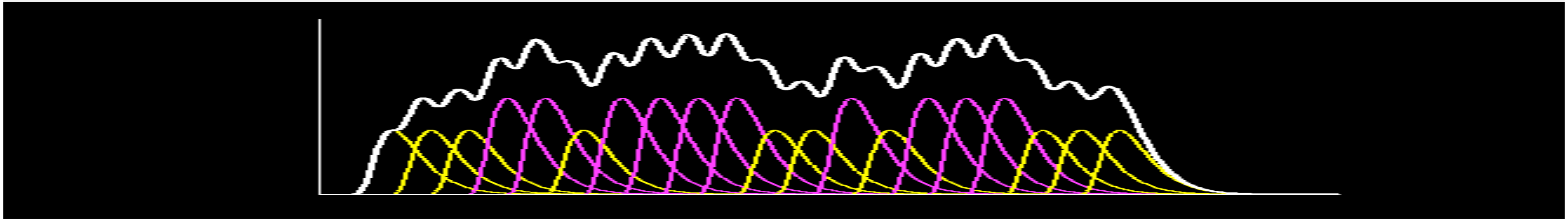
Event-related design efficiency and
How to plot fMRI time series



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NeuroSpin Methods Meeting
15. Sept. 2008

Event-related averaging or FIR?

- event-related fMRI → ability to average responses in peristimulus time
- <u>simple selective averaging</u>
  - for all trials of a given condition, averages the corresponding points in peristimulus time
- <u>FIR (finite-impulse response) formulation of GLM model</u>
  - models each point in PST as a separate regressor of stick functions
  - removes all other modelled effects (effects of no interest and effects of other trial conditions)

ER-averaging

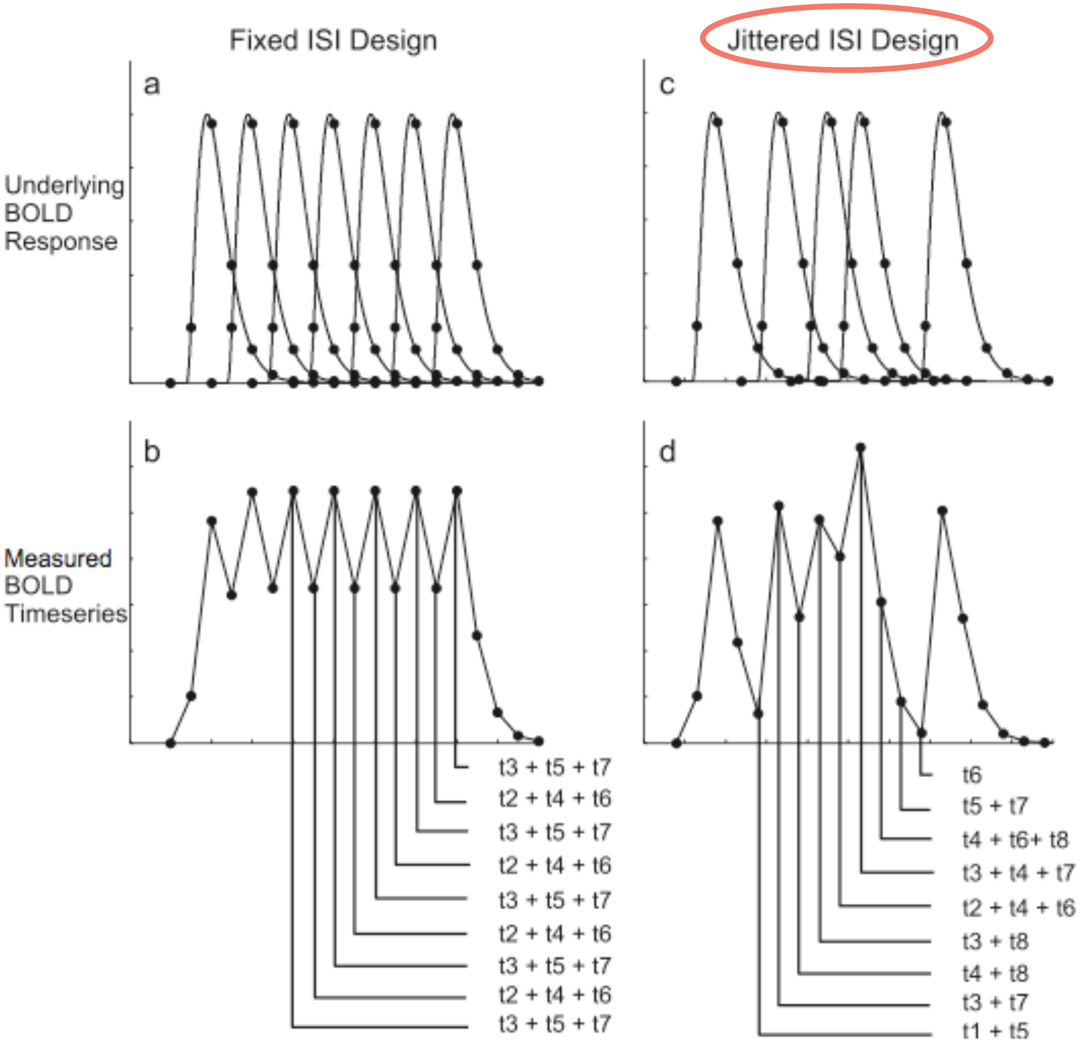
- Adopted from event-related potential literature
- Possible even at ISIs $\geq$ 3s (Dale & Buckner *HBM* 1997)
- Random noise assumed to cancel out over repeated trials
- Strictly necessary: randomised event order! (to average out BOLD-overlap)

