

SPM Basics

OHBA Analysis Workshop



By members & collaborators of the Wellcome Trust Centre for Neuroimaging
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Statistical Parametric Mapping

Introduction

Statistical Parametric Mapping refers to the construction and assessment of spatially extended statistical processes used to test hypotheses about functional imaging data. These ideas have been instantiated in software that is called SPM.

The SPM software package has been designed for the **analysis of brain imaging data sequences**. The sequences can be a series of images from different cohorts, or time-series from the same subject. The current release is designed for the analysis of [fMRI](#), [PET](#), SPECT, [EEG](#) and [MEG](#).

Getting Started

The best starting point is to read the introductory article on SPM available [here](#). You could then download the latest version of the [software](#) and a [data set](#) to analyse. Step-by-step instructions for this analysis are available in the [SPM manual](#).

If you're new to imaging, perhaps an epoch fMRI data set would be appropriate. The data sets are provided with instructions on how to use SPM to analyse them. These tutorials therefore give practical instructions on how to implement the various methodologies. Our methods have been written up in books, technical reports and journal papers which are available from our [Online Bibliography](#). This groups documentation according to year, category, author and keyword.

If you're looking for help on a particular topic you can find the relevant papers from the Online Bibliography. Alternatively, you can search the SPM pages using the [search](#) facility that appears at the bottom of every page. Also browse and search the [SPM WikiBook](#) and please feel free to edit it if you can. If you still can't find what you need, you could send an email to the SPM [Email list](#), which gives you access to our community of experts.

You should also be aware of the many [courses](#) on SPM. If there isn't one in your country this year then there's always the annual short course in London. Finally, once you've mastered SPM you can learn about the various [extensions](#) provided by experts in the wider community.

Good luck !

Latest news

▶ SPM Course for M/EEG Videos

July 2012: [Videos](#) recorded at the May 2012 SPM Course for M/EEG are now freely available online.

▶ SPM Course for fMRI/PET/VBM Videos

November 2011: [Videos](#) recorded at the May 2011 SPM Course for fMRI/PET/VBM are now freely available online.

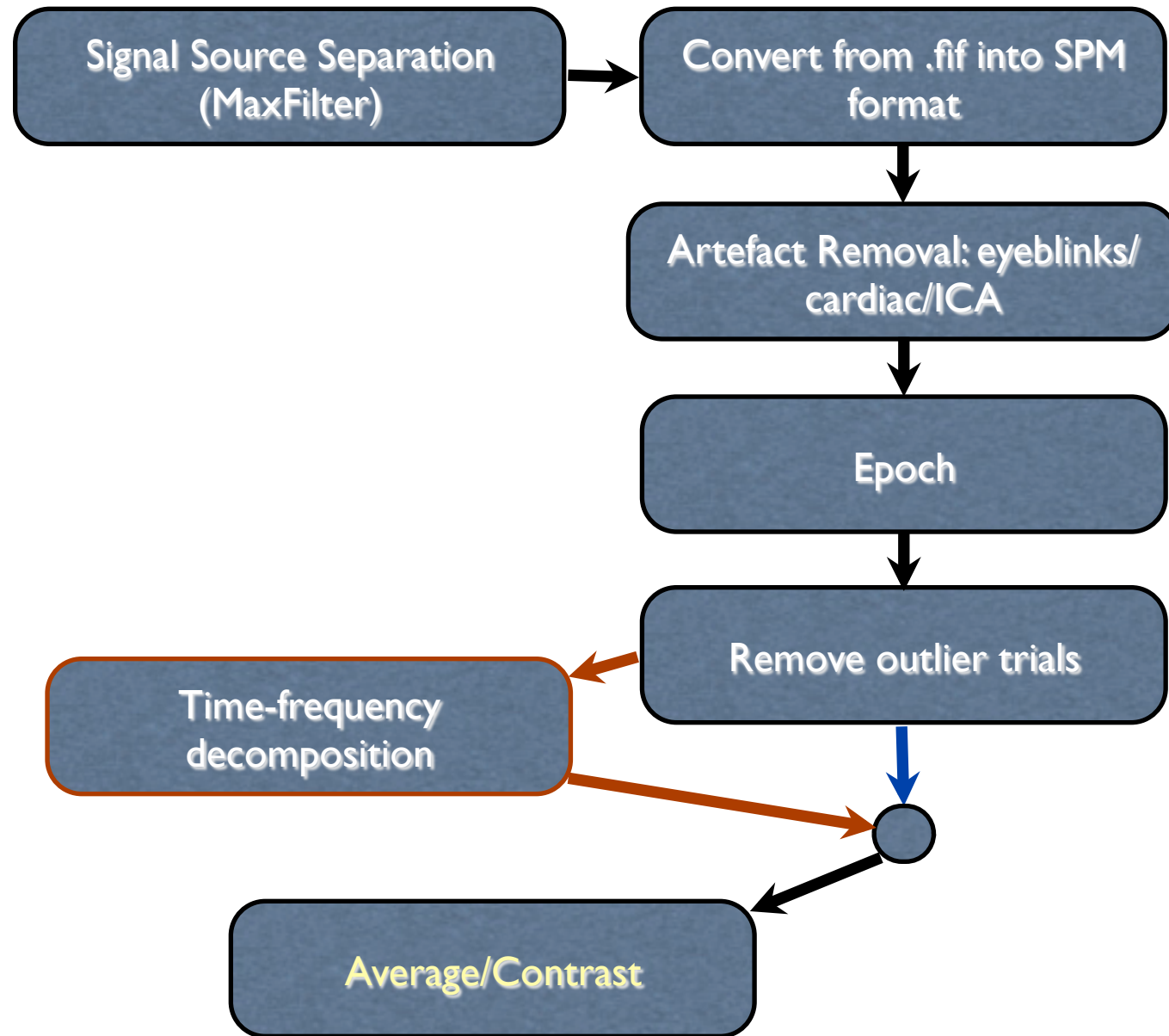
▶ SPM8 released

April 2009: SPM8 is a major update to the SPM software, containing substantial theoretical, algorithmic, structural and interface enhancements over previous versions ([more info](#)).

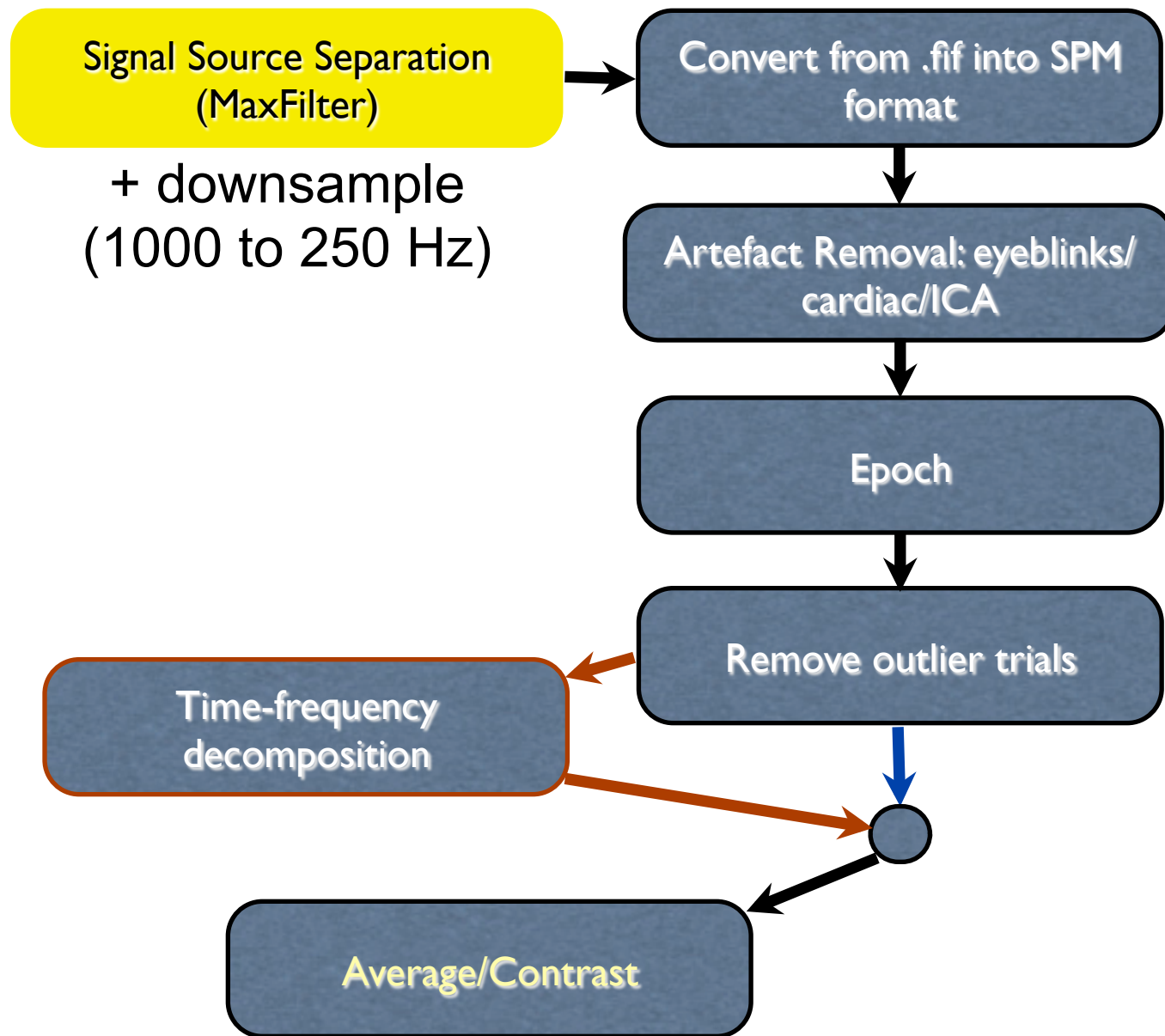


Beta version: SPM12b

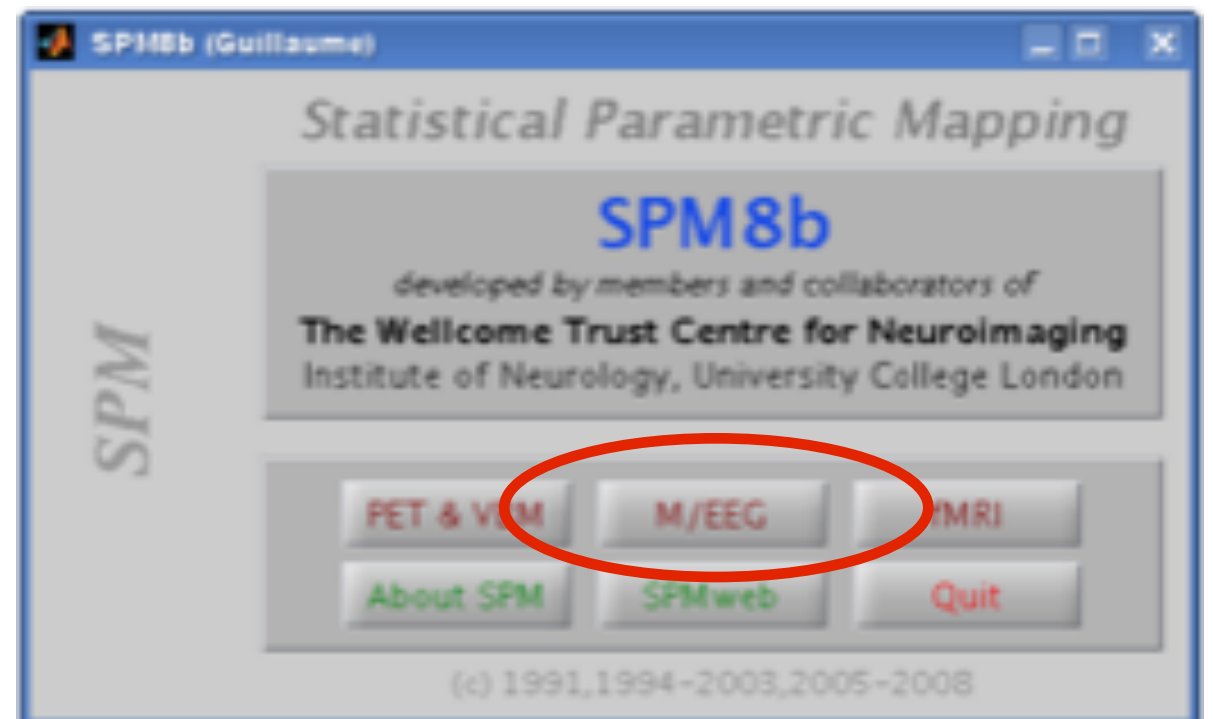
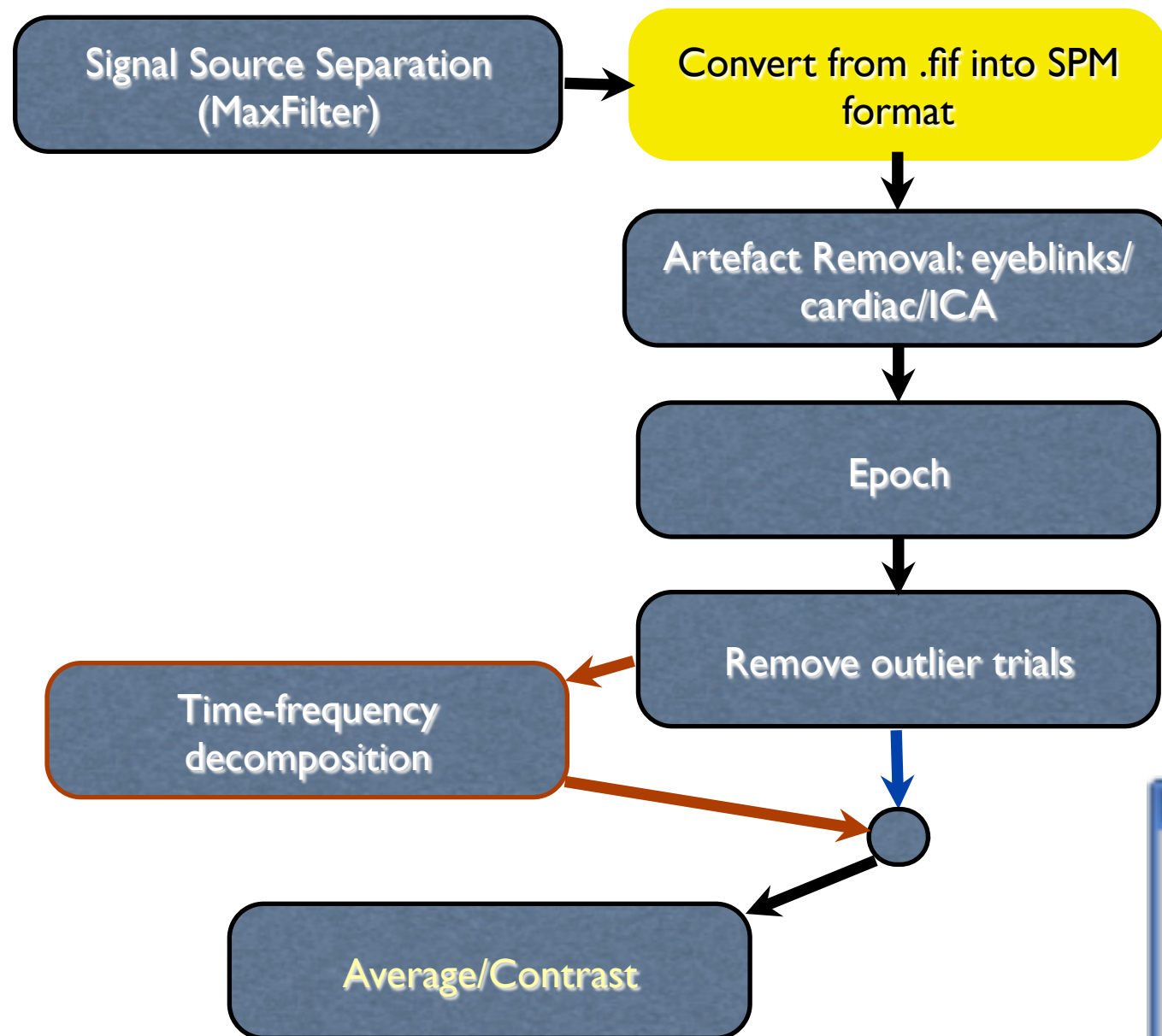
MEG Analysis



