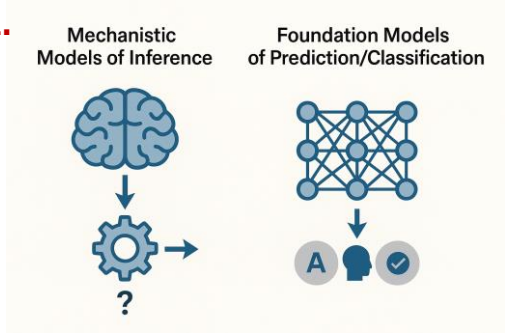
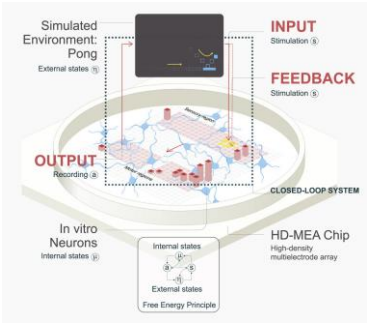
Computational Neuroscience Laboratory

1.



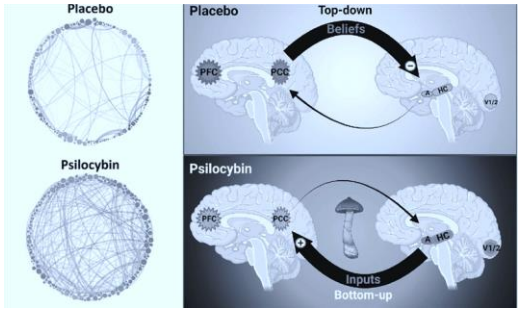
Mechanistic and Predictive Brain Modelling

2.



Synthetic Biological Intelligence

3.



Mechanisms of Psychedelics Action in Brain for Therapeutics

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Clinical Neuropsych

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PhD Student
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Zhenzhen Yang
PhD Student
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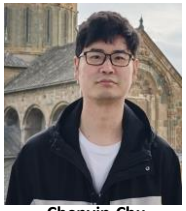

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Philosophy

Lars Sandved-Smith
PhD Student
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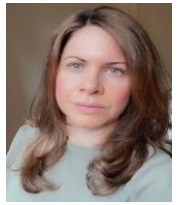
Vidushani Dhanawansa
PhD Student
Electronic Engineering



Salma Mansour
PhD Student
Psychology

Adrian May
Research Officer
Pharmacology

Brain as input-state-output system

- **Inputs**: experimental manipulations
  - External input on brain, e.g. visual stimuli
  - Context, e.g. attention
- **State (hidden) variables**: neuronal activities in the brain
- **Outputs**: electromagnetic or hemodynamic responses over brain regions
  - Measured in scanner

