

# (Demo-ing) fMRI Connectivity using Dynamic Causal Modelling (DCM)

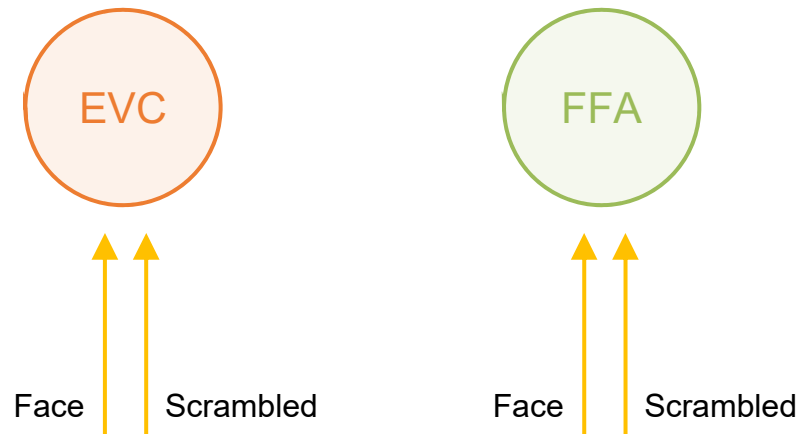
Rik Henson, Pranay Yadav

Theoretical background:

