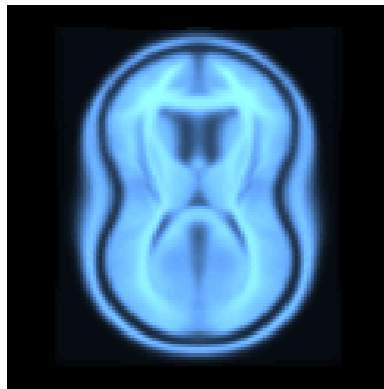


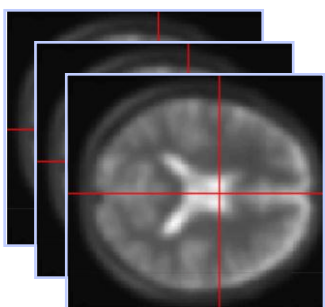
MEG and EEG analysis in SPM8



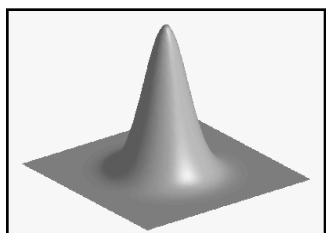
Vladimir Litvak

Wellcome Trust Centre for Neuroimaging
UCL Institute of Neurology

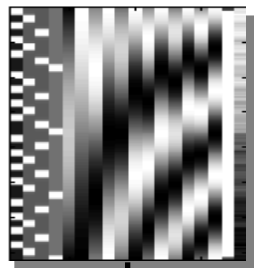
Image time-series



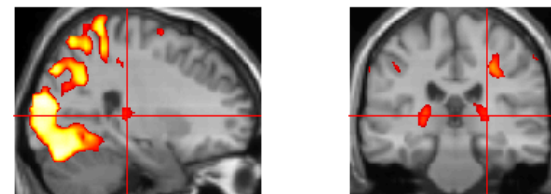
Spatial filter



Design matrix



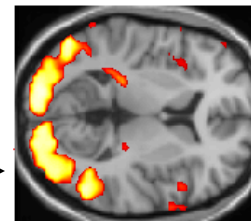
Statistical Parametric Map



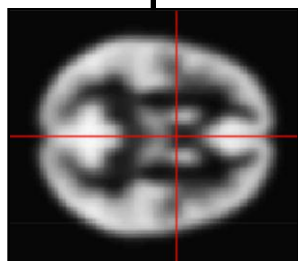
Realignment

Smoothing

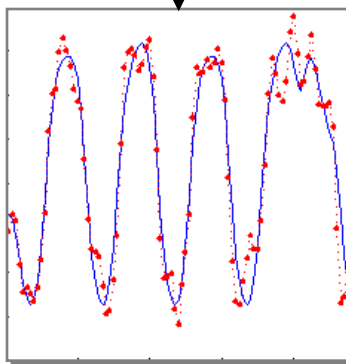
General Linear Model



Normalisation



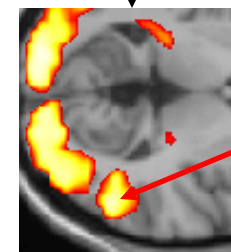
Anatomical reference



Parameter estimates

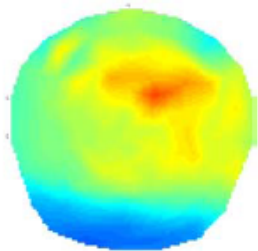
Statistical Inference

RFT

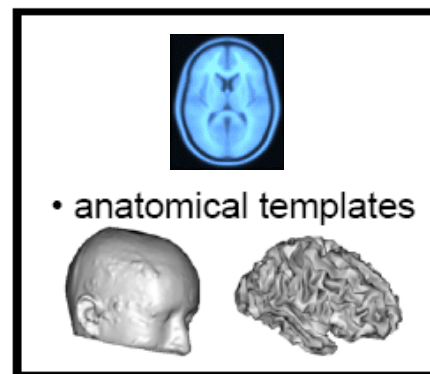
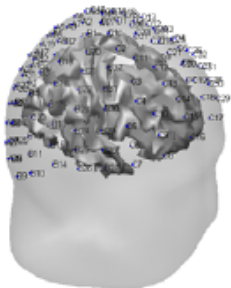


