

# Analysis of Functional Magnetic Resonance Imaging (fMRI) Brain Network – Functional Connectivity

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## Teaching Materials

• [http://www.ym.edu.tw/~cflu/CFLu\\_course\\_fMRIana.html](http://www.ym.edu.tw/~cflu/CFLu_course_fMRIana.html)

• **Week 11: Brain Network – Functional Connectivity**

• <Handout> [Lesson11\\_slides.pdf](#)

<Materials> [fMRIana11\\_materials.zip](#)

## Employed Software

### • MRICRO

- <https://people.cas.sc.edu/rorden/mricro/mricro.html#Installation>
- <https://www.mccauslandcenter.sc.edu/crnl/mricro>

### • Statistical Parametric Mapping (SPM 12)

- <http://www.fil.ion.ucl.ac.uk/spm/>



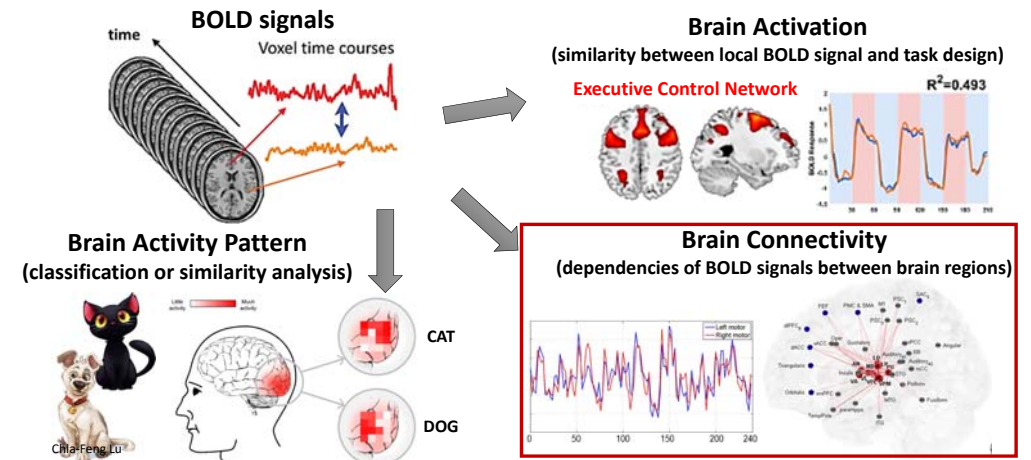
### • Data Processing & Analysis for Brain Imaging (DPABI)

- <http://rfmri.org/dpabi>



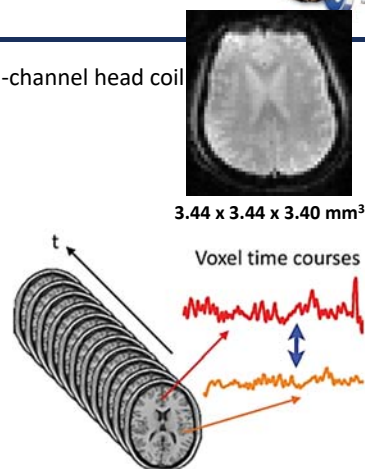
[Caution] File name\path contains Chinese character or space may cause error!

## fMRI Analysis



## fMRI Protocol

- Siemens 3T MAGNETOM Trio Scanner @ NYMU, 32-channel head coil
- Single-Shot 2D EPI (GRE-EPI), T2\* weighting
- Repetition Time = 2000 ms
- Echo Time = 20 ms
- Flip Angle = 70~90°
- NEX = 1
- Slice thickness = 3.4 mm
- Field of View = 220 x 220 mm<sup>2</sup>
- Matrix size = 64 x 64
- Slice number = 40
- Volume number (depends on experiment design)

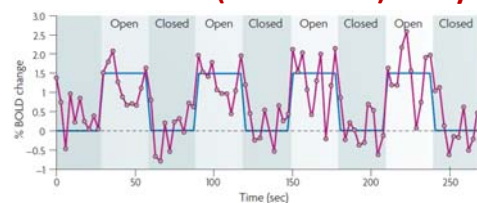


## Functional Connectivity of fMRI

## BOLD Fluctuation

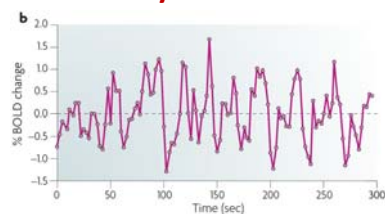
### • Task-specific fMRI

- ✓ Model-based Analysis
- ✓ **Model-free (data-driven) Analysis**



### • Resting-state fMRI (rs-fMRI)

- ✓ **Model-free (data-driven) Analysis**



*Nature Reviews Neuroscience* 8.9 (2007): 700-711.

