Dynamic causal modeling

Stefan Frässle

Translational Neuromodeling Unit (TNU)
University of Zurich & ETH Zurich

Methods and Models for fMRI analysis, Practical Session
Tuesday, December 10th 2019

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.

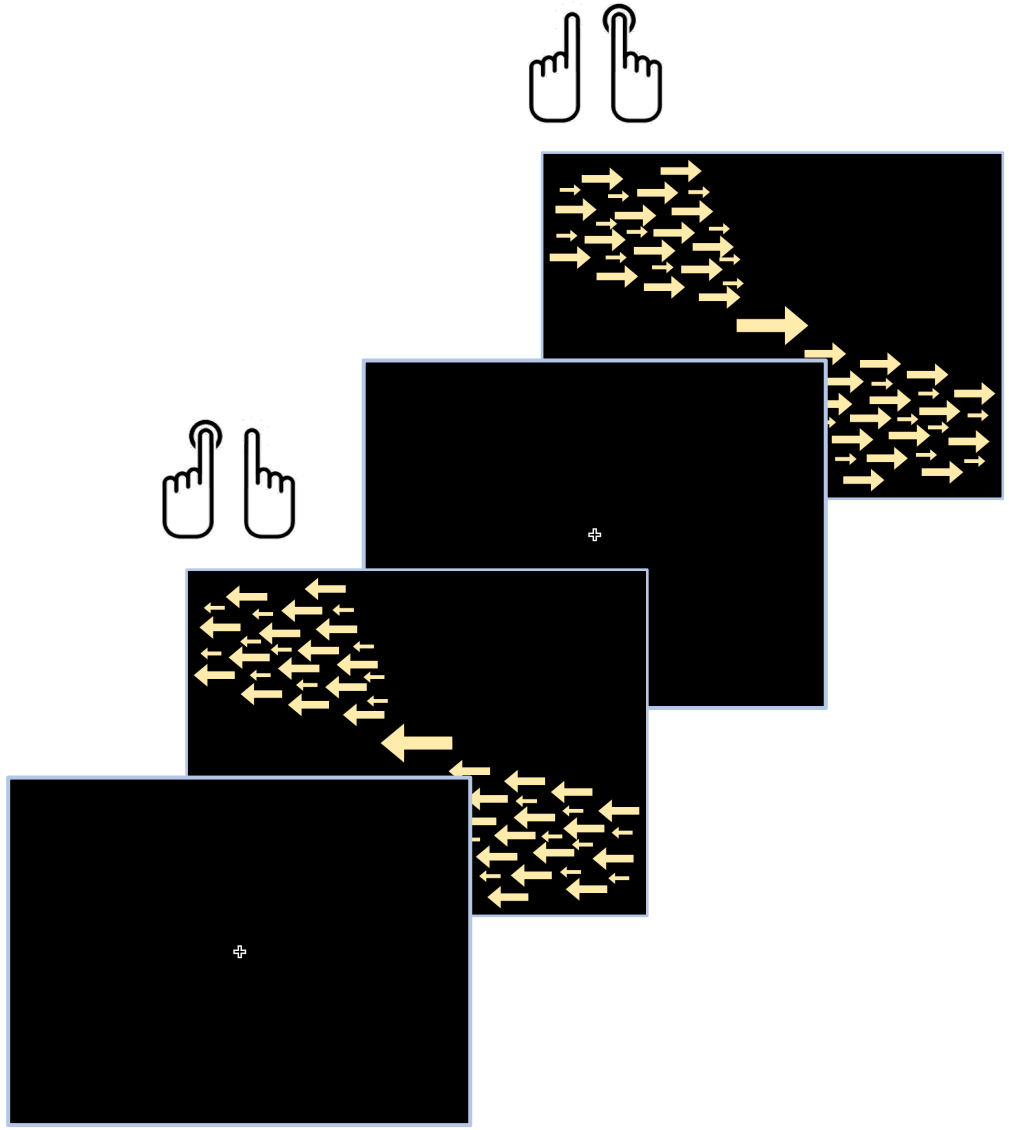
Scanning: Button presses with respective hand.