$p < 0.05$

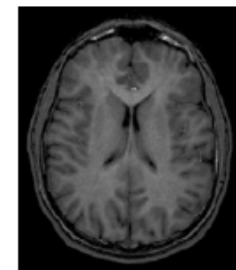
EEG/MEG data



Sensor locations



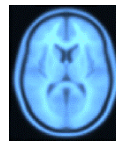
structural MRI



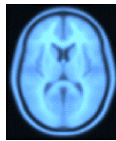

- data convert
- epoching



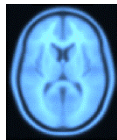
- BEM forward modelling



- spatial denormalisation



- baseline correction
- averaging over trials
- low pass filter (20Hz)



- inverse modelling
- 1st level contrast



- standard SPM analysis

trials

gain matrix

evoked responses

cortical sources

individual meshes

SPM M/EEG Interface



SPM8 (vltvak): Menu

Temporal preprocessing

Convert Filter Averaging

Epoching Artefacts Other...

Spatio-temporal modelling

3D Source Reconstr. DCM

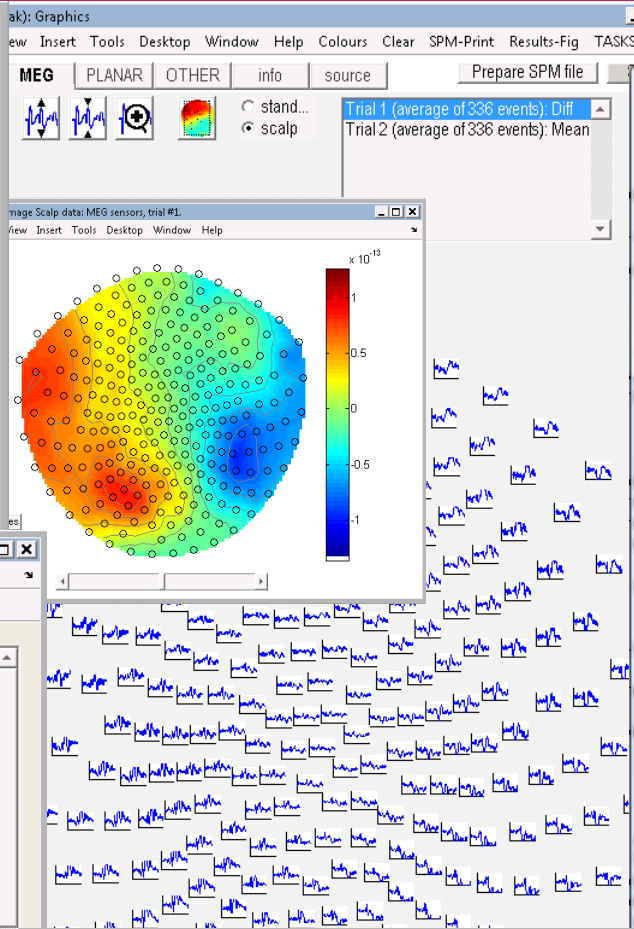
Model specification, review and estimation

Specify 1st-level Review

Specify 2nd-level Estimate

Inference

Results



DCM for M/EEG

load Study (DCM) filename IND ERP

save DCM_FnBn.mat new data

data and design

display >

time window (ms) -50 300 trials hanning

betw... effects 1 2

effect 1 1.00 0.00

detrend 1

subsample 1

modes 4

electromagnetic model dipoles

source names and locations: prior mean (mm)