MEG Analysis

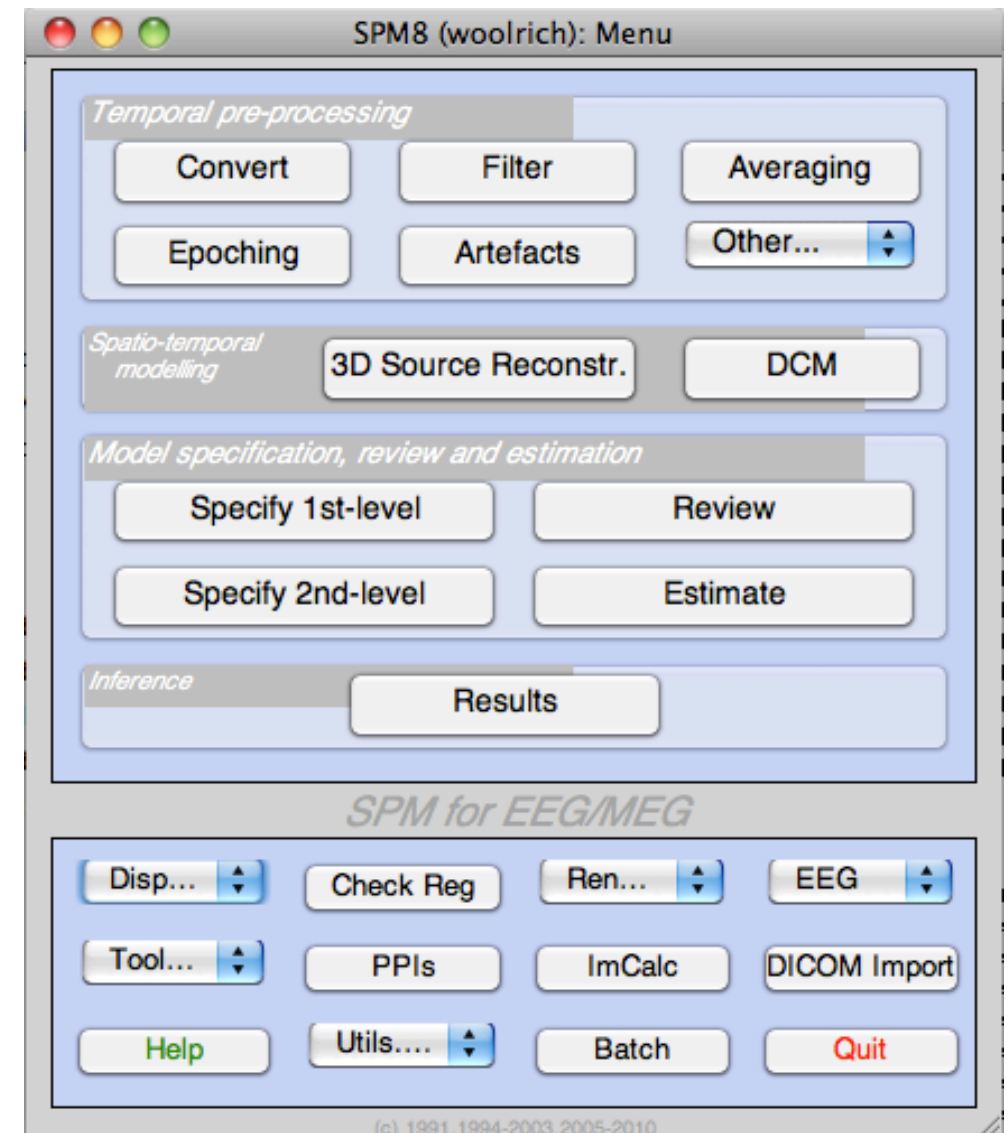


MEG Analysis



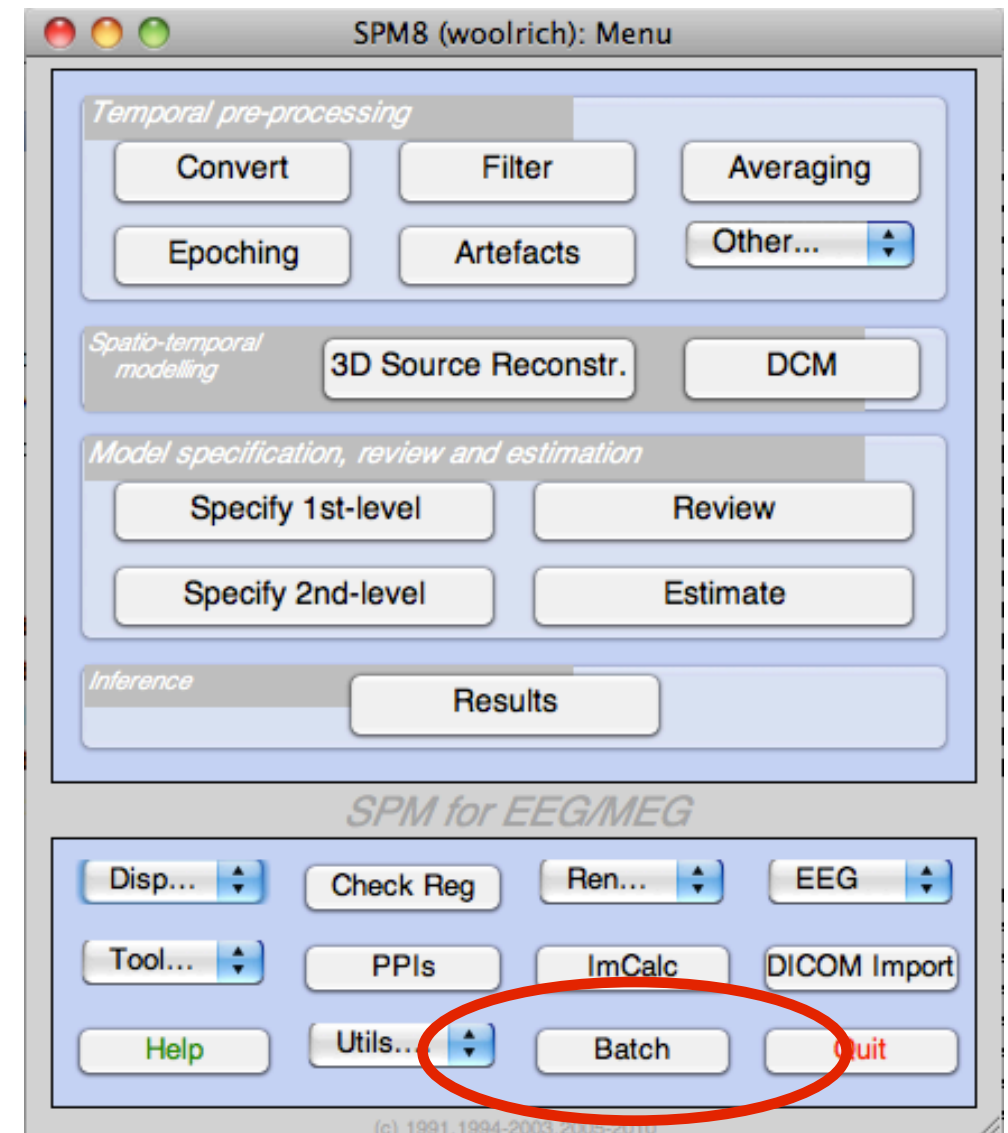
SPM

- Using the command line/scripts:
 - ➔ e.g. `>> D=spm_eeg_convert(S);`
- Using the GUI:
 - ➔ `>> spm` (or `>> spm eeg`)



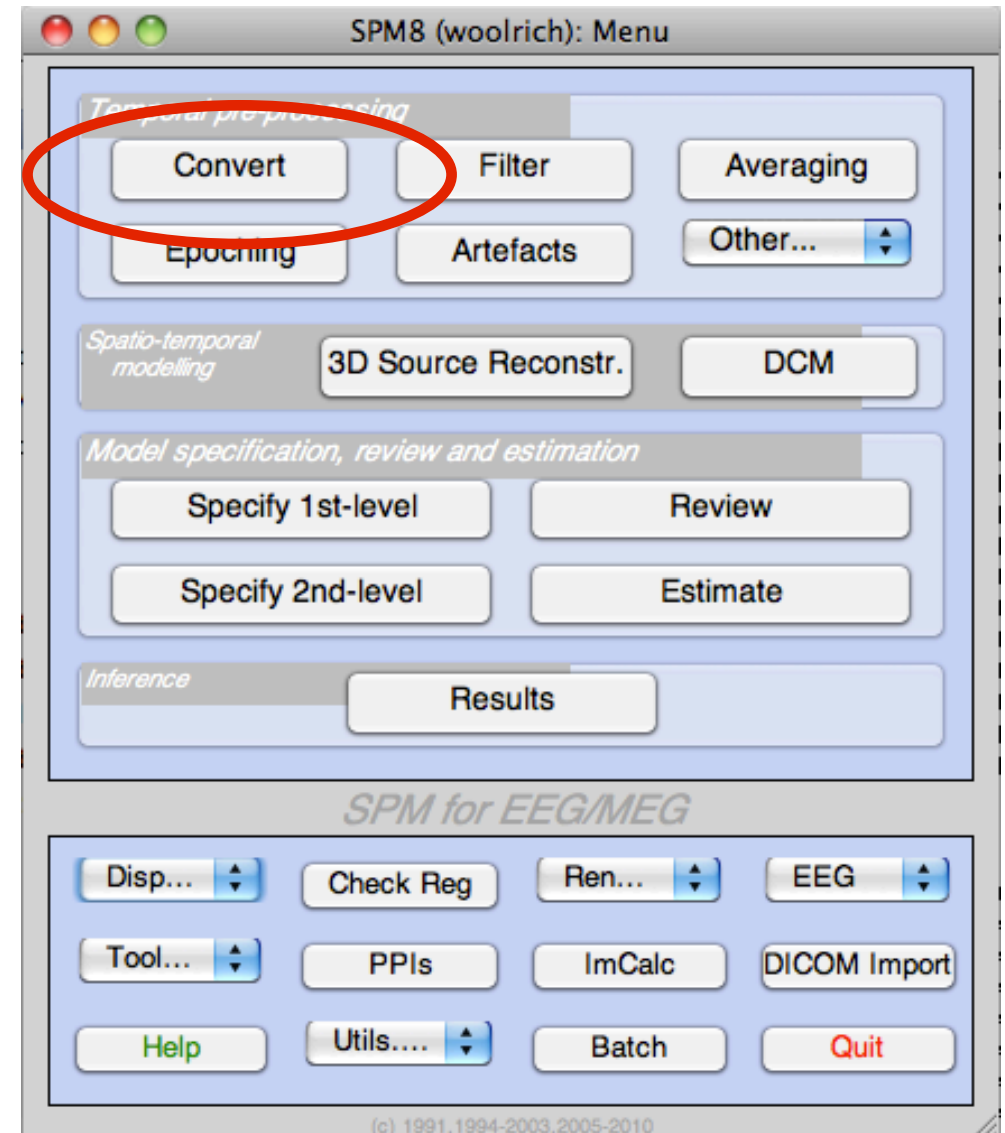
SPM

- Using the command line/scripts:
 - ➔ e.g. `>> D=spm_eeg_convert(S);` note: “history” cheat
- Using the GUI:
 - ➔ `>> spm` (or `>> spm eeg`)
- Using the batch facility:
 - ➔ GUI for setting up batching
 - ➔ ‘jobman’



