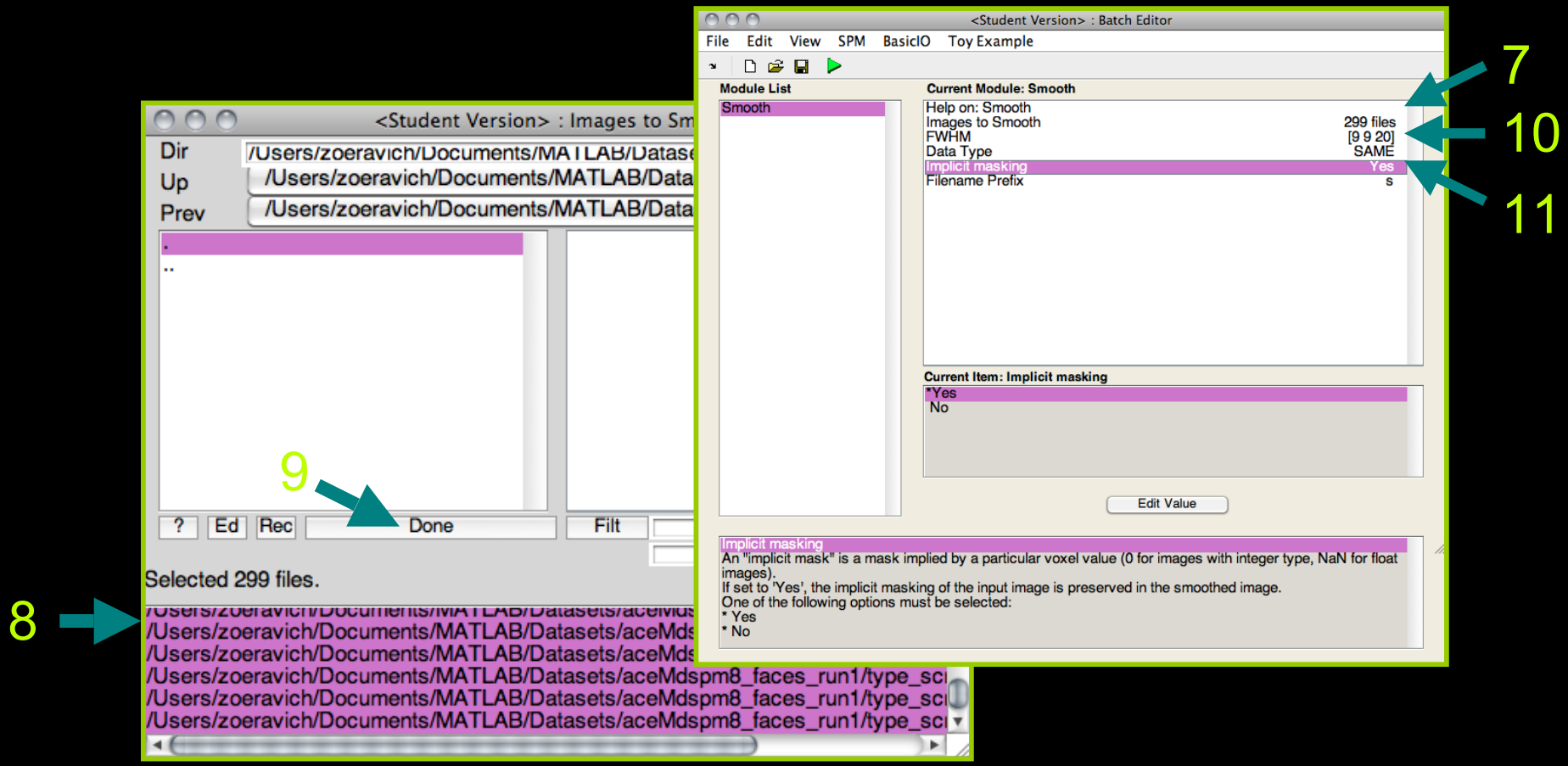
Processing…



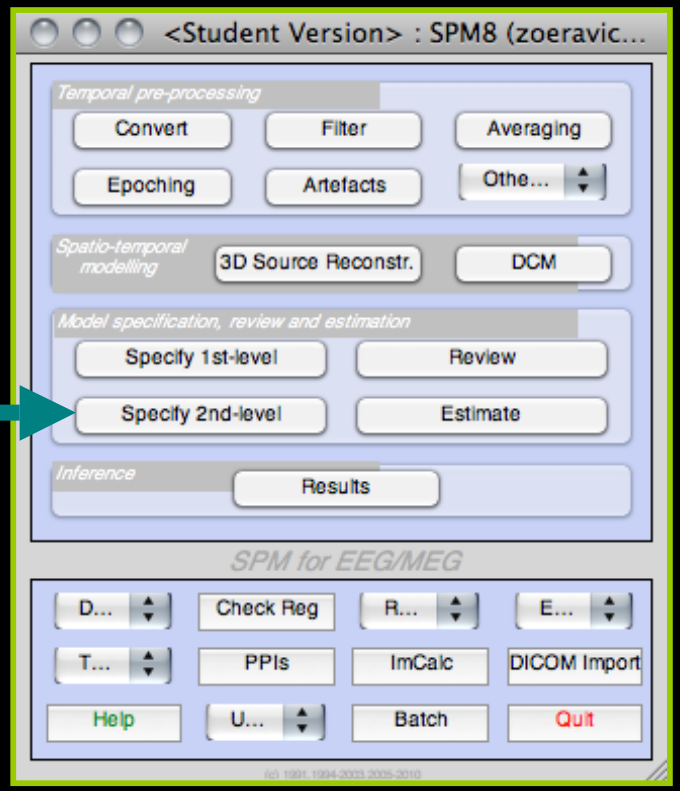
Step 13
3D SPMs



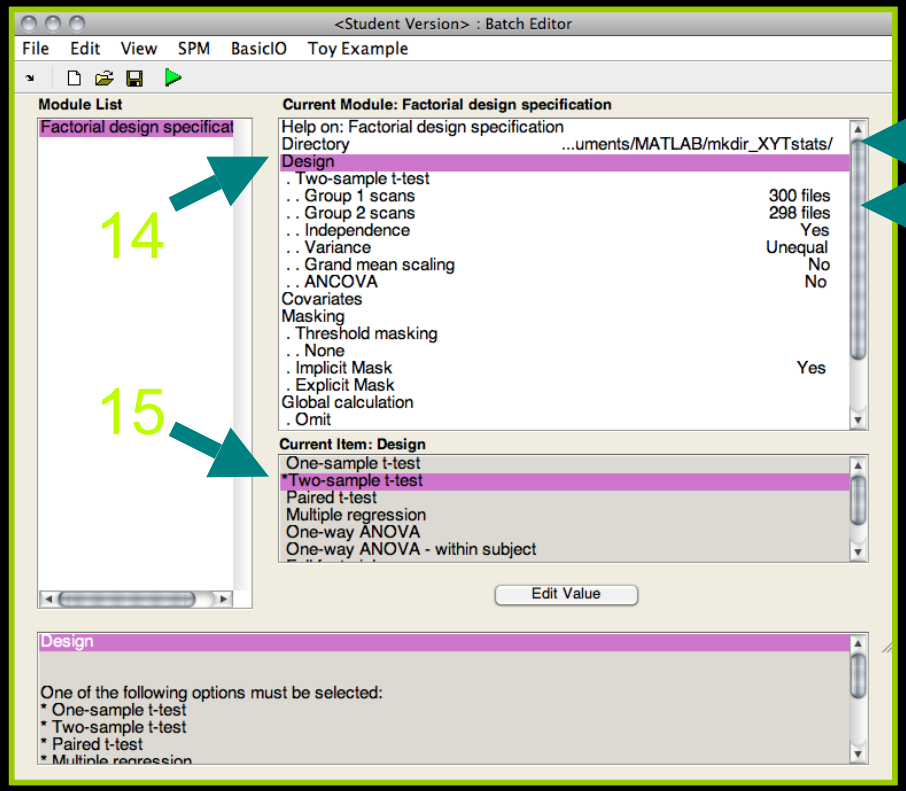
Step 13
3D SPMs



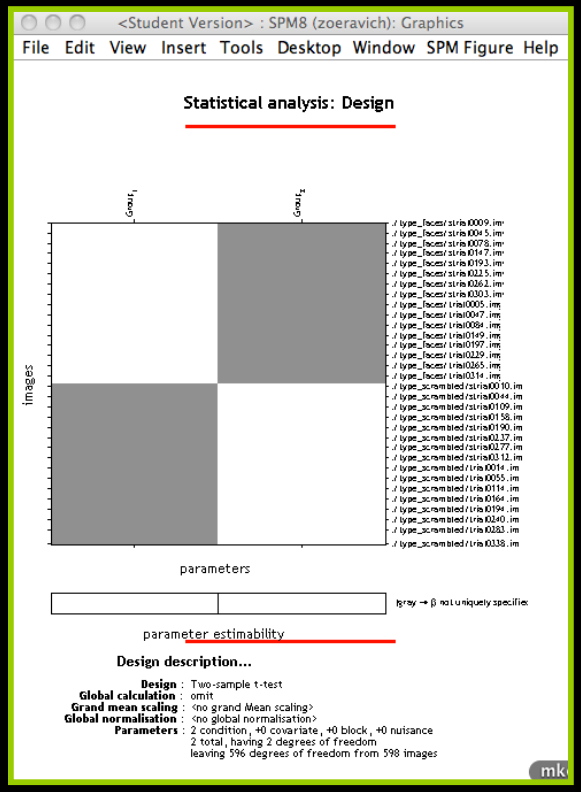
Step 13
3D SPMs



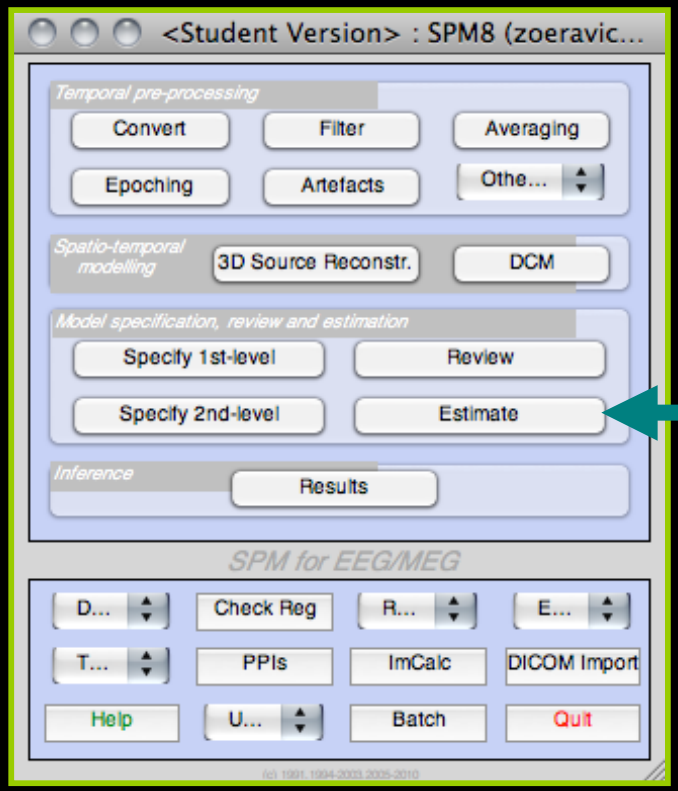
