



# Dynamic causal modeling

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# TODAY'S TUTORIAL

Dynamic causal modeling (DCM):

- Brief reminder on task and dataset
- Setting up a DCM analysis using SPM12
- Bayesian model selection (BMS) and Bayesian model averaging (BMA)

# DATASET: BUTTON PRESSES

Experimental Paradigm:

**Stimuli:** Arrows pointing to the left or right.

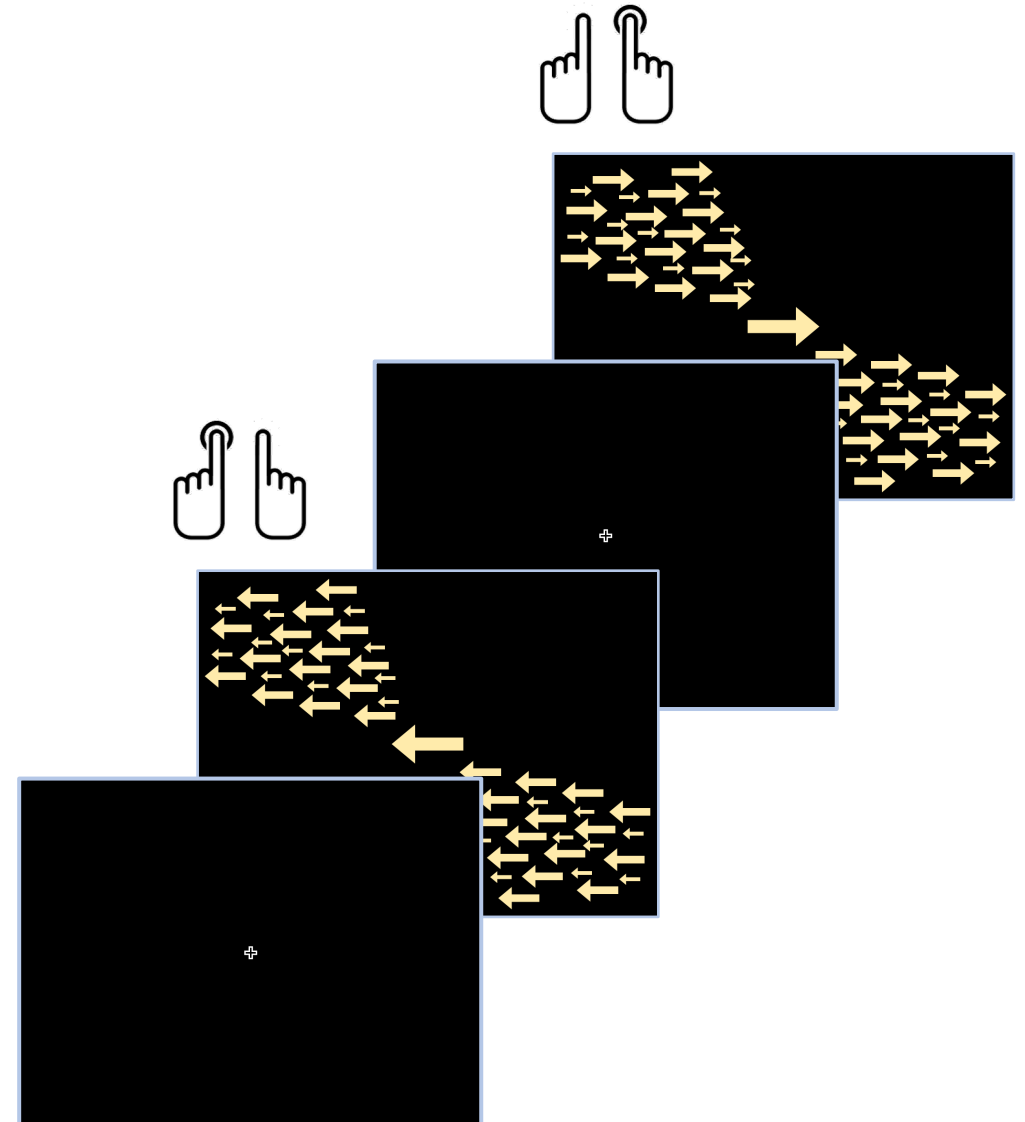
**Scanning:** Button presses with respective hand.