Getting data into SPM

- Convert function, appends “spm8_”
- From the command line/scripts:
➔ `>> D=spm_eeg_convert(S);`
- From the GUI:



SPM meeg objects

- Loaded MEG data is represented in Matlab as an meeg “object”
- Objects - bit like a clever struct
 - ➔ contain information/data describing the object
 - ➔ can call functions (‘methods’) on the object
 - these provide a simple and safe interface for getting information from the object and updating it
- Saved to disk as two files:
 - ➔ binary memory mapped data file (*.dat*)
 - ➔ header file (*.mat*)

Some useful commands

- `D=spm_eeg_load('fname')`
- Typing “D” summarises the object:

```
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

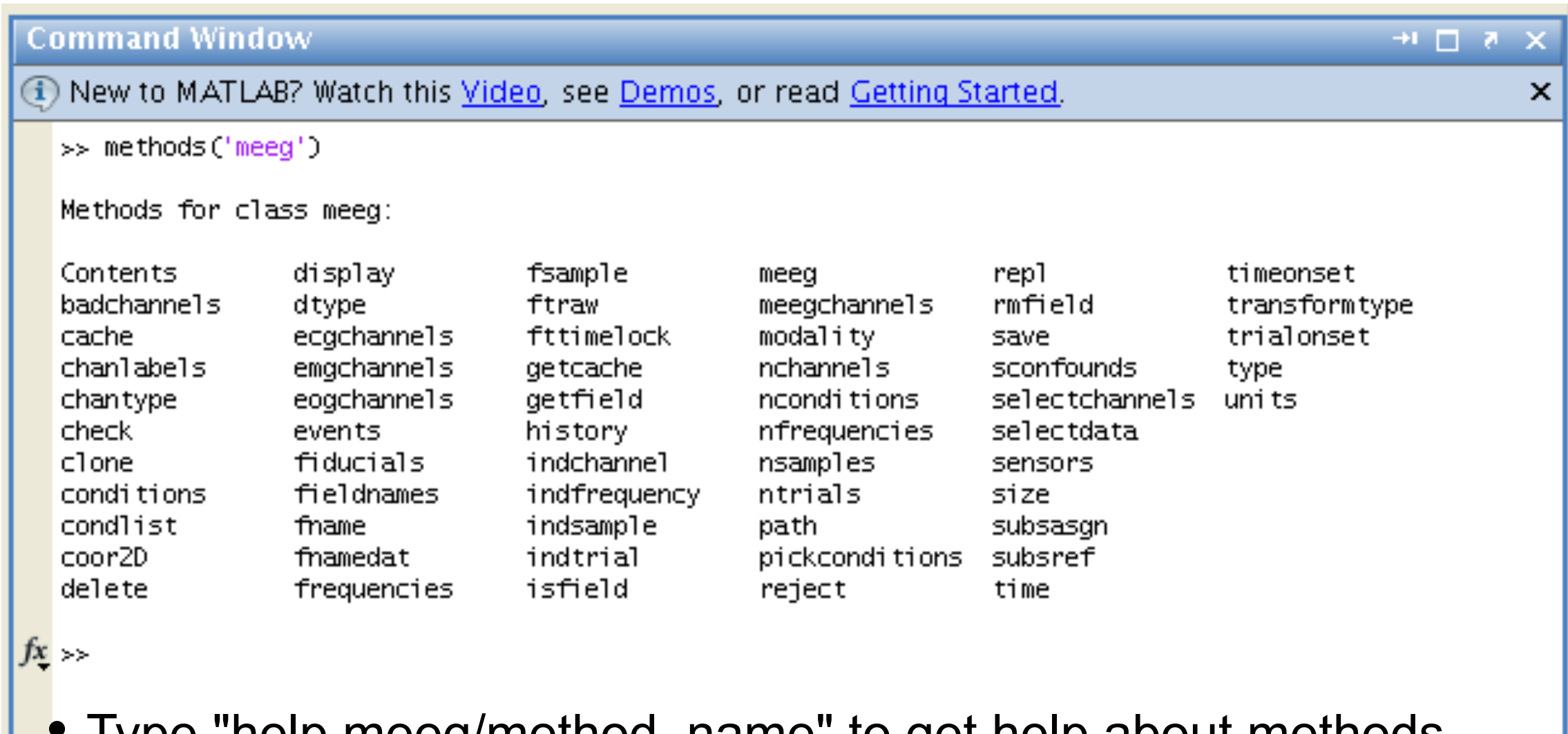
>> D
SPM M/EEG data object
Type: evoked
Transform: time
2 conditions
327 channels
2001 samples/trial
2 trials
Sampling frequency: 500 Hz
Loaded from file /home/disk3/mstokes/Eduard/Sub01/mespm8_Grating.mat

Use the syntax D(channels, samples, trials) to access the data
Type "methods('meeg')" for the list of methods performing other operations with the object
Type "help meeg/method_name" to get help about methods

fx >>
```

Get data: `data= D(:,:,:)`
Set data: `D(1,2,3) = 1;`

Some useful commands



```
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

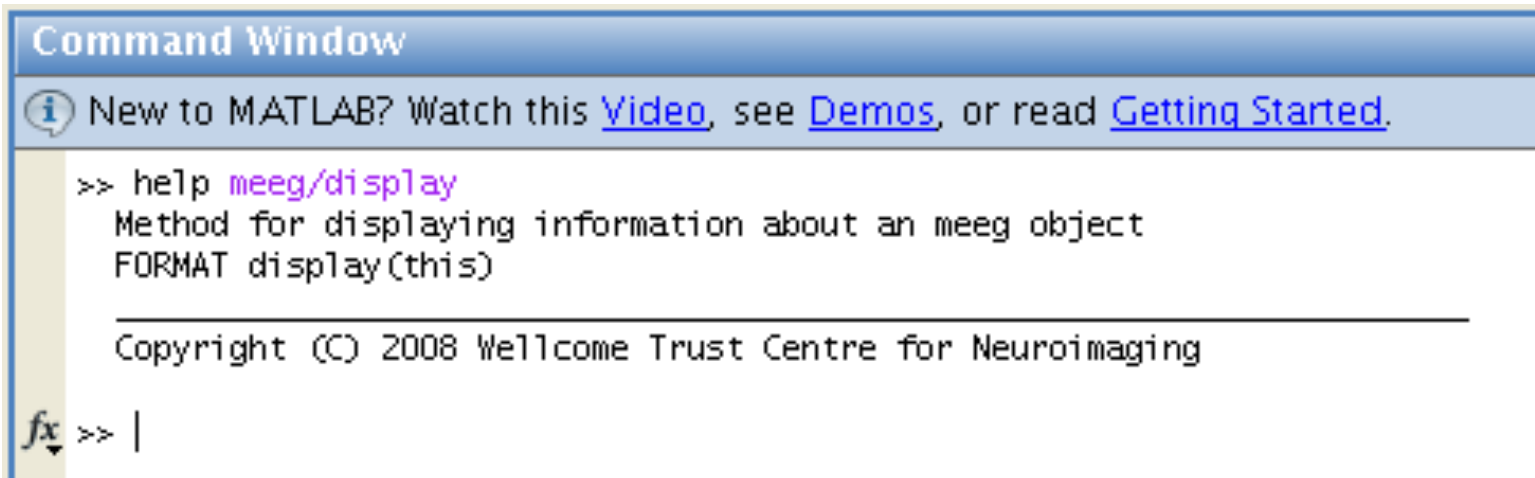
>> methods('meeg')

Methods for class meeg:

Contents          display          fsample          meeg             repl             timeonset
badchannels       dtype            ftraw            meegchannels     rmfield          transformtype
cache             ecgchannels     fttimelock      modality         save             trialonset
chanlabels       emgchannels     getcache        nchannels        sconfound        type
chantype         eogchannels     getfield        nconditions     selectchannels  units
check            events          history          nfreqencies     selectdata
clone            fiducials       indchannel      nsamples         sensors
conditions       fieldnames     indfrequency    ntrials          size
condlist         frame          indsample       path             subsasgn
coor2D           fnamedat       indtrial        pickconditions  subsref
delete           frequencies     isfield         reject           time

fx >>
```

- Type "help meeg/method_name" to get help about methods



```
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

>> help meeg/display
Method for displaying information about an meeg object
FORMAT display(this)

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fx >> |
```

Some methods read and write

Get data: `data= D(:,:,:)`

Set data: `D(1,2,3) = 1;`

`chind = D.badchannels`, returns the indices of all bad channels.

`D.badchannels([43:55], 1)` will flag channels 43 to 55 as bad.

SPM meeg objects

- help meeg
 - ➔ help text for creating an meeg object
 - ➔ and lists the fields
 - e.g. channels, sensors, trials ...

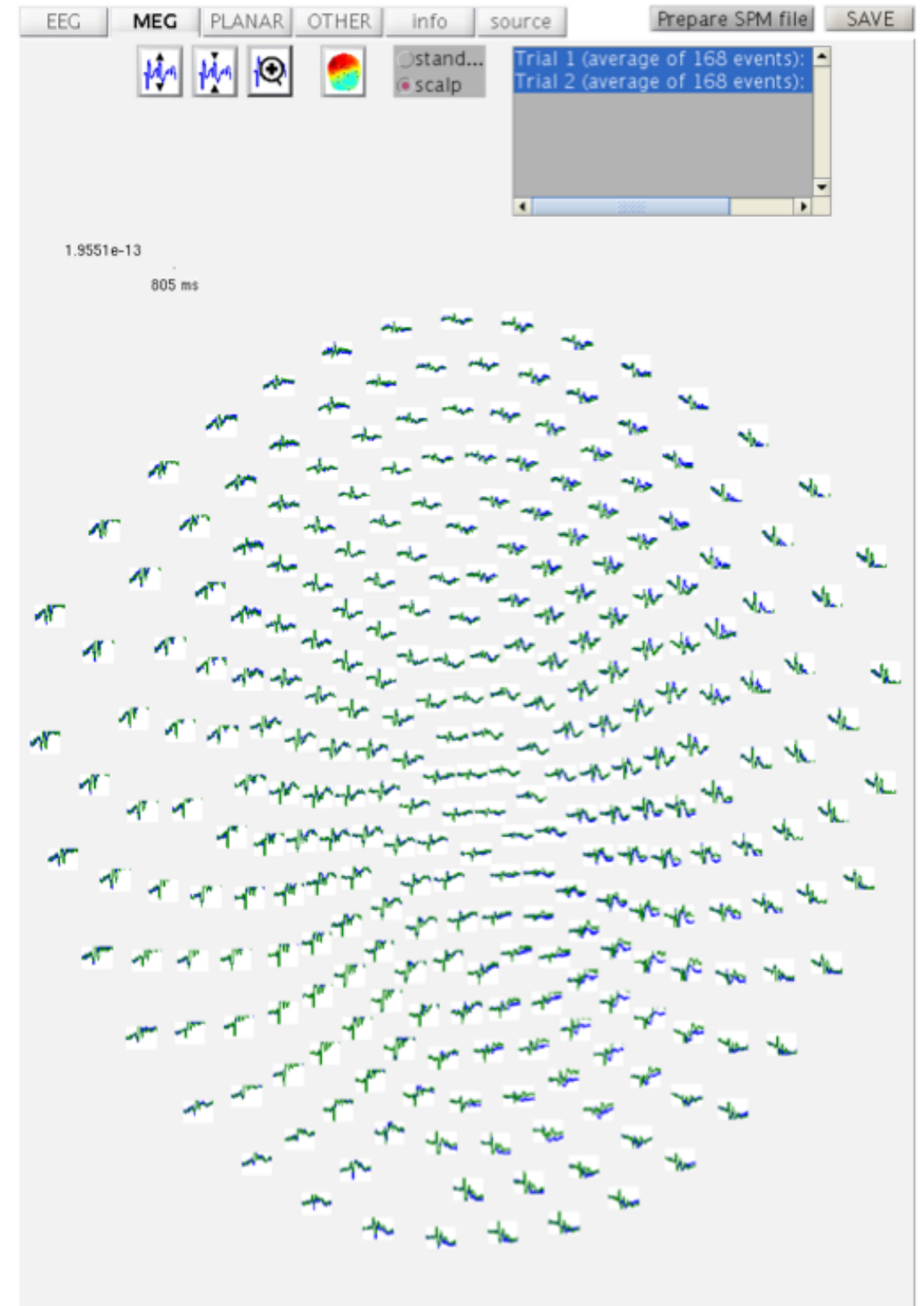
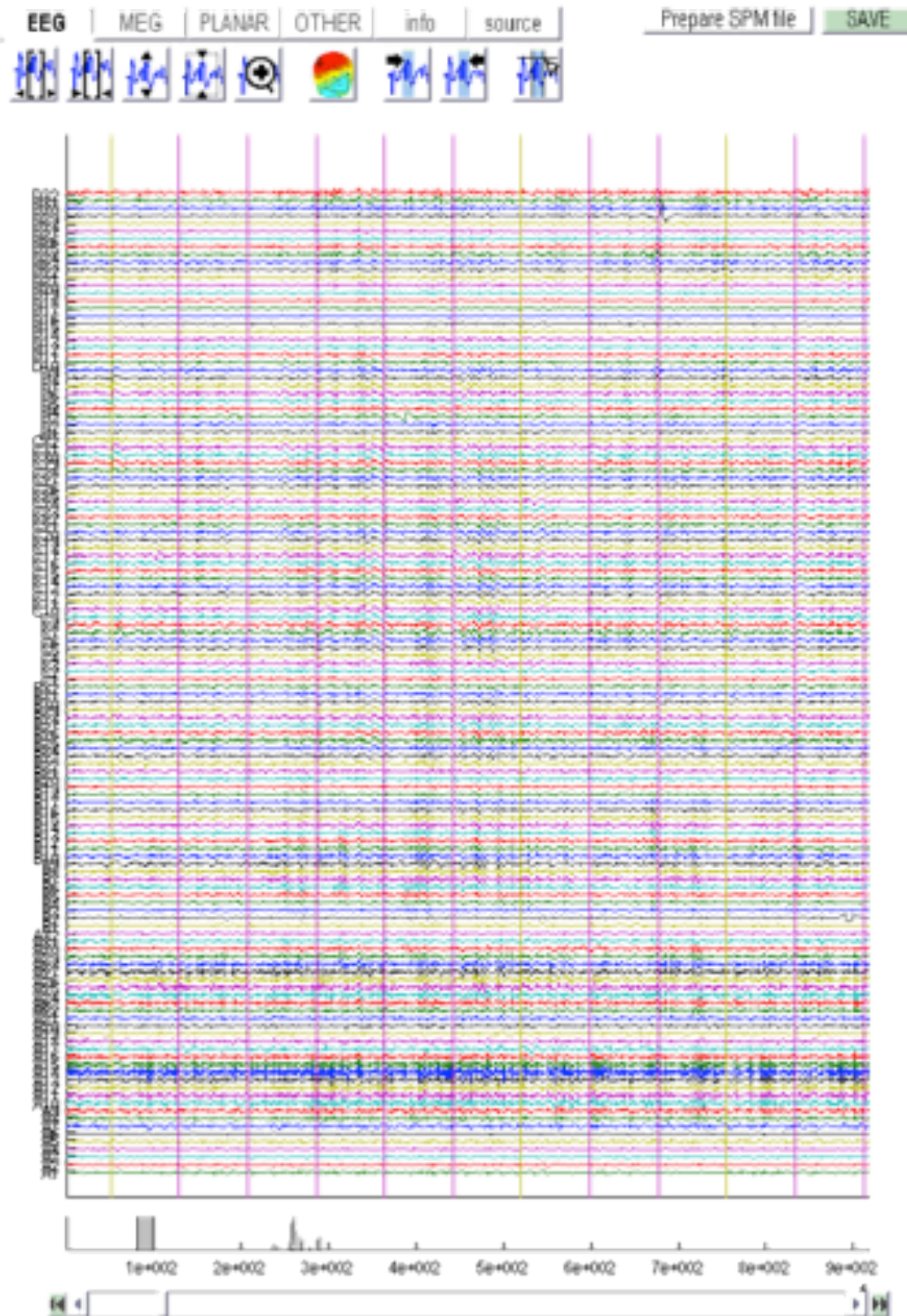
Viewing data