Step 13
3D SPMs



Step 13
3D SPMs

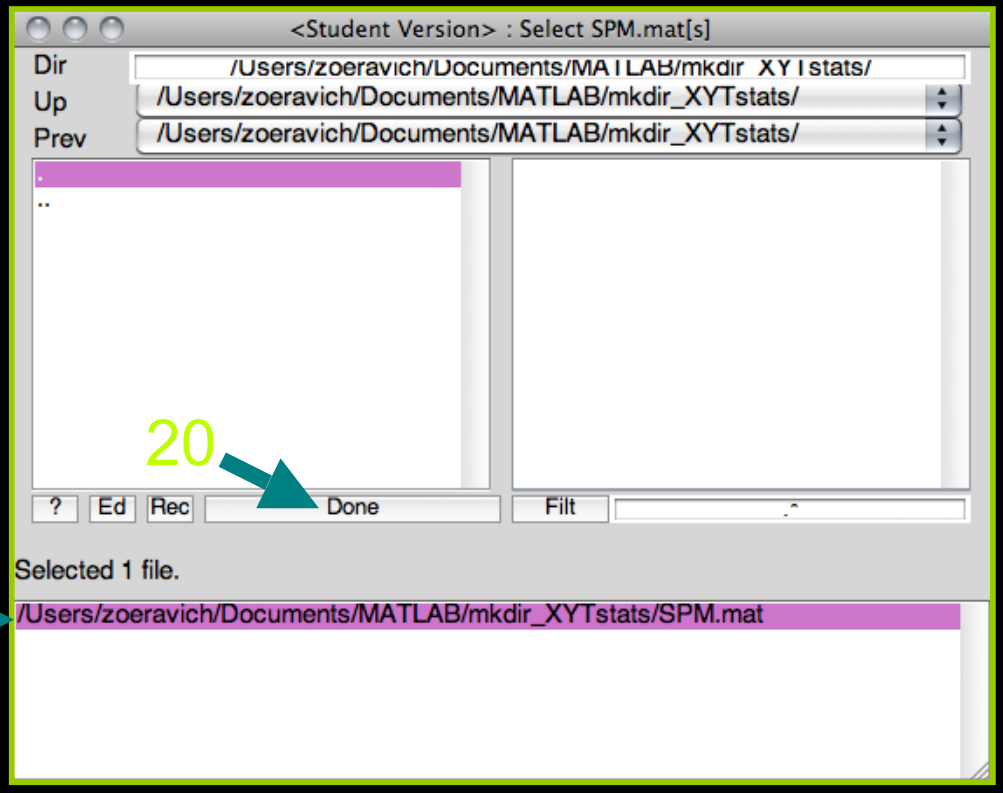


Step 13
3D SPMs

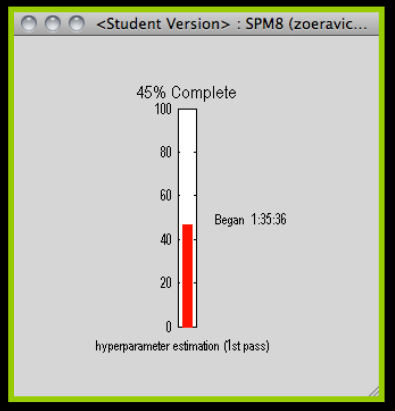


18

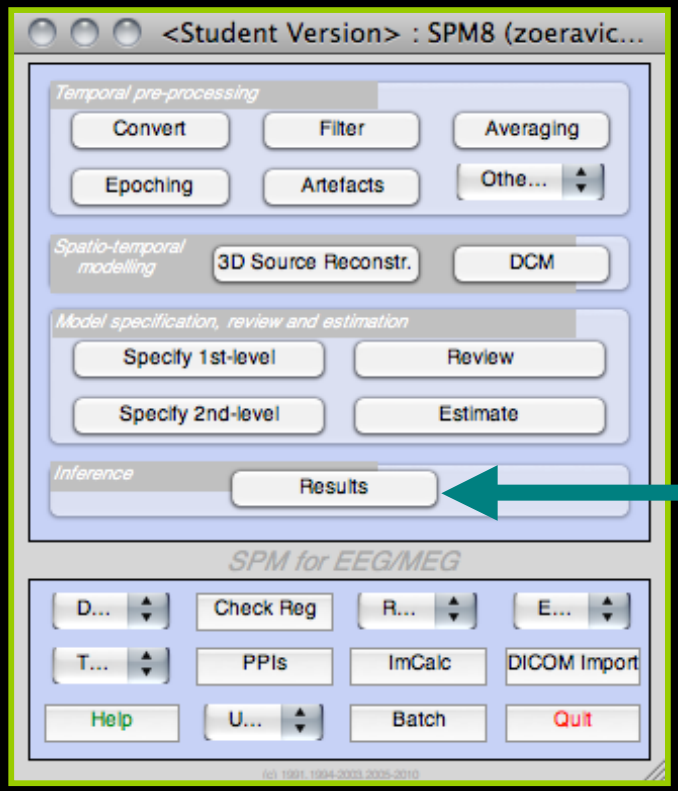
Step 13
3D SPMs



Processing…

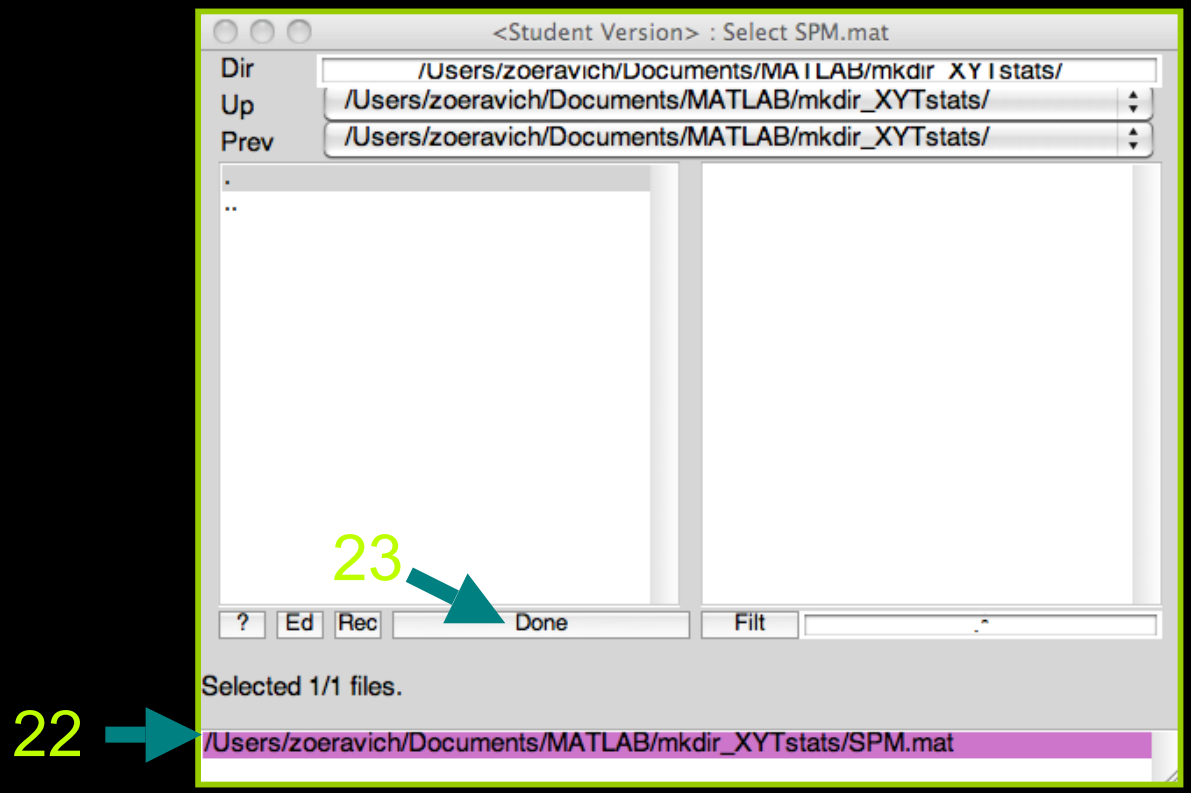


Step 13