- F: fixation
- LH: button press with left hand
- RH: button press with right hand

6 LH- and 6 RH-blocks (10 button presses per block)

Each block lasted roughly 14 s

TR = 2.2 s, TE = 36 ms

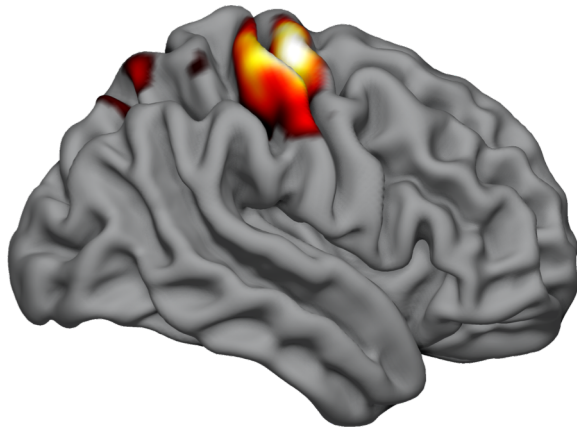


# RESULTS: BOLD ACTIVITY

Exemplary single-subject (*Sub003*) results:

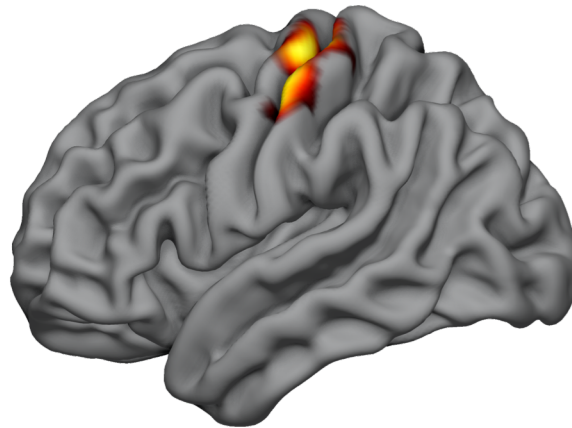
## right M1

(left hand > right hand)



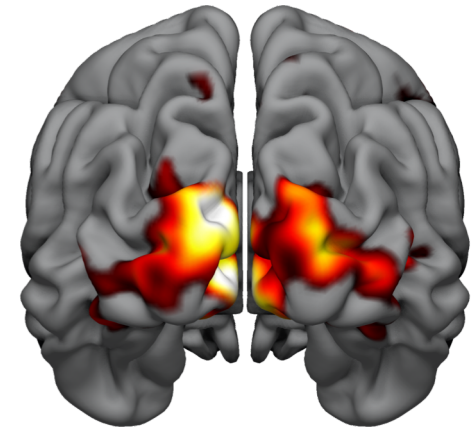
## left M1

(right hand > left hand)



## V1

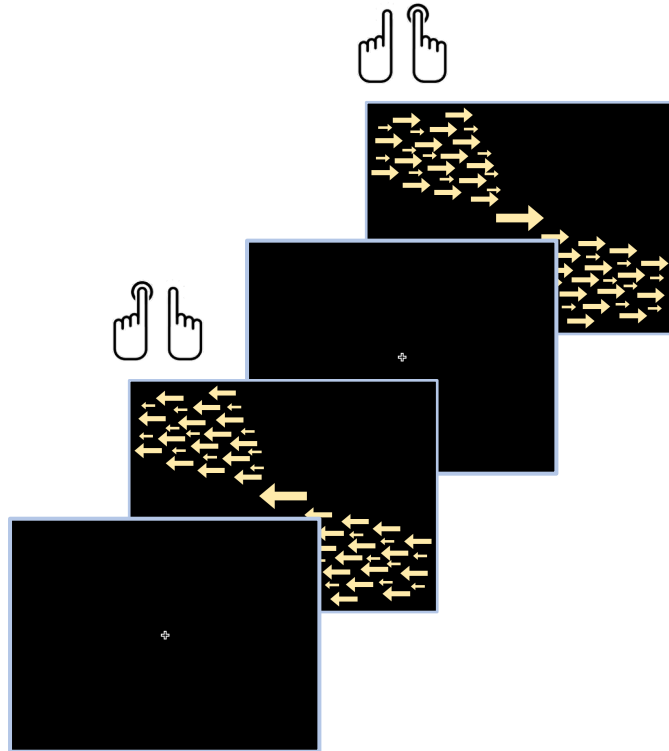
(left + right hand > baseline)