<https://www.youtube.com/watch?v=1VOKsWWLgjk>

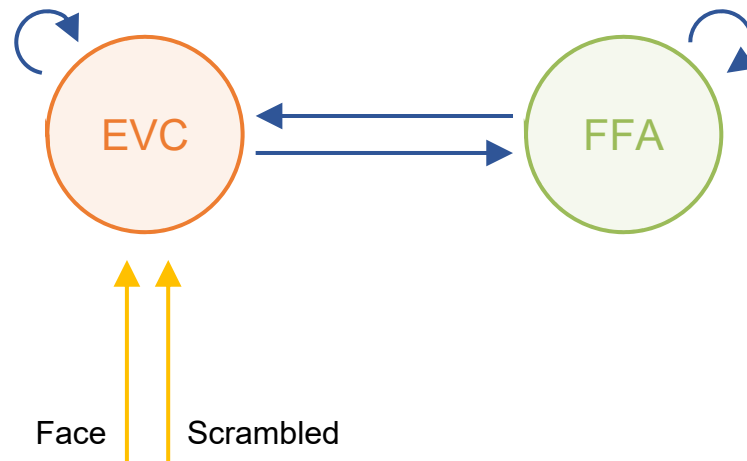
# Background

## Brain Mapping



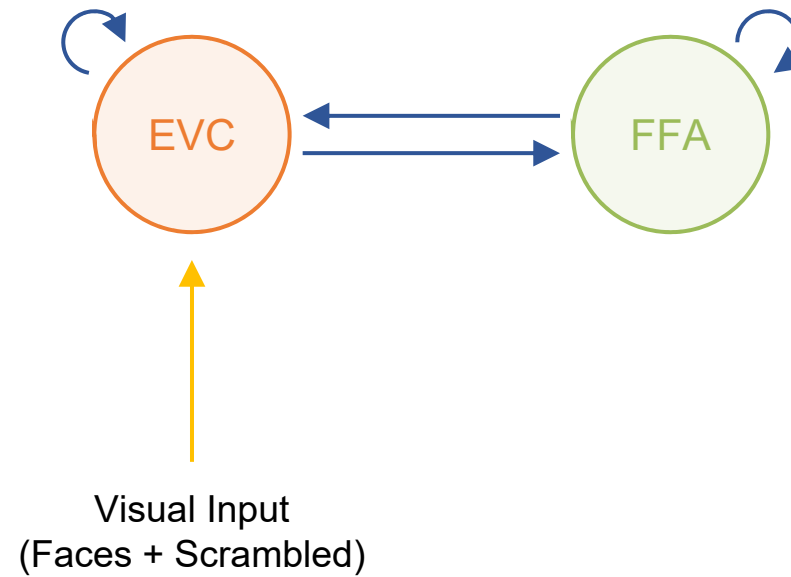
# Background

## Network Modelling



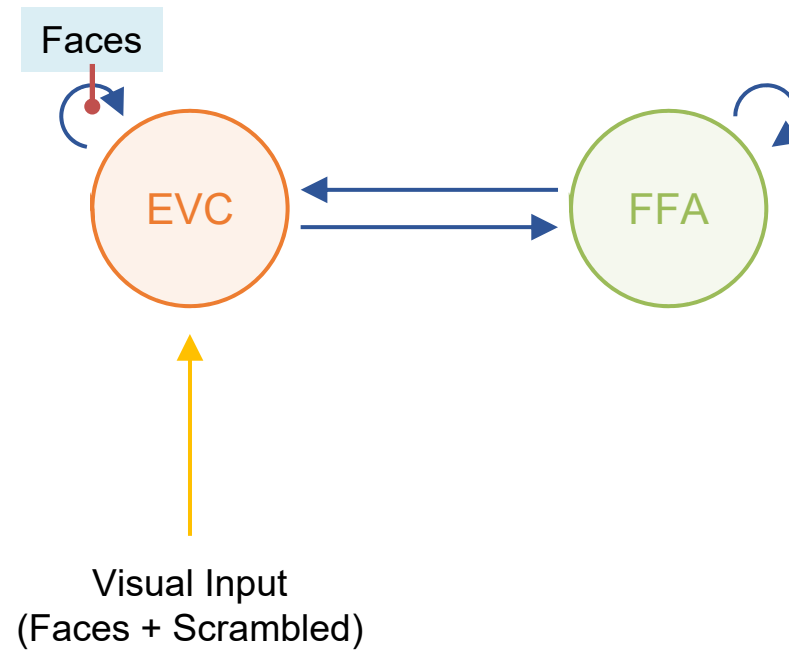
# Background

## Network Modelling



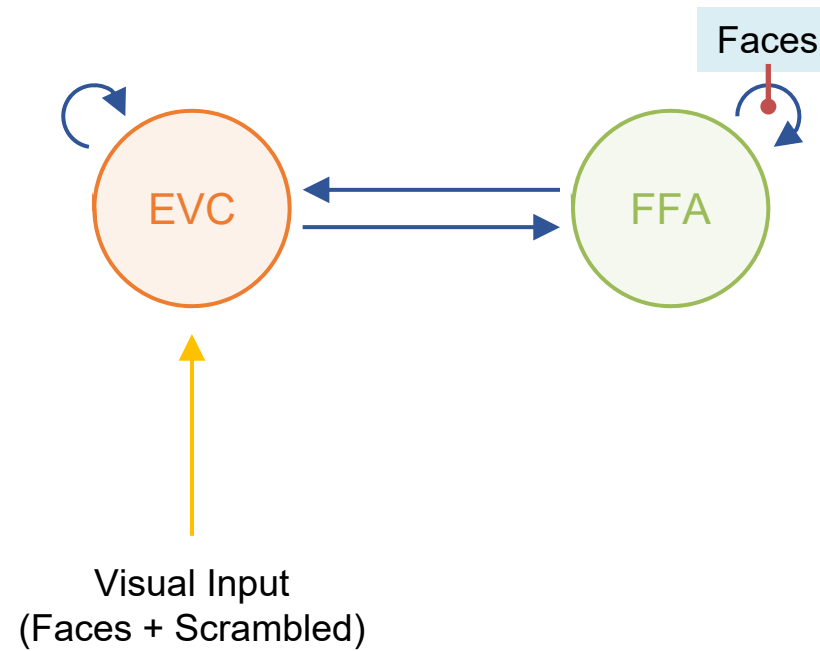
# Background

## Network Modelling



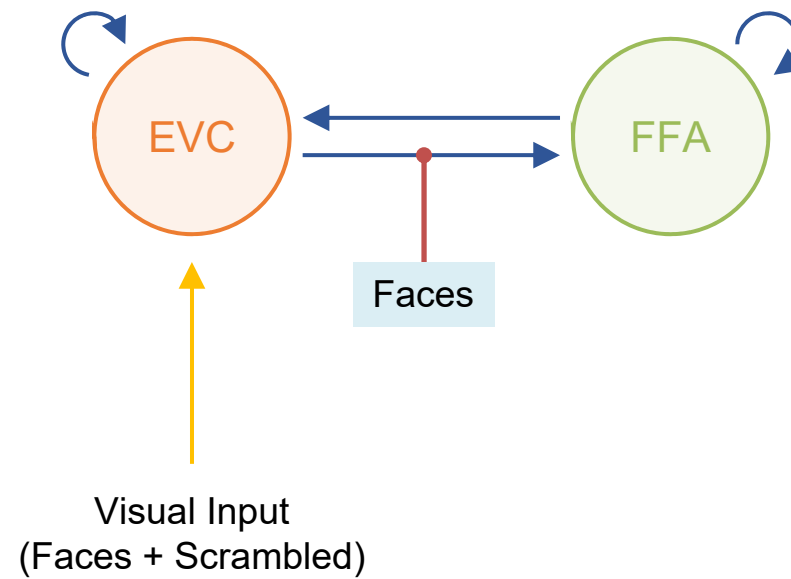
# Background

## Network Modelling



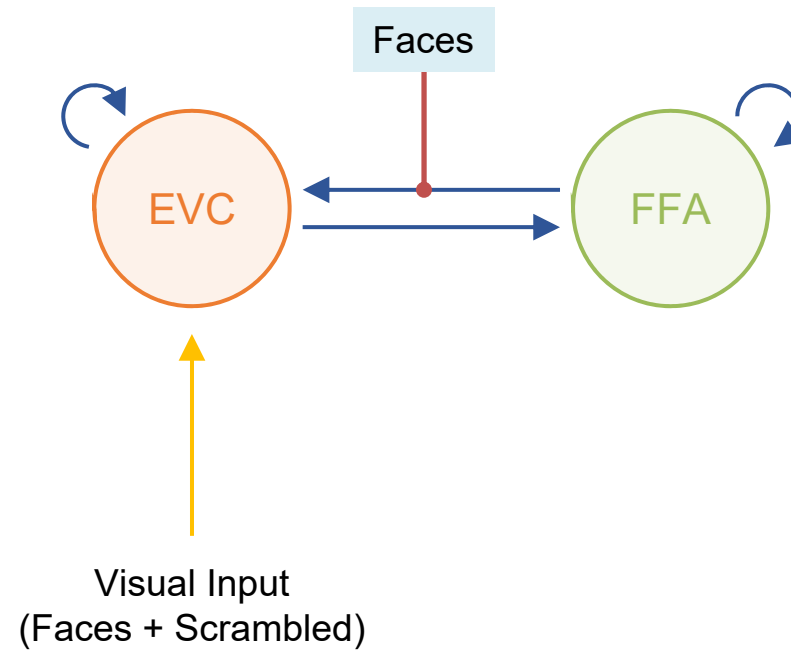
# Background

## Network Modelling



# Background

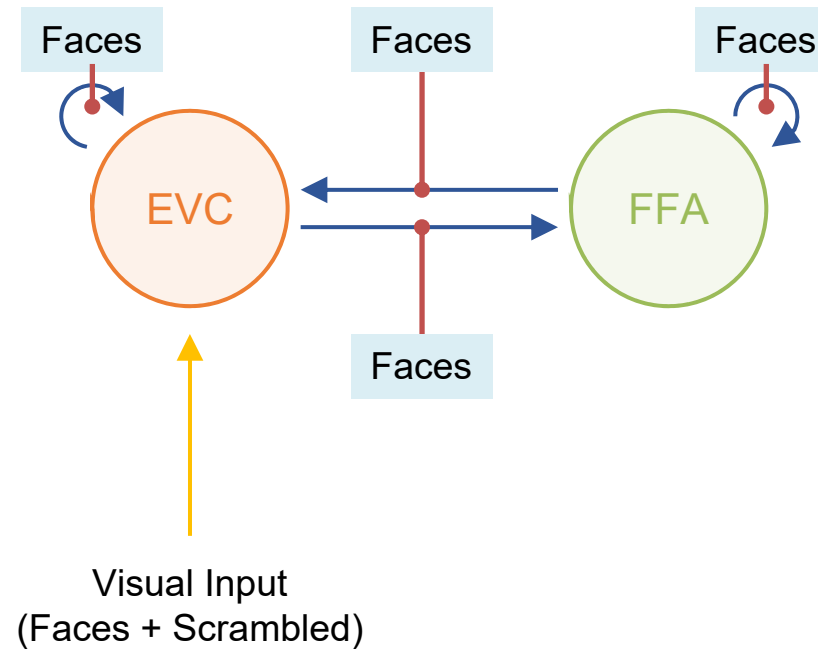
## Network Modelling





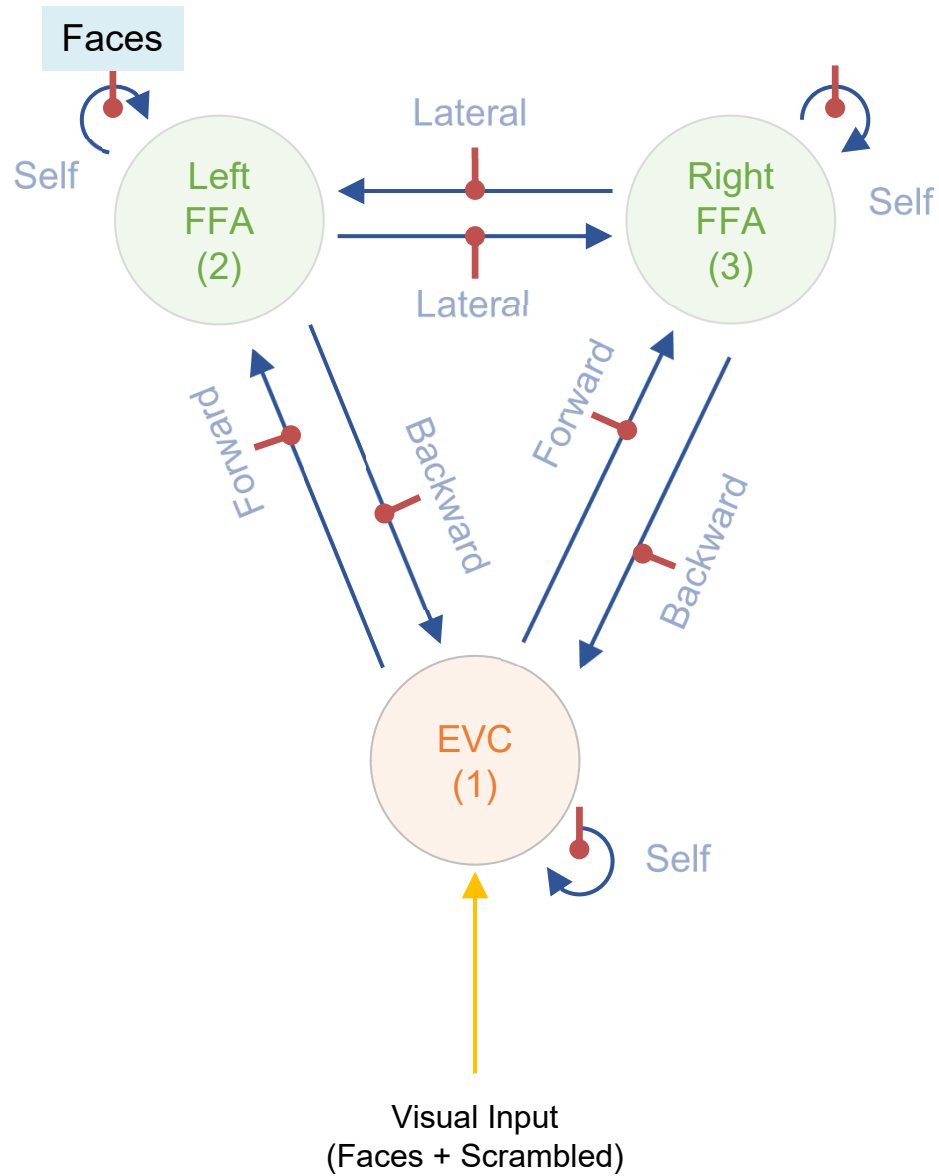
# Background

## Network Modelling



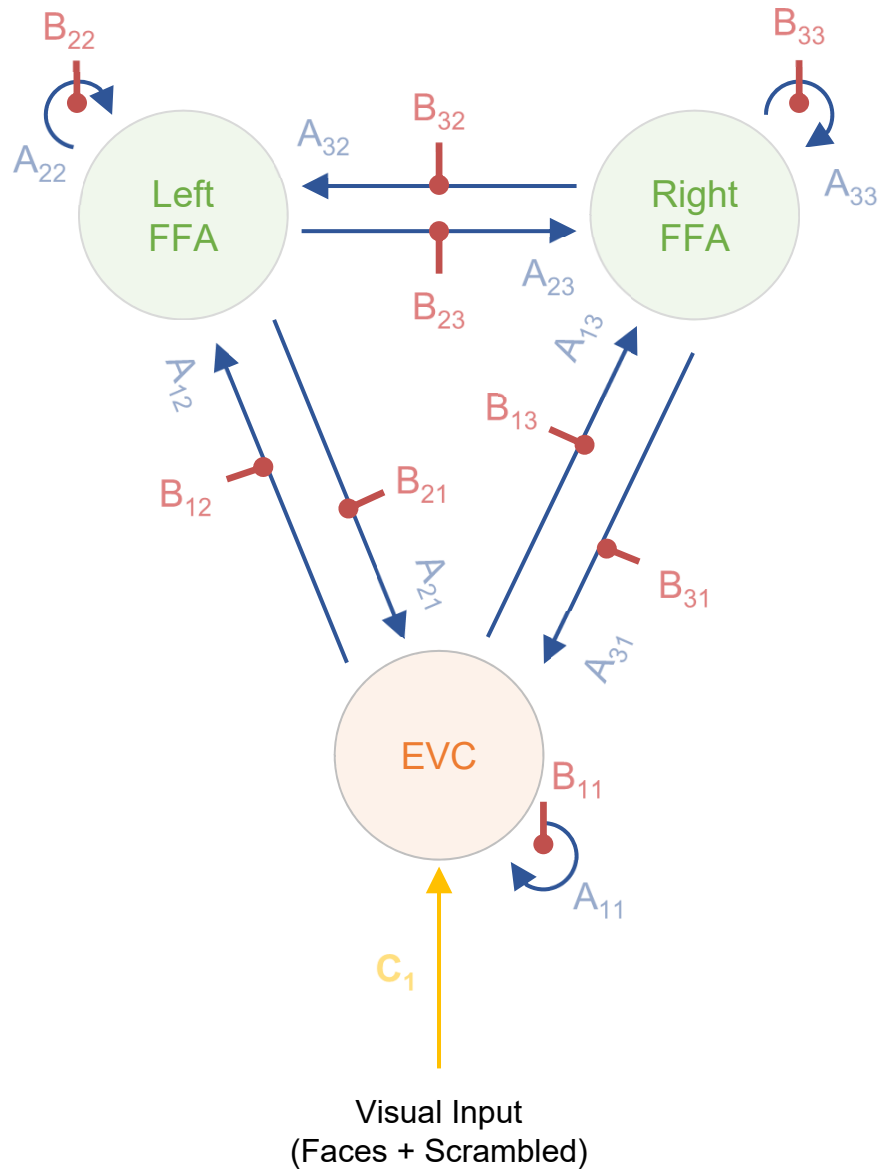
# 'Full' model

Faces modulate both between-region & self connections



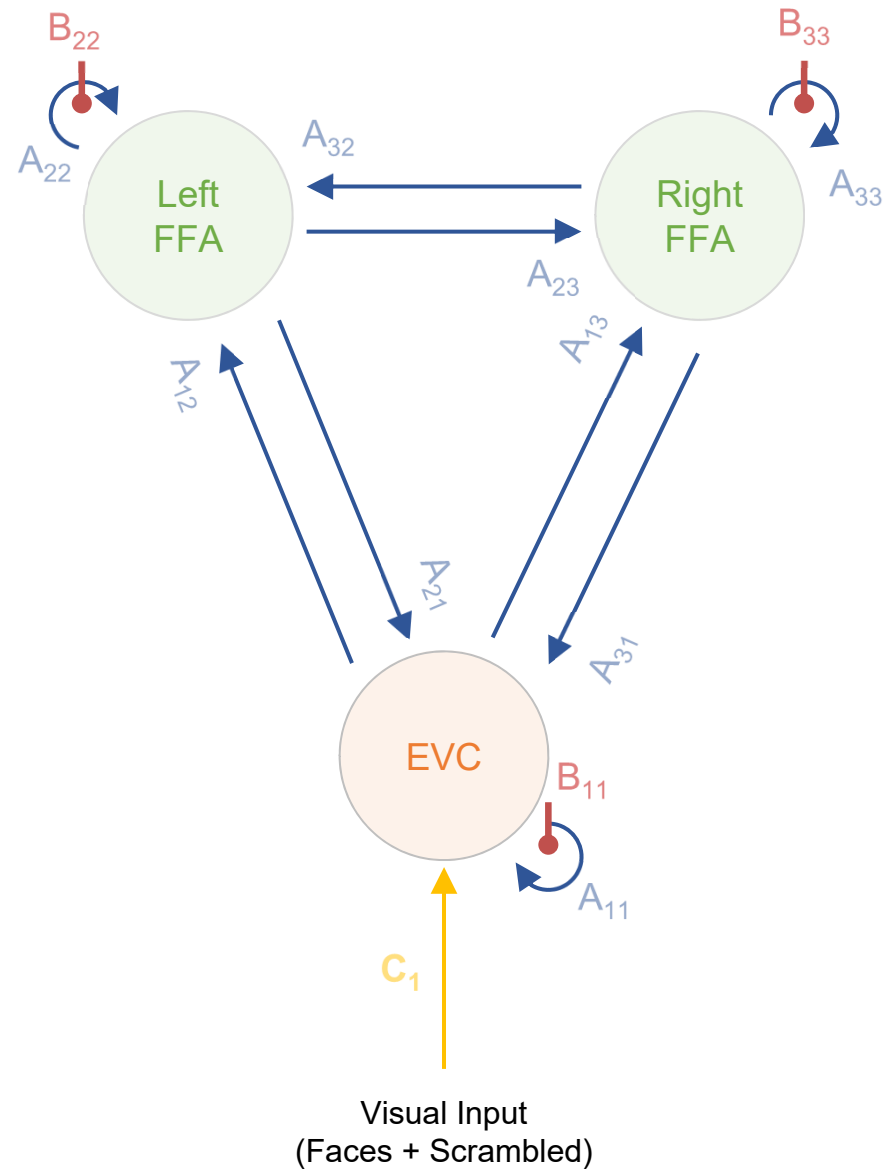
## 'Full' model

Faces modulate both between-region & self connections



## 'Self' model

Faces modulate only self connections



# DCM bilinear model

modulatory  
inputs

intrinsic connectivity      modulatory connectivity      direct inputs      driving inputs