Dynamic Causal Modelling

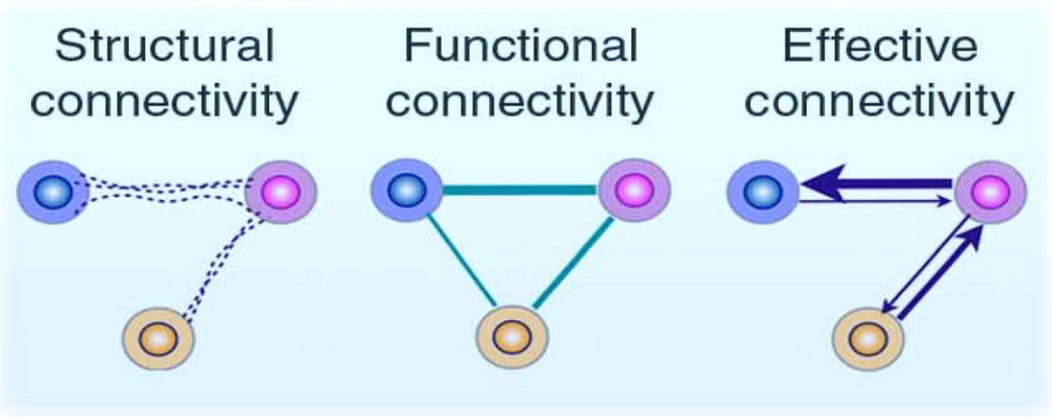
is a framework

for inferring neural responses / effective connectivity

in the brain

Brain connectivity

structural, functional and effective



Structural connectivity

presence of axonal connections

Functional connectivity

statistical dependencies between regional time series

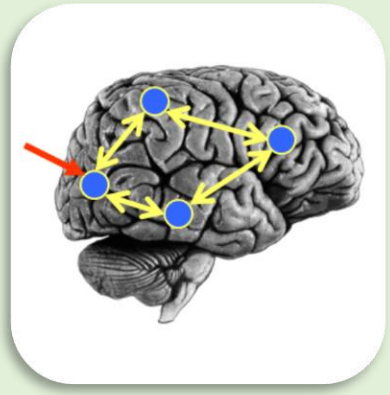
Effective connectivity

causal (directed) influences between hidden neuronal populations

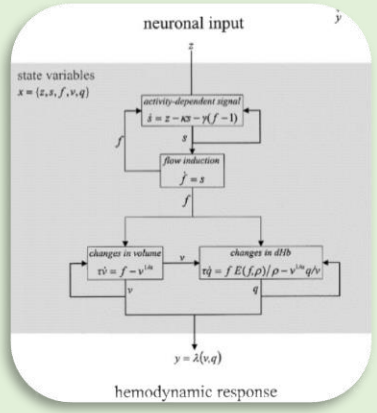
DCM Framework

Experimental Stimulus (u)

Neural Model



Observation Model



Observations (y)

How brain activity **x** changes over time

$$\dot{x} = f(x,u,\theta^n)$$

What we would see in the scanner, y, given the neural model?