$p < 0.001$ , uncorrected

# DYNAMIC CAUSAL MODELING

Ingredients for DCM analysis:



- Specific hypothesis/question
- Model: based on hypothesis
- Time-series: extract from the SPM
- Inputs: experimental conditions from the design matrix

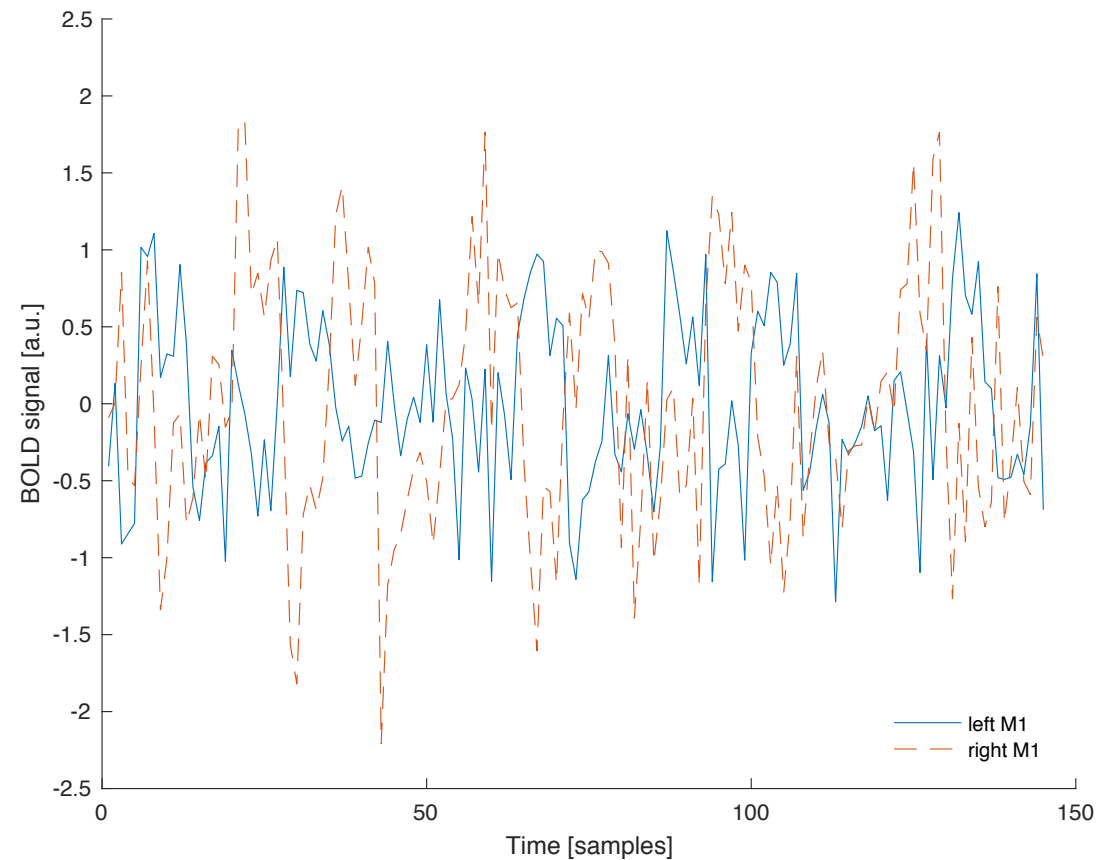
# DYNAMIC CAUSAL MODELING

Recipe for DCM analysis (using the GUI in SPM):