$$\begin{bmatrix} \dot{z}_1 \\ \vdots \\ \dot{z}_n \end{bmatrix} = \left\{ \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} + \sum_{j=1}^m u_j \begin{bmatrix} b_{11}^{(j)} & \cdots & b_{1n}^{(j)} \\ \vdots & \ddots & \vdots \\ b_{n1}^{(j)} & \cdots & b_{nn}^{(j)} \end{bmatrix} \right\} \begin{bmatrix} z_1 \\ \vdots \\ z_n \end{bmatrix} + \begin{bmatrix} c_{11} & \cdots & c_{1d} \\ \vdots & \ddots & \vdots \\ c_{n1} & \cdots & c_{nd} \end{bmatrix} \begin{bmatrix} u_1 \\ \vdots \\ u_d \end{bmatrix}$$

$n$  regions                       $m$  mod inputs                       $d$  drv inputs

$$\dot{z} = \left( A + \sum_{j=1}^m u_j B^{(j)} \right) z + C u$$

# SPM Manual for fMRI+M/EEG

## SPM12 Manual

---

The FIL Methods Group  
(and honorary members)

John Ashburner  
Gareth Barnes  
Chun-Chuan Chen  
Jean Daunizeau  
Guillaume Flandin  
Karl Friston  
Stefan Kiebel  
James Kilner  
Vladimir Litvak  
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Klaas Stephan  
Sungho Tak  
Peter Zeidman  
  
Darren Gitelman  
Rik Henson  
Chloe Hutton  
Volkmar Glauche  
J er mie Mattout  
Christophe Phillips