From GUI, or call

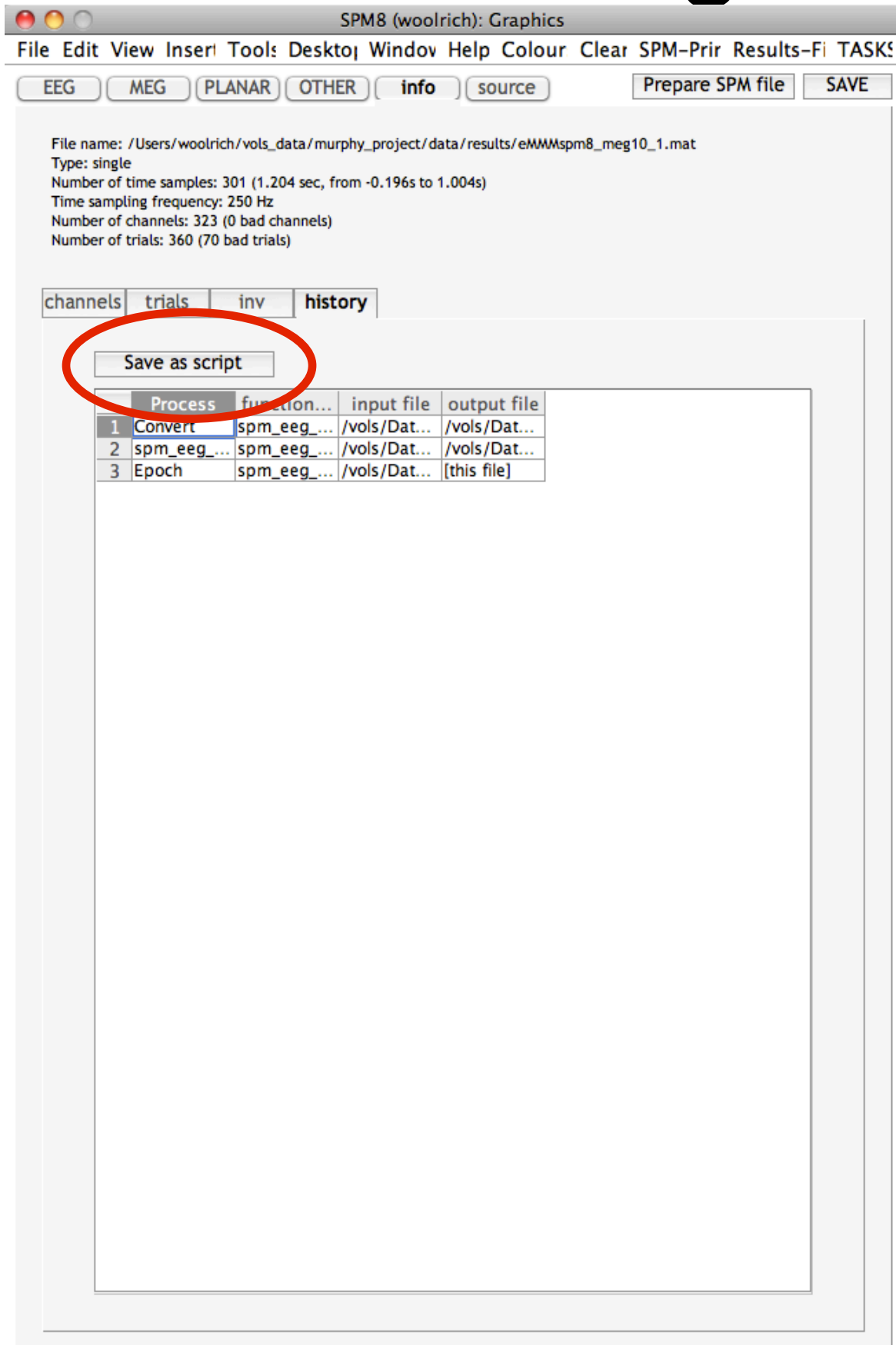
```
D=spm_eeg_load('filename');  
spm_eeg_review(D);
```



Viewing data



Viewing Command History



SPM8 (woolrich): Graphics

File Edit View Insert Tools Desktop Window Help Colour Clear SPM-Prir Results-Fi TASKS

EEG MEG PLANAR OTHER info source Prepare SPM file SAVE

File name: /Users/woolrich/vols_data/murphy_project/data/results/eMMMspm8_meg10_1.mat
Type: single
Number of time samples: 301 (1.204 sec, from -0.196s to 1.004s)
Time sampling frequency: 250 Hz
Number of channels: 323 (0 bad channels)
Number of trials: 360 (70 bad trials)

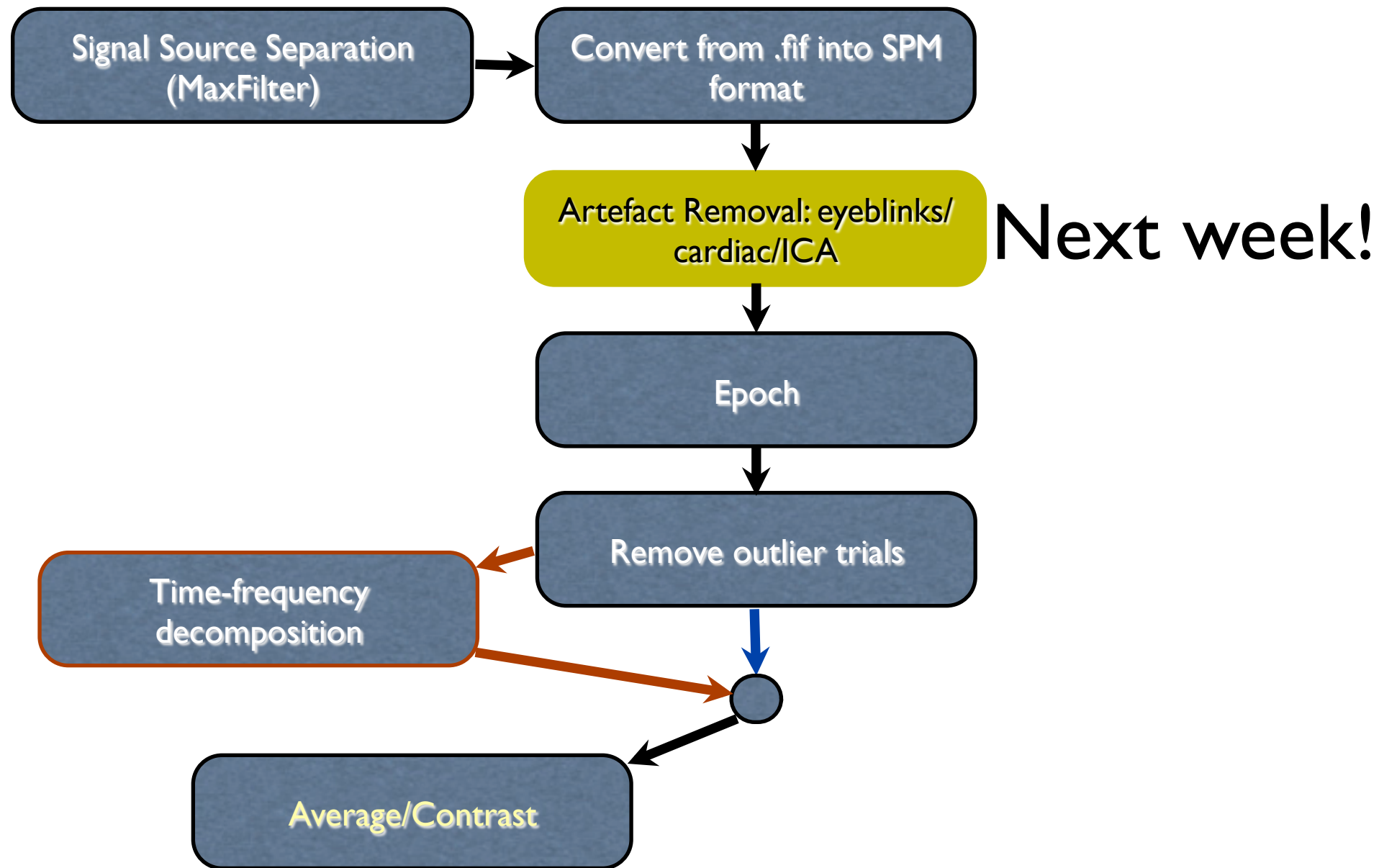
channels trials inv **history**

Save as script

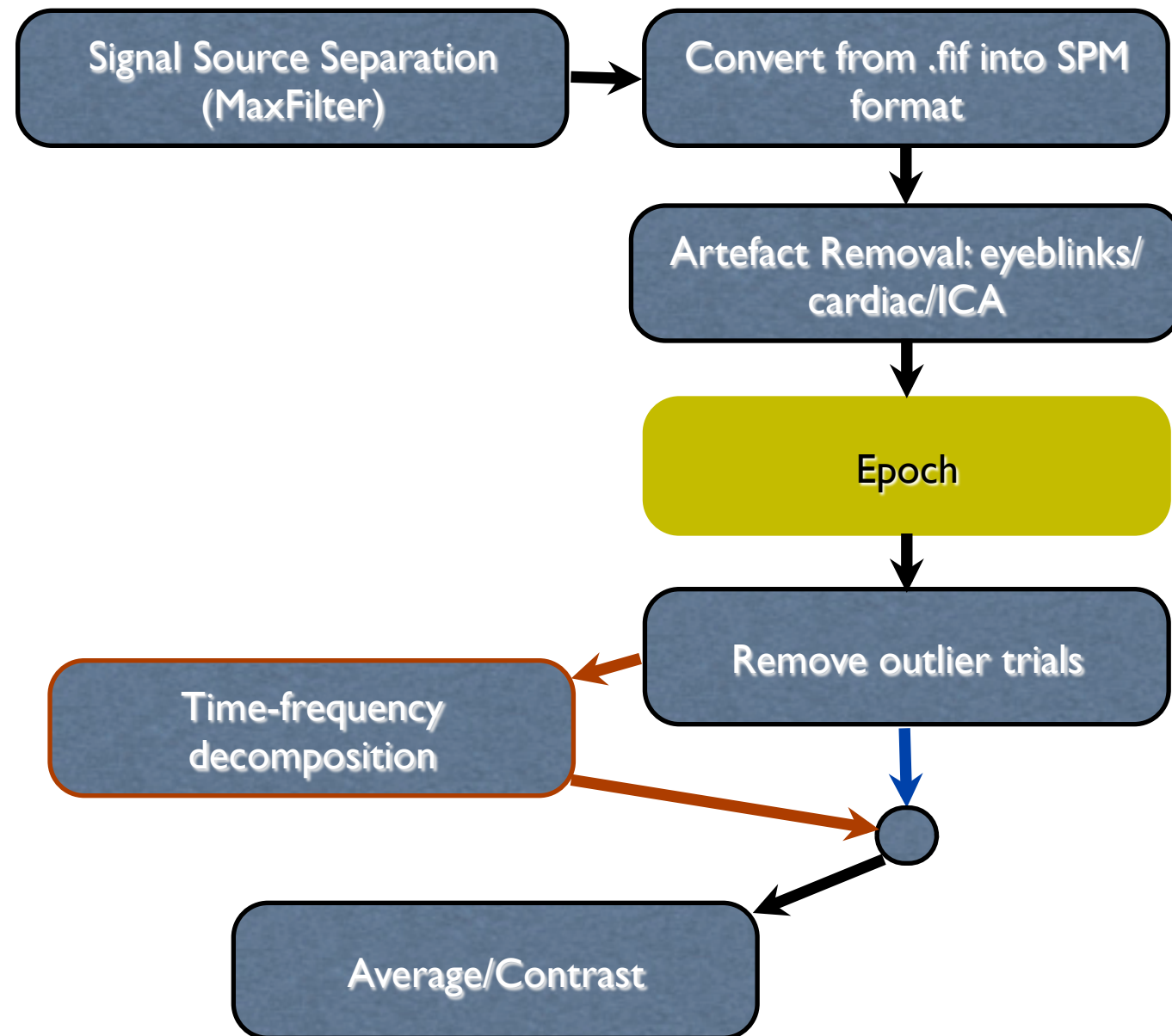
	Process	function...	input file	output file
1	Convert	spm_eeg_...	/vols/Dat...	/vols/Dat...
2	spm_eeg_...	spm_eeg_...	/vols/Dat...	/vols/Dat...
3	Epoch	spm_eeg_...	/vols/Dat...	[this file]

```
D = spm_eeg_load('filename');  
H = D.history;  
H.fun; H.args
```