1. extract the time series from all regions of interest (eigenvariate of all voxels in the regions of interest) → **Done!**

# DYNAMIC CAUSAL MODELING

Get a feeling for the data: exemplary single-subject (*Sub003*)



# DYNAMIC CAUSAL MODELING

Recipe for DCM analysis (using the GUI in SPM):

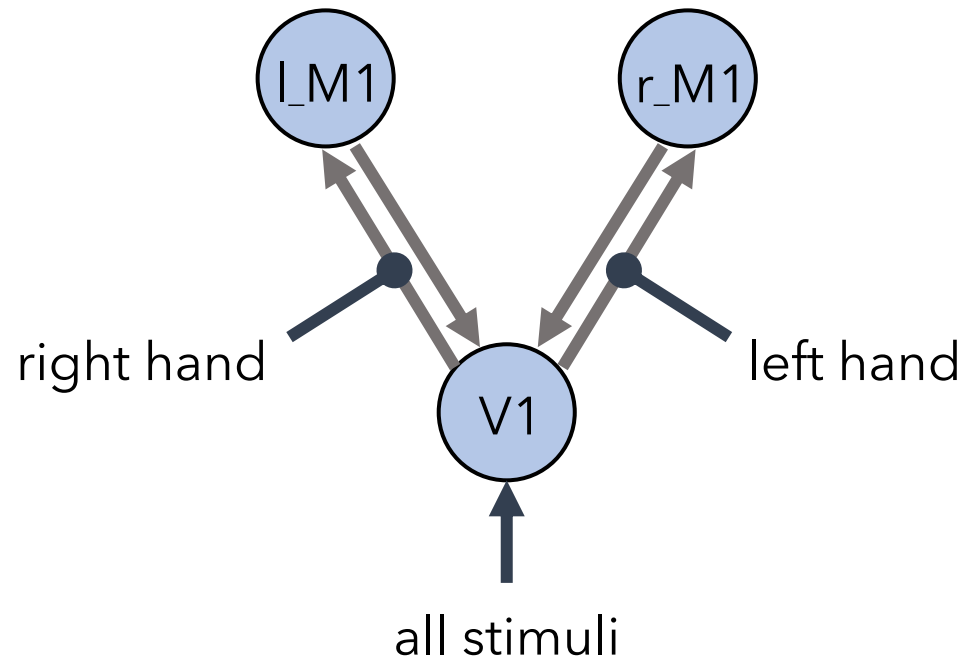
1. extract the time series from all regions of interest (eigenvariate of all voxels in the regions of interest) → **Done!**
2. specify the model according to your hypotheses about the underlying network architecture