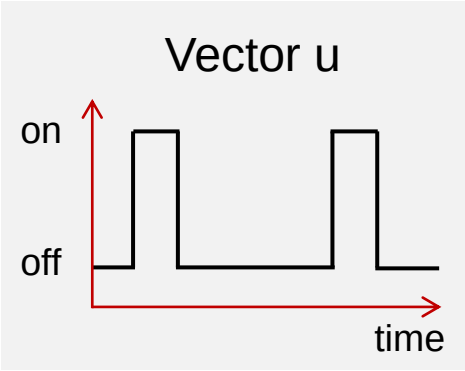
$$y = g(x, \theta^h)$$

The system of interest

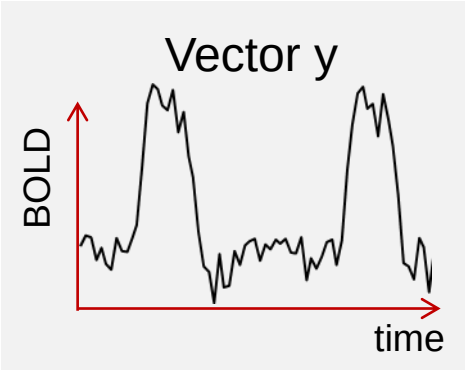
Experimental Stimulus

(Hidden) Neural Activity

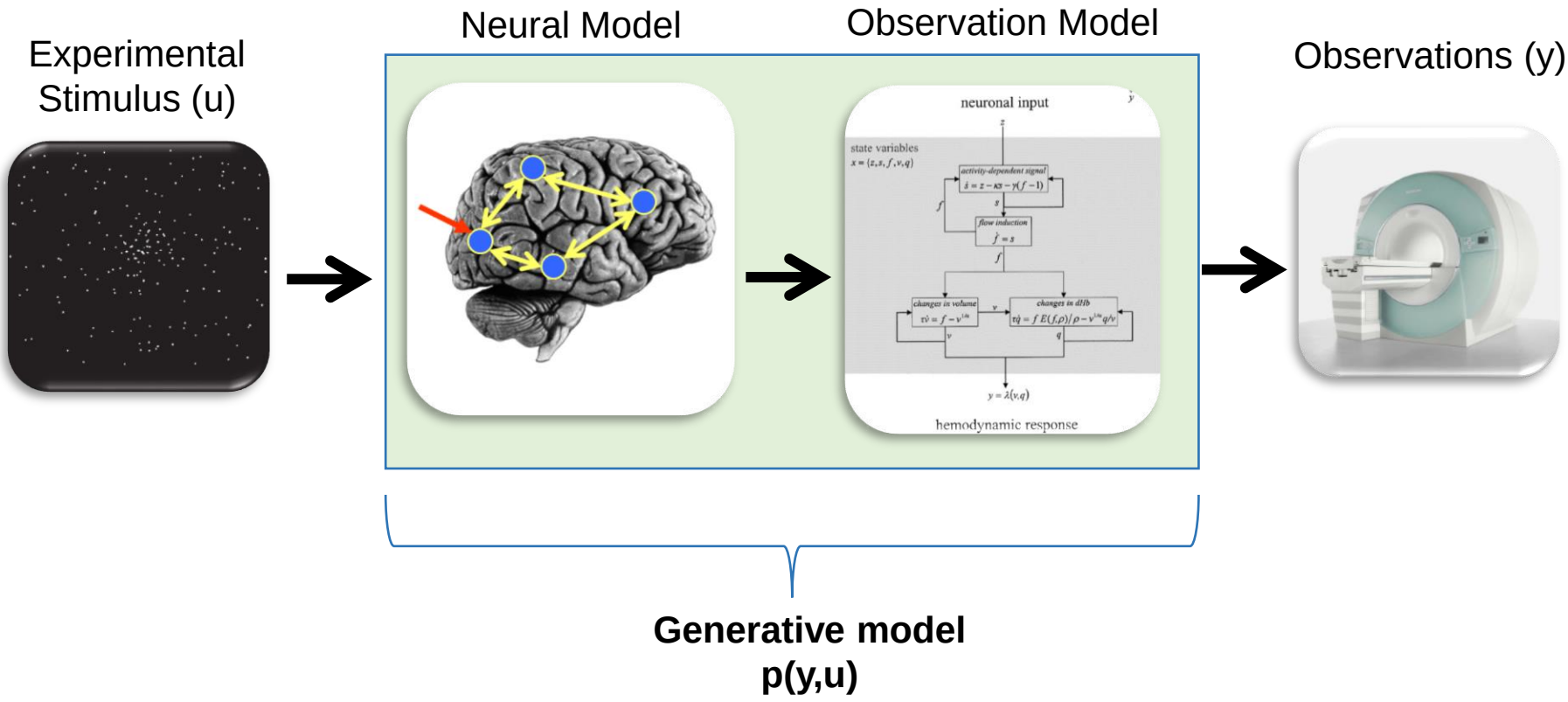
Observations (BOLD)



?



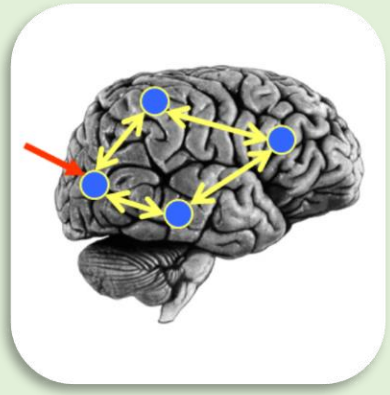
DCM Framework



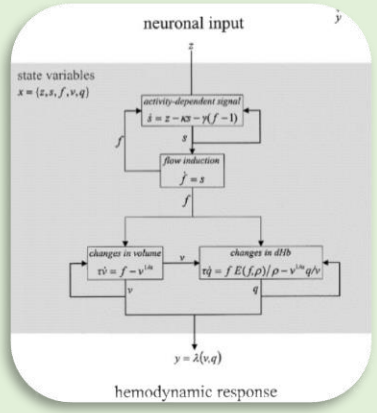
DCM Framework

Experimental Stimulus (u)