## Chapter 42

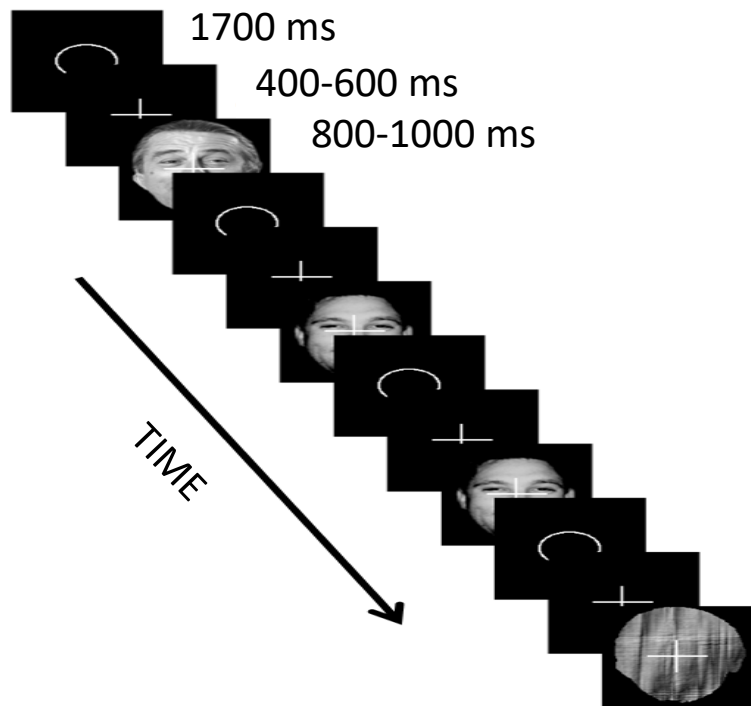
### Multimodal, Multisubject data fusion

#### 42.1 Overview

This dataset contains EEG, MEG, functional MRI and structural MRI data from 16 subjects who undertook multiple runs of a simple task performed on a large number of Famous, Unfamiliar and Scrambled faces. It will be used to demonstrate:

1. batching and scripting of preprocessing of multiple subjects/runs of combined MEG and EEG data,
2. creation of trial-averaged evoked responses,
3. 3D scalp-time statistical mapping of evoked responses across trials within one subject,
4. 2D time-frequency statistical mapping of time-frequency data across subjects,
5. preprocessing and group analysis of fMRI data from the same subjects and paradigm,
6. source-reconstruction of the “N/M170” face component (using structural MRI for forward modelling),
7. individual and group-based fusion of EEG and MEG during source reconstruction,
8. statistical mapping across subjects of cortical power in a time-frequency window, using the functional MRI results as spatial priors.

# The Dataset



N=16 subjects (BIDS format)

EEG = 70 channels, nose-reference (concurrent with MEG)

MEG = 102 magnetometers + 204 planar gradiometers

fMRI = BOLD EPI 3x3x3mm (3T Siemens Trio)

MRI = T1 MPAGE 1x1x1mm

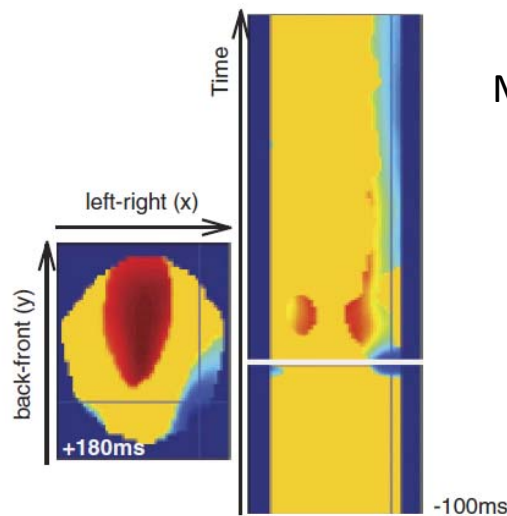
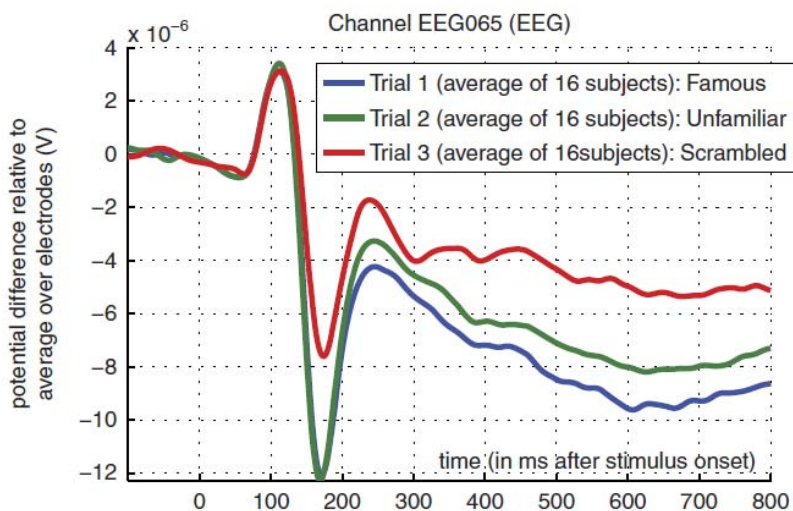
Stimuli: 3 types of greyscale face images:

~300 x Famous

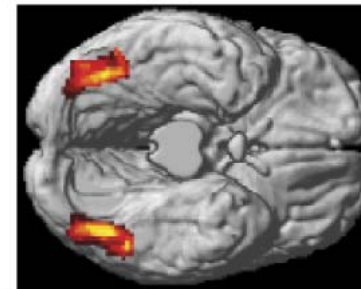
~300 x Nonfamous (previously unseen)

~300 x Phase-scrambled versions of above

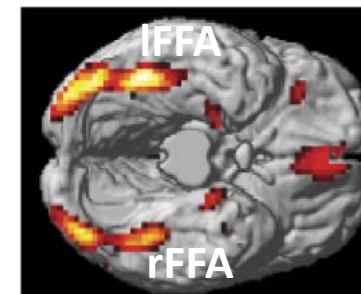
Task: Judge left-right symmetry



M/EEG



fMRI



# SCIENTIFIC DATA

OPEN

SUBJECT CATEGORIES

- » Electroencephalography  
-EEG
- » Brain imaging
- » Functional magnetic  
resonance imaging
- » Cognitive neuroscience

Received: 07 April 2014

Accepted: 05 January 2015

Published: 20 January 2015

## A multi-subject, multi-modal human neuroimaging dataset

Daniel G. Wakeman<sup>1,2</sup> & Richard N. Henson<sup>2</sup>

We describe data acquired with multiple functional and structural neuroimaging modalities on the same nineteen healthy volunteers. The functional data include Electroencephalography (EEG), Magnetoencephalography (MEG) and functional Magnetic Resonance Imaging (fMRI) data, recorded while the volunteers performed multiple runs of hundreds of trials of a simple perceptual task on pictures of familiar, unfamiliar and scrambled faces during two visits to the laboratory. The structural data include T<sub>1</sub>-weighted MPAGE, Multi-Echo FLASH and Diffusion-weighted MR sequences. Though only from a small sample of volunteers, these data can be used to develop methods for integrating multiple modalities from multiple runs on multiple participants, with the aim of increasing the spatial and temporal resolution above that of any one modality alone. They can also be used to integrate measures of functional and structural connectivity, and as a benchmark dataset to compare results across the many neuroimaging analysis packages. The data are freely available from <https://openfmri.org/>.



# <https://openneuro.org/datasets/ds000117/versions/1.0.5>

## MRI Multisubject, multimodal face processing

Follow 6 Bookmark 15

BIDS Validation 4 WARNINGS Valid Clone

Files Download Derivatives Metadata

**README**

This dataset was obtained from the OpenNeuro project (<https://www.openneuro.org>). Accession #: ds000117

The same dataset is also available here: [ftp://ftp.mrc-cbu.cam.ac.uk/personal/rik.henson/wakemandg\\_hensonrn/](ftp://ftp.mrc-cbu.cam.ac.uk/personal/rik.henson/wakemandg_hensonrn/), but in a non-BIDS format (which may be easier to download by subject rather than by modality)

Note that it is a subset of the data available on OpenfMRI (<http://www.openfMRI.org>; Accession #: ds000117).