ECD	IOFA	-39 -81 -15
	rOFA	42 -81 -15
	rFFA	-39 -51 -24
	rFFA	42 -45 -27

onset[s] (ms) 60 load

neural model review priors

linear nonlinear (not used) input

B effect 1

dipolar symmetry constraints

optimisa source locations

lock trial-specific effects

frequency window (Hz) Wavelnet number

Wavelnet transform 4 48 7 image API

invert DCM Frequency modes initialise BMS

Batch Editor

File Edit SPM BasicIO

Module List

Current Module: M/EEG Conversion

Help on: M/EEG Conversion

File Name <-X

Reading mode

. Continuous

. Read all

Channel selection

. All

Output filename <-X

Data type float32-le

Event padding 0

Block size 3276800

Check boundary Check boundaries

Input data format autodetect

Current Item: File Name

Select Files

File Name

Select data set file.

SPM8: EEG/MEG source localisation

Data file [mcdbespm8_SPM_CTF_MEG_example_faces1_ Load Save help

next previous 1:t new clear delete

Mesh template render

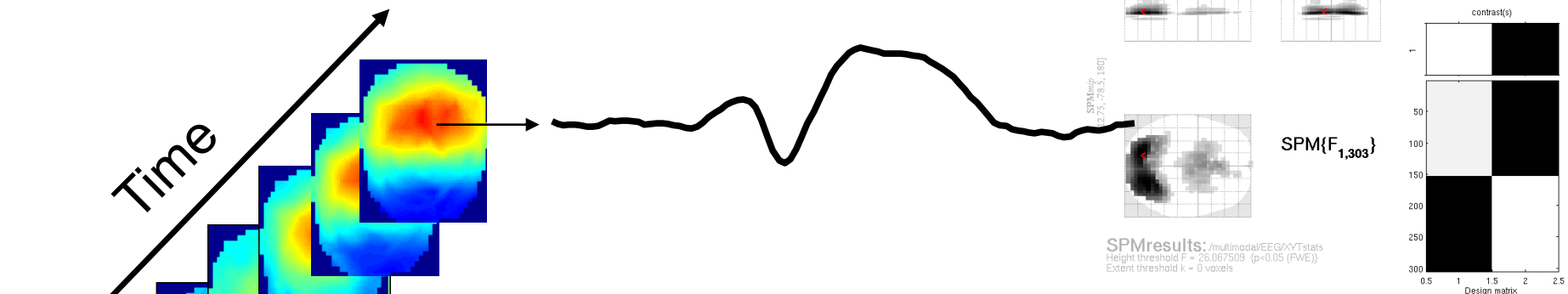
MRI Co-register Forward Model Invert Window Image

display display display mip display display

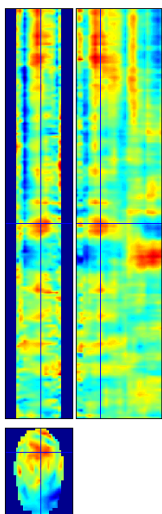
ms or mm condition 1

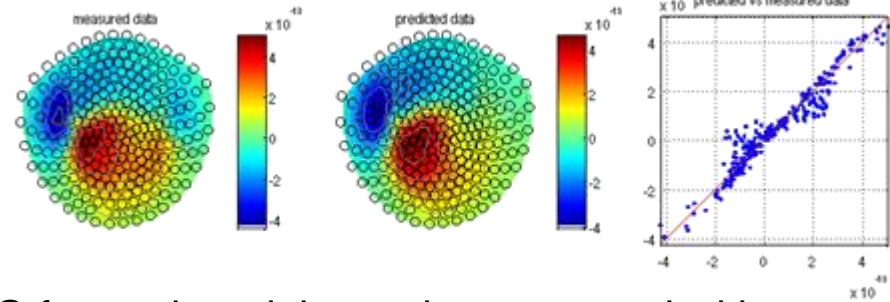
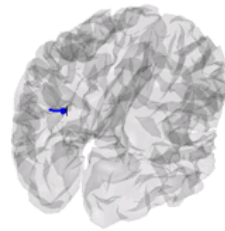
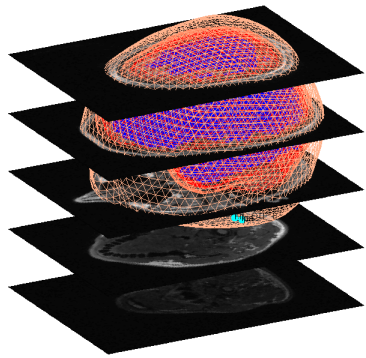
Group inversion