3D SPMs

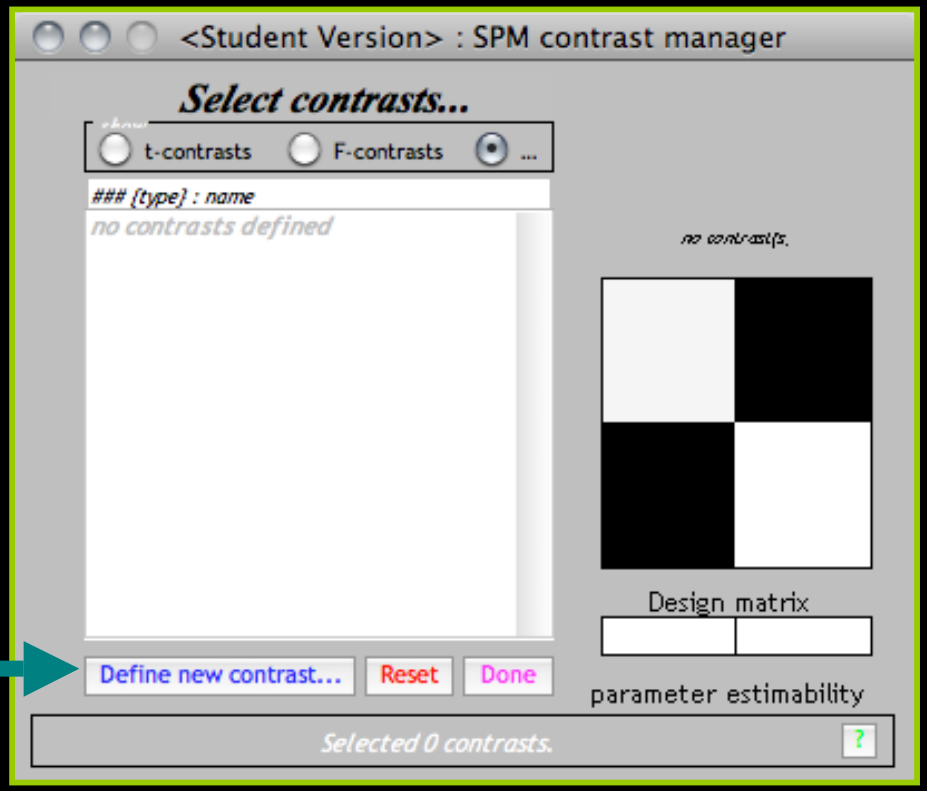


21

Step 13
3D SPMs

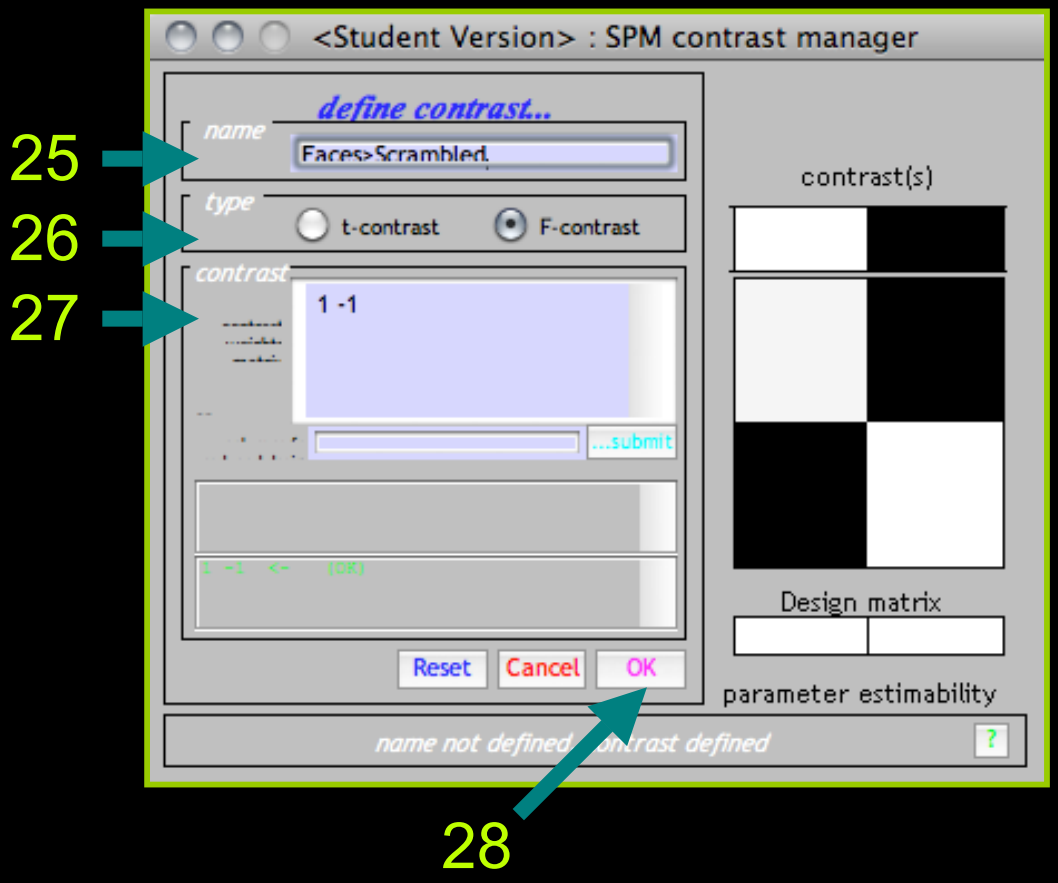


Step 13
3D SPMs

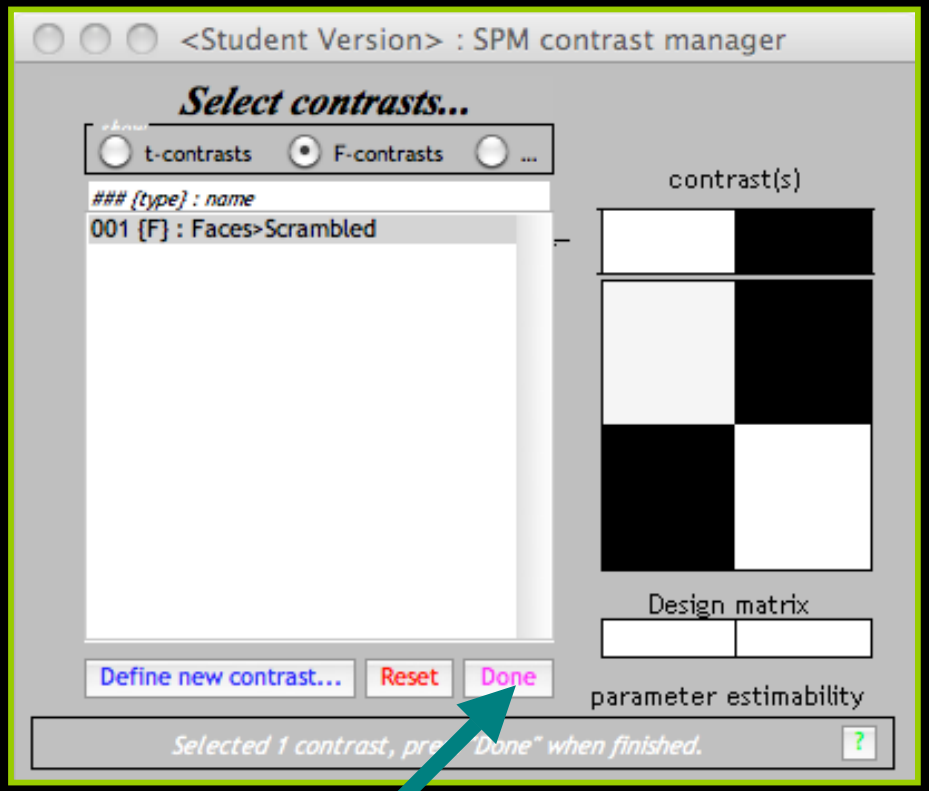


24

Step 13
3D SPMs

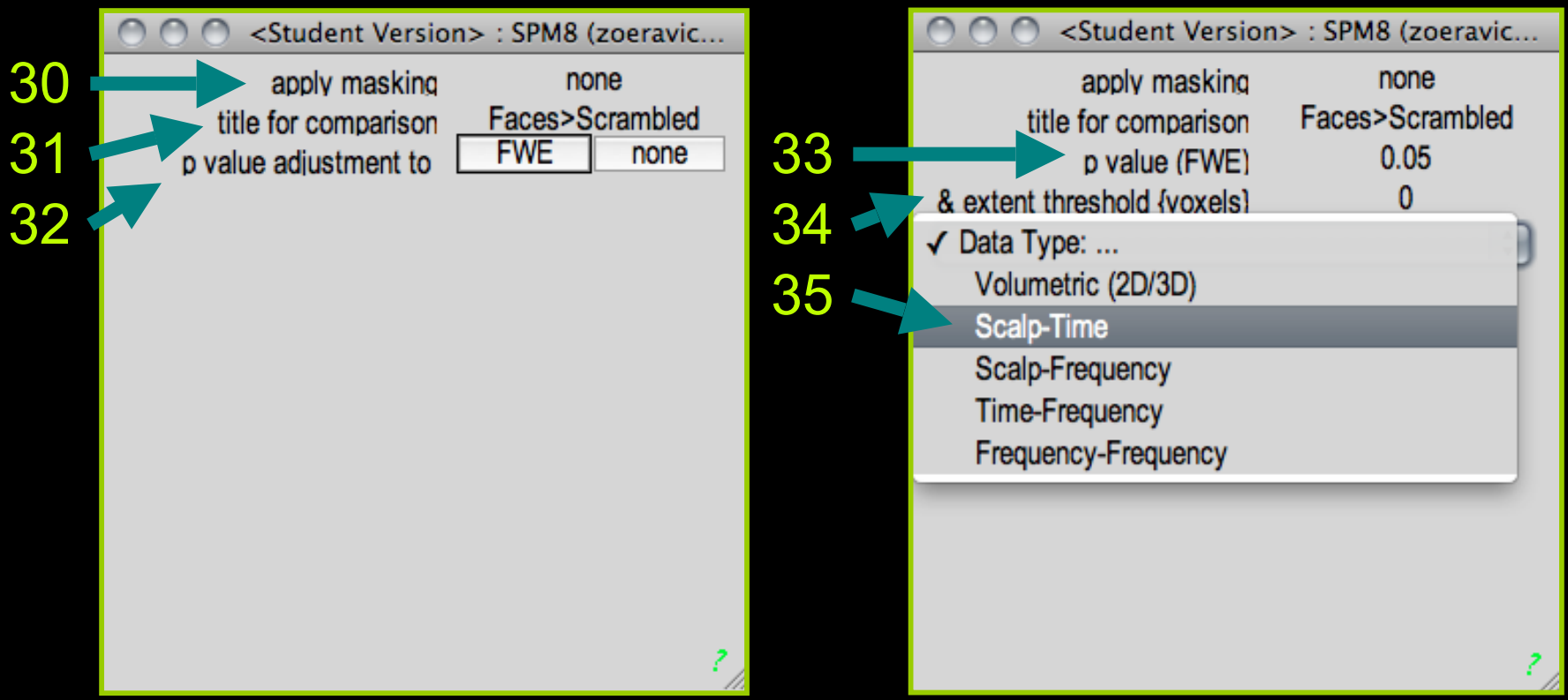


Step 13
3D SPMs