Description: Multi-subject, multi-modal (sMRI+fMRI+MEG+EEG) neuroimaging dataset on face processing

Please cite the following reference if you use these data:

```
Wakeman, D.G. & Henson, R.N. (2015). A multi-subject, multi-modal human neuroimaging dataset. Sci. Data 2:150001 doi:10.1038/sdata.2015.1
```

The data have been used in several publications including, for example: [READ MORE](#)

File Name	Files	Size
Multisubject, multimodal face processing	1671	84.82GB
.bidsignore		
acq-mprage_T1w.json		
CHANGES		
dataset_description.json		
participants.tsv		
README		
run-1_echo-1_FLASH.json		
run-1_echo-2_FLASH.json		
run-1_echo-3_FLASH.json		
run-1_echo-4_FLASH.json		
run-1_echo-5_FLASH.json		
run-1_echo-6_FLASH.json		
run-1_echo-7_FLASH.json		

OpenNeuro Accession Number  
ds000117

Authors  
Wakeman, DG, Henson, RN

Available Modalities  
**MRI** **MEG**

Versions  
**1.0.5** Created: 2021-09-27 Versions

Tasks  
facerecognition

Uploaded by  
Richard Henson on 2018-03-30 - over 4 years ago

Last Updated  
2021-09-27 - 11 months ago

Sessions  
2

Participants  
16

Dataset DOI  
[doi:10.18112/openneuro.ds000117.v1.0.5](https://doi.org/10.18112/openneuro.ds000117.v1.0.5)

License  
CC0

How To Cite  
[Text](#) [BibTeX](#) [Copy](#)

Wakeman, DG and Henson, RN (2021). Multisubject, multimodal face processing. OpenNeuro. [Dataset] doi: 10.18112/openneuro.ds000117.v1.0.5

[More citation info](#)

# Dynamic Causal Modelling of fMRI data in SPM12

**Pranay Yadav<sup>1\*</sup> & Richard N Henson<sup>1,2</sup>**

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<sup>2</sup>Department of Psychiatry, University of Cambridge, Cambridge, UK

**\* Correspondence:**

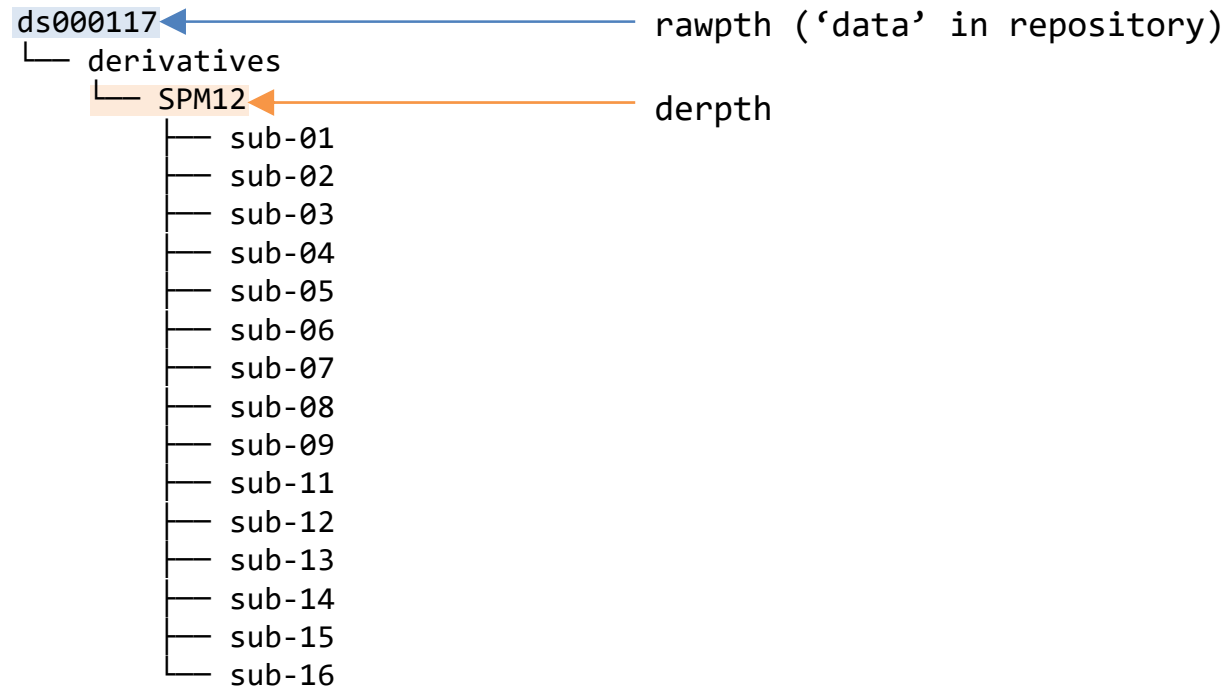
Corresponding Author

pranay.yadav@mrc-cbu.cam.ac.uk

**Keywords:** MEG, EEG, fMRI, multimodal, fusion, SPM, inversion, faces

*Contains links to processed data, batches, scripts...*

# Data organization



# Data organization

```
ds000117
├── derivatives
│   └── SPM12
│       ├── sub-01
│       ├── sub-02
│       ├── sub-03
│       ├── sub-04
│       ├── sub-05
│       ├── sub-06
│       ├── sub-07
│       ├── sub-08
│       ├── sub-09
│       ├── sub-11
│       ├── sub-12
│       ├── sub-13
│       ├── sub-14
│       ├── sub-15
│       └── sub-16
```



These should already be present if you began with raw data and processed as per Henson et al 2019.

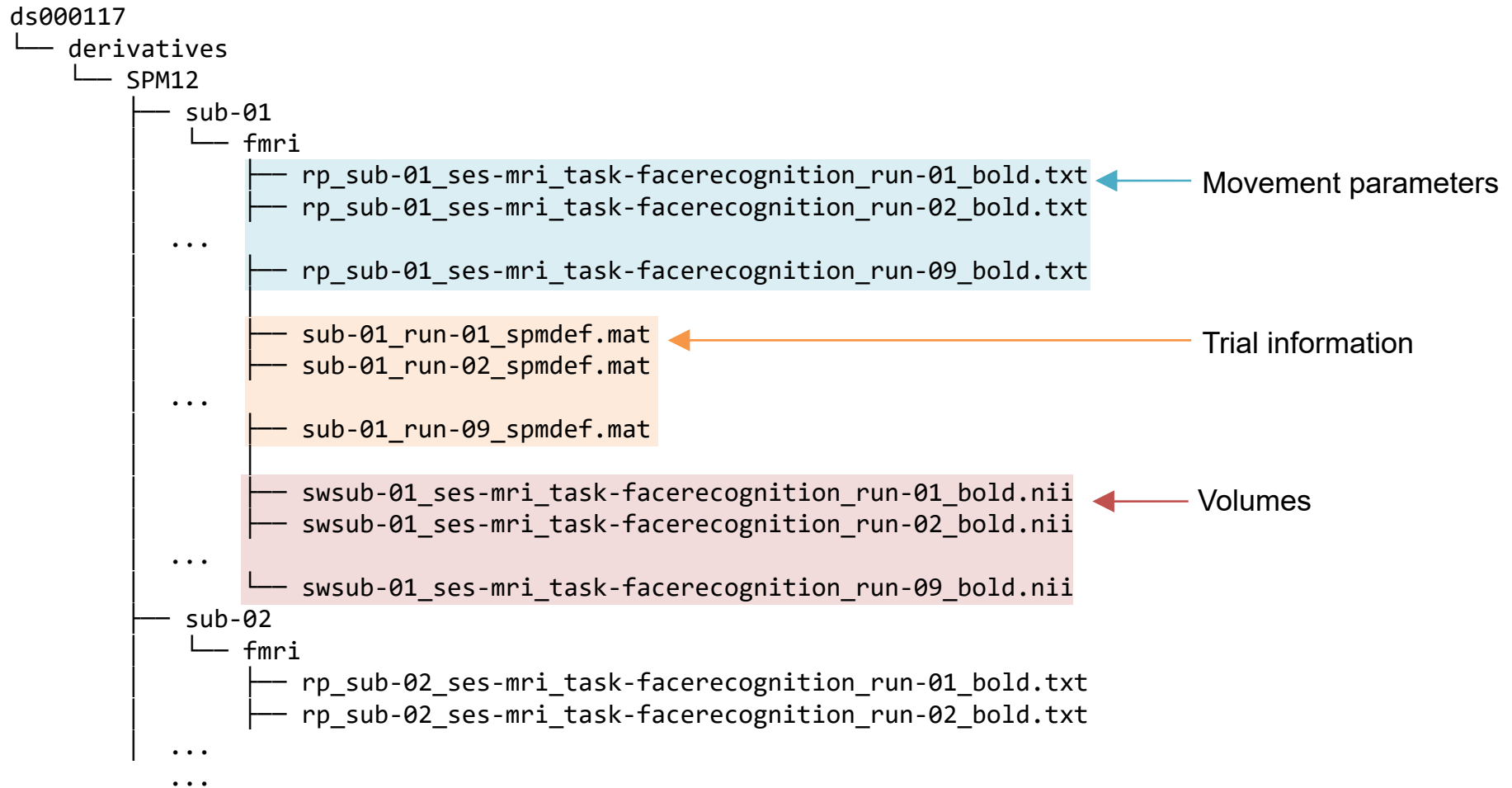
Else, download from figshare and extract here.