## Rs-fMRI Analyses

### 1. Depicting local features of BOLD signal

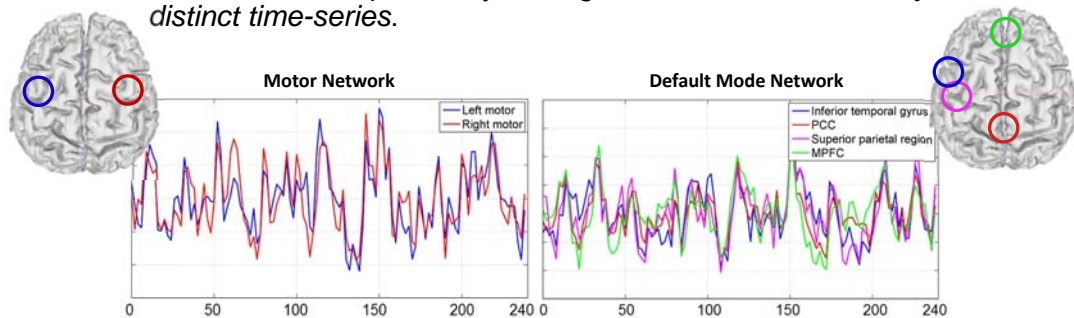
- Regional homogeneity (**ReHo**; Zang et al., *NeuroImage* 2004)
- Amplitude of low-frequency fluctuation (**ALFF**; Zang et al., *Brain & Development* 2007)
- Fractional ALFF (**fALFF**; Zou et al., *J Neurosci Methods* 2008)

### 2. Functional connectivity analysis

- Linear correlation (**FC**; Biswall et al., *MRM* 1995)
- Granger causality analysis (**GCA**), effective connectivity
- Independent component analysis (**ICA**; McKeown et al., *HBM* 1998; Calhoun et al., *HBM* 2001)

# Functional connectivity

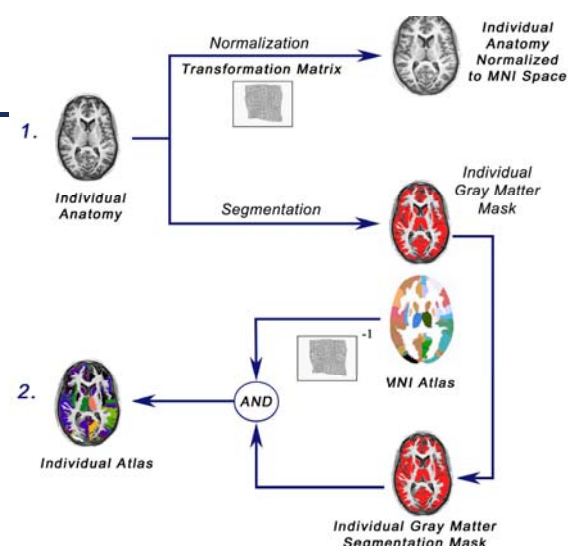
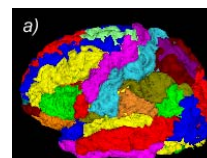
- Functional connectivity (FC) is defined as the statistical association or dependency among two or more anatomically distinct time-series.



(Friston 1994, HBM 20, 56-78 & Friston et al., 1996, Cereb Cortex, 60 156-164)

# AAL Atlas

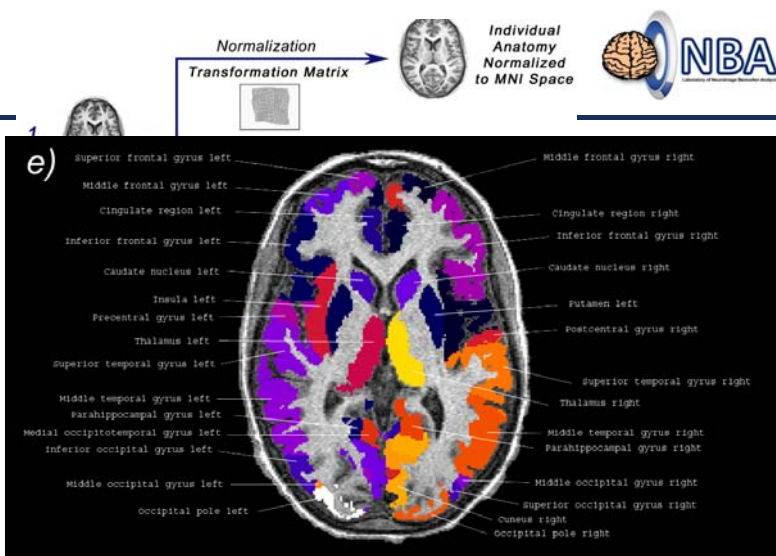
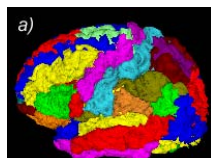
- Individual atlas flowchart



Tzourio-Mazoyer et al. Neuroimage 15: 273-289. 2002.