Neural Model



Observation Model



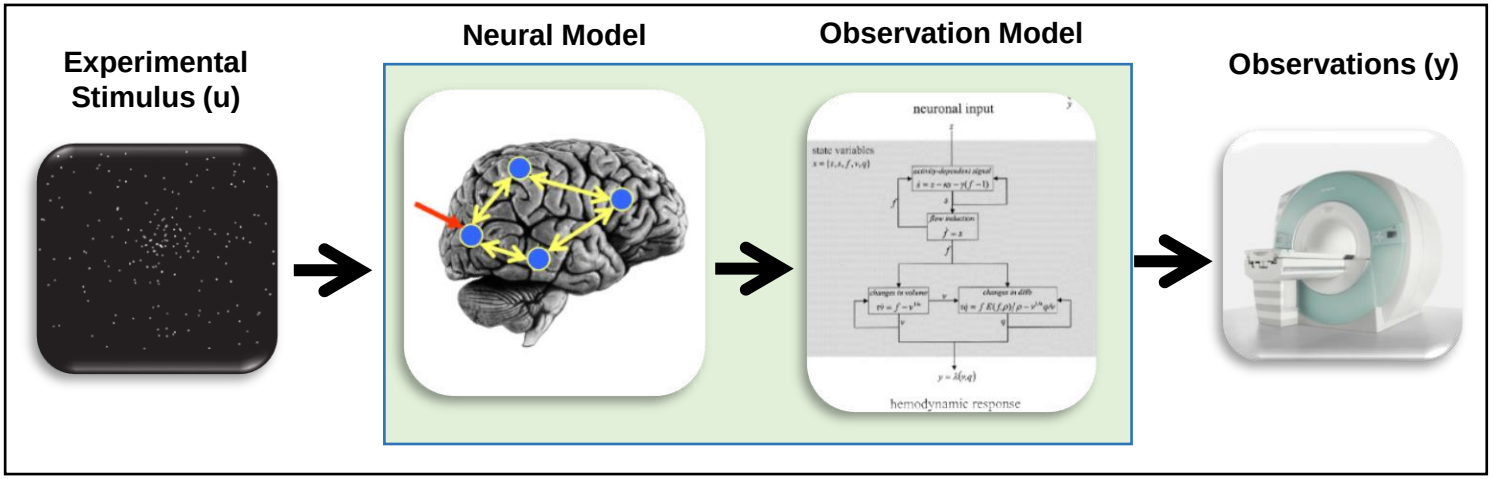
Observations (y)

Model Inversion
(Variational EM)

Given our observations y, and stimuli u, what parameters **θ** make the model best fit the data?

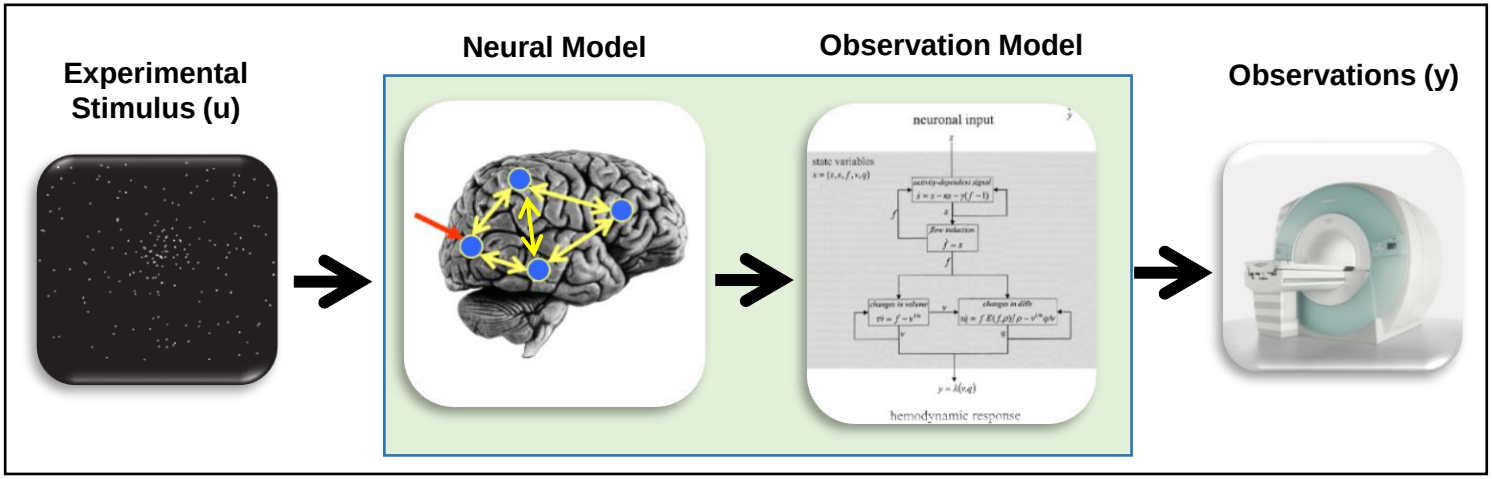
DCM Framework

Model 1:



Model comparison: Which model best explains my observed data?

Model 2:



Where DCM sits in the pipeline?