FIR modelling

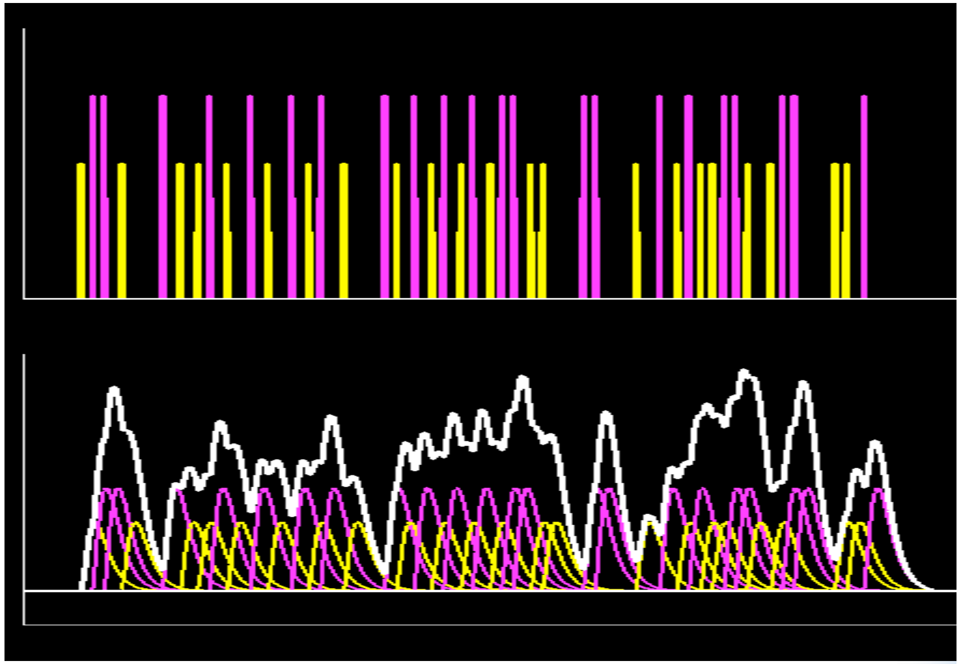
$$
\begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \\ s_5 \\ s_6 \\ s_7 \\ s_8 \\ s_9 \\ \vdots \\ s_t \end{bmatrix}
=
\begin{array}{c}
\begin{array}{ccccccccccc} C & x_{1,1} & x_{1,2} & x_{1,3} & x_{1,4} & x_{1,5} & x_{2,1} & x_{2,2} & x_{2,3} & x_{2,4} & x_{2,5} \end{array} \\
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
\end{array}
*
\begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \\ b_6 \\ b_7 \\ b_8 \\ \vdots \\ b_n \end{bmatrix}
+
\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \\ \varepsilon_9 \\ \vdots \\ \varepsilon_t \end{bmatrix}
$$