# Data organization

```
ds000117
├── derivatives
│   └── SPM12
│       ├── sub-01
│       │   └── fmri
│       │       ├── rp_sub-01_ses-mri_task-facerecognition_run-01_bold.txt
│       │       ├── rp_sub-01_ses-mri_task-facerecognition_run-02_bold.txt
│       │       ├── ...
│       │       ├── rp_sub-01_ses-mri_task-facerecognition_run-09_bold.txt
│       │       ├── sub-01_run-01_spmdef.mat
│       │       ├── sub-01_run-02_spmdef.mat
│       │       ├── ...
│       │       ├── sub-01_run-09_spmdef.mat
│       │       ├── swsub-01_ses-mri_task-facerecognition_run-01_bold.nii
│       │       ├── swsub-01_ses-mri_task-facerecognition_run-02_bold.nii
│       │       ├── ...
│       │       └── swsub-01_ses-mri_task-facerecognition_run-09_bold.nii
│       ├── sub-02
│       │   └── fmri
│       │       ├── rp_sub-02_ses-mri_task-facerecognition_run-01_bold.txt
│       │       ├── rp_sub-02_ses-mri_task-facerecognition_run-02_bold.txt
│       │       ├── ...
│       │       └── ...
```

3 × 9 = 27 files  
(per subject)

# Data organization

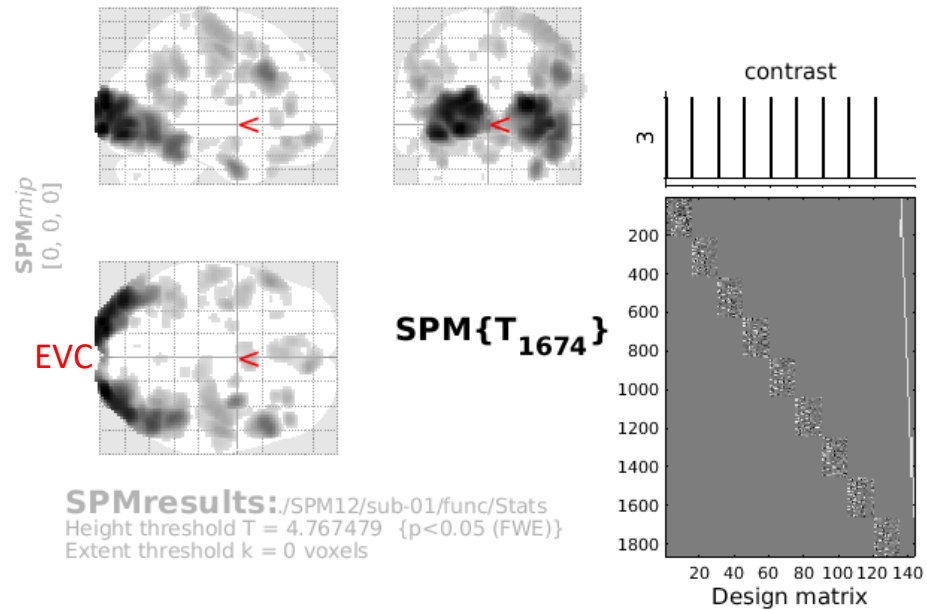


Single-subject  
(fMRI timeseries)

GLM  
(1<sup>st</sup>-level)

SPM

Famous - All Sessions



Statistics: *p-values adjusted for search volume*

set-level		cluster-level				peak-level					mm mm mm		
$p$	$c$	$p_{FWE-corr}$	$q_{FDR-corr}$	$k_E$	$p_{uncorr}$	$p_{FWE-corr}$	$q_{FDR-corr}$	$T$	$(Z_E)$	$p_{uncorr}$			
0.000	37	0.000	0.000	10065	0.000	0.000	0.000	22.70	Inf	0.000	26	-98	12
						0.000	0.000	22.38	Inf	0.000	-22	-100	-4
						0.000	0.000	21.81	Inf	0.000	-18	-98	16
		0.000	0.000	816	0.000	0.000	0.000	13.75	Inf	0.000	48	18	34
						0.000	0.000	6.46	6.42	0.000	46	16	50
		0.000	0.000	278	0.000	0.000	0.000	12.79	Inf	0.000	32	-4	-32
		0.000	0.000	702	0.000	0.000	0.000	10.18	Inf	0.000	-52	22	28
						0.000	0.000	7.67	7.60	0.000	-46	4	38
						0.000	0.000	7.47	7.41	0.000	-40	0	34
		0.000	0.000	1754	0.000	0.000	0.000	9.50	Inf	0.000	54	-12	50
						0.000	0.000	9.24	Inf	0.000	42	-16	64
						0.000	0.000	9.02	Inf	0.000	46	-12	58
		0.000	0.000	652	0.000	0.000	0.000	9.21	Inf	0.000	8	50	-12
						0.000	0.000	7.35	7.29	0.000	0	30	-26
						0.000	0.000	7.07	7.01	0.000	-10	38	-18
		0.000	0.001	83	0.000	0.000	0.000	8.42	Inf	0.000	-36	-10	-28
		0.000	0.000	139	0.000	0.000	0.000	8.40	Inf	0.000	46	36	10
		0.000	0.000	104	0.000	0.000	0.000	8.39	Inf	0.000	30	34	-14
		0.000	0.000	267	0.000	0.000	0.000	8.25	Inf	0.000	-38	-60	22
						0.000	0.002	6.09	6.05	0.000	-48	-56	14
		0.000	0.000	294	0.000	0.000	0.000	8.01	Inf	0.000	6	8	52
						0.000	0.000	6.42	6.38	0.000	-6	4	56

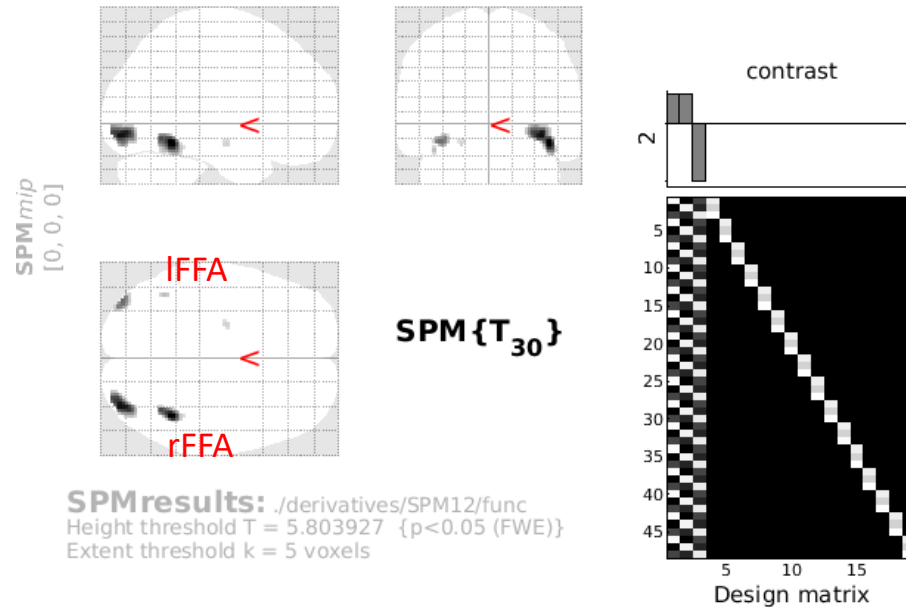
table shows 3 local maxima more than 8.0mm apart

Height threshold:  $T = 4.77$ ,  $p = 0.000$  (0.050) Degrees of freedom = [1.0, 1674.0]  
 Extent threshold:  $k = 0$  voxels FWHM = 10.6 10.5 10.3 mm mm mm; 5.3 5.3 5.1 {voxel  
 Expected voxels per cluster,  $\langle k \rangle = 4.518$  Volume: 1737816 = 217227 voxels = 1415.5 resels  
 Expected number of clusters,  $\langle c \rangle = 0.05$  Voxel size: 2.0 2.0 2.0 mm mm mm; (resel = 142.70 vo  
 FWEp: 4.767, FDRp: 5.503, FWEc: 2, FDRc: 23 Page 1