MEG Analysis

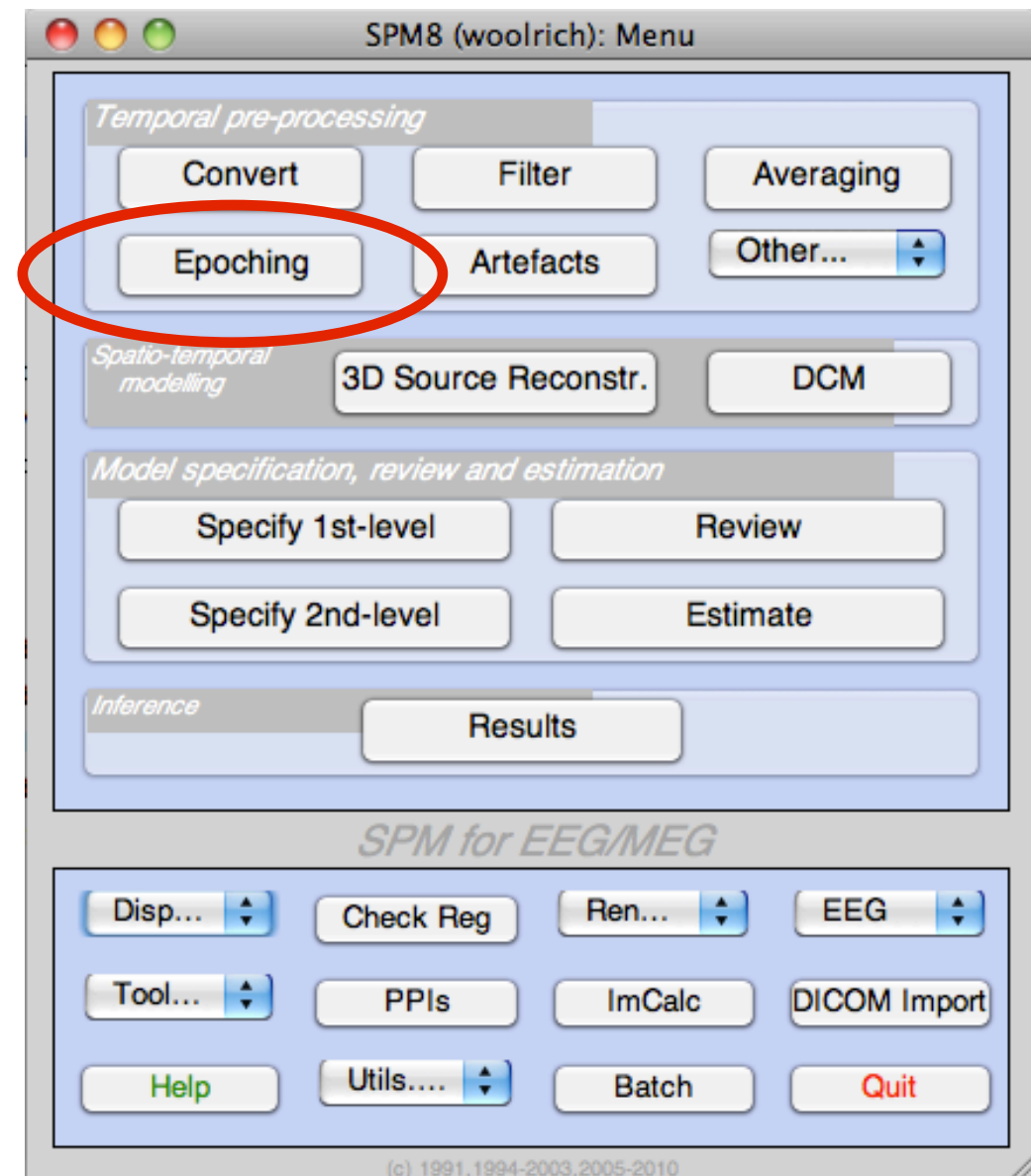
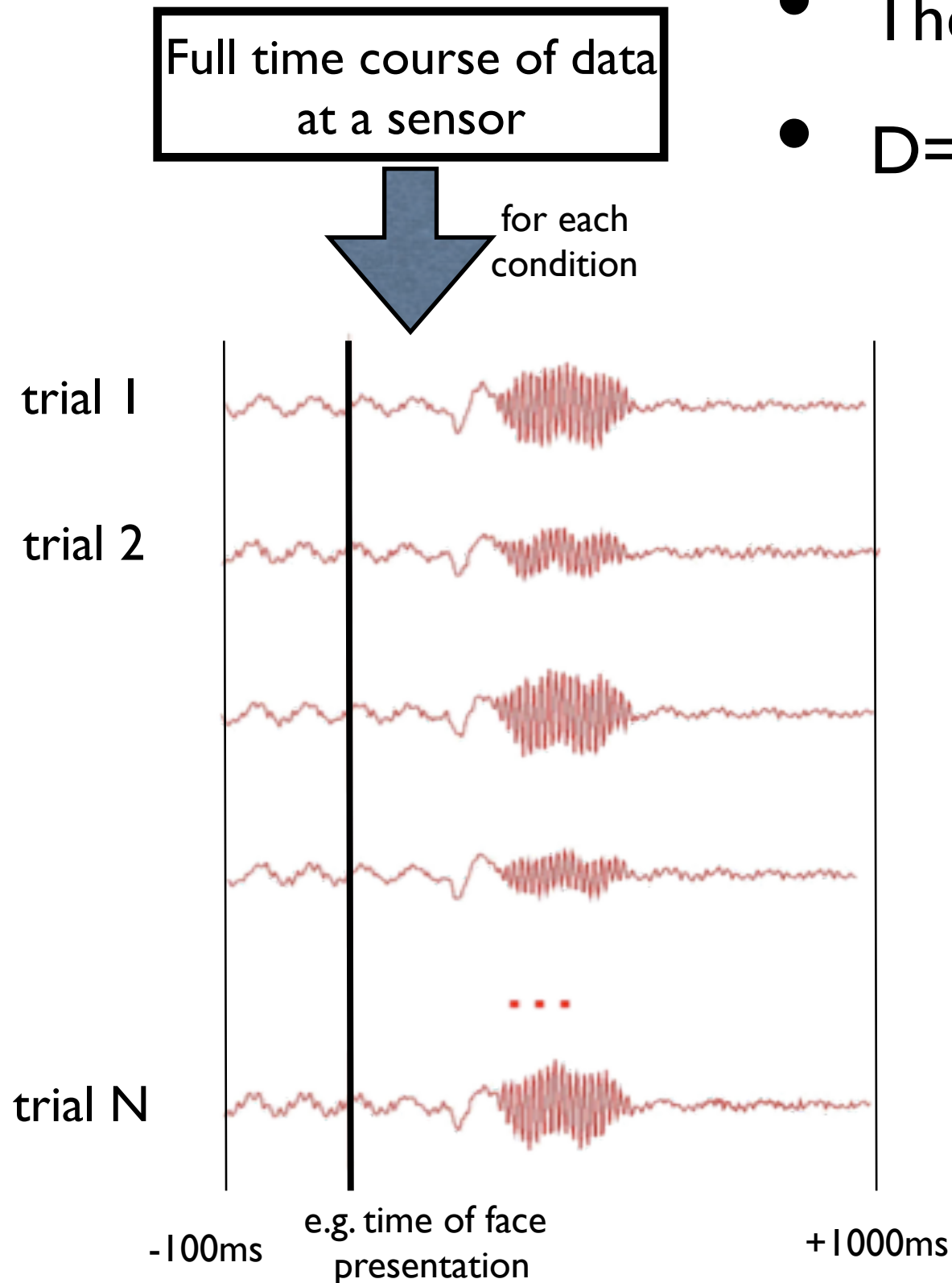


MEG Analysis

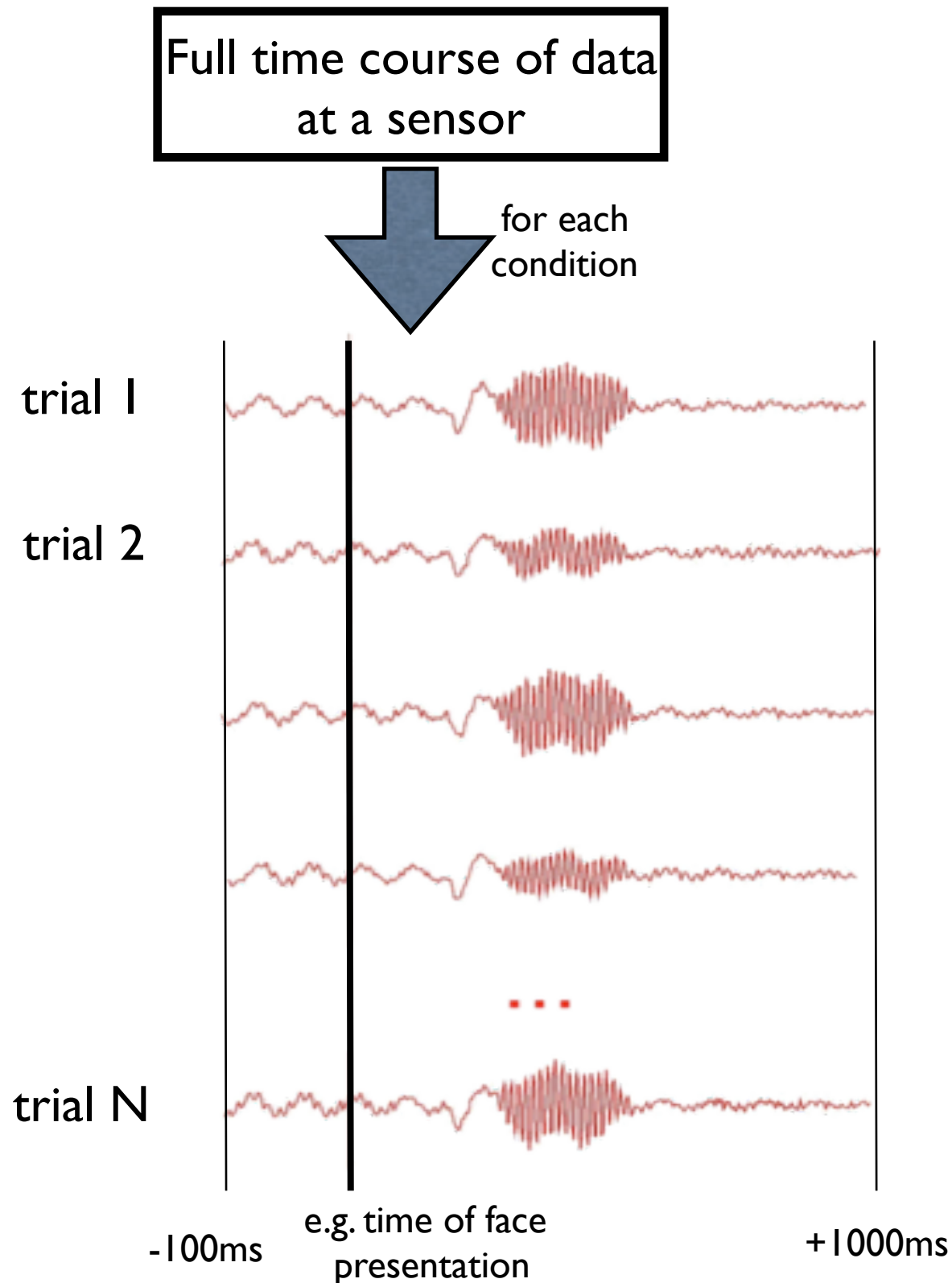


Epoching

- The definition of segments around events.
- $D = \text{spm_eeg_epochs}(S)$; appends 'e'