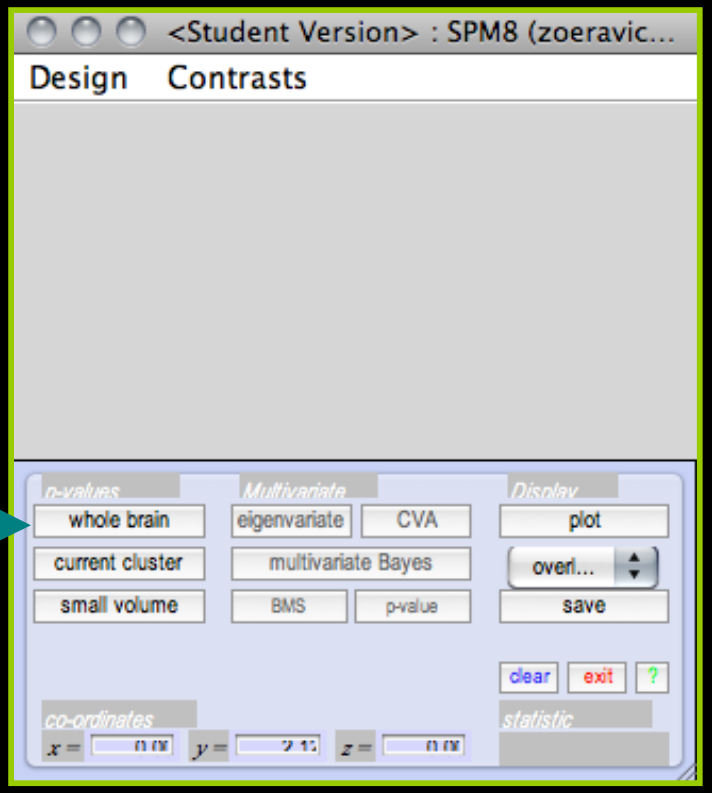


29

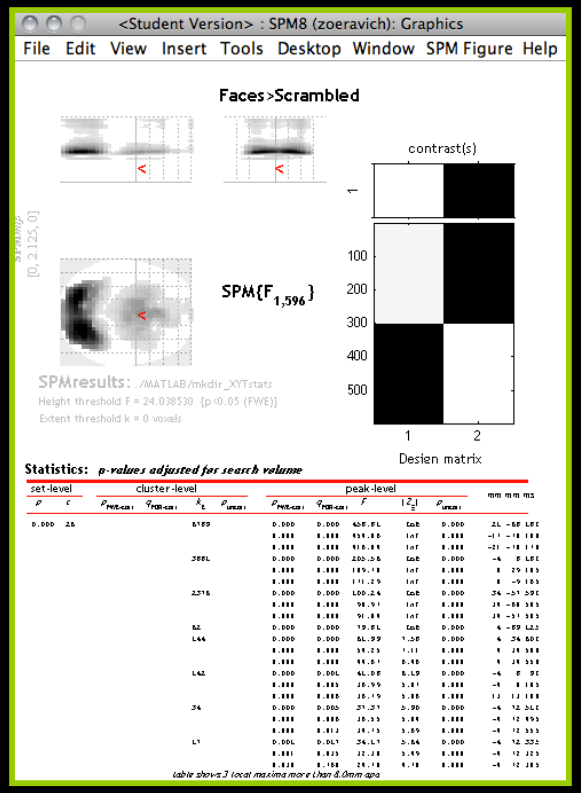
Step 13
3D SPMs



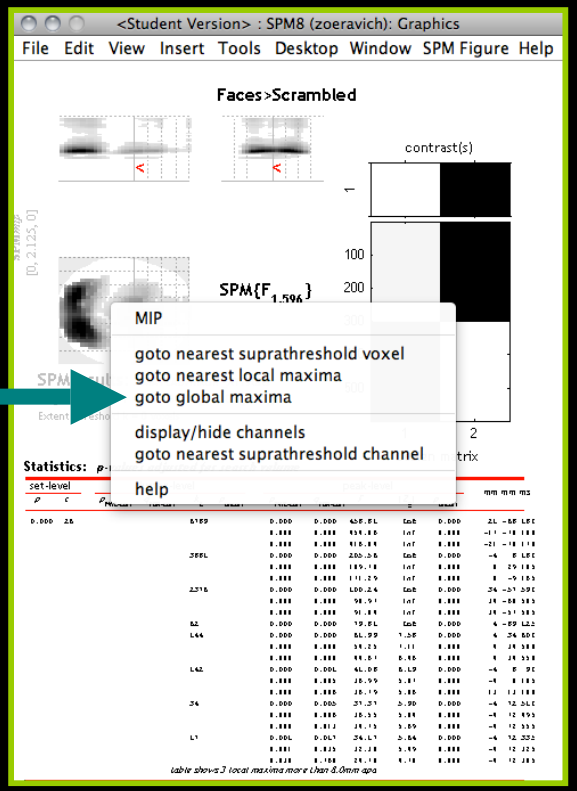
Step 13
3D SPMs



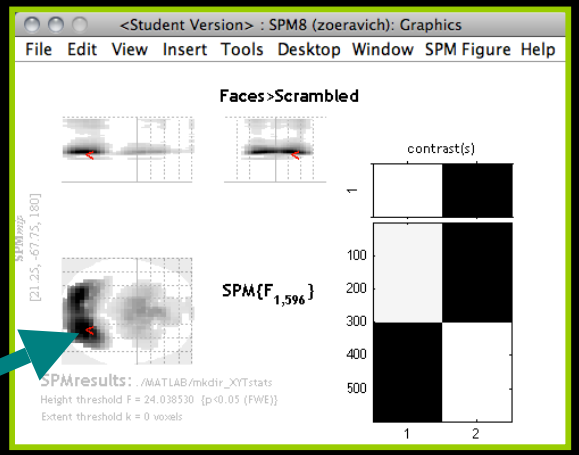
36

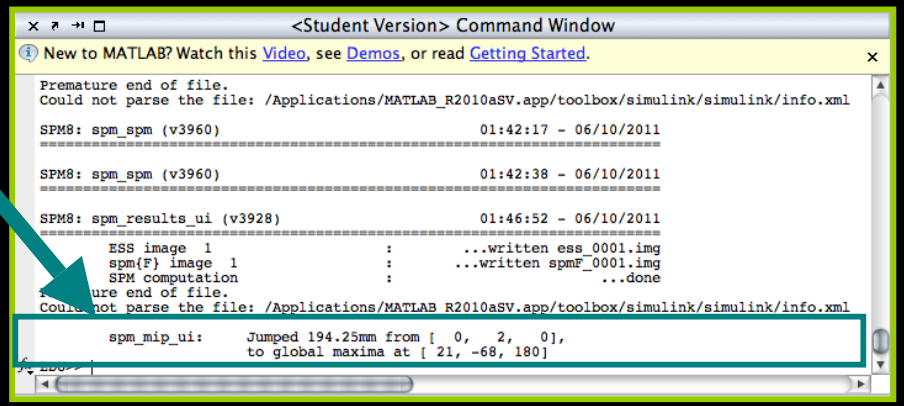


Step 13
3D SPMs (Exploratory)