- 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

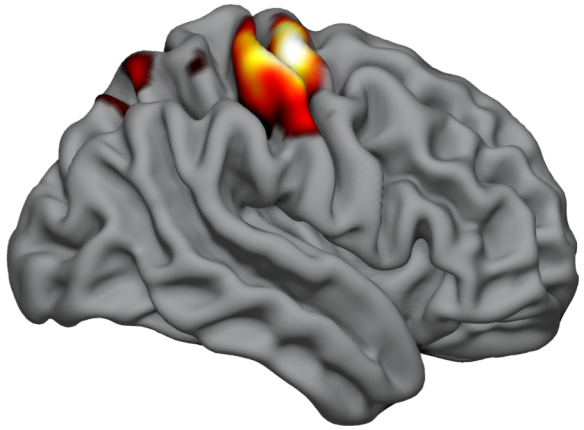


Results: BOLD activity

Exemplary single-subject (*Sub003*) results:

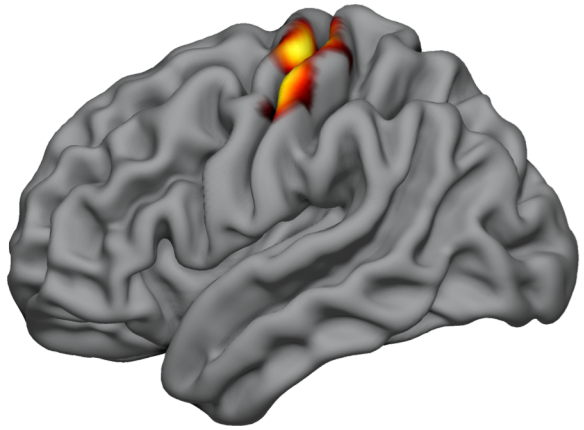
right M1

(left hand > right hand)



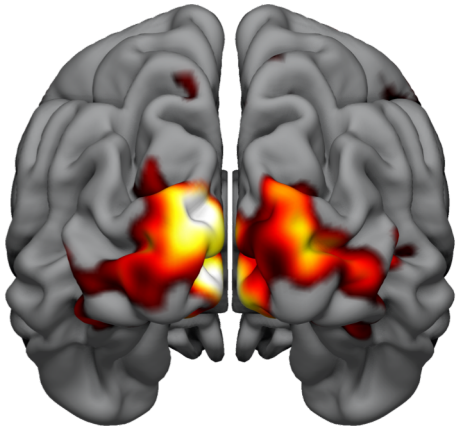
left M1

(right hand > left hand)



V1

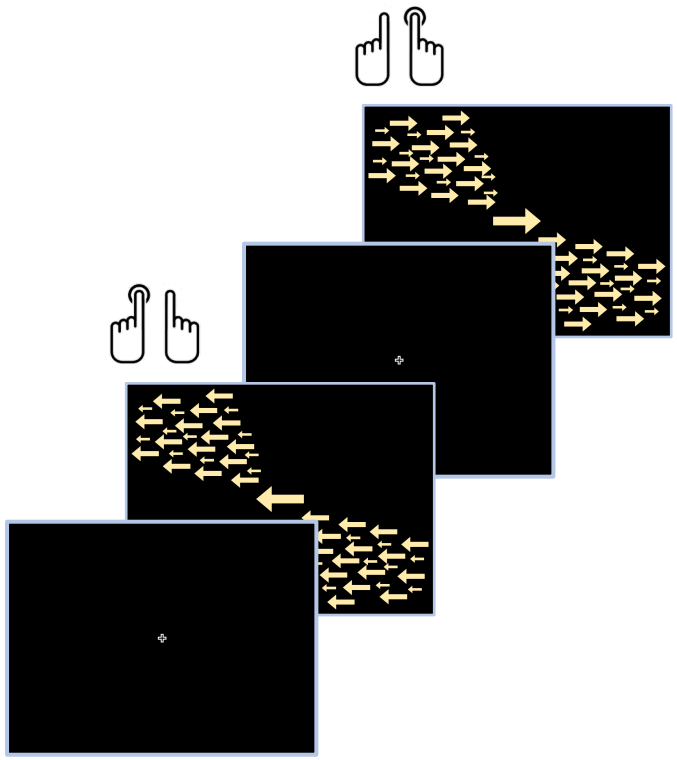
(left + right hand > baseline)