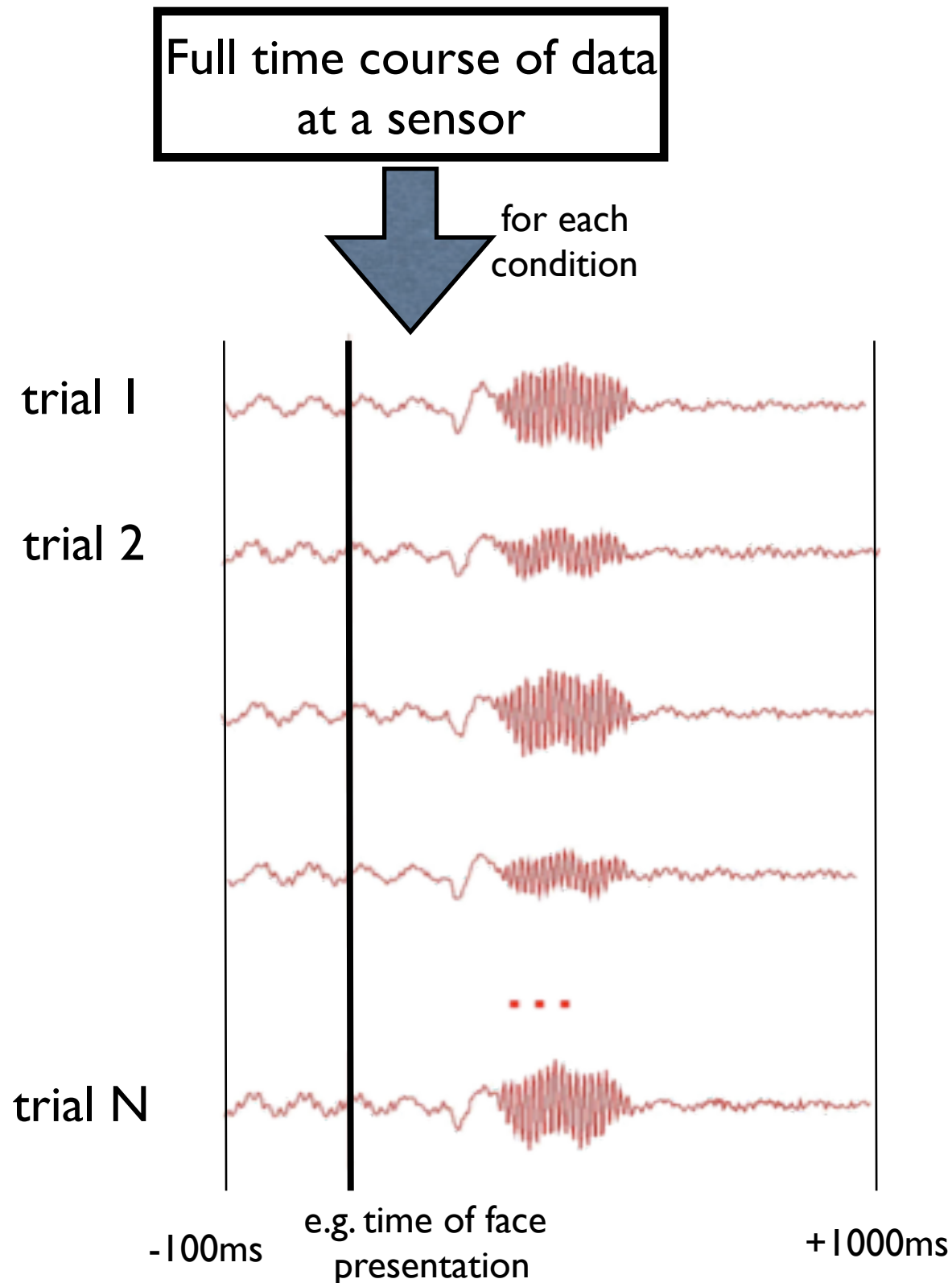


Epoching



- The definition of segments around events.
- $D = \text{spm_eeg_epochs}(S)$;
- Need to know:
 - ➔ event type (e.g. 'STI101_down')
 - ➔ event values (e.g. 1 or 2),
 - ➔ condition label (e.g. 'faces' or 'scrambled faces').
 - ➔ time window to use around events (e.g. -100 to 1000 ms).
- Note:
 - ➔ SPM8 only supports fixed length trials

Epoching



```
>> help spm_eeg_epochs
```

Epoching continuous M/EEG data

```
FORMAT D = spm_eeg_epochs(S)
```

S - input structure (optional) (optional) fields of S:

S.D - MEEG object or filename of M/EEG mat-file with continuous data

S.bc - baseline-correct the data (1 - yes, 0 - no). Either (to use a ready-made trial definition):

S.epochinfo.trl - Nx2 or Nx3 matrix (N - number of trials) [start end offset]

S.epochinfo.conditionlabels - one label or cell array of N labels

S.epochinfo.padding - the additional time period around each trial for which the events are saved with the trial (to let the user keep and use for analysis events which are outside) [in ms] Or (to define trials using (spm_eeg_definetrial)):

S.pretrig - pre-trigger time [in ms]

S.posttrig - post-trigger time [in ms]

S.trialdef - structure array for trial definition with fields

S.trialdef.conditionlabel - string label for the condition

S.trialdef.eventtype - string

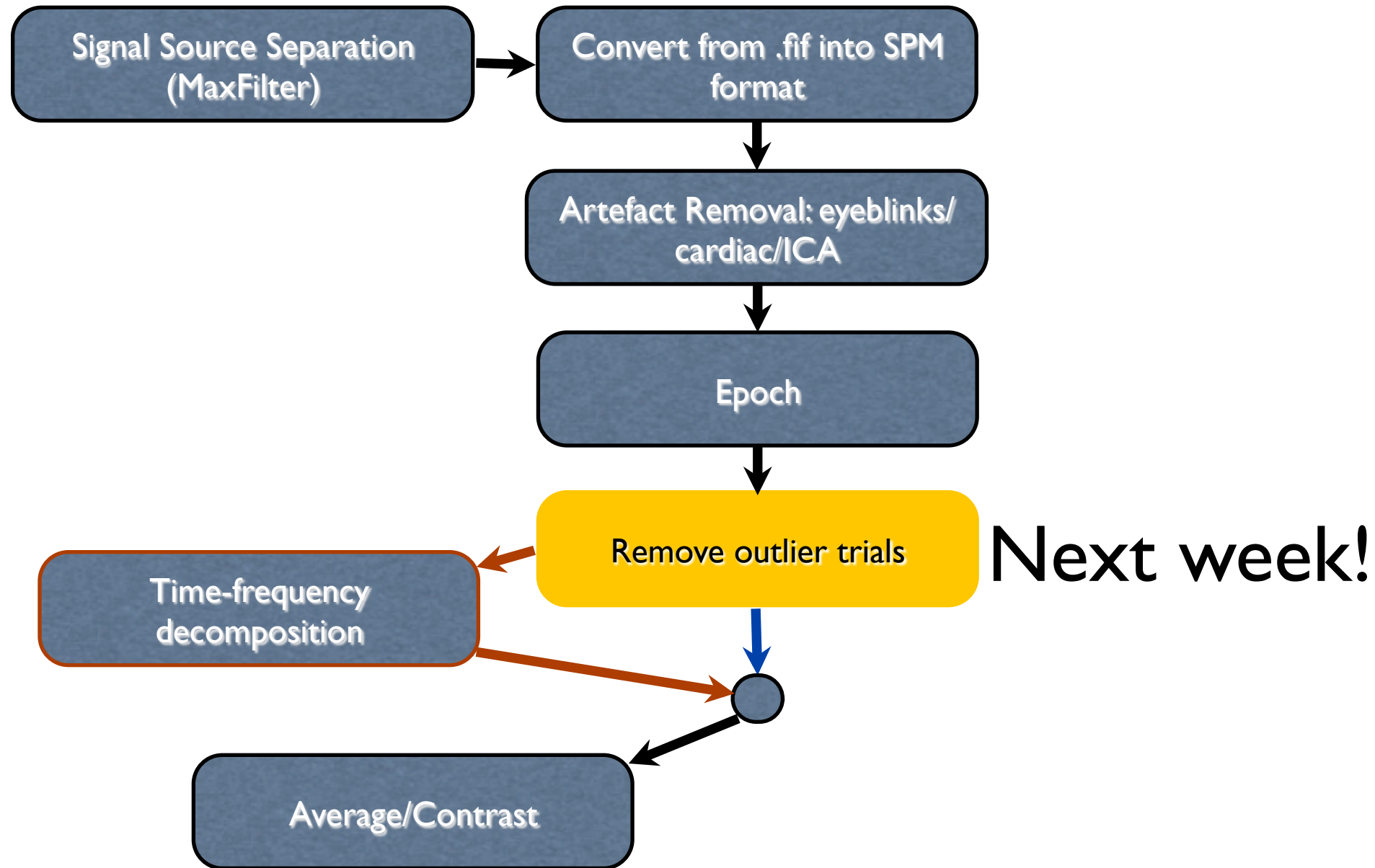
S.trialdef.eventvalue - string, numeric or empty

S.reviewtrials - review individual trials after selection

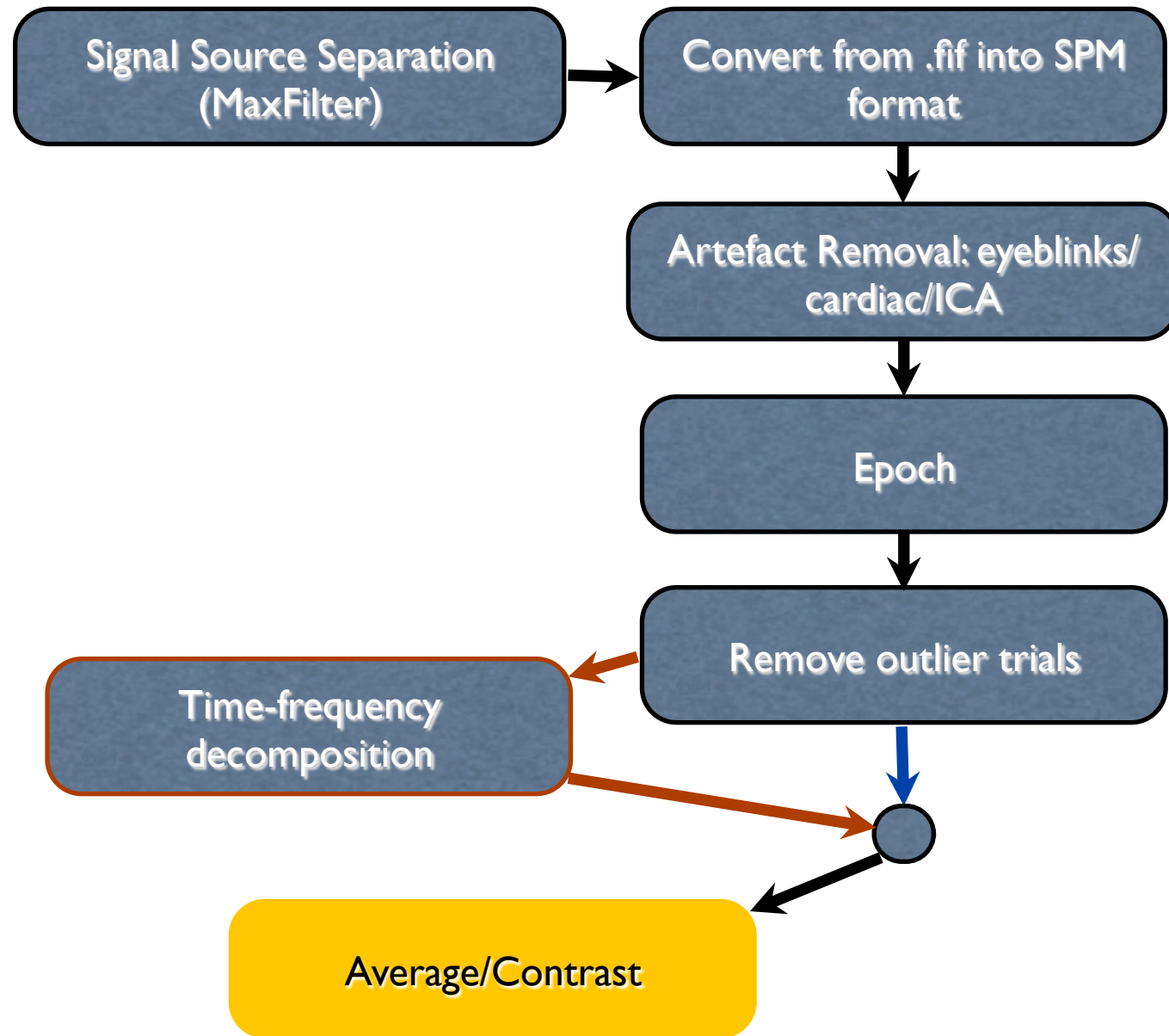
S.save - save trial definition

Output: D - MEEG object (also written on disk)