Group  
GLM  
(2<sup>nd</sup>-level)  
SPM

Faces (Fam+Unf) > Scrambled



Statistics: *p-values adjusted for search volume*

set-level		cluster-level				peak-level				mm	mm	mm	
<i>p</i>	<i>c</i>	<i>p</i> <sub>FWE-corr</sub>	<i>q</i> <sub>FDR-corr</sub>	<i>k</i> <sub>E</sub>	<i>p</i> <sub>uncorr</sub>	<i>p</i> <sub>FWE-corr</sub>	<i>q</i> <sub>FDR-corr</sub>	<i>T</i>	( <i>Z</i> <sub>E</sub> )	<i>p</i> <sub>uncorr</sub>			
0.000	5	0.000	0.000	122	0.000	0.000	0.005	9.00	6.22	0.000	42	-52	-14
		0.000	0.000	180	0.000	0.000	0.005	8.68	6.09	0.000	36	-88	-10
		0.000	0.012	39	0.007	0.001	0.042	7.42	5.55	0.000	-38	-86	-14
		0.014	0.284	5	0.284	0.017	0.399	6.27	4.97	0.000	-42	-56	-20
		0.012	0.284	6	0.242	0.031	0.624	6.01	4.83	0.000	-22	-10	-16

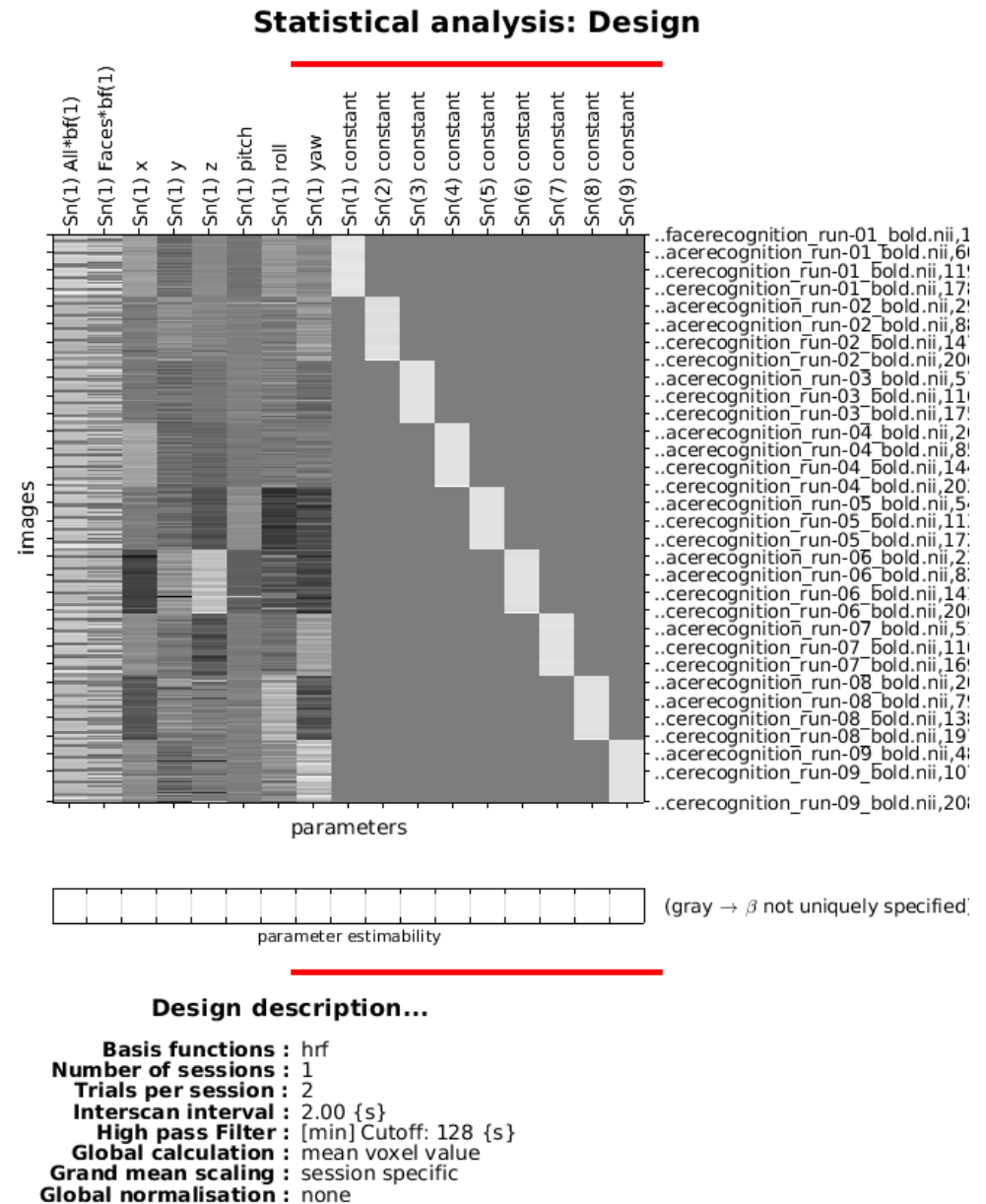
table shows 3 local maxima more than 8.0mm apart

Height threshold: *T* = 5.80, *p* = 0.000 (0.050) Degrees of freedom = [1.0, 30.0]  
 Extent threshold: *k* = 5 voxels, *p* = 0.284 (0.014) FWHM = 13.0 12.9 12.6 mm mm mm; 6.5 6.4 6.3 {voxe  
 Expected voxels per cluster, <*k*> = 4.709 Volume: 1515968 = 189496 voxels = 671.9 resels  
 Expected number of clusters, <*c*> = 0.01 Voxel size: 2.0 2.0 2.0 mm mm mm; (resel = 261.78 vo  
 FWEp: 5.804, FDRp: 7.424, FWEc: 5, FDRc: 39