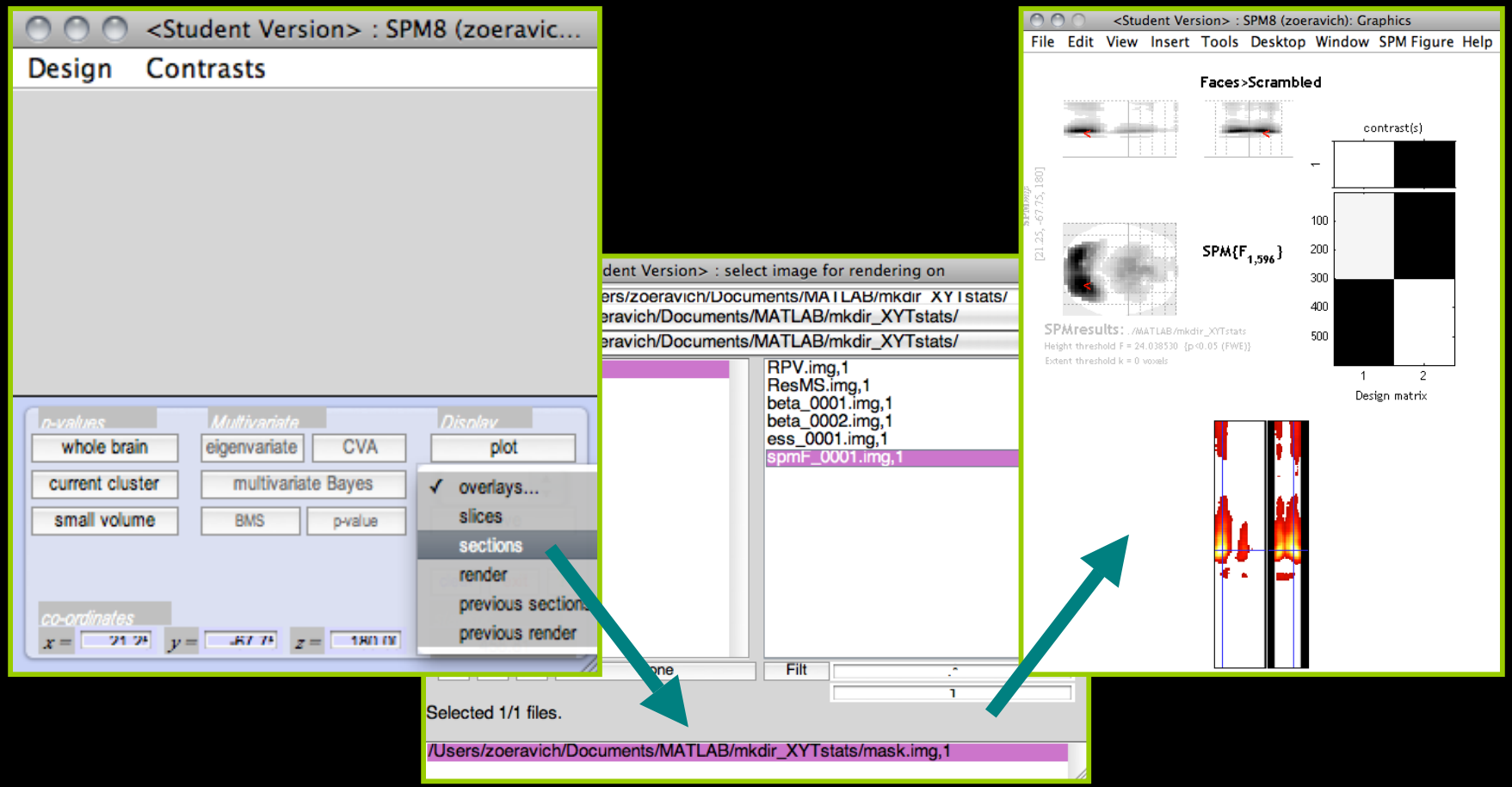


1





Step 13
3D SPMs (Exploratory)



Step 14
3D "Imaging" Reconstruction

- Press the 3D SOURCE RECONSTRUCTION button
  - Press the "Load" button
    - Select the wmaceMdspm8_faces_run1.mat file
    - "Label"; Type "N170 MSP"
  - Press "Save"
  - Press the "MRI" button
    - Select the smri.img file
    - "Cortical mesh"; Click "Normal"
  - Press "Save"
  - Press the "Co-register" button
    - Click "OK"
    - "How to specify nas"; Click "Type"
    - "[3] Input MNI coordinates"; Type [0 91 -28]

Step 14
3D "Imaging" Reconstruction Continued

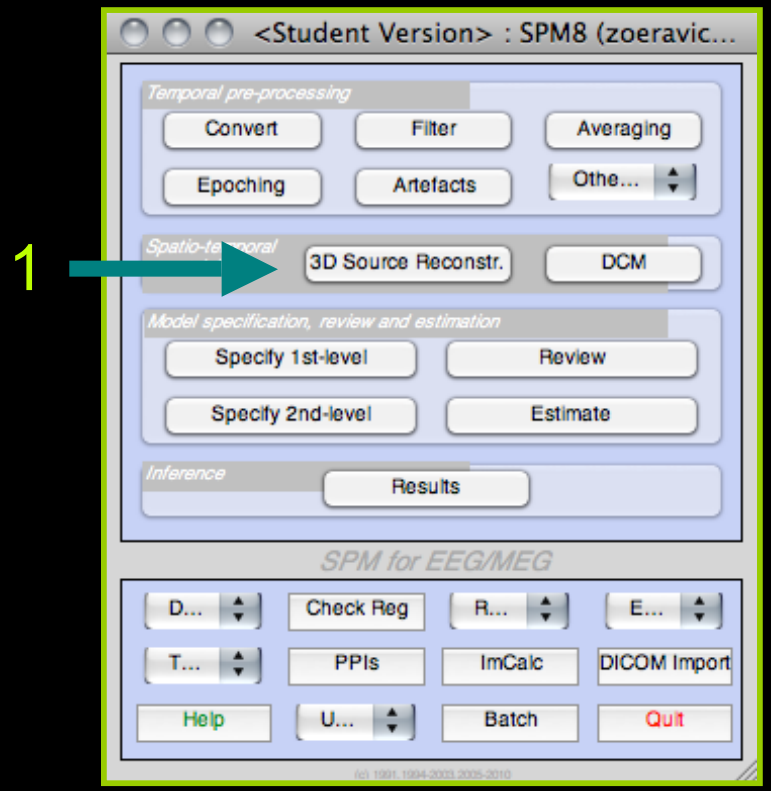
- "How to specify lpa"; Click "Type"
- "[3] Input MNI coordinates"; Type [-72 4 -59]
- "How to specify rpa"; Click "Type"
- "[3] Input MNI coordinates"; Type [71 -6 -62]

– Press "Save"
– Press the "Forward Model" button
- Select "EEG BEM"

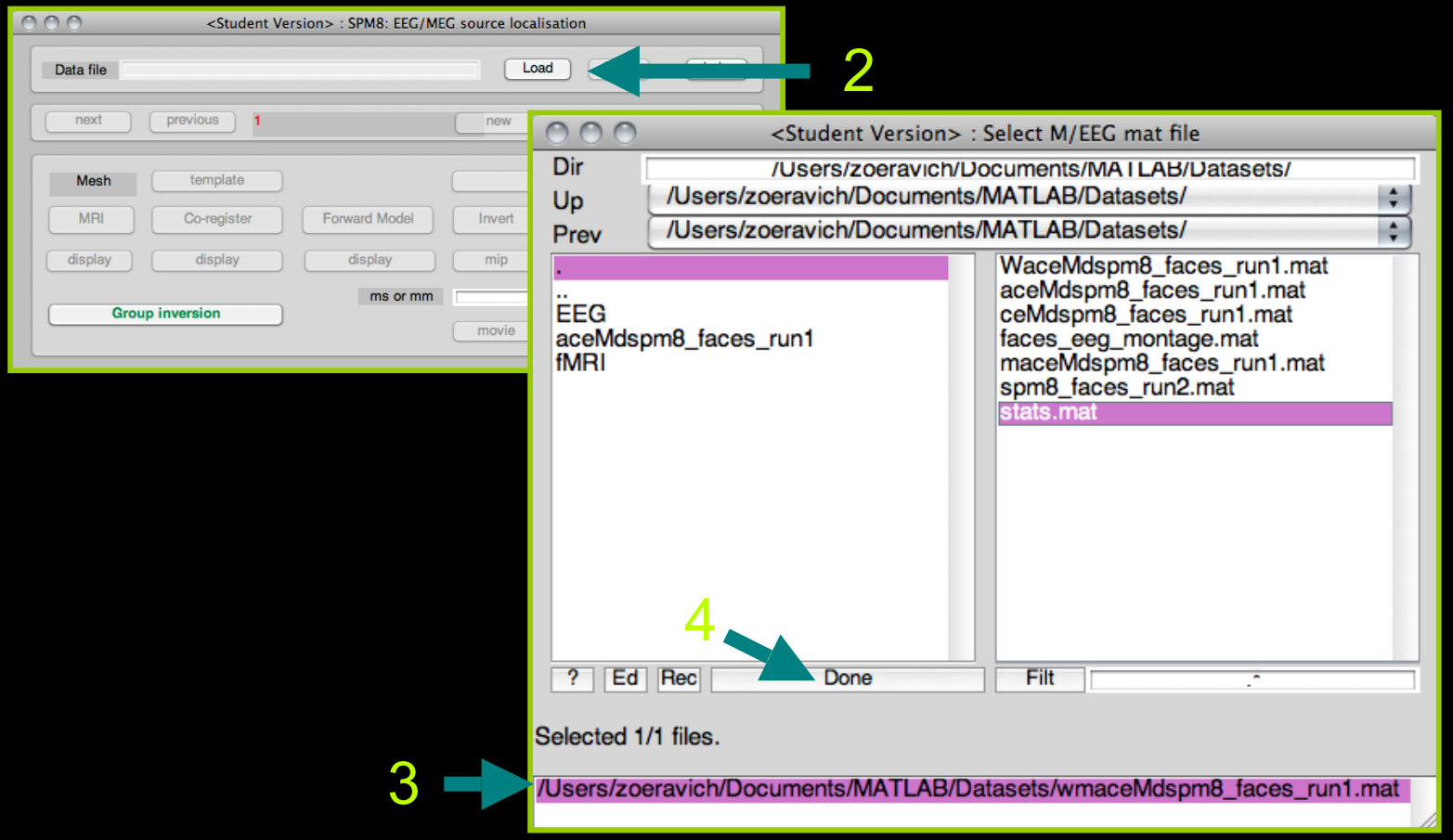
– Press "Save"
– Press the "Invert" button
- "Reconstruction"; Click "Imaging"
- "All conditions or trials"; Click "Yes"
- "Model"; Click "Standard"

– Press "Save"