movie 0 300 ms



- ❑ Multichannel event-related fields are converted to 3D images and analyzed with SPM mass univariate approach.
- ❑ This makes it possible to reveal significant effects in time-space while correcting for multiple comparisons.
- ❑ Complex parametric models can be tested.
- ❑ Time-frequency matrices, results of source reconstruction and other data types representable as 2D or 3D images can be analyzed in a similar way.





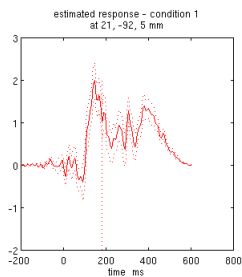
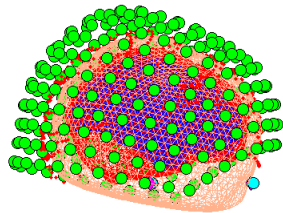
- Several kinds of MEG forward models can be generated with or without using individual MRI and/or head shape measurement.

- Bayesian imaging source reconstruction makes it possible to

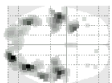
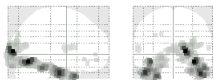
- incorporate prior knowledge (e.g. fMRI)
- constrain the solutions to be similar across a group of subjects
- perform multimodal fusion (EEG+MEG, planar gradiometers+magnetometers+EEG in Neuromag)

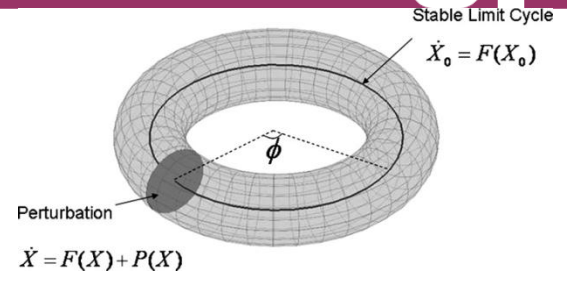
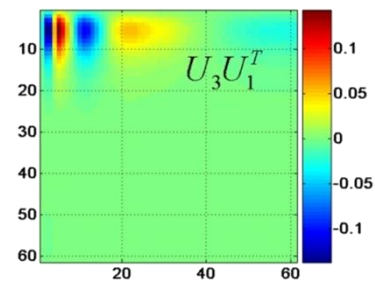
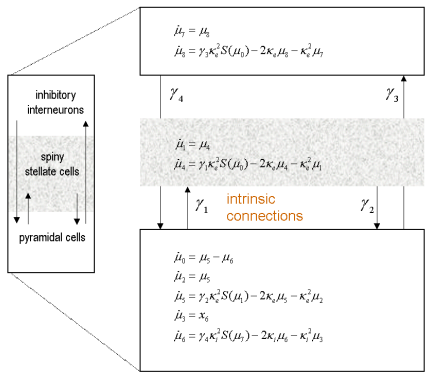
- Both evoked and induced activity can be reconstructed.

- There is also equivalent current dipole -based tool that makes it possible to compare dipole solutions using Bayesian model evidence (including selecting the optimal number of dipoles).