# AAL Atlas

- Individual atlas flowchart



Tzourio-Mazoyer et al. Neuroimage 15: 273-289. 2002.

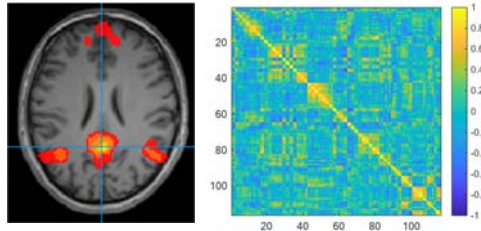
# Key Steps for FC analysis

- Essential fMRI preprocessing steps
  - Slice timing, realign, segment, normalize, and smooth
- Regress out the nuisance covariates
  - Signals from white matter, cerebrospinal fluid (CSF), and global mean signal
- Signal filtering
  - Frequency band associated with brain activity: 0.01~0.1Hz
- Pearson's correlation coefficients
  - Linear correlation between BOLD signals
- Fisher r-to-z transform
  - transform the Pearson's correlation coefficient r to a normal distribution.

## Methodological Terms

- Seed-based ROIs
  - Define an ROI by the MNI coordinate (ex: [0,-53,26] for PCC with a 6-mm radius)
- Atlas-based ROIs
  - Define regional ROIs based on an image atlas (es: AAL atlas)

- Functional Connectivity Maps
- Functional Connectivity Matrix



## DPABI Toolbox

### Functional Connectivity

## DPABI

- DPABI is evolving from DPARSF, which is based on SPM.
  - **fMRI preprocessing pipeline** (slice timing, realign, segment, normalize, and smooth).
  - **rs-fMRI analyses** (ALFF/fALFF, ReHo, degree centrality, and **functional connectivity**)
- Online videos
  - [http://rfmri.org/WebinarCourse\\_20160125](http://rfmri.org/WebinarCourse_20160125)

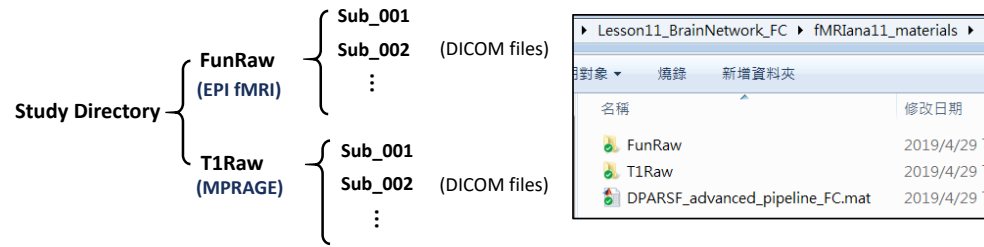


## Common Errors When using DPABI

- No Chinese character or space is allowed in the file path.
- Please install parallel computing toolbox in MATLAB (e.g., R2019a didn't install this toolbox by default).
- For MAC OS, FreeSurfer is demanded for perform BET process.