$p < 0.001$, *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

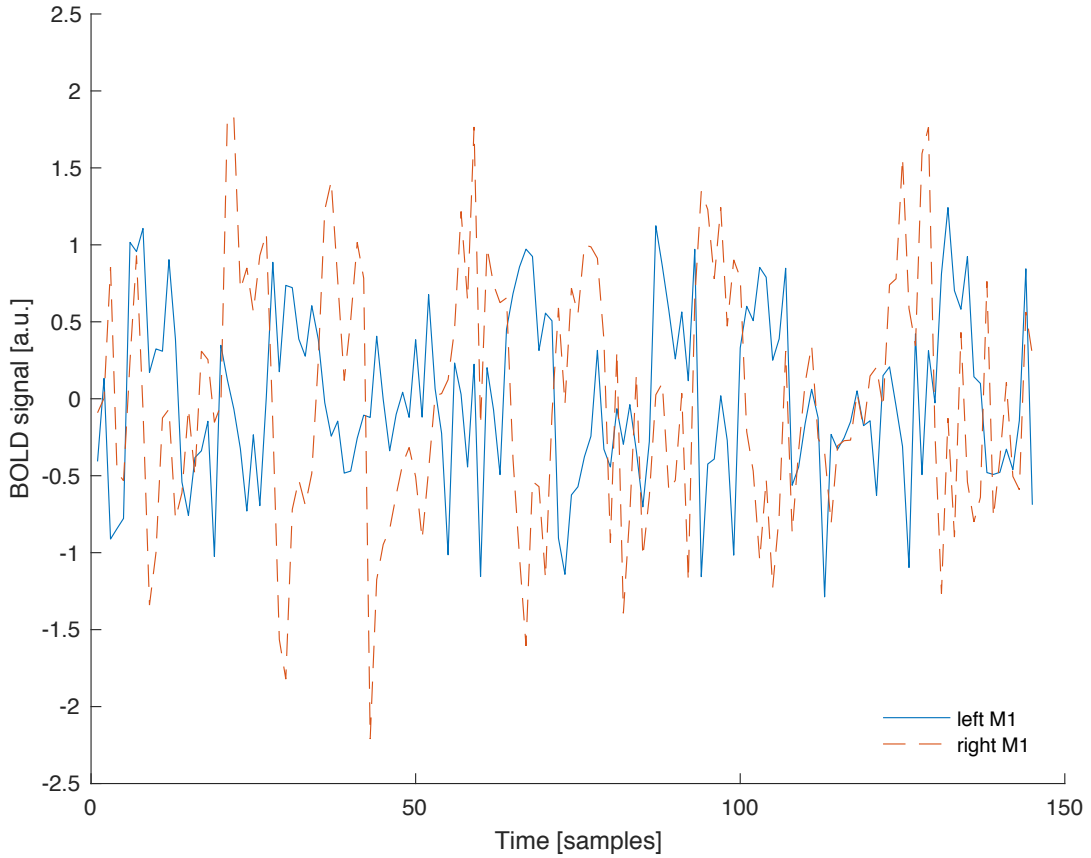
Dynamic Causal Modeling

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

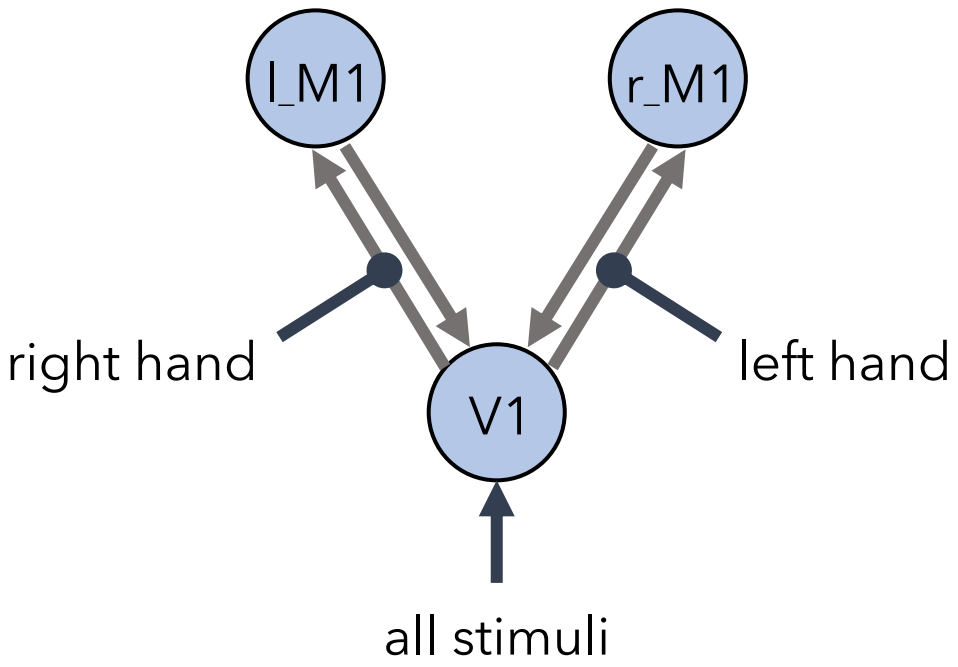
Recipe for DCM analysis (using the GUI in SPM):