$$S = X * b + \varepsilon$$

FIR modelling – estimation efficiency



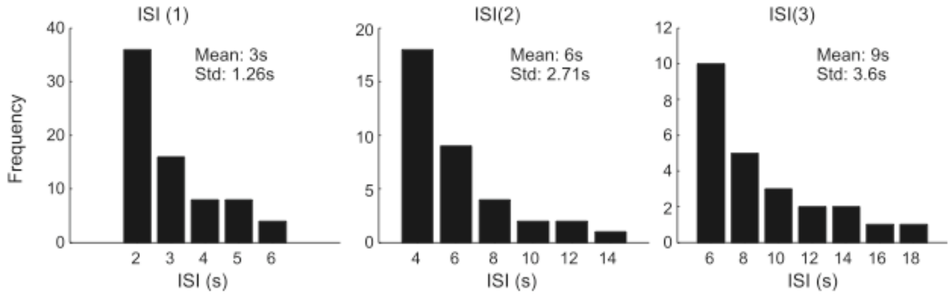
Best estimation efficiency:
jittered ISI and
randomised event order



Direct comparison: simulations
Serences, *NeuroImage* 2004

Methods:

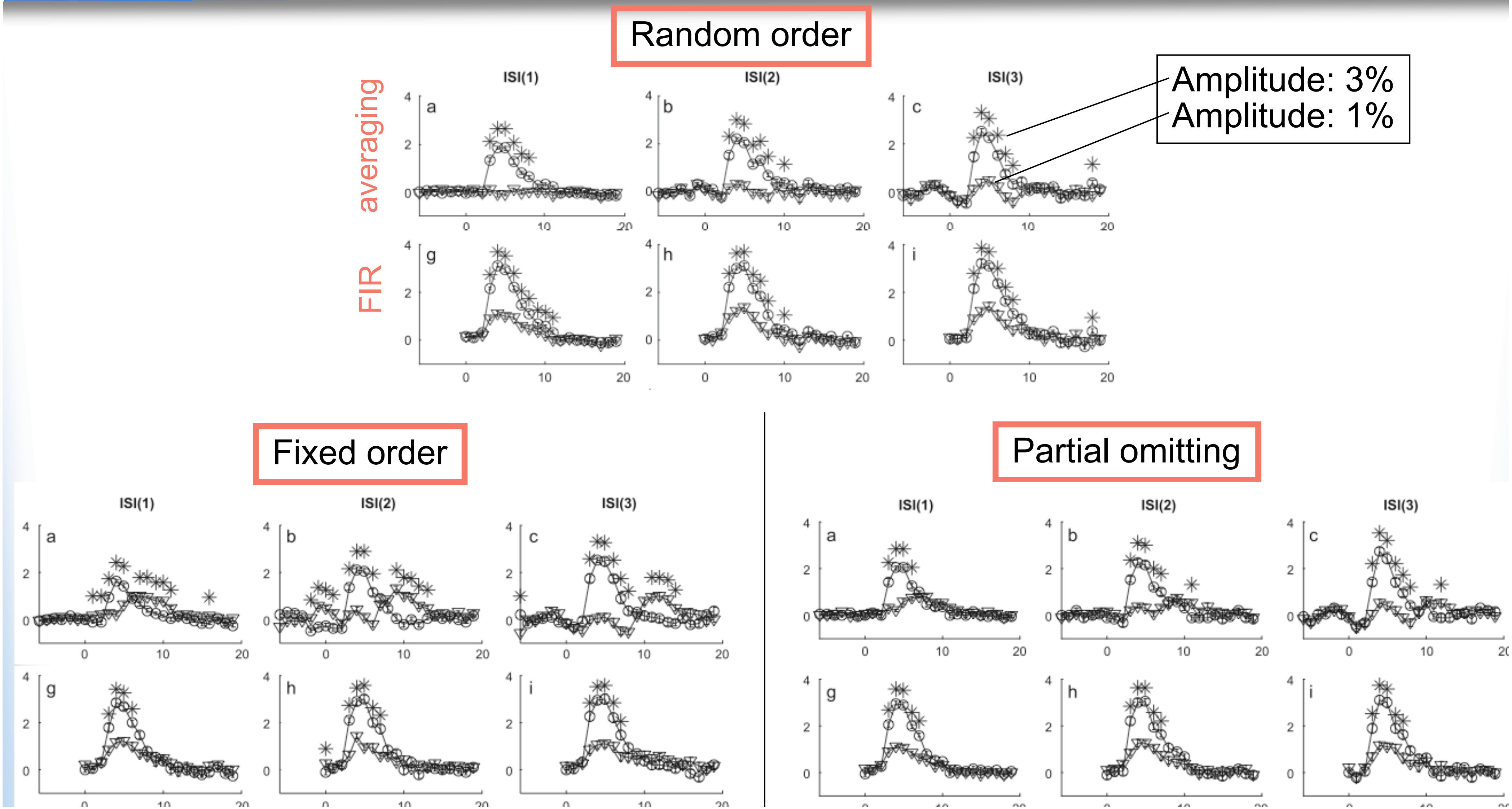
- simulated experiments using a gamma HRF and 4 conditions
  - [1] Independent event ordering
    [2] Fixed event ordering (event A always followed by event B)
    [3] "Partial" event ordering (30% omissions of event B)
  - each experiment at different jitter ranges (always jittered)



- analyse with