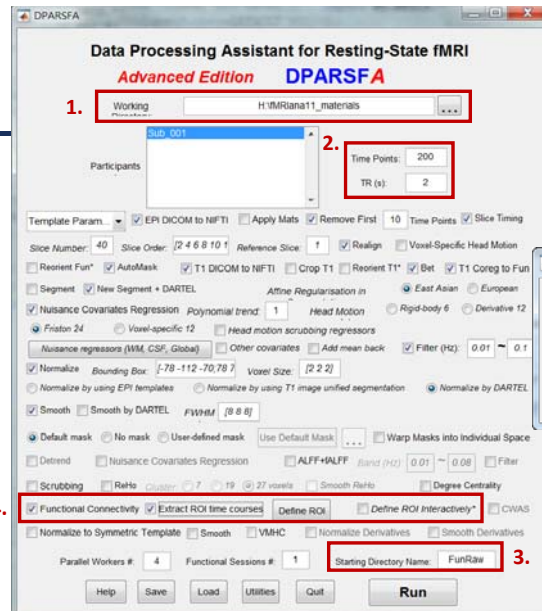
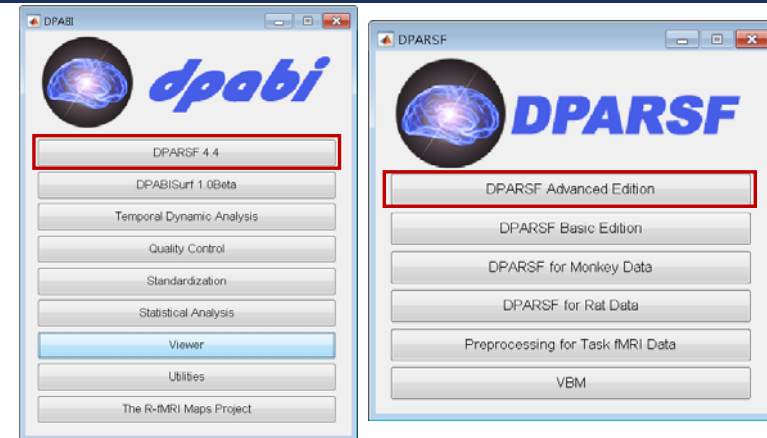
## Step 1: Data Organization

- Before using DPABI toolbox, you have to organize subject data by the following way,



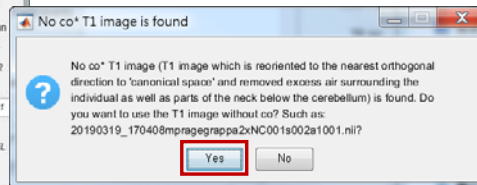
## Step 2: Pipeline Setup

Include DPABI\_V4.0\_190305 path and key in `dpabi` in MATLAB command window



## Step 2: Pipeline Setup

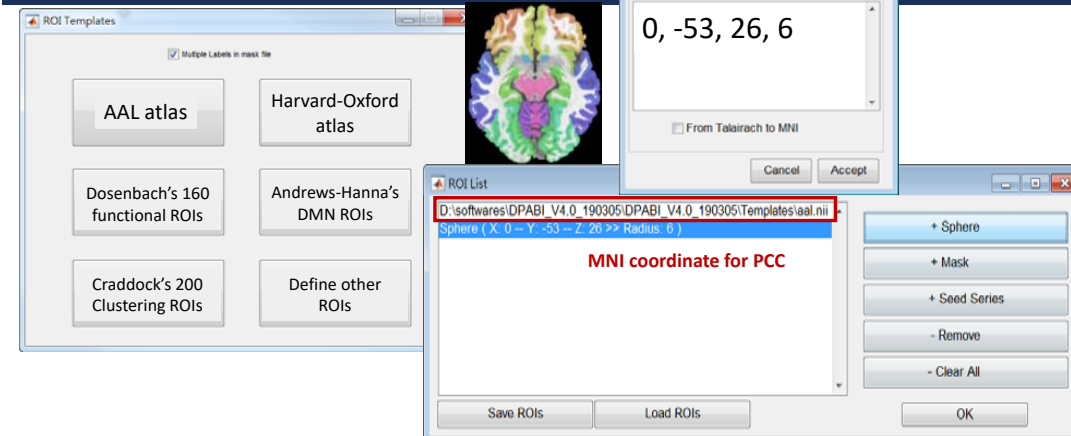
Takes 10~20 minutes for each subject



**DPARSF\_advanced\_pipeline\_FC.mat**

<https://youtu.be/5Pdrwi5Z5Xc>

## Define ROIs



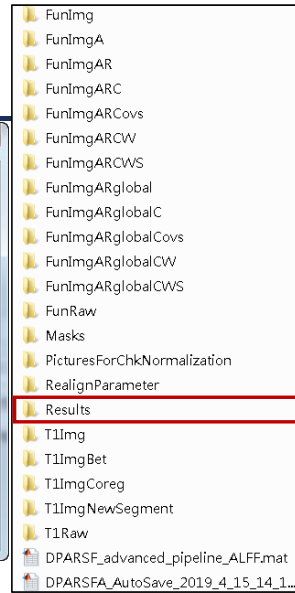
## Step 3: Review Results

Congratulations, the running of DPARSFA is done!!! :)