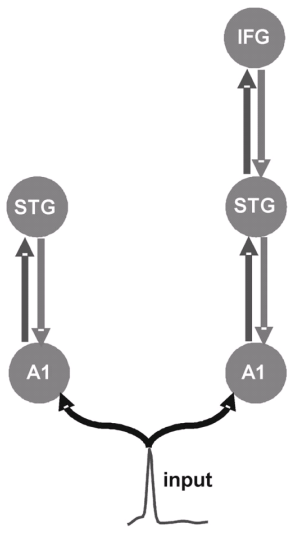


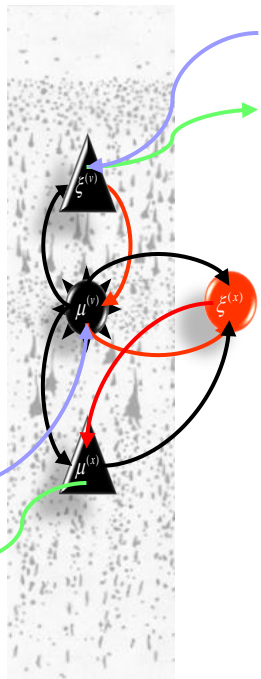
PPM at 100 ms (66 percent confidence)
512 dipoles
Percent variance explained 98.94 (37.91)
log-evidence = 1850.9





- ❑ Dynamic Causal Modelling (DCM) is a novel approach that combines data analysis and neural modelling.
- ❑ DCM makes it possible to directly test predictions of theoretical models against the data, estimate physiologically meaningful model parameters and compare different models using Bayesian model comparison.
- ❑ DCM can serve as the basis for a new integrative approach in neuroscience where different experiments are used to inform and refine the same model.
- ❑ DCM is presently available for evoked responses, induced responses, phase coupling and steady state responses (power spectra and cross spectra).





- ❑ DCM for steady state responses has been extended to complex spectra (Friston et al., Neuroimage 2012).
- ❑ More sophisticated model comparison strategies.
- ❑ DCM for neural fields makes it possible to assess spatial properties of active cortical patches (Pinotsis et al., Neuroimage 2012)
- ❑ GLM application for analysis of continuous time-frequency data to better characterise induced responses to temporally overlapping events.
- ❑ Multivariate tests for sensor- and source- level data.
- ❑ Support for fusion of sensor types in VB-ECD and DCM.
- ❑ Physiologically realistic DCMs for time-varying spectra (epileptic seizures, induced responses, phase coupling).

FieldTrip

<http://fieldtrip.fcdonders.nl/>



What is FieldTrip?