  - [1] ER-averaging
  - [2] deconvolution

Direct comparison: simulations

Serences, *NeuroImage* 2004



ER-averaging or FIR-modelling?

- A question of experimental design!
- Very sparse ER-design (ISI>20s)
  or ISI>6s AND strictly randomised order
  → ER-averaging possible
- Otherwise, FIR-modelling. Estimation efficiency of deconvolution depends on order randomisation and ISI jittering (Dale, *HBM* 1999)

Time course plotting

Defining ROI

ROIs from <u>MarsBar</u> (functional, geometric, anatomic)

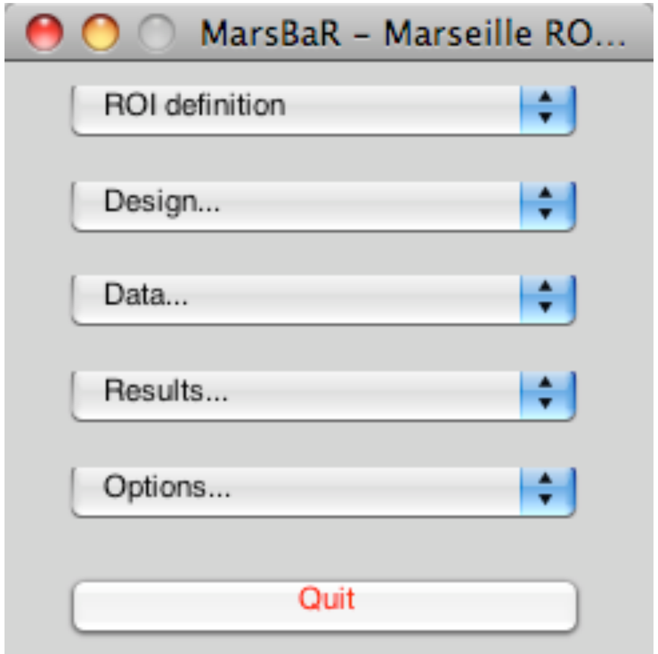
ROIs from <u>Anatomy toolbox</u> (cytoarchitectonic)