MEG Analysis

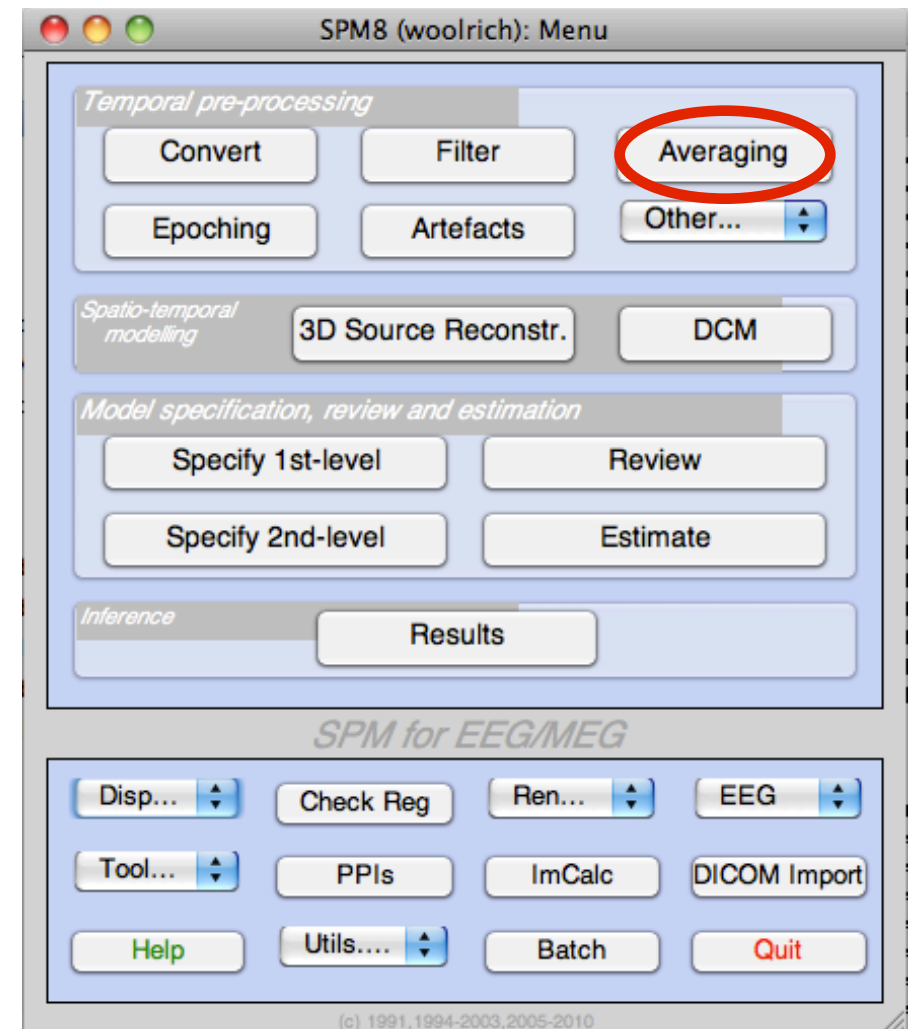
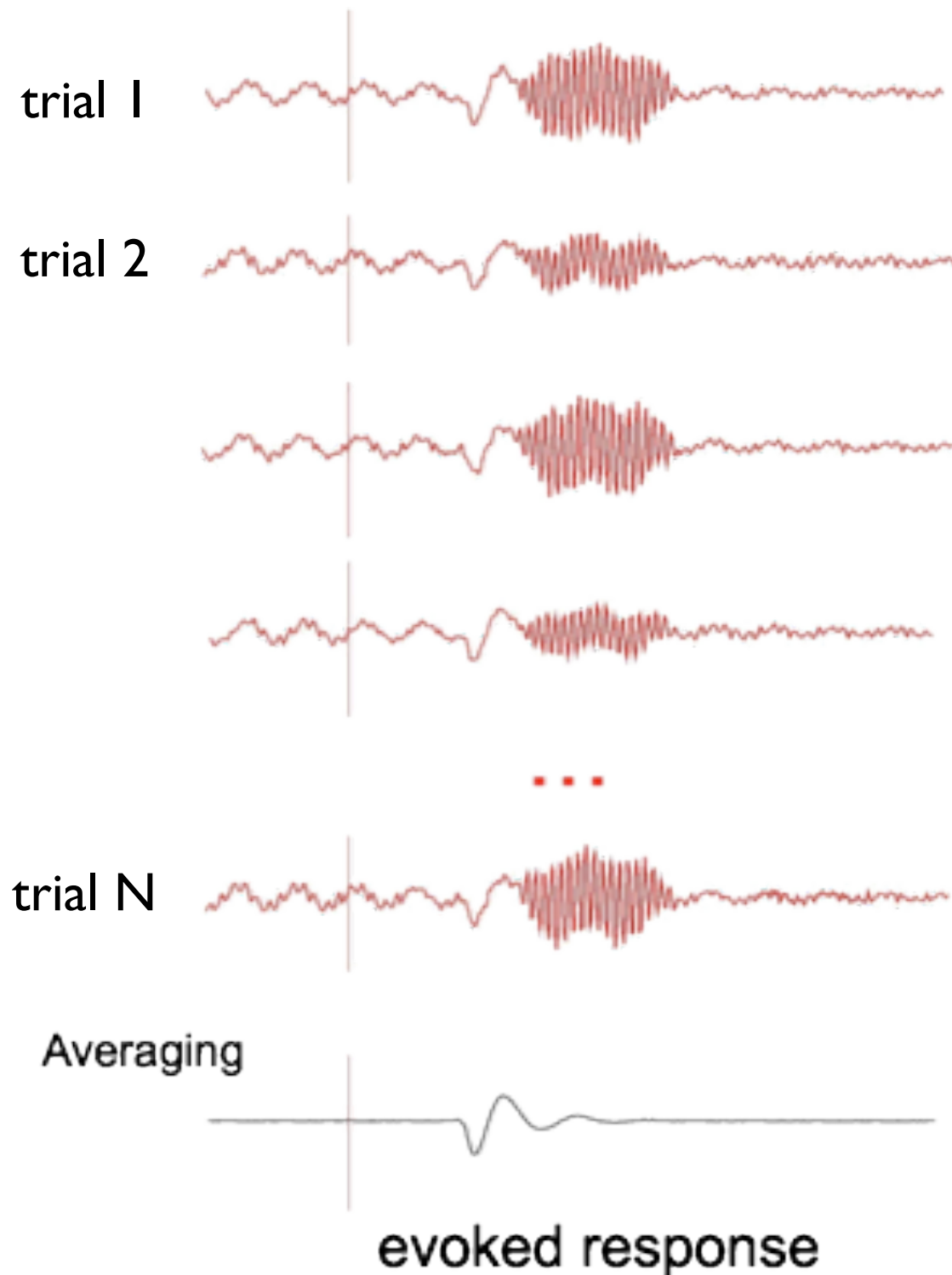


MEG Analysis



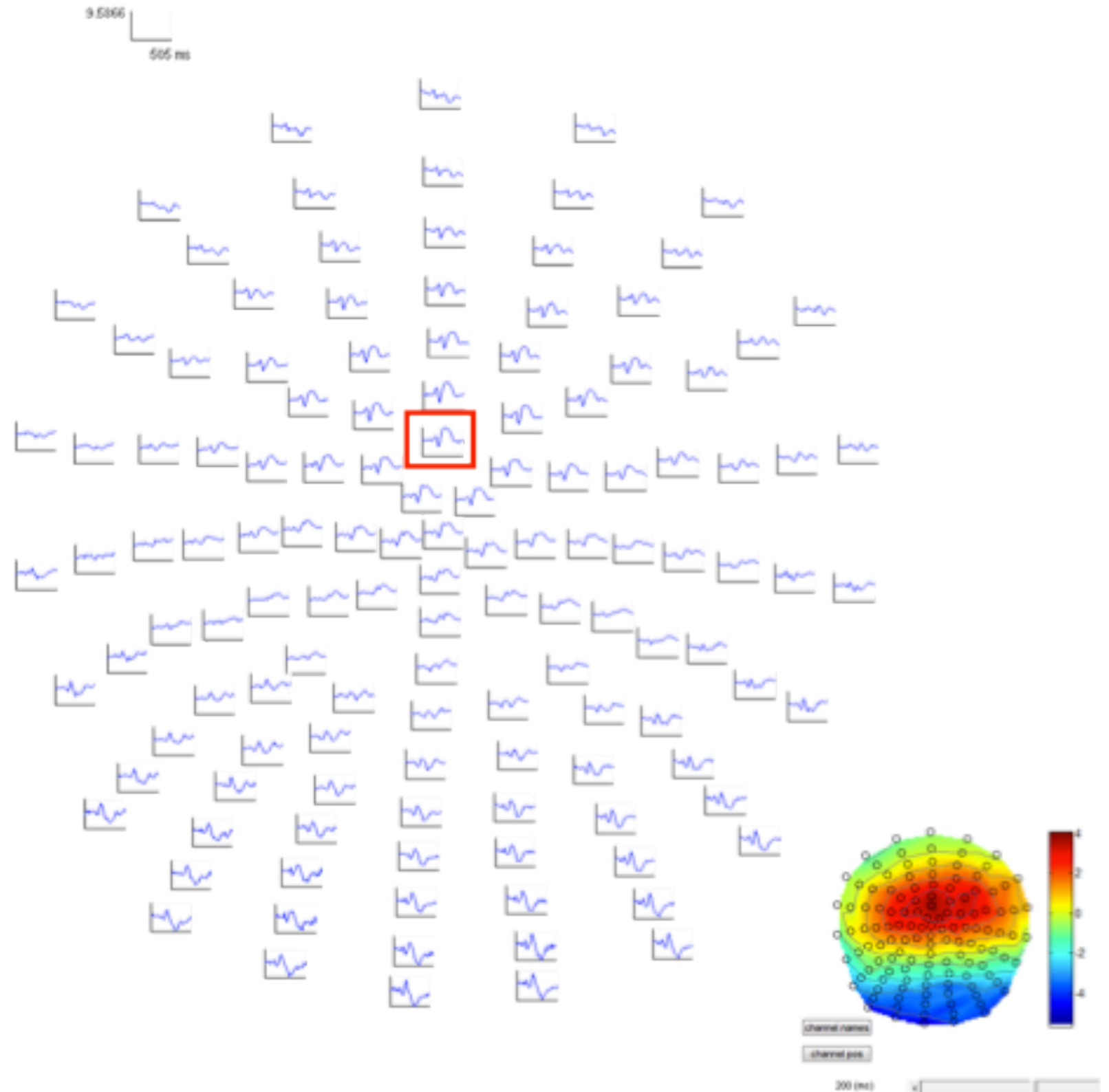
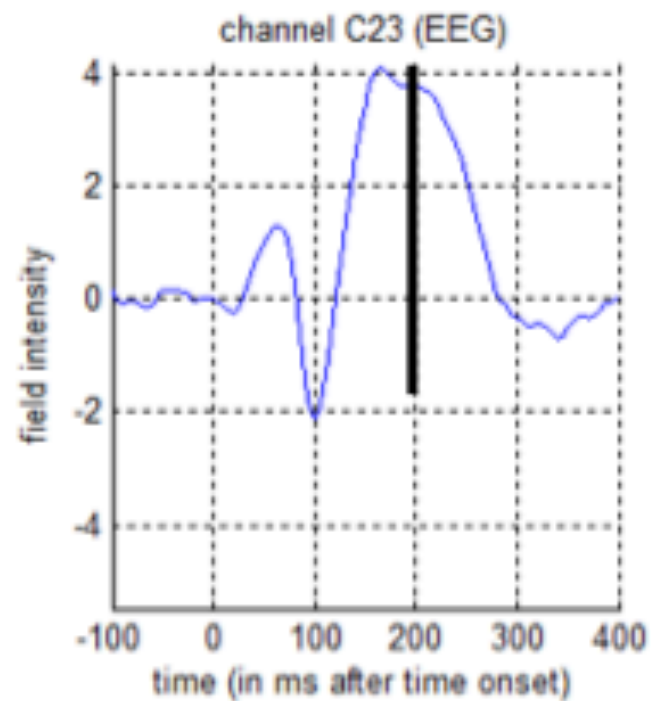
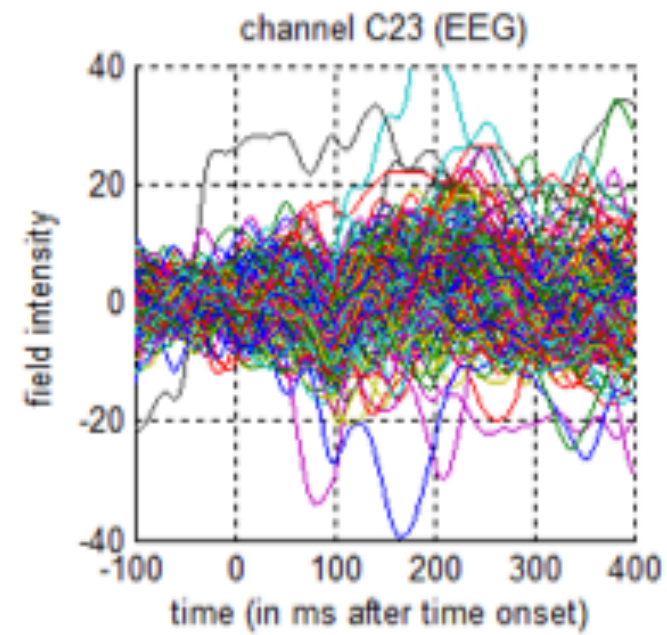
Averaging: spm_eeg_average, appends 'm'

For each condition:



- “robust” averaging option (downweights outlier trials)
- Useful, but slow

Averaging: spm_eeg_average, append 'm'