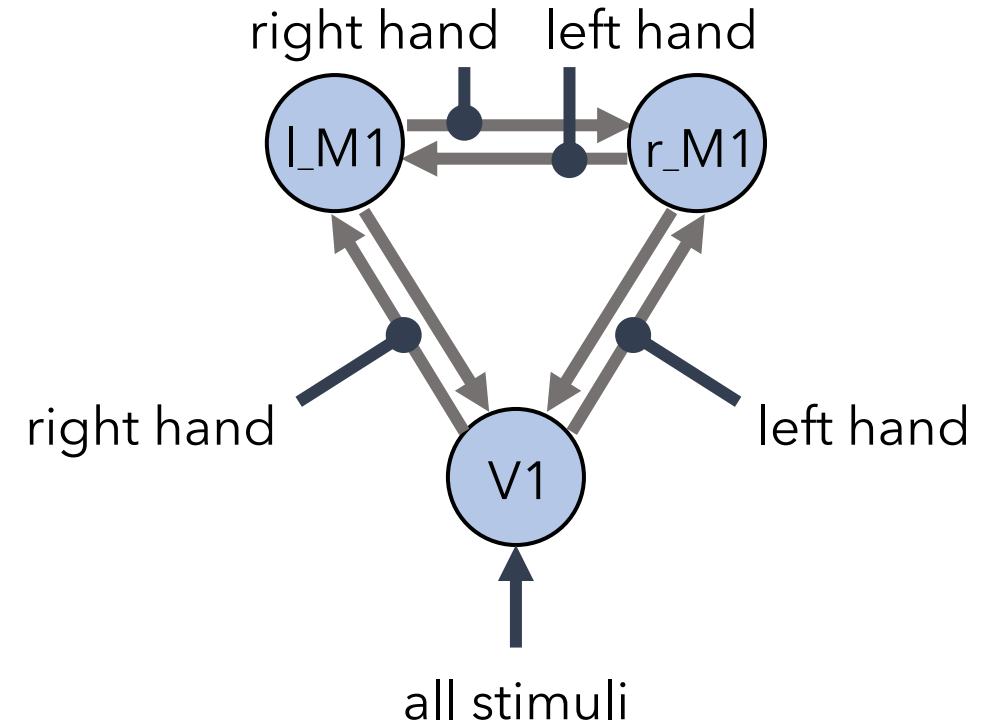
# DYNAMIC CAUSAL MODELING

Is there interhemispheric inhibition during motor responses ?

Model 1



Model 2



# DYNAMIC CAUSAL MODELING

Where to specify DCMs in SPM2 ?

The screenshot displays the MATLAB SPM12 interface. On the left, the 'HOME' menu is visible with various options. The 'Dynamic Causal Modelling' button is circled in red and labeled with a red '1'. Below it, the 'Specify 1st-level' and 'Specify 2nd-level' buttons are also visible. The 'Results' section is also circled in red and labeled with a red '2'. The main window shows the 'Welcome to SPM12' message, a brain diagram, and a 'Command History' window on the right containing MATLAB code for plotting a histogram.

```
hold on
ha(1) = bar(X+0.0001,N,'E...
axis square
box off
set(gca,'TickDir','out');
h.CurrentAxes.FontSize = 18;
title(['histogram - asymm...
xlabel('degree of asymmet...
ylabel('number #','FontS...
xlim([-1 1])
legend(ha,'asymmetry','c...
legend boxoff
1082000
1082000/25
208*12
208*2
208*2-43280
lose all
close all
statistics_rDCM_parameter...
N
1076400/25
208*2
(208*2)-43056
ylim([0 100000])
ylim([0 500000])
ylim([0 50000])
ylim([0 500000])
ylim([0 100000])
ylim([0 500000])
ylim([0 50000])
ylim([0 1500000])
ylim([0 1200000])
ylim([0 1100000])
ylim([0 100000])
close all
%-- 06.12.19, 08:58 --%
get_rDCM_time_MainExperim...
p0_array = 0.4:0.05:0.95
length(p0_array)
2x edit spm_nlsi_GN.m
```