A MATLAB toolbox for electrophysiological data analysis



Features: high-level functions for electrophysiological data analysis

Data reading

all commercial MEG systems, many different EEG systems

Preprocessing

filtering, segmenting

Time-locked ERF analysis

Frequency and time-frequency analysis

multitapers, wavelets, welch, hilbert, parametric spectral estimates

Features: high-level functions for electrophysiological data analysis

Functional connectivity analysis

coherence, phase locking value, granger causality, and many more

Source reconstruction

beamformers, dipole fitting, linear estimation

Statistical analysis

parametric, non-parametric, channel and source level

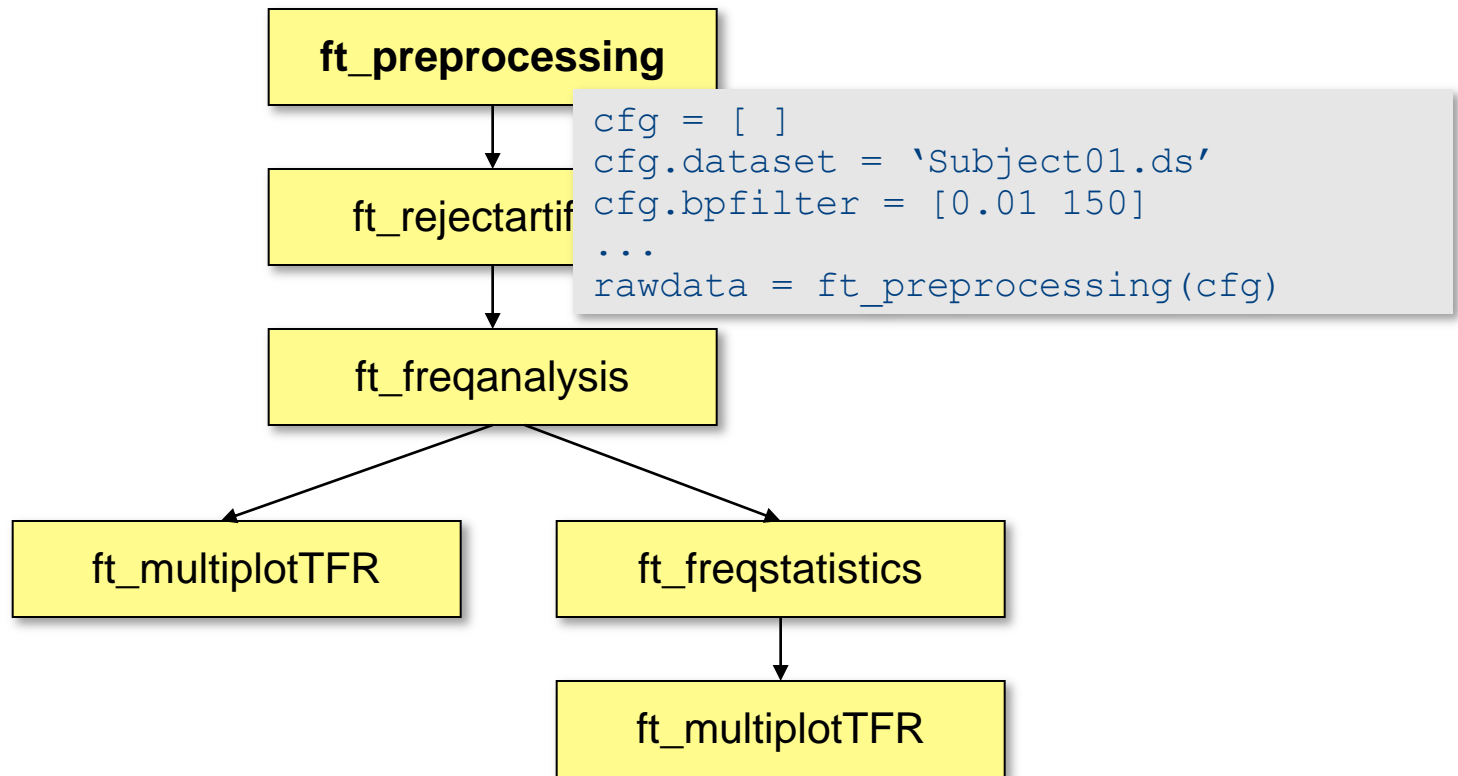
All other operations that are required around it

But...



Features

Analysis steps are incorporated in functions



FieldTrip toolbox - code reused in SPM8

*SPM8 end-user
perspective*

SPM8 main functions
with graphical user interface

fileio

forwinv

preproc

distrib.
comput.

fieldtrip

private

- ❑ SPM8 provides complete analysis toolkit for M/EEG that can be easily applied to common experimental paradigms using GUI.
- ❑ Although there is complex theoretical background behind some of the methods implemented in SPM, the application of the methods is straightforward and does not necessarily require mathematical training or programming skills.
- ❑ DCM is a novel method different from all other available M/EEG analysis methods because it allows making inferences not about data features but about the underlying hidden causes.
- ❑ SPM8 developers have a formal collaborations with the developers of Fieldtrip toolbox and a fully functional version of Fieldtrip is included in SPM8. SPM and Fieldtrip functionality can be combined to create powerful custom analysis tools.