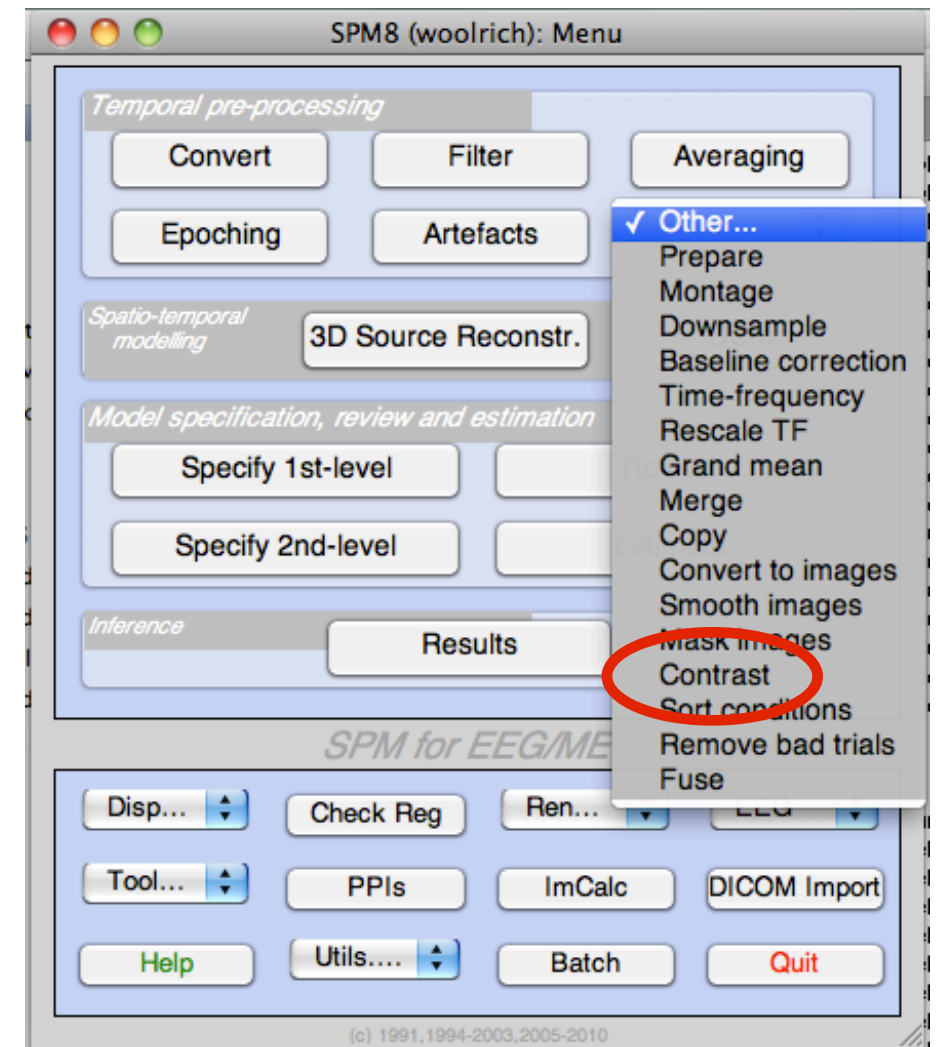
Contrasting: `spm_eeg_weight_epochs`, append 'w'

- Contrast of evoked responses for different conditions.
- In data with 2 conditions (e.g. faces and scrambled faces), to compute the average evoked response across both conditions, use the contrast:

→ $[1 \ 1]$ (e.g. scrambled faces ERF + faces ERF)

- To compute the difference between two conditions, use:

→ $[-1 \ 1]$ (e.g. scrambled faces ERF - faces ERF)

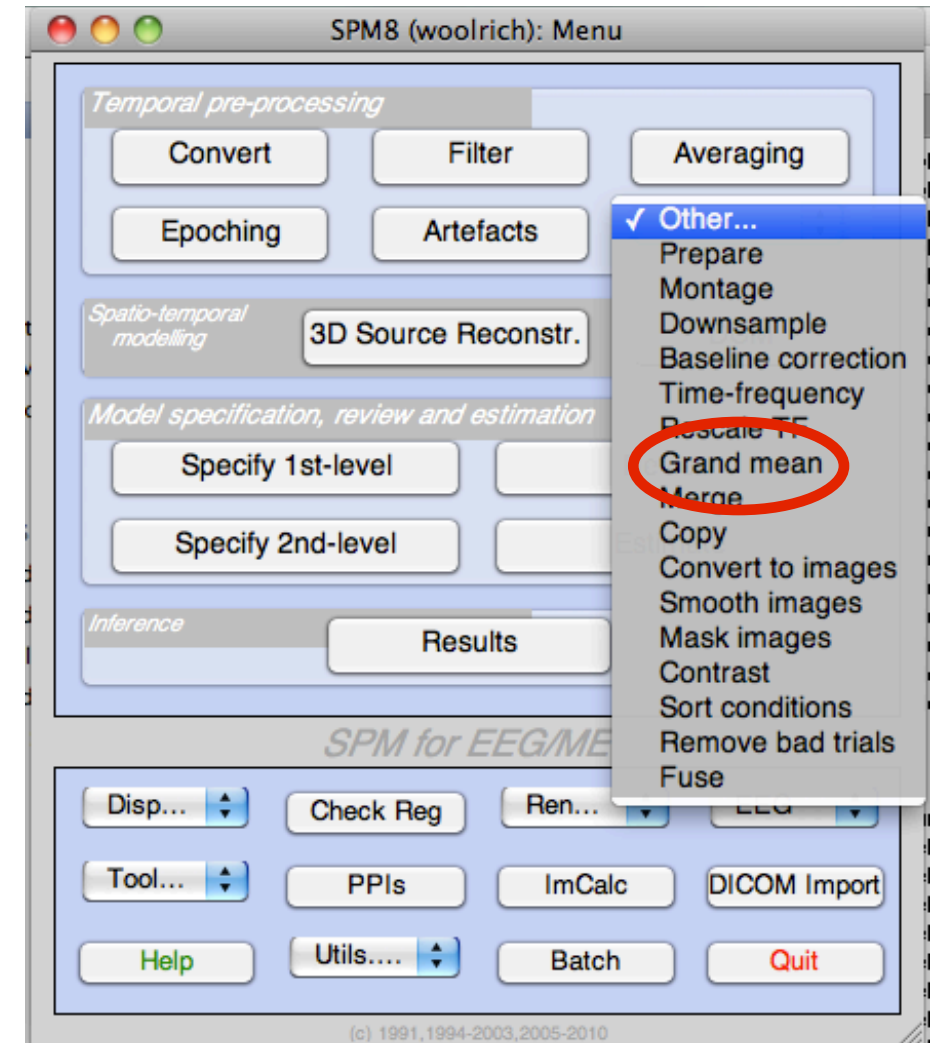


Note: Linear combination, not average. Careful to be fair: $[2 \ -1 \ -1]$

Grand Mean

`spm_eeg_grandmean(S)`, appends 'g'.

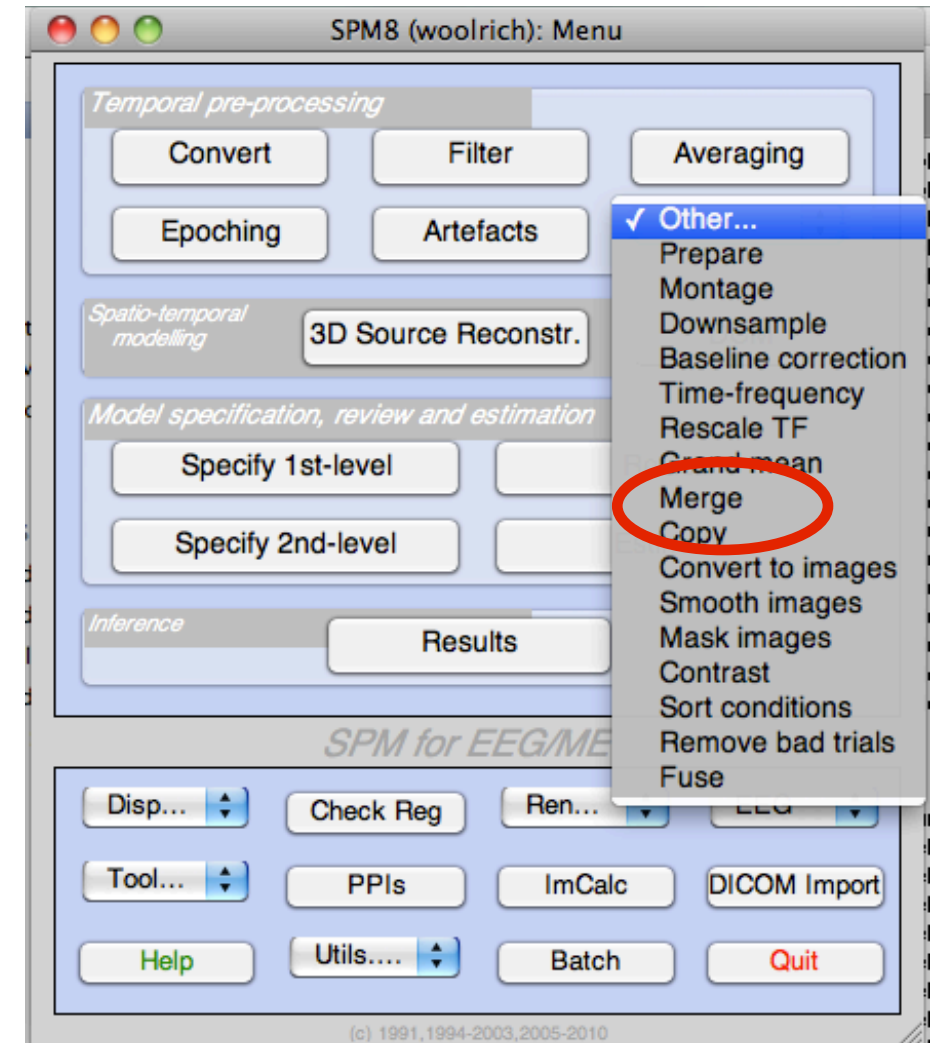
Option to either do averaging weighted by the number of trials in each file (suitable for averaging across sessions within a subject) or do unweighted averaging (suitable for averaging across subjects).



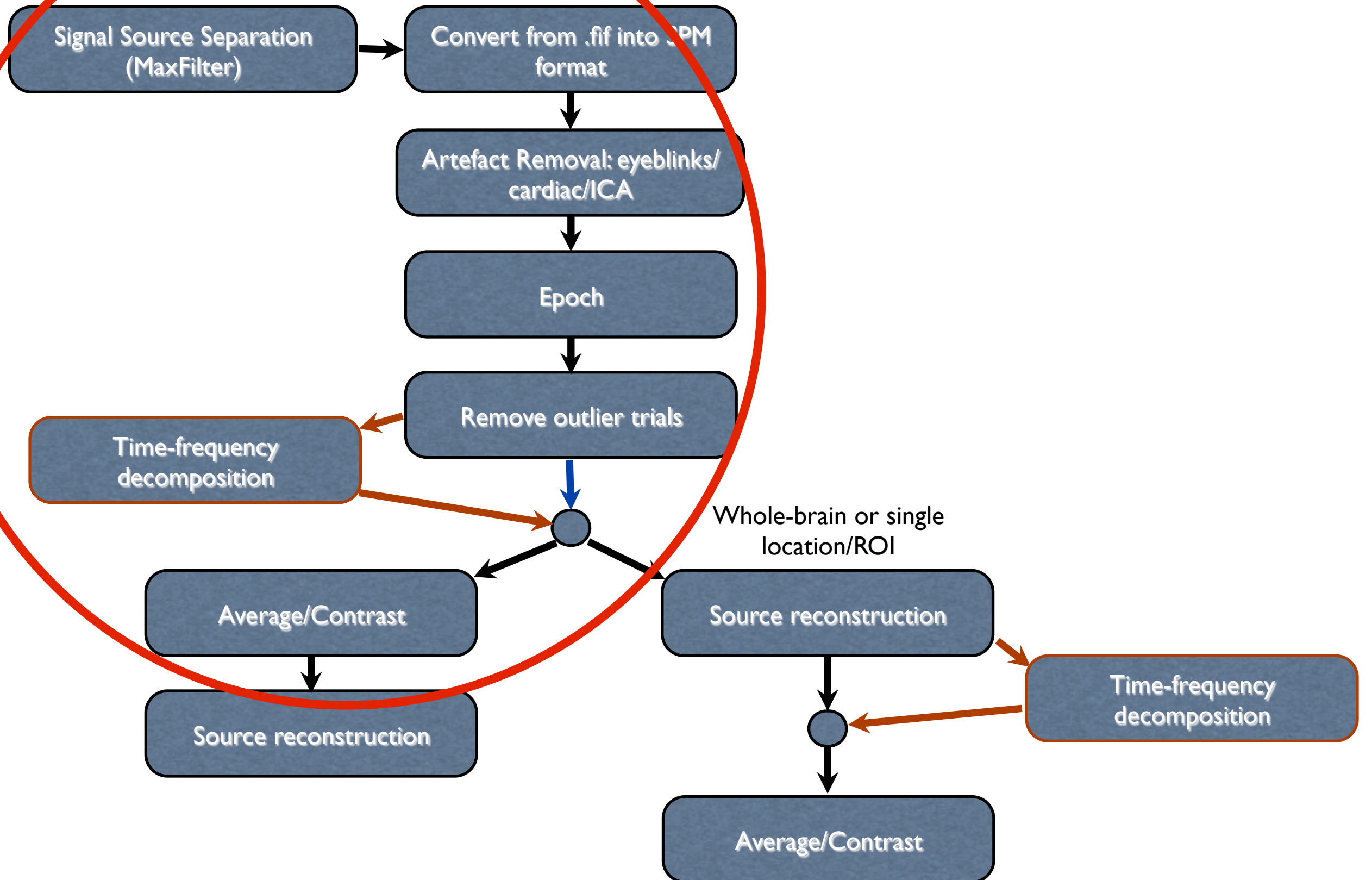
Merge

`spm_eeg_merge(S)`, appends 'c'.

Useful for concatenating multiple sessions for the same subject



MEG Analysis



Resources

- SPM @ Wikipedia
 - ➔ http://en.wikipedia.org/wiki/Statistical_parametric_mapping
- SPM @ Scholarpedia
 - ➔ <http://www.scholarpedia.org/article/SPM>
 - ➔ SPM @ WikiBooks
 - <http://en.wikibooks.org/wiki/SPM>
- MRC-CBU MEG wiki
 - ➔ <http://imaging.mrc-cbu.cam.ac.uk/meg>

Practical: Exploring the M/EEG object

- Download the practical dataset, from the Multi-modal face dataset SPM website.
- See sections 37.1 and 37.2 in the SPM8 manual for a description of the MEG data.
- Open Matlab and enter "spm eeg" from the Matlab command line to launch SPM.
- Follow sections 37.5 to 37.5.8 and 37.5.10 to 37.5.12 in the SPM8 manual (Multimodal face-evoked responses: MEG Analysis).
- Note that the "MEG" directory referred to at the start of section 37.5 is the directory created when you unzip the practical dataset.