ROIs from <u>WFU PickAtlas toolbox</u> (anatomic)

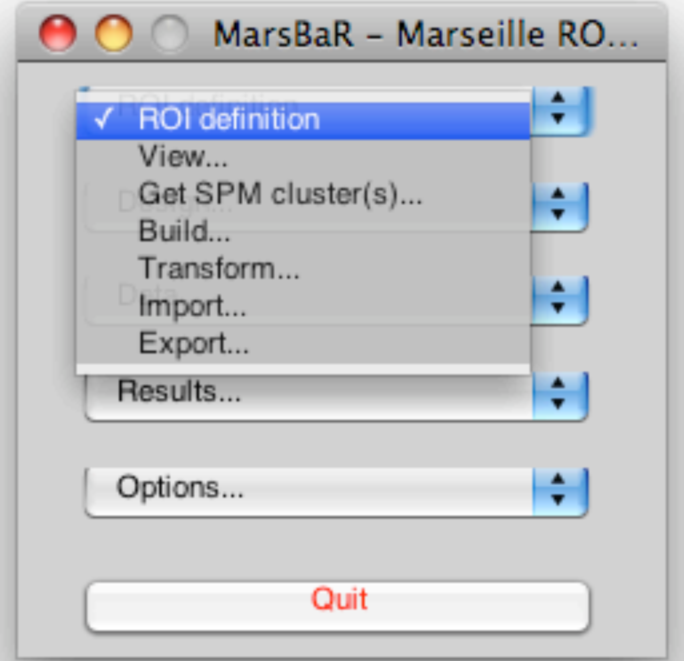
Segmented compartments (grey matter, white matter, CSF (spm)

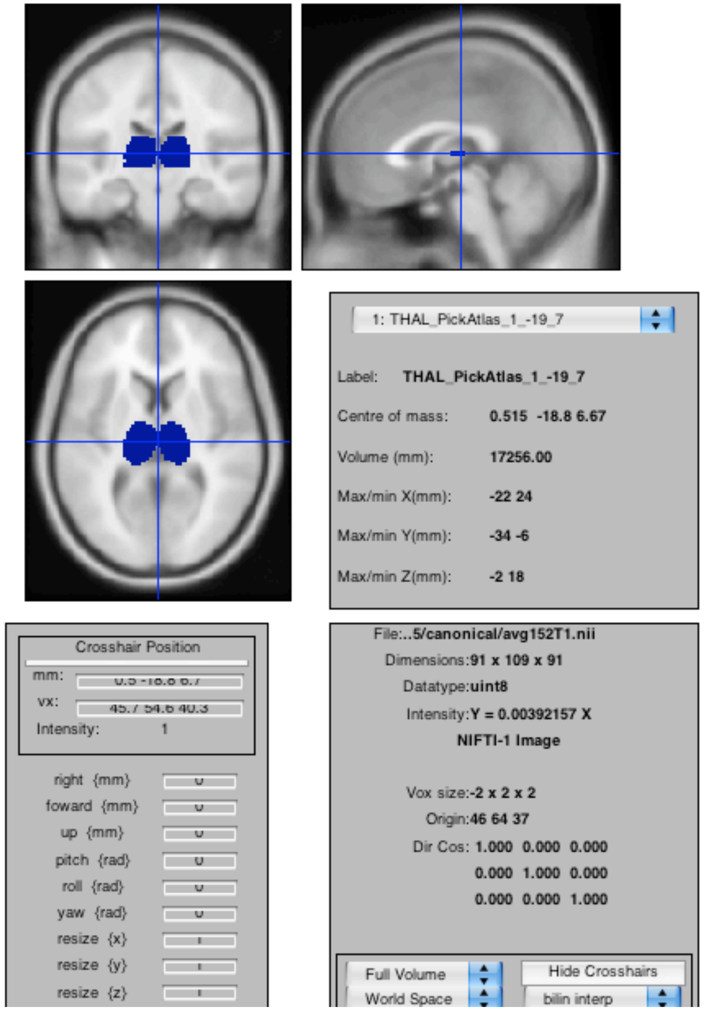
MarsBaR
(MARSeille Boîte À Région d'Intérêt)