Functional MRI acquisition and image reconstruction

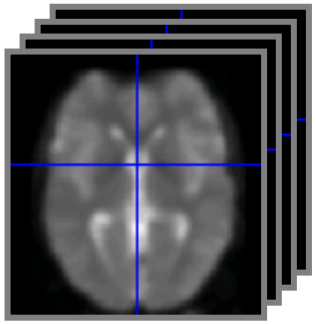
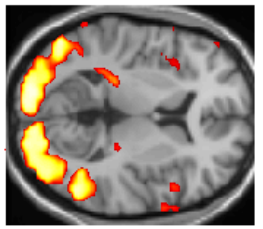
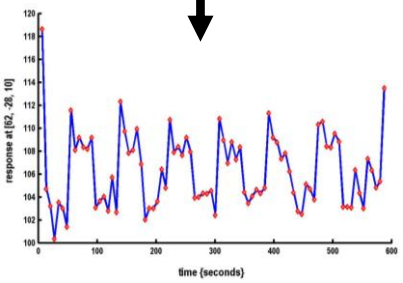


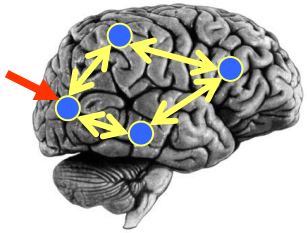
Image preprocessing (realignment, coregistration, normalisation, smoothing)



Statistical Parameter Mapping (SPM) / General Linear Model



Timeseries extraction from Regions of Interest (ROIs)

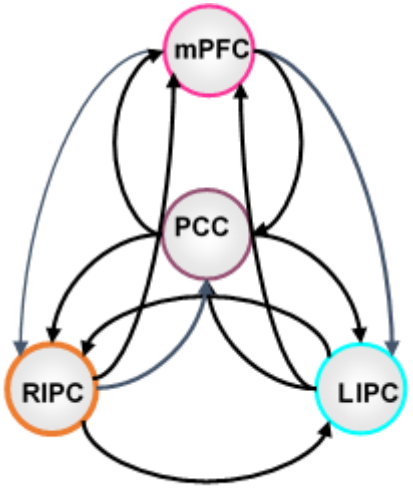


Dynamic Causal Modelling (DCM)

Worked example (using GUI)

1. **GLM estimation – to get SPM.mat**
2. **Extraction of time series from ROIs**
3. **Specify DCM**
4. **Estimate DCM**
5. **Review DCM**

PCC [0 -52 26]
mPFC [3 54 -2]
L-IPC [-50 -63 32]
R-IPC [48 -69 35]



Di & Biswal, NeuroImage 2014 and Razi et al NeuroImage, 2015

Worked example (using code/script)

1. **GLM estimation – to get SPM.mat**
2. **Extraction of time series from ROIs**
3. **Specify DCM**
4. **Estimate DCM**
5. **Review DCM**

PCC [0 -52 26]
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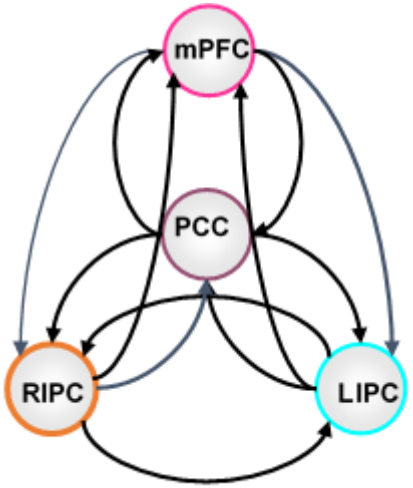


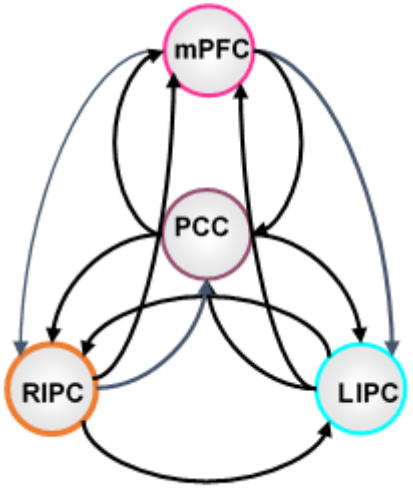
Di & Biswal, NeuroImage 2014 and Razi et al NeuroImage, 2015

Worked example

for multiple patients using for loop

1. **GLM estimation – to get SPM.mat**
2. **Extraction of time series from ROIs**
3. **Specify DCM**
4. **Estimate DCM**
5. **Review DCM**