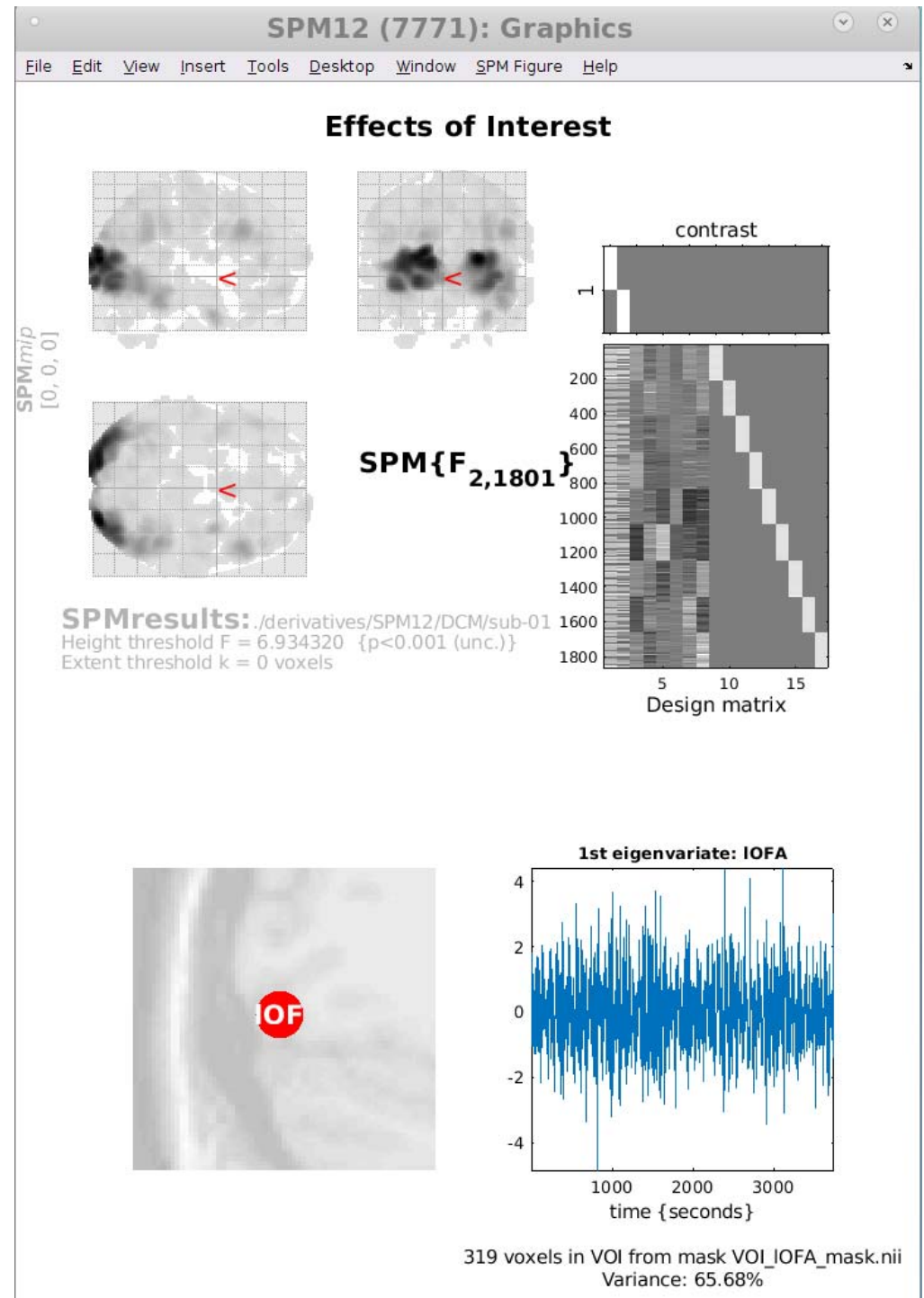
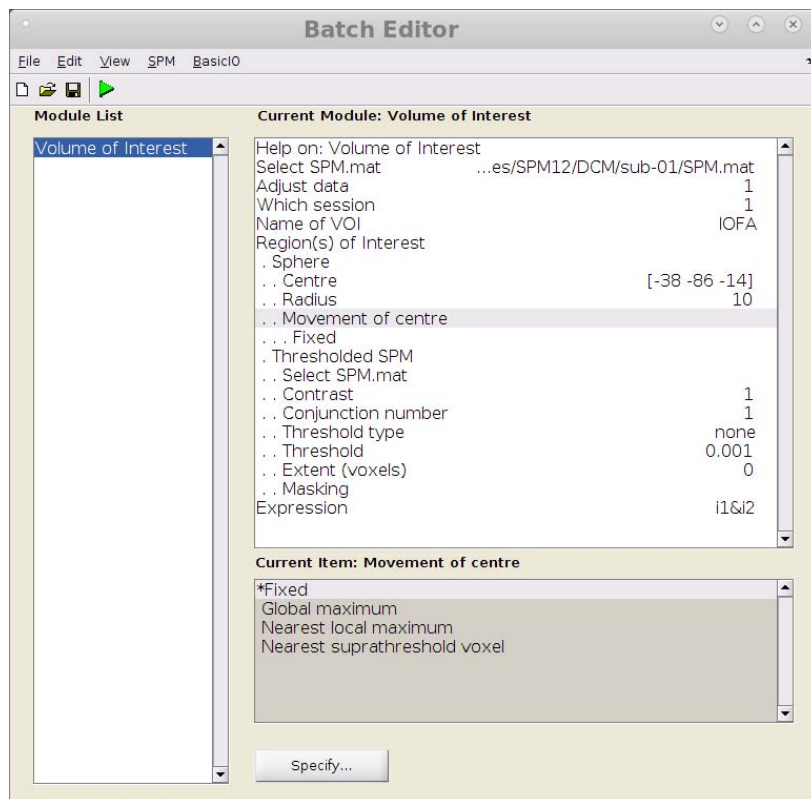
# Concatenation

- Could estimate each run separately, but easier to concatenate into one run
- Re-parametrise conditions by:
  - Collapsing famous and nonfamous faces
  - Defining two conditions: 1) Faces + Scrambled, 2) Faces only
  - 838 trials in total
  - 1872 volumes (TRs) per subject

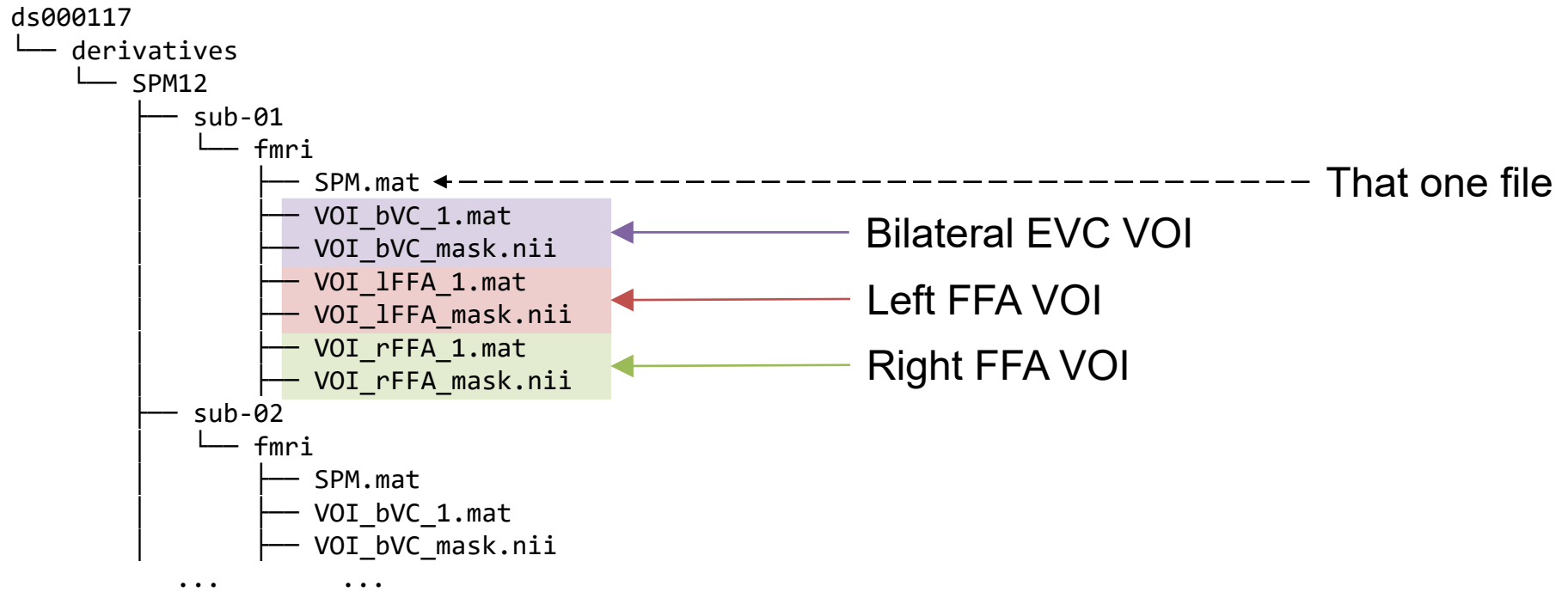


# Extract data from VOIs

- bEVC, IFFA, rFFA (order important)



# Data organization

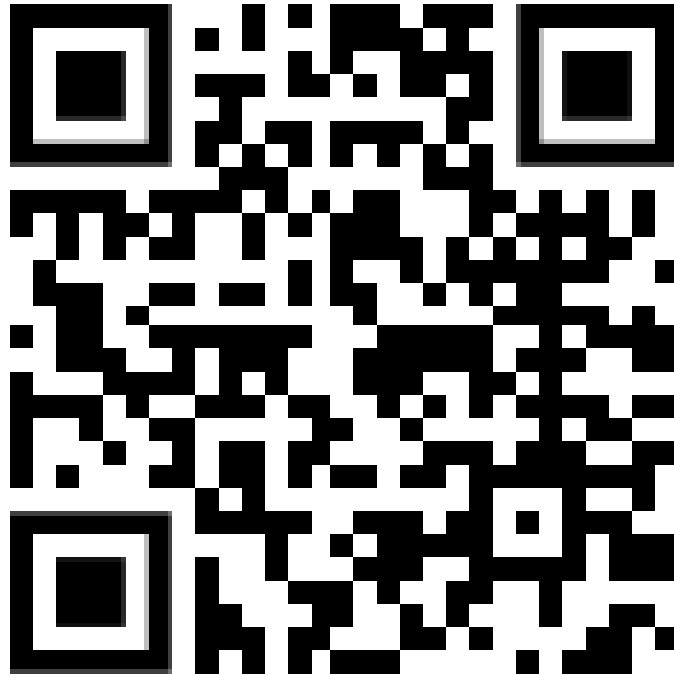


# Tomorrow

- DCM for evoked M/EEG responses:

Talk by Pranay: <https://www.youtube.com/watch?v=HNaAvKmVCYo>

# Feedback



<https://www.surveymonkey.com/r/X525RCT>