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

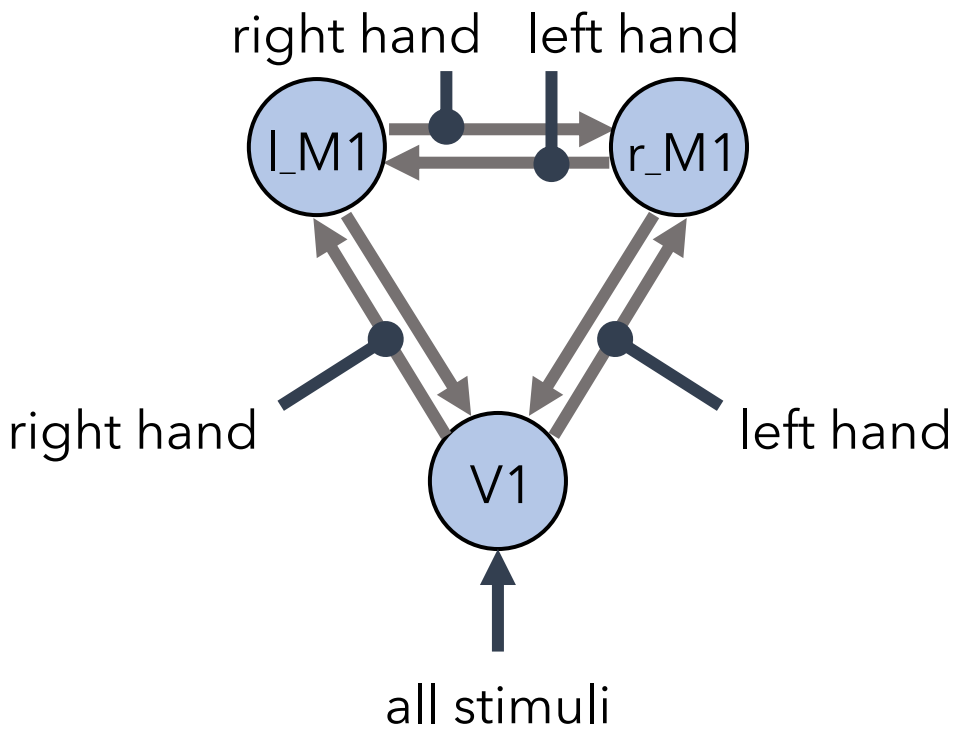
Dynamic Causal Modeling

Is there interhemispheric inhibition during motor responses ?