- http://marsbar.sourceforge.net/
- Toolbox for SPM, all platforms

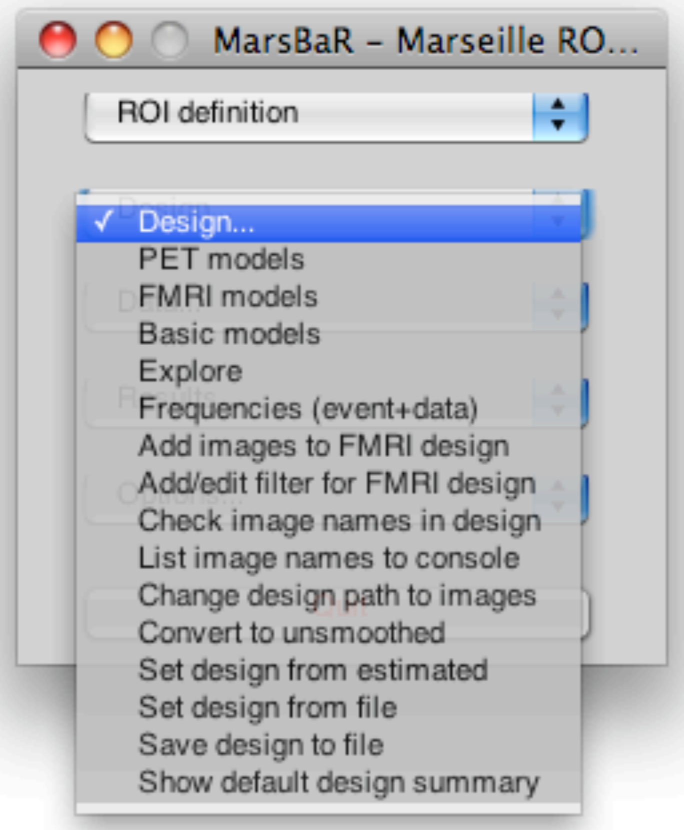


MarsBaR
ROI definition

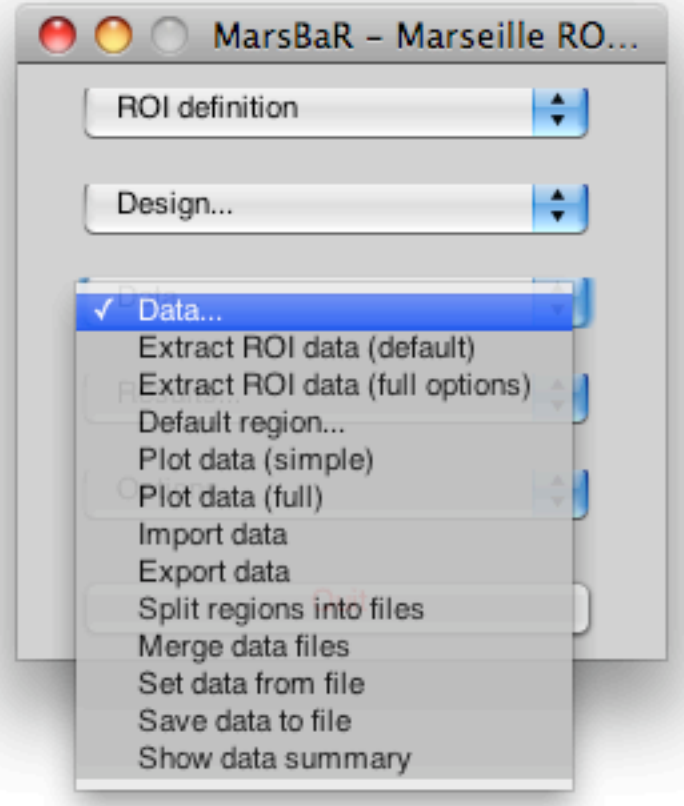


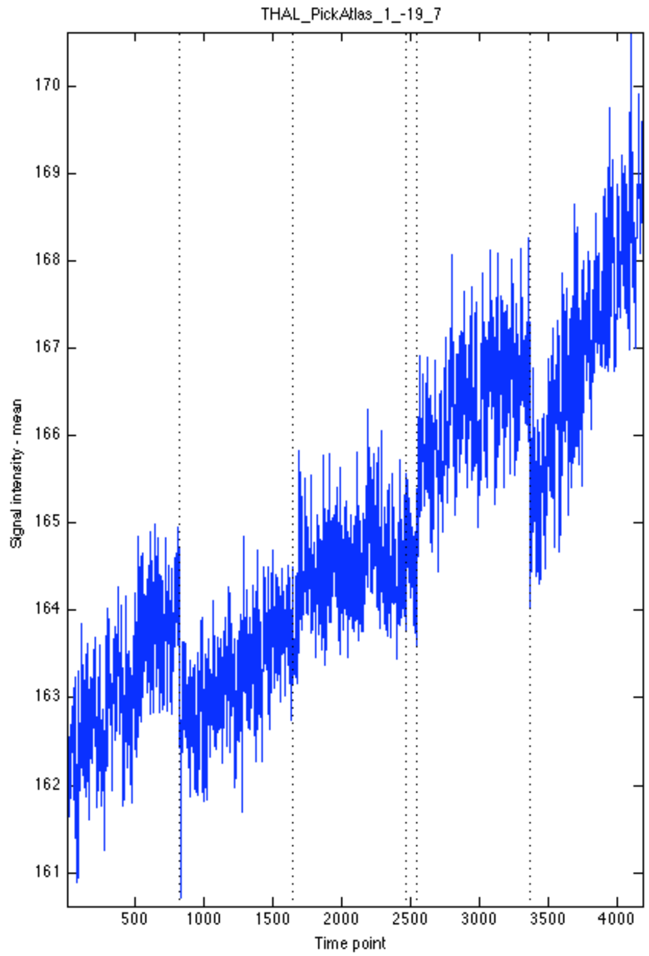


MarsBaR design specification

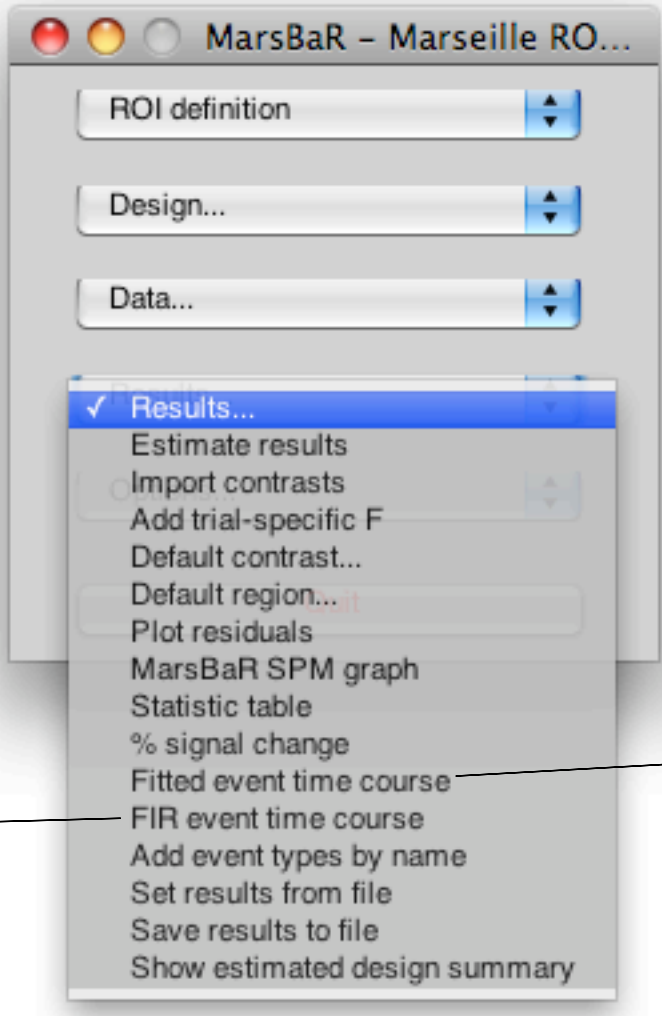


MarsBaR data extraction





MarsBaR
model estimation + plotting



ER-averaging???

Statistics:
"does area A on average activate more for condition 1 than condition 2 ?"

Regressor * Beta
(in forward convolution model!

FIR

MATLAB/SPM Scripting

1. Define voxels
   from which time course is to be extracted
2. Extract data
   (raw signal or beta estimates)
3. Arrange data

   Separate beta estimates (FIR)

   or

   perform selective averaging (ER)

1. Define voxels – Clucter from maskfile

```
% get cluster of interest from a maskfile, e.g.
                    - ROIs from marsbar, Anatomy toolbox, WFU PickAtlas toolbox

                                                          % XYZ is a 3xn matrix of x-y-z-triplets