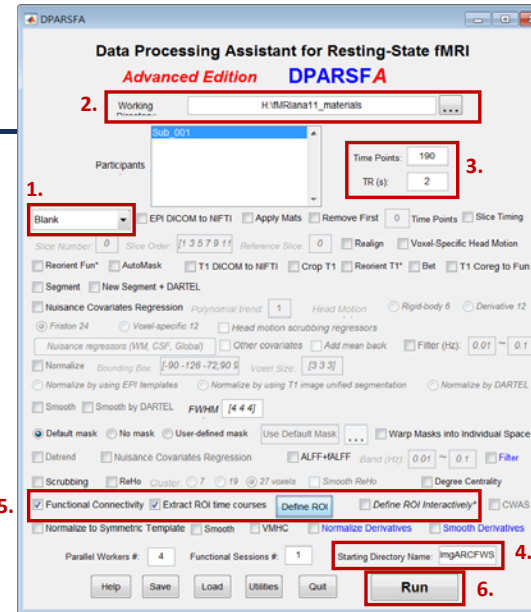


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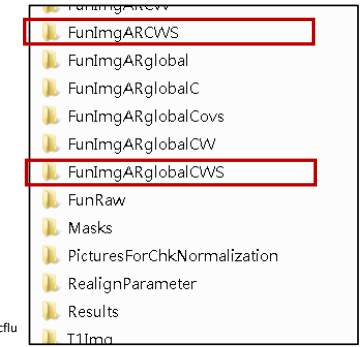
<http://www.ym.edu.tw/~cflu>



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## FC Analysis by Skipping Preprocessing

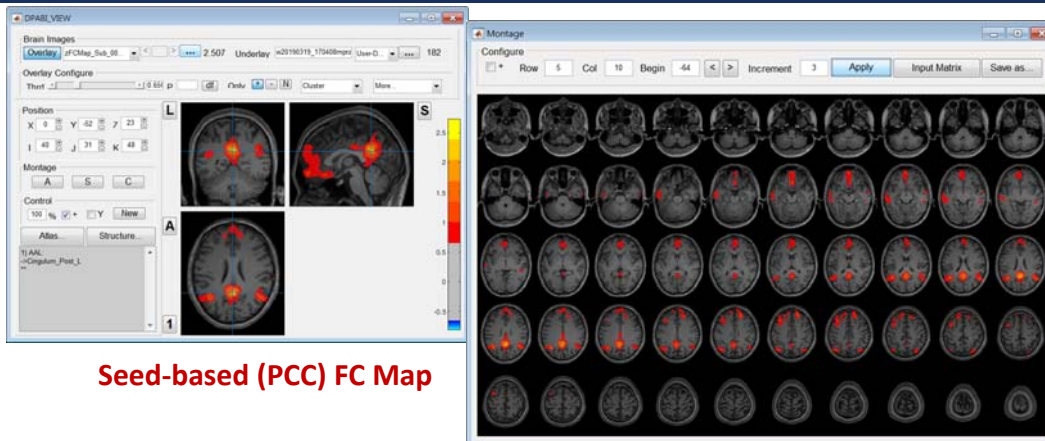


tw/~cflu

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## Step 3: Review Results



Seed-based (PCC) FC Map

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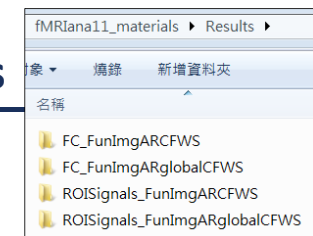
<http://www.ym.edu.tw/~cflu>

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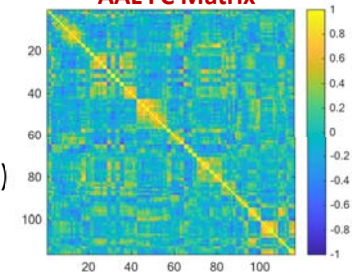


## Step 3: Review Results

- `load('ROISignals_Sub_001.mat')`
- `figure,plot(ROISignals)`
- `load('ROICorrelation_Sub_001.mat')`
- `figure,imagesc(ROICorrelation),caxis([-1 1])`
- `load('ROICorrelation_FisherZ_Sub_001.mat')`
- `figure,imagesc(ROICorrelation_FisherZ)`



AAL FC Matrix



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## Step 4: Statistical Analysis

DPABI

DPARSF 4.4

DPABISurf 1.0Beta

Temporal Dynamic Analysis

Quality Control

Standardization

**Statistical Analysis**

Viewer

Utilities

The R-fMRI Maps Project

Statistical Analysis

One-Sample T-test

Two-Sample T-test

Paired T-test

ANCOVA

ANCOVA (Repeated Measures)

Correlation Analysis

Mixed Effect Analysis

Base 0 Remove Add

Output

Mask File

Output Dir H:\

Prefix T

Permutation test (PALM) Run

<http://www.ym.edu.tw/~cflu>

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# THE END

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