Model 1

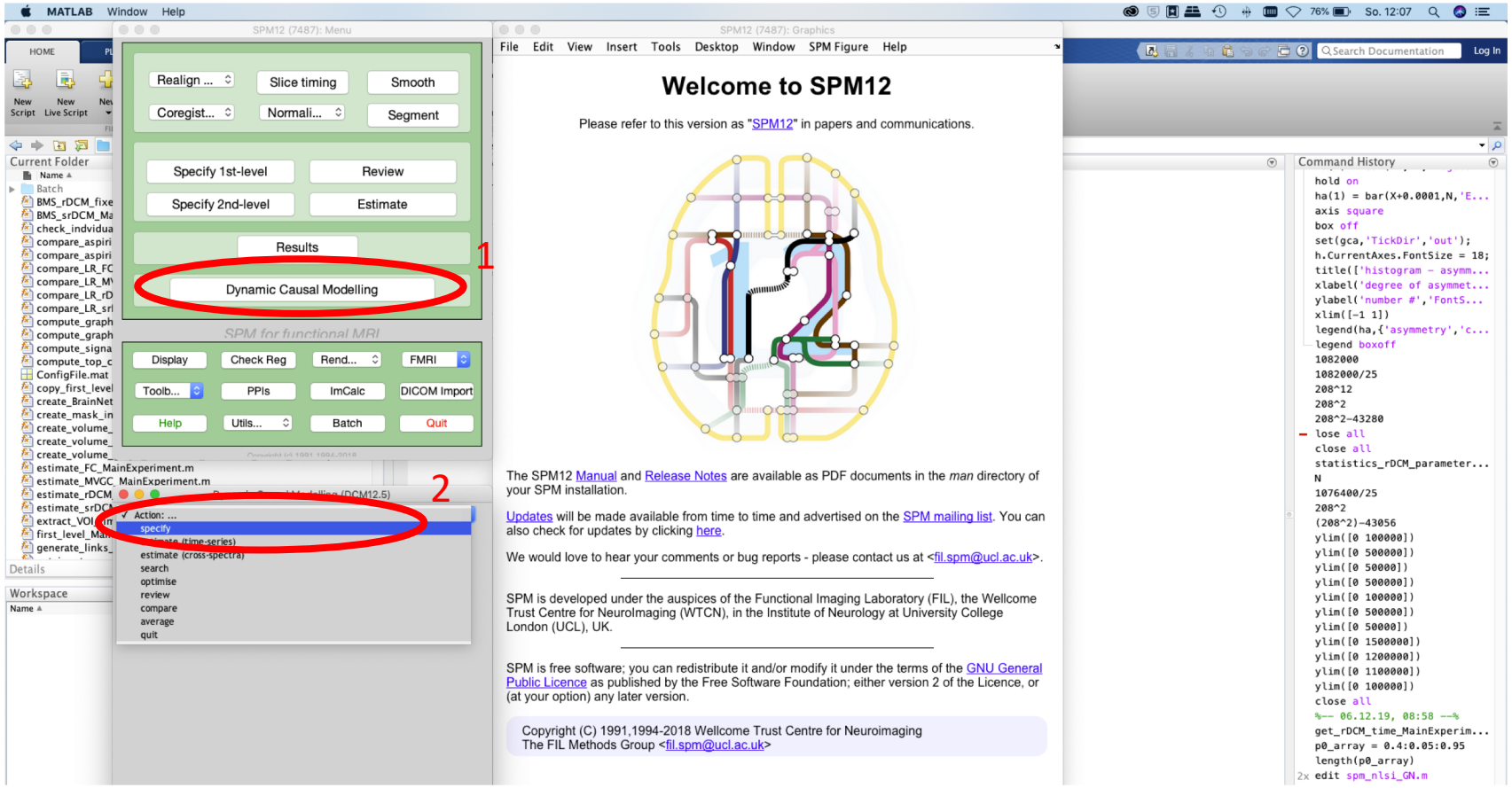


Model 2



Dynamic Causal Modeling

Where to specify DCMs in SPM2 ?



Dynamic Causal Modeling

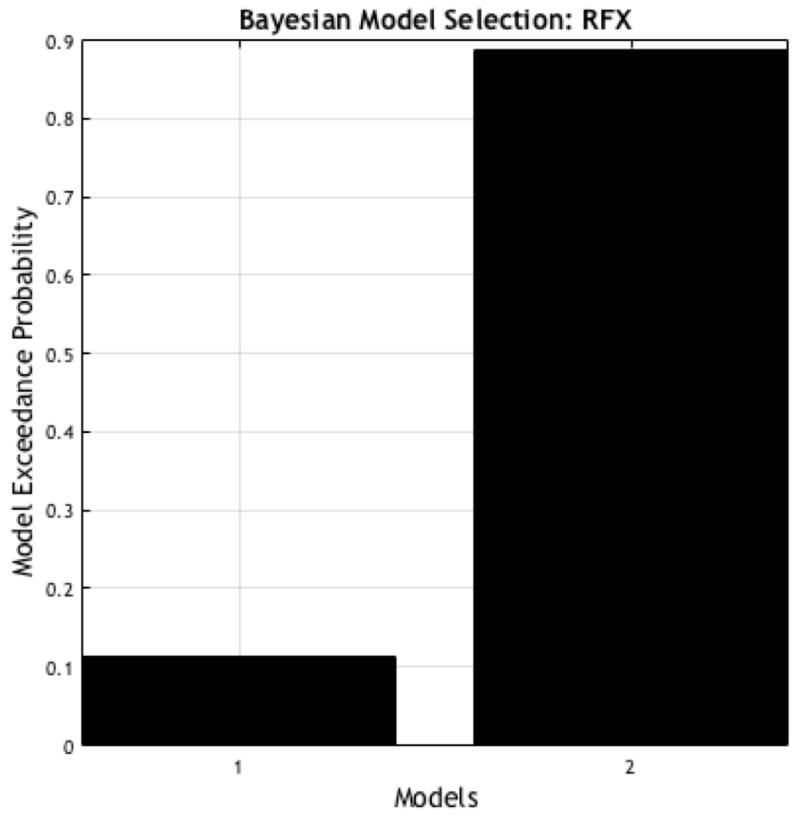
Recipe for DCM analysis (using the GUI in SPM):