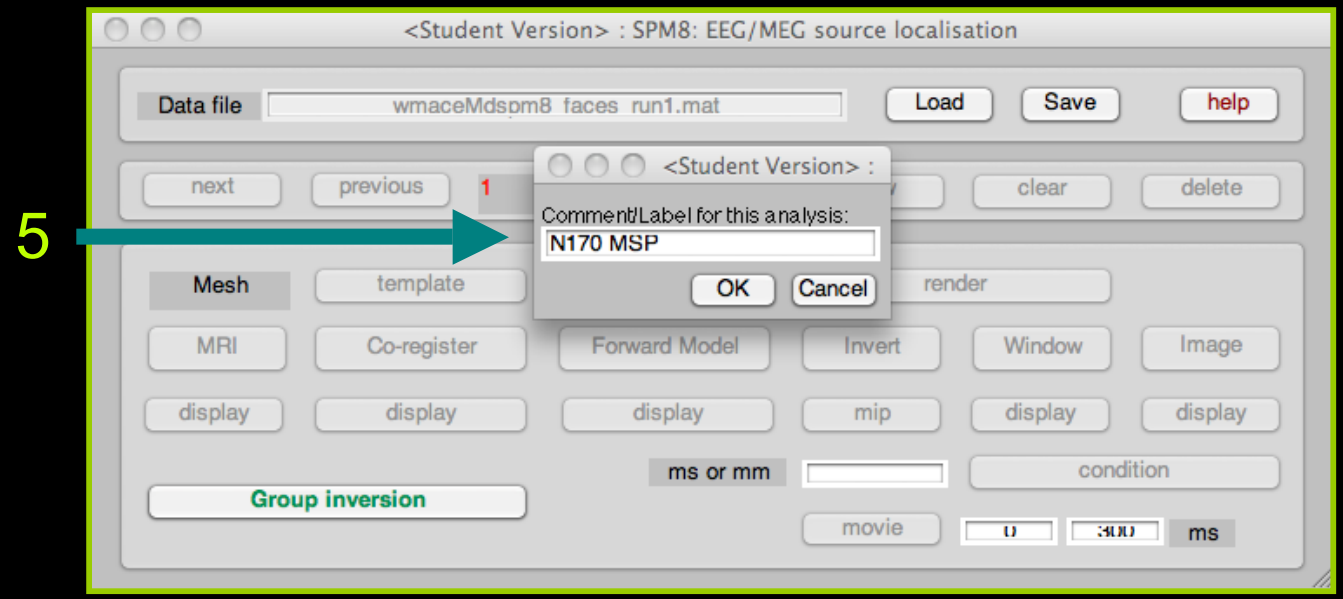
Step 14
3D "Imaging" Reconstruction



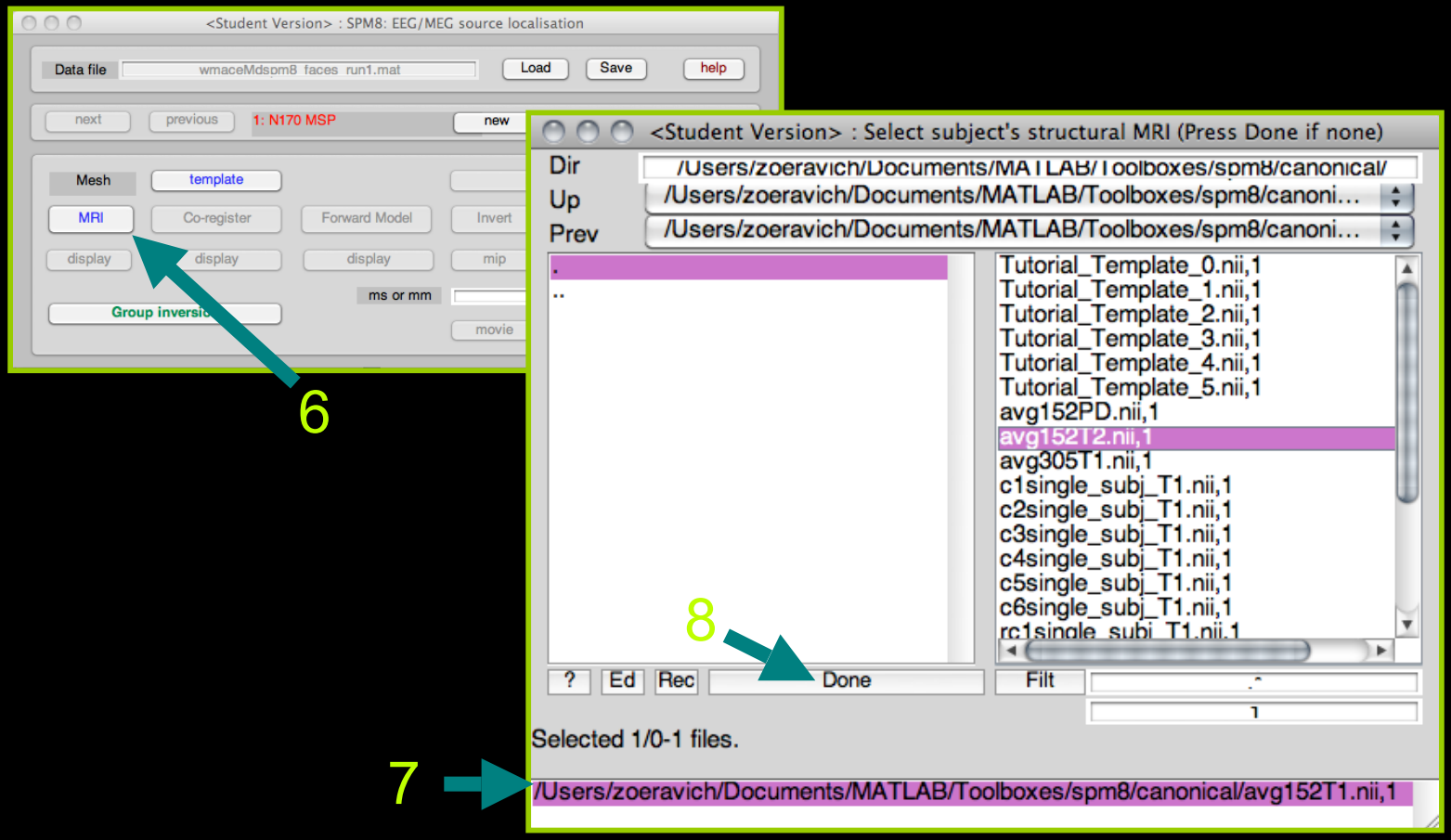
Step 14
3D “Imaging” Reconstruction



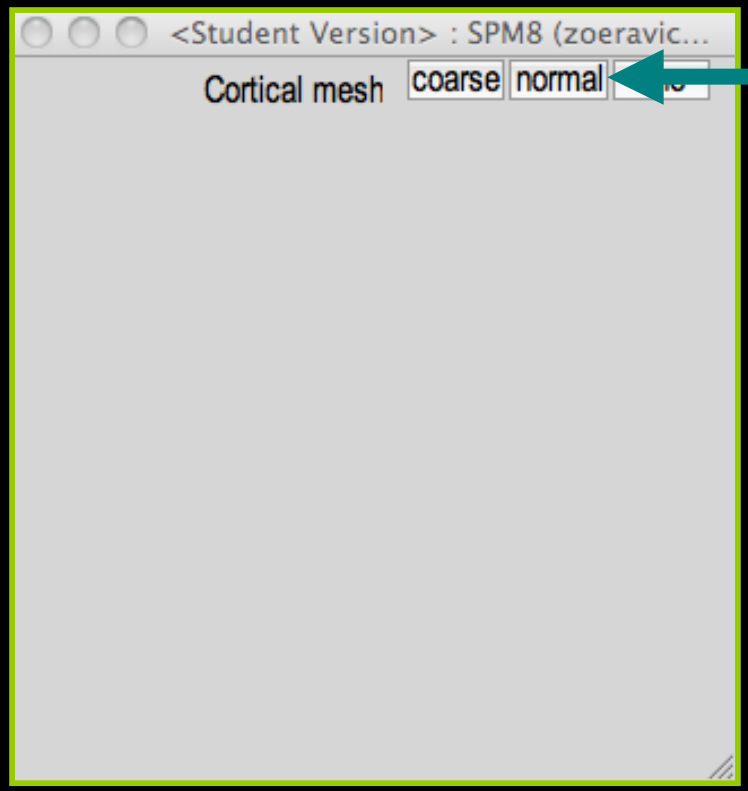
Step 14
3D "Imaging" Reconstruction



Step 14
3D “Imaging” Reconstruction

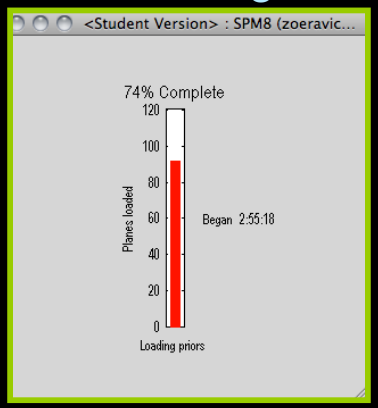


Step 14
3D “Imaging” Reconstruction

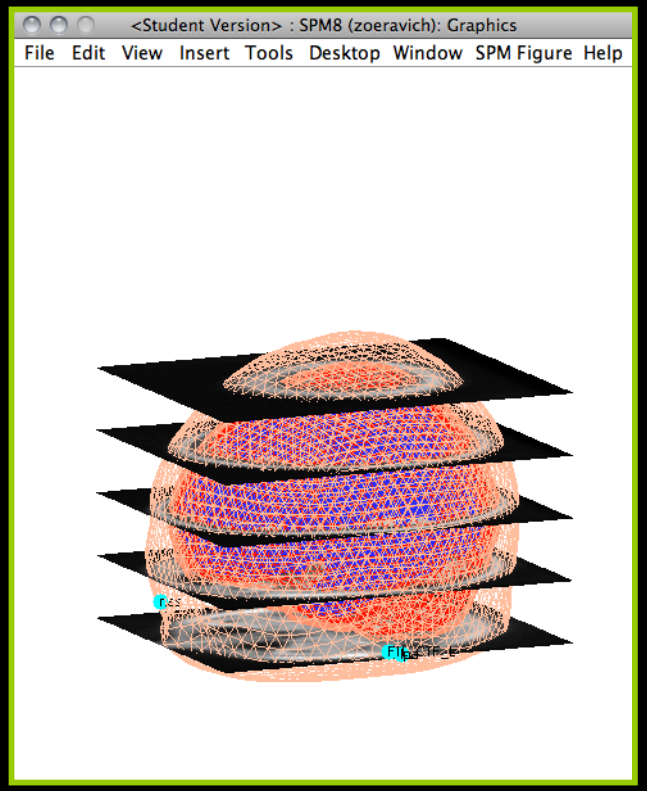