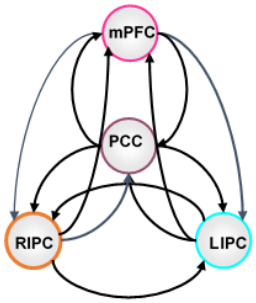
PCC [0 -52 26]
mPFC [3 54 -2]
L-IPC [-50 -63 32]
R-IPC [48 -69 35]

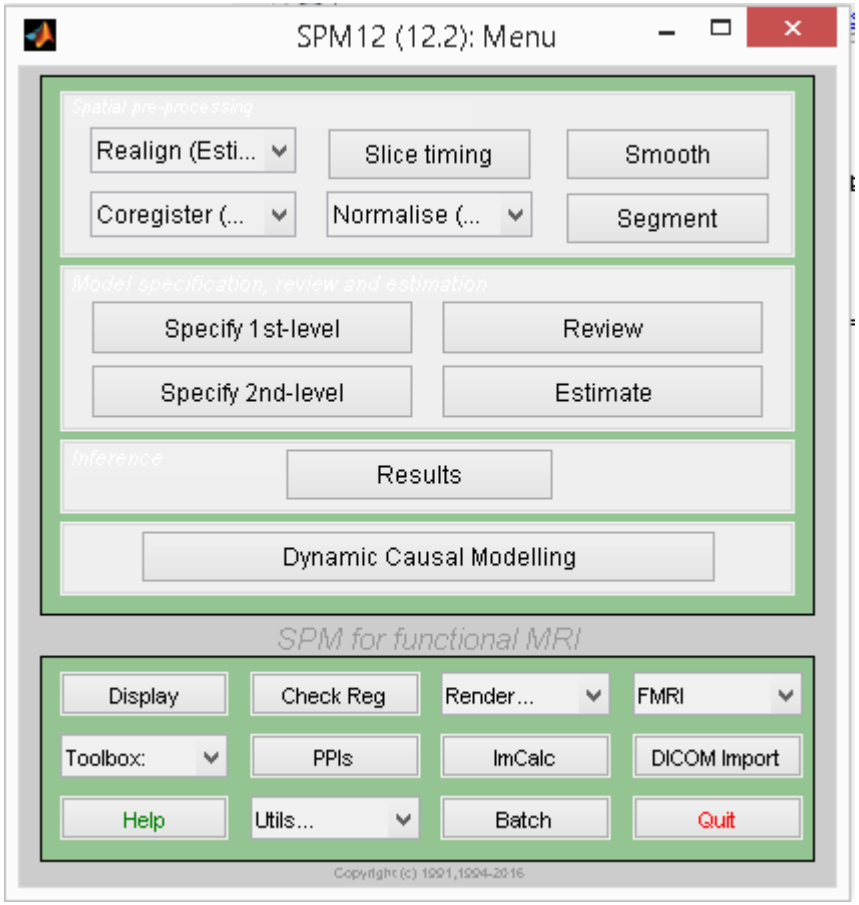


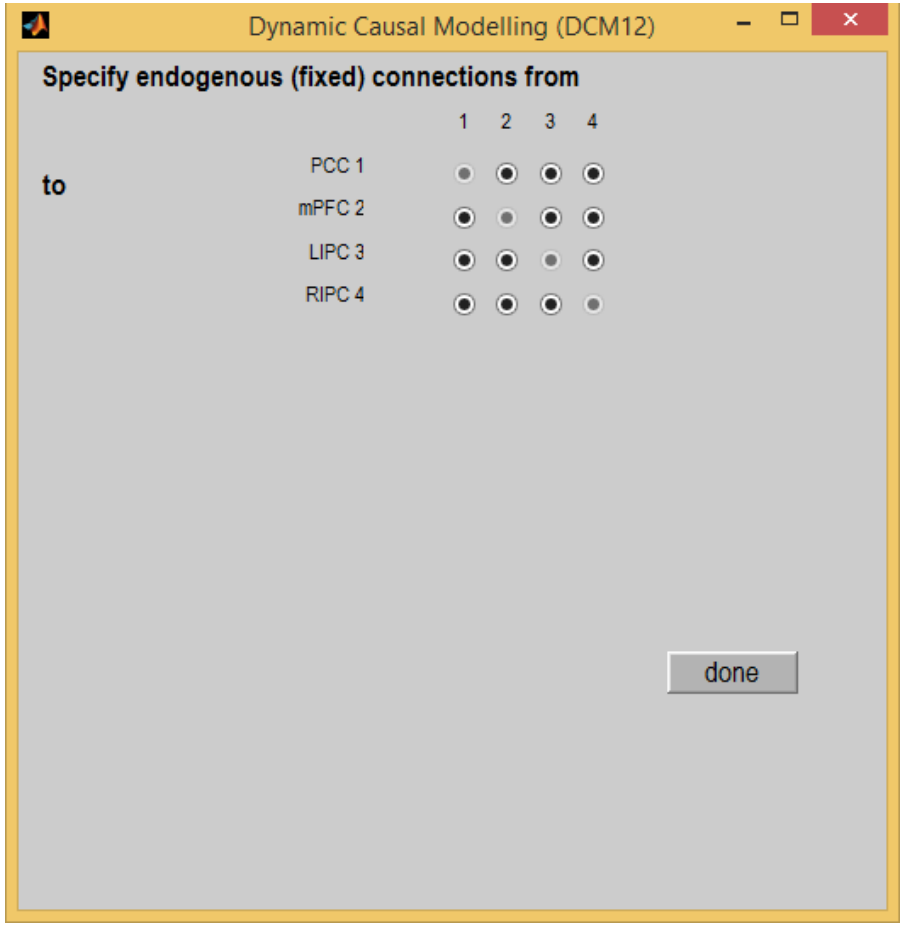
Di & Biswal, NeuroImage 2014 and Razi et al NeuroImage, 2015