maskfile = 'filename.nii'     % or .img
maskvalues = spm_get_data(maskfile, XYZ);      % nx1 linear array of values
myCluster = XYZ(:, find(maskvalues>0.5));        % triplets of x-y-z-indices
```

1. Define voxels – Cluster from loaded contrast

```
% get cluster of interest from spm graphics window (for a loaded contrast --> xSPM)
[xyz,vx_i]=spm_XYZreg('NearestXYZ', spm_XYZreg('GetCoords',hReg),xSPM.XYZmm);

    % or alternatively set pre-specified location of voxel
    xyz = [66 -27 24];              % in Talairach space
    vx_i = spm_XYZreg('FindXYZ', xyz, xSPM.XYZmm);

XYZ = xSPM.XYZ(:, vx_i);       % in SPM space
%-----------------------------------------------------
% peak voxel
myCluster = XYZ;

% activation cluster    (from marsbar's mars_blob2roi.m)
clusters = spm_clusters(xSPM.XYZ);
myCluster = xSPM.XYZ(:, clusters==clusters(vx_i));  % all voxels that have the same cluster
                                                     index as xyz's index
% sphere     (from spm_regions.m)
d  = [xSPM.XYZmm(1,:) - xyz(1);     xSPM.XYZmm(2,:) - xyz(2);    xSPM.XYZmm(3,:) - xyz(3)];
Q = find(sum(d.^2) <= sphere_radius^2);
myCluster = xSPM.XYZ(:, Q);
```

2. Extract data

```
load SPM.mat;


% beta estimates of FIR model        % SPM.Vbeta contains filenames of beta-maps
y = spm_get_data(SPM.Vbeta, myCluster);


%----------------------------
% or original time course for selective (ER-) averaging
                                          % SPM.xY.VY contains filenames of orig data
y = spm_get_data(SPM.xY.VY, myCluster);      % data from original images that were fed
                                              into the GLM analysis

% eventually in addition
y = SPM.xX.W*y;                           % prewhitening (sphericity correction)
y = spm_filter(SPM.xX.K, y);              % high-pass filtering
% or for linear detrending
y = spm_detrend(y, 1)                         % but split y session-wise !!!
```

3. Arrange data

separate Beta estimates for the different events

Or

perform selective averaging across all occurrences of each event