9

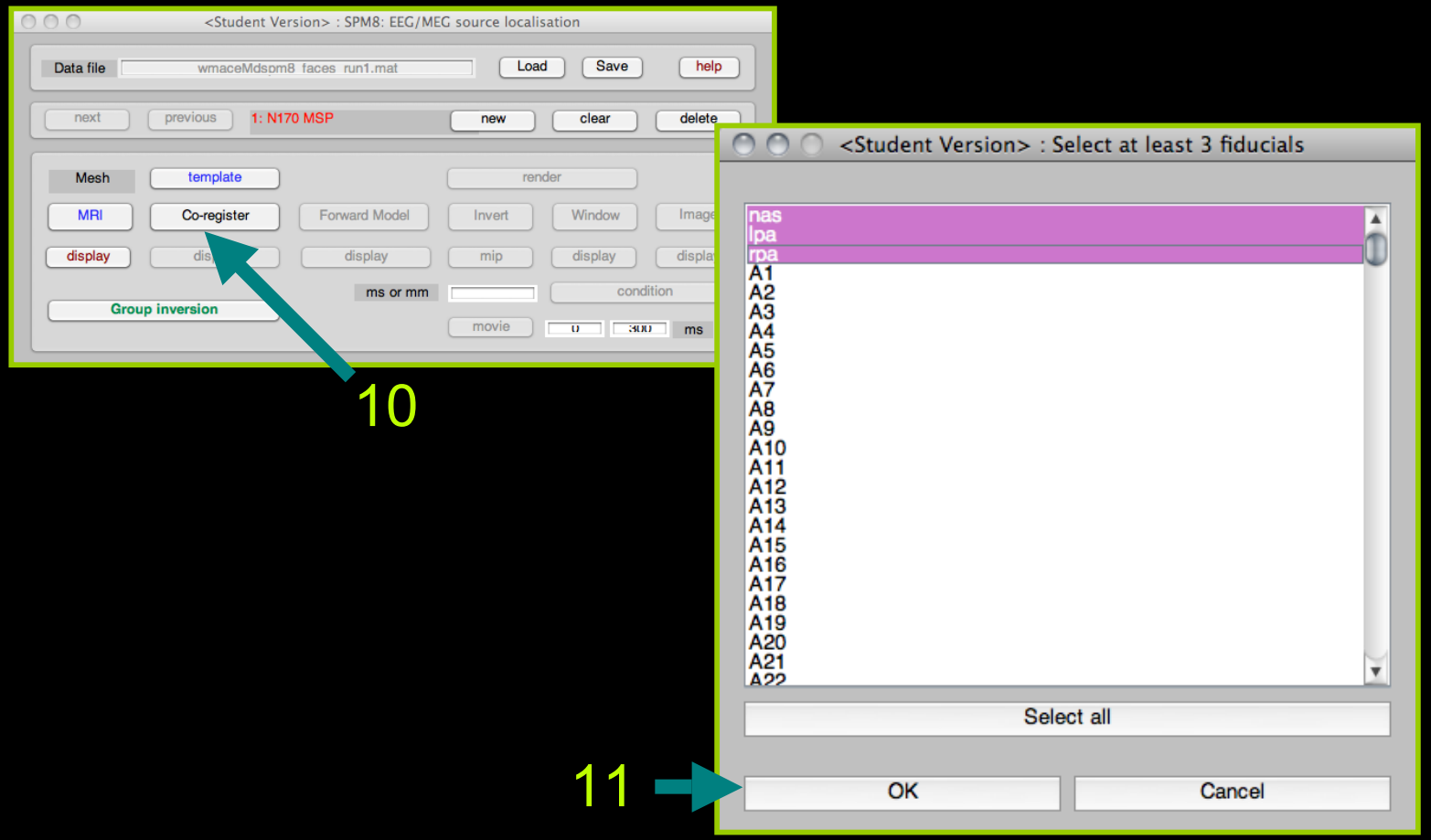
Processing…



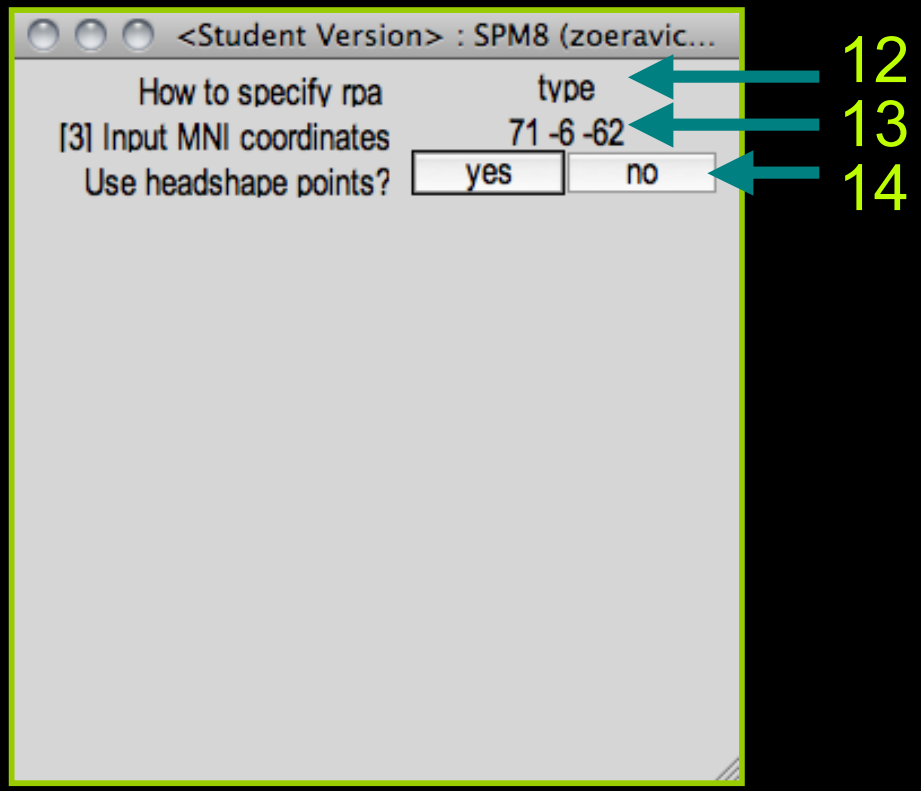
Step 14
3D “Imaging” Reconstruction



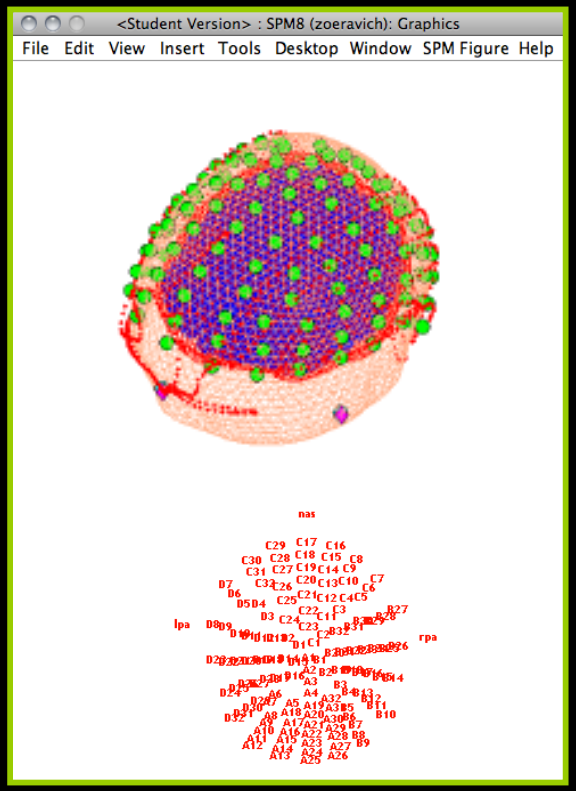
Step 14
3D "Imaging" Reconstruction



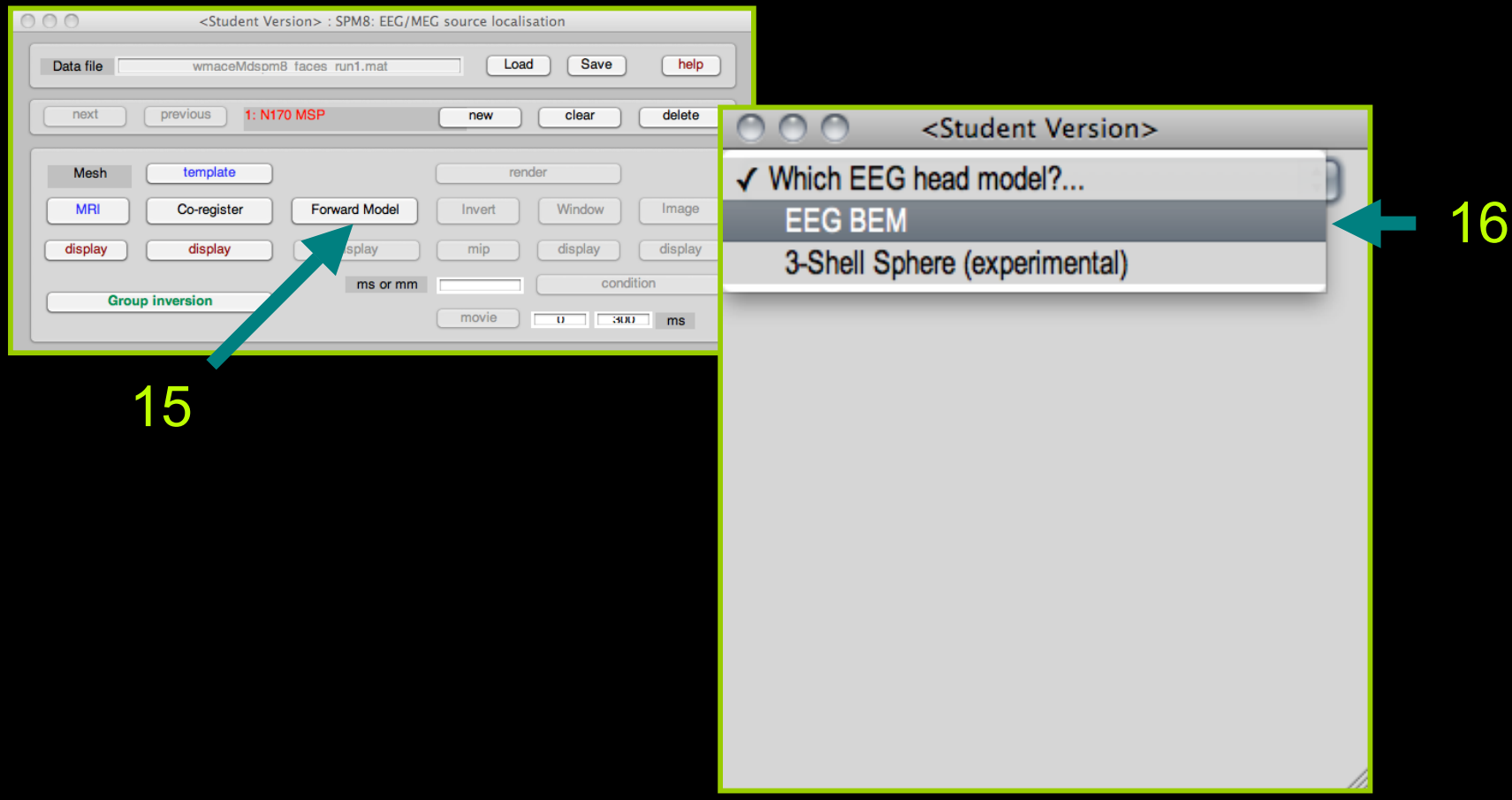
Step 14
3D “Imaging” Reconstruction



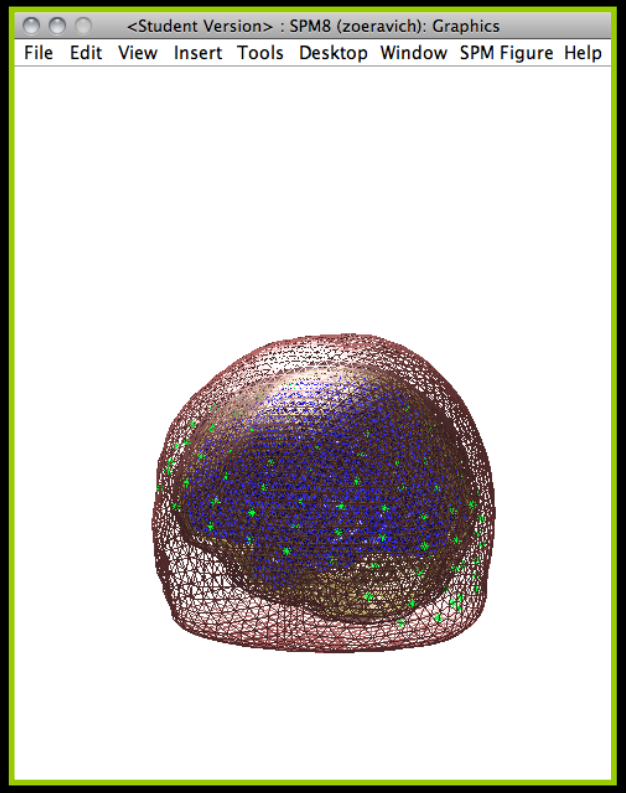
Step 14