Worked example

Default mode network

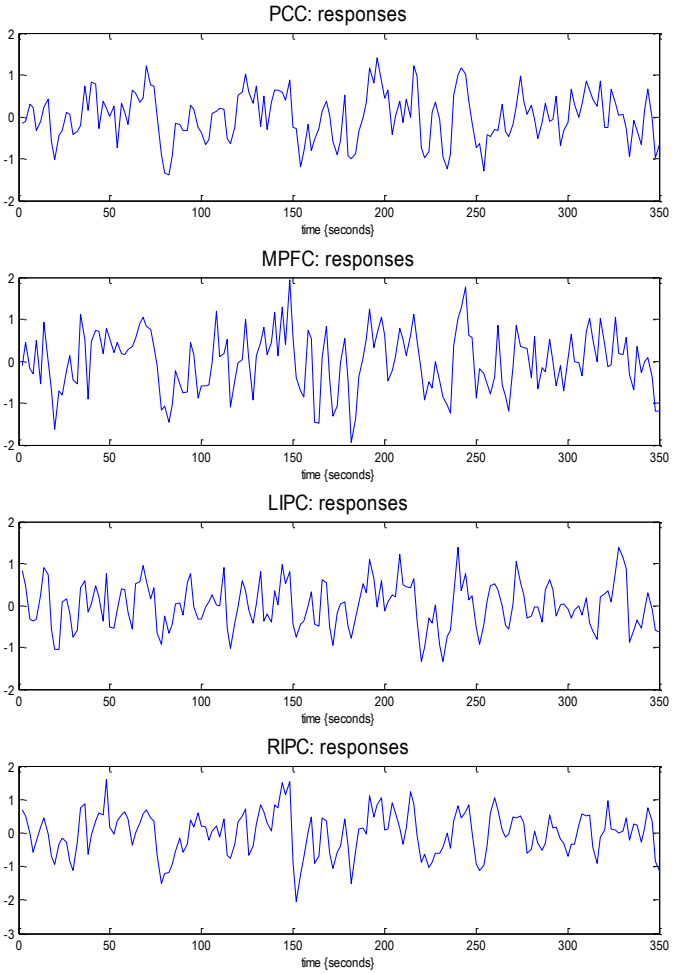




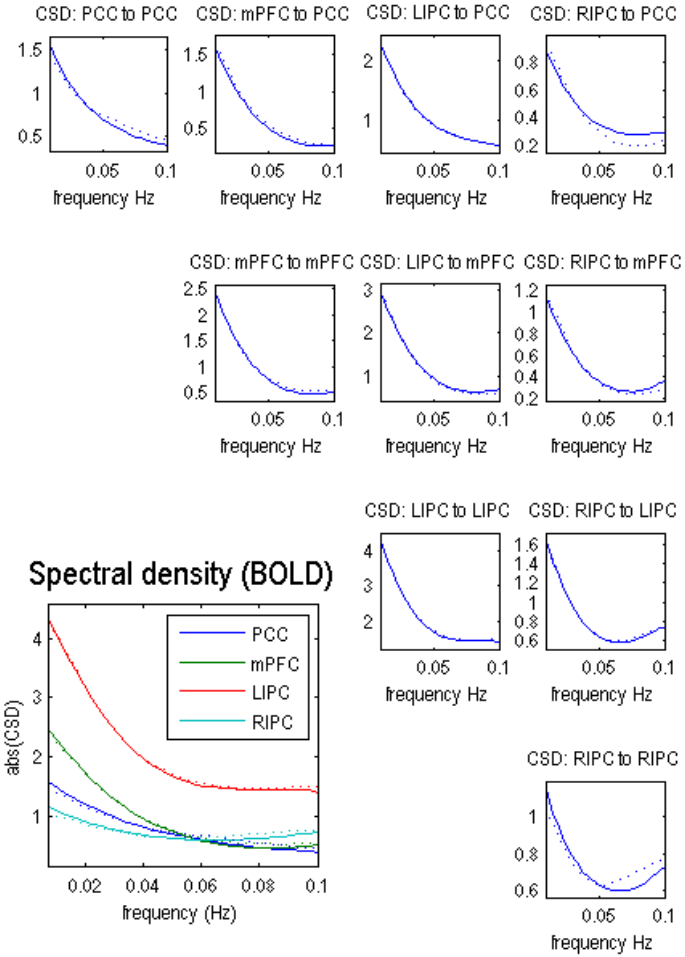


Worked example

Default mode network



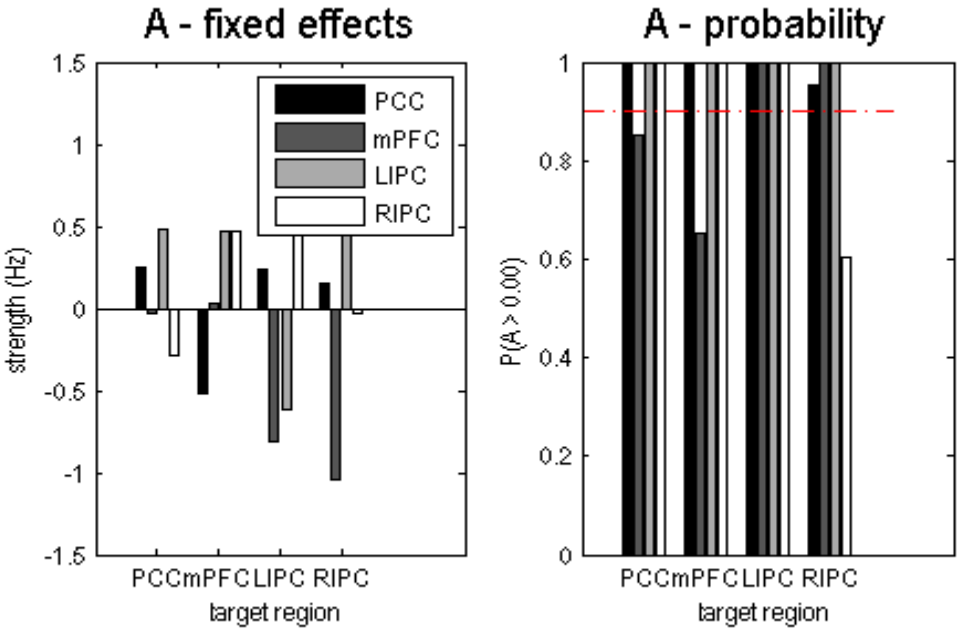
Input time series



Data fits for CSD

Worked example

Default mode network



Connectivity parameters: DCM.Ep.A
Neural fluctuation parameters: DCM.Ep.a

```
>> load('DCM_DMN.mat')
>> DCM.Ep.A

ans =

    0.2451   -0.0359    0.4764   -0.2926
   -0.5201    0.0349    0.4647    0.4746
    0.2431   -0.8065   -0.6187    1.1881
    0.1499   -1.0462    0.8346   -0.0293

>> DCM.Ep.a

ans =

   -0.6714   -0.5323    4.2406   -0.5629
   -1.3155   -1.1841   -2.2338   -0.8349
```