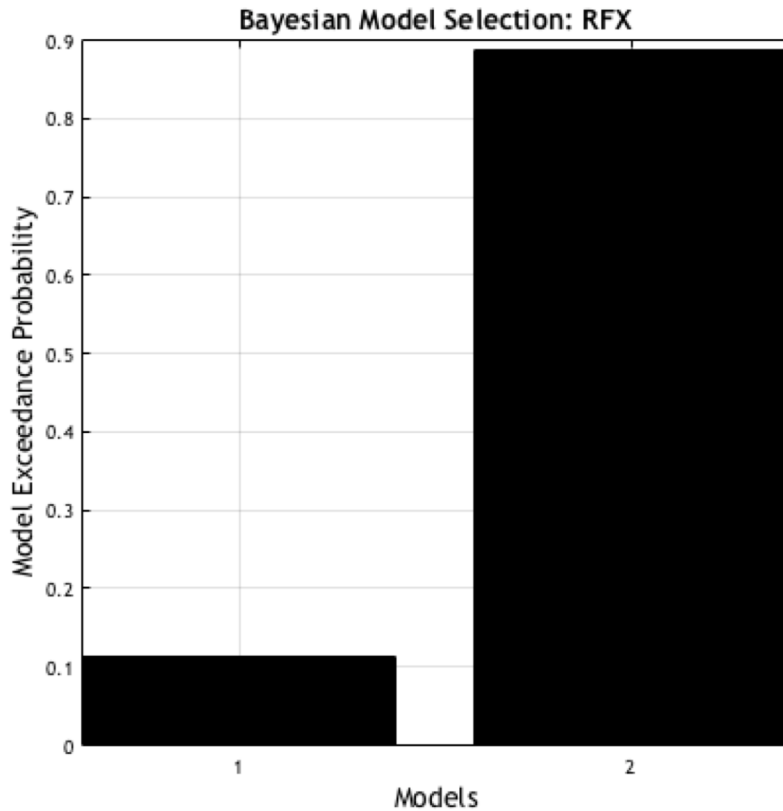
# DYNAMIC CAUSAL MODELING

Recipe for DCM analysis (using the GUI in SPM):

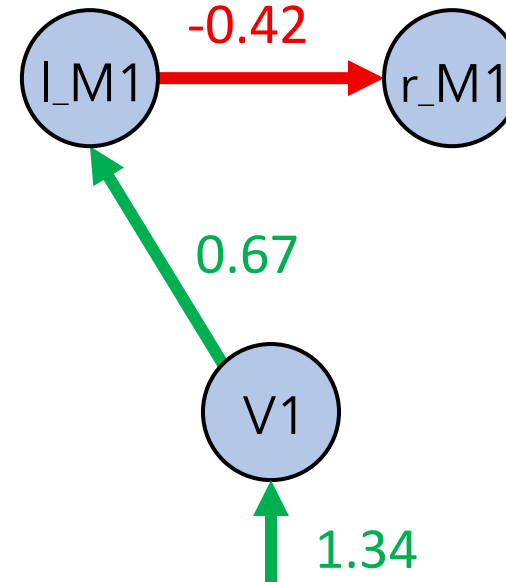
1. extract the time series from all regions of interest (eigenvariate of all voxels in the regions of interest) → **Done!**
2. specify the model according to your hypotheses about the underlying network architecture
3. estimate the model
4. repeat steps 2 and 3 for all models in your model space and all the subjects
5. perform Bayesian model selection (BMS) or Bayesian model averaging (BMA)
6. inspect posterior parameter estimates of effective connectivity parameters (A, B, and C-matrix)

# DYNAMIC CAUSAL MODELING

Bayesian model selection and Bayesian model averaging results:

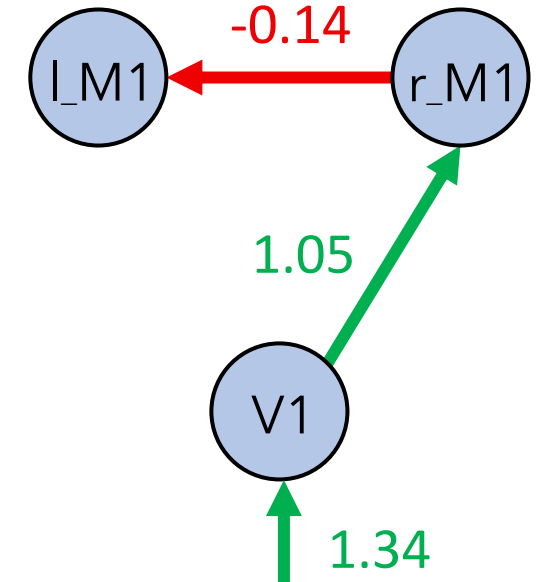


right hand  
(modulatory influences)



all stimuli  
(driving inputs)

left hand  
(modulatory influences)



all stimuli  
(driving inputs)

Questions



THANK YOU FOR YOUR ATTENTION !

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