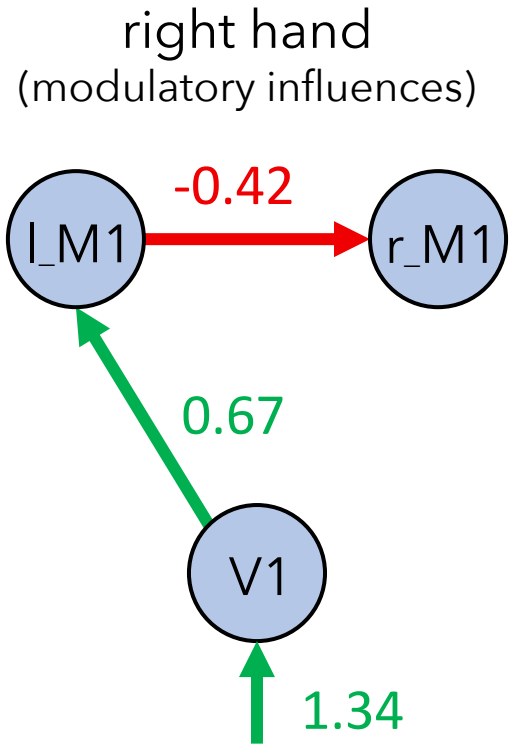
1. extract the time series from all regions of interest (eigenvariate of all voxels in the regions of interest) → **Done!**
2. specify the model according to your hypotheses about the underlying network architecture
3. estimate the model
4. repeat steps 2 and 3 for all models in your model space and all the subjects

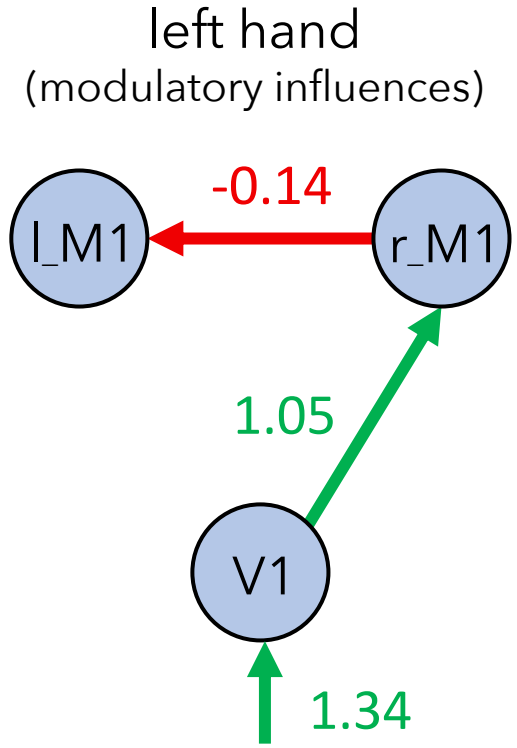
5. perform Bayesian model selection (BMS) or Bayesian model averaging (BMA)
6. inspect posterior parameter estimates of effective connectivity parameters (A, B, and C-matrix)

Dynamic Causal Modeling

Bayesian model selection and Bayesian model averaging results:







Questions

Thank you for your Attention !

Stefan Frässle, PhD
Translational Neuromodeling Unit (TNU)
University of Zurich & ETH Zurich

Email: stefanf@biomed.ee.ethz.ch
Phone: +41 44 634 91 14
@stefan_fraessle