3D “Imaging” Reconstruction



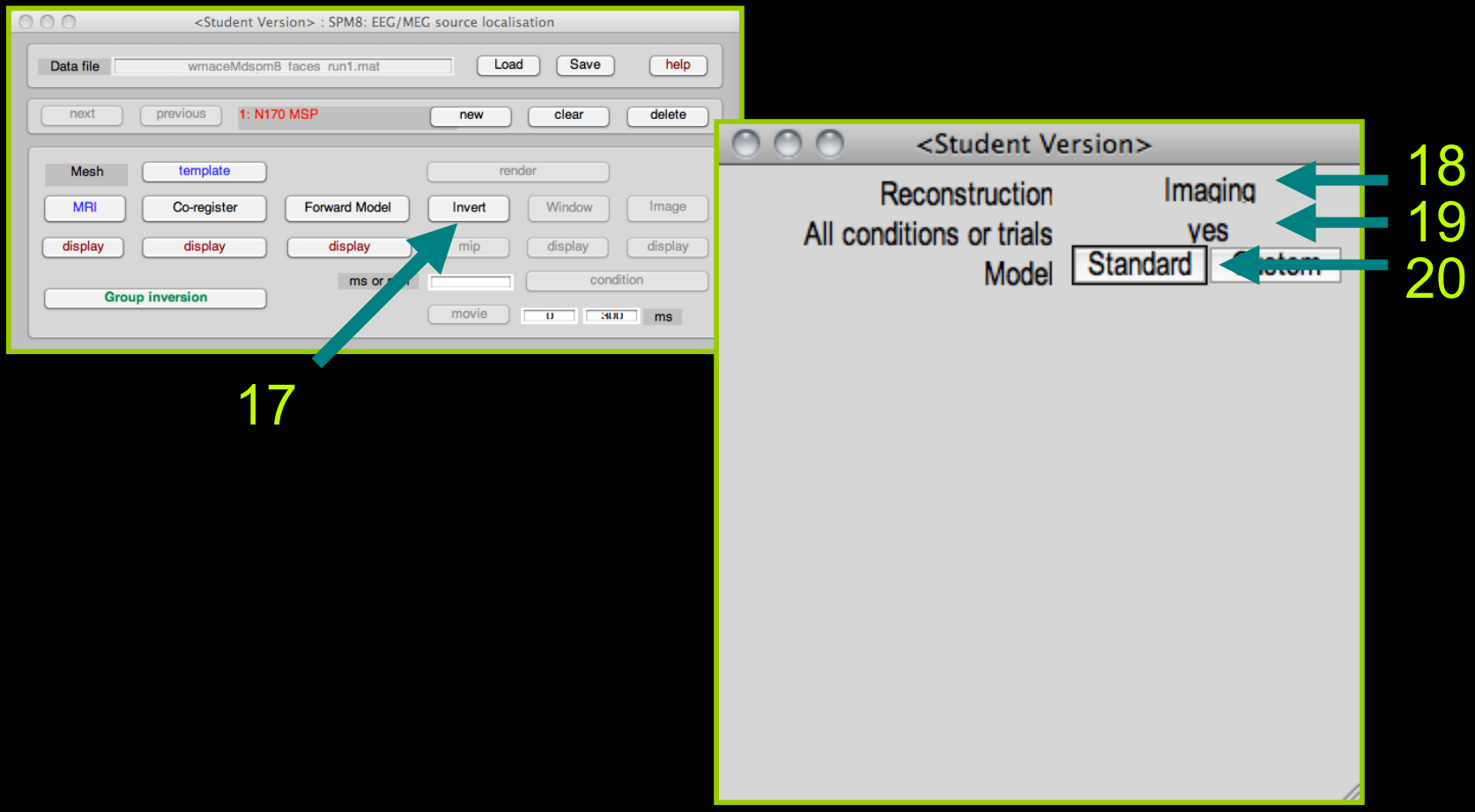
Step 14
3D “Imaging” Reconstruction



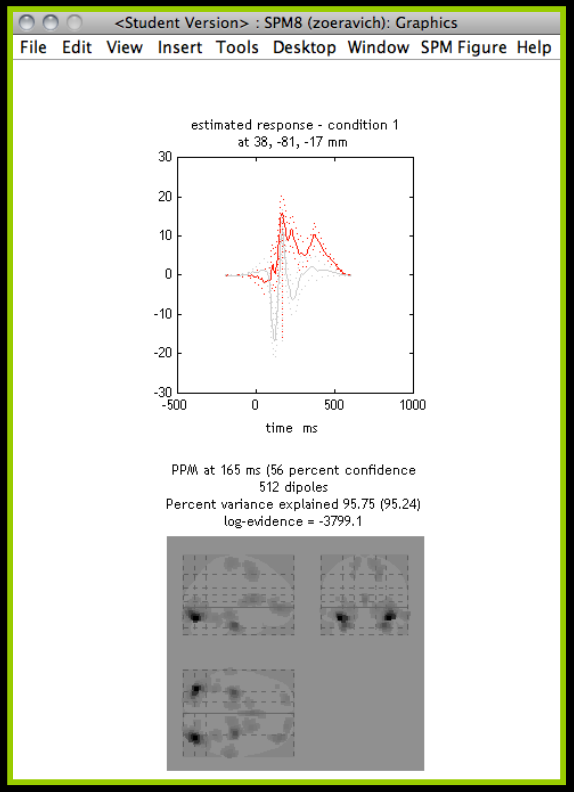
Step 14
3D “Imaging” Reconstruction



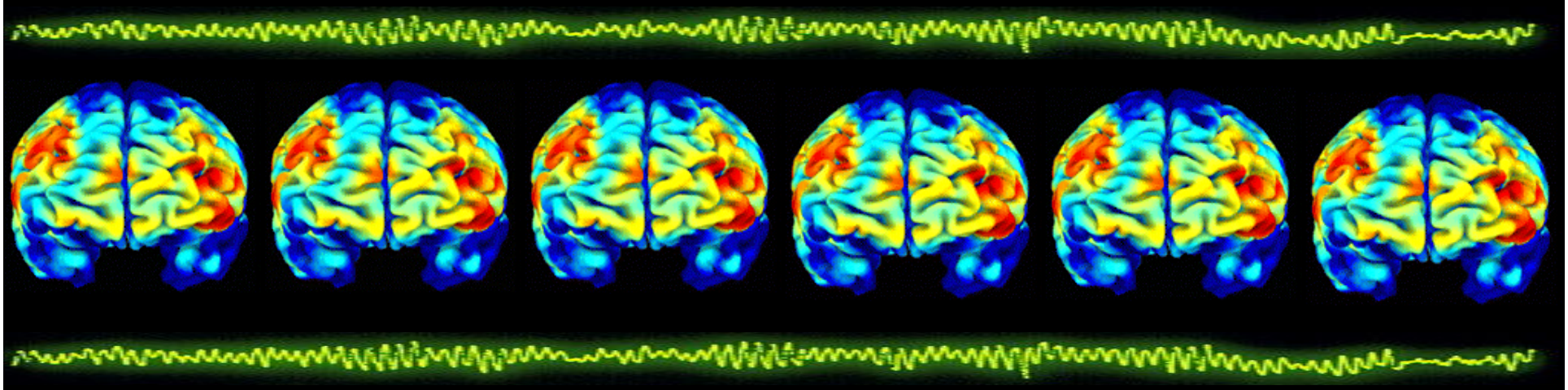
Step 14
3D “Imaging” Reconstruction



Step 14
3D "Imaging" Reconstruction



Congratulations!



You Successfully Processed and Explored SPM's EEG Dataset!