动态功能连接分析

黎超
微信：13591648206
邮箱：lichao19870617@163.com

悦影科技
YUEYING

- ICA基本原理及在fMRI中的实现
- ICA实际操作
- 独立成分的筛选与提取
- 独立成分之间的动态连接
- 动态连接相关指标
- 基于ROI的动态连接分析

ICA基本原理

A cocktail-party problem

Number of microphones ≥ number of speakers

Speaker 1 Speaker 2 Speaker 3

Microphone 1: $x_1(t) = 0.7s_1(t) + 0.2s_2(t) + 0.1s_3(t)$

Microphone 2: $x_2(t) = 0.3s_1(t) + 0.4s_2(t) + 0.3s_3(t)$

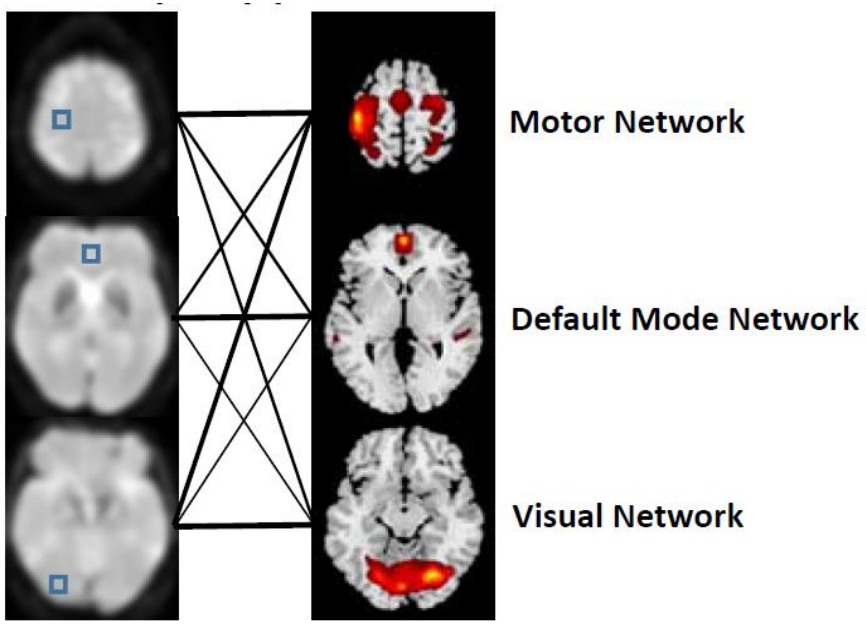
Microphone 3: $x_3(t) = 0.1s_1(t) + 0.2s_2(t) + 0.7s_3(t)$

Blind Source Separation

$$\begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_m(t) \end{bmatrix} = \mathbf{A} \begin{bmatrix} s_1(t) \\ s_2(t) \\ \vdots \\ s_k(t) \end{bmatrix}$$

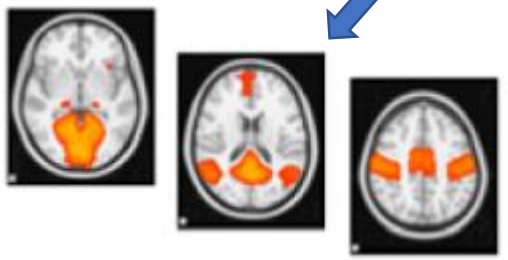
A is the mixing matrix.

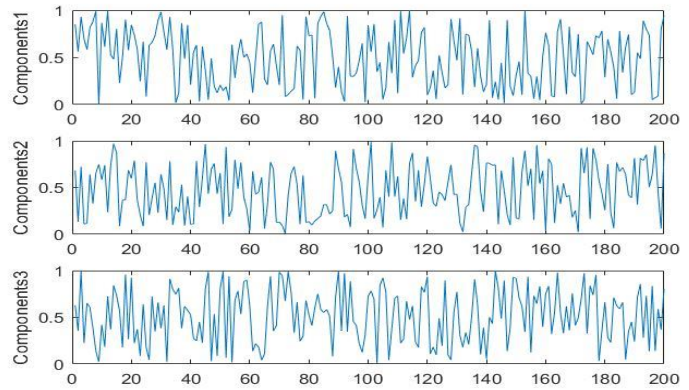
ICA基本原理



Number of voxels ≥ number of networks

X = AS

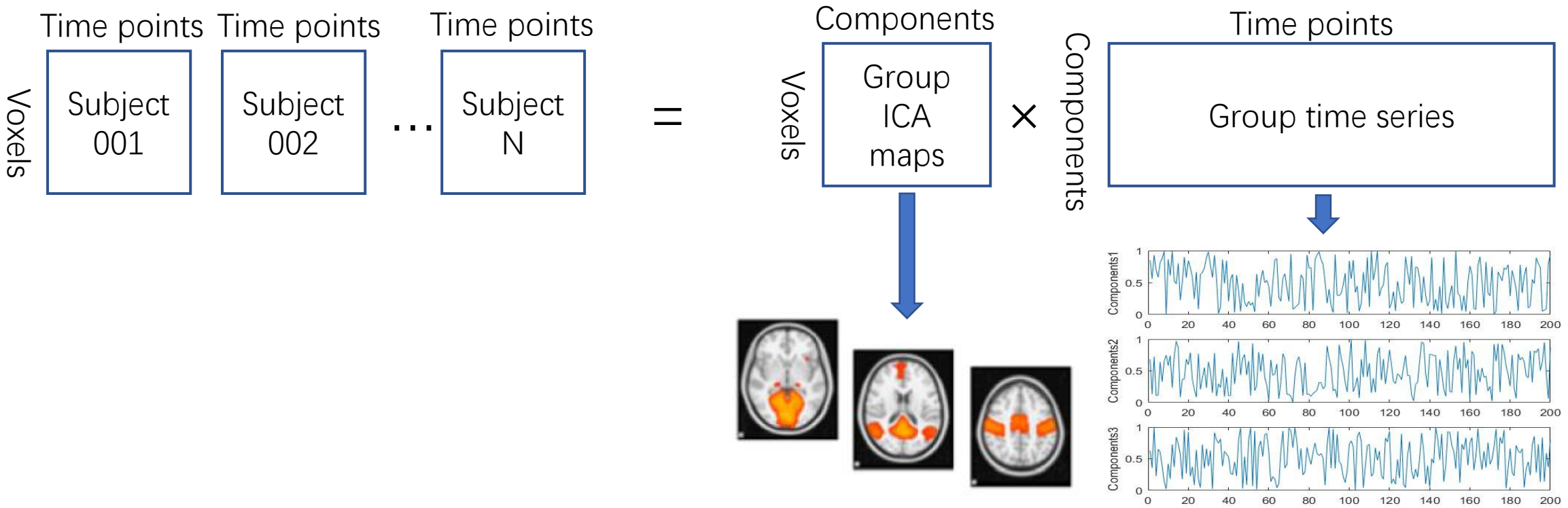




图片修改自盧家鋒老师的课件https://www.ym.edu.tw/~cflu/CFLu_course_fMRIana.html

ICA基本原理

- Group-ICA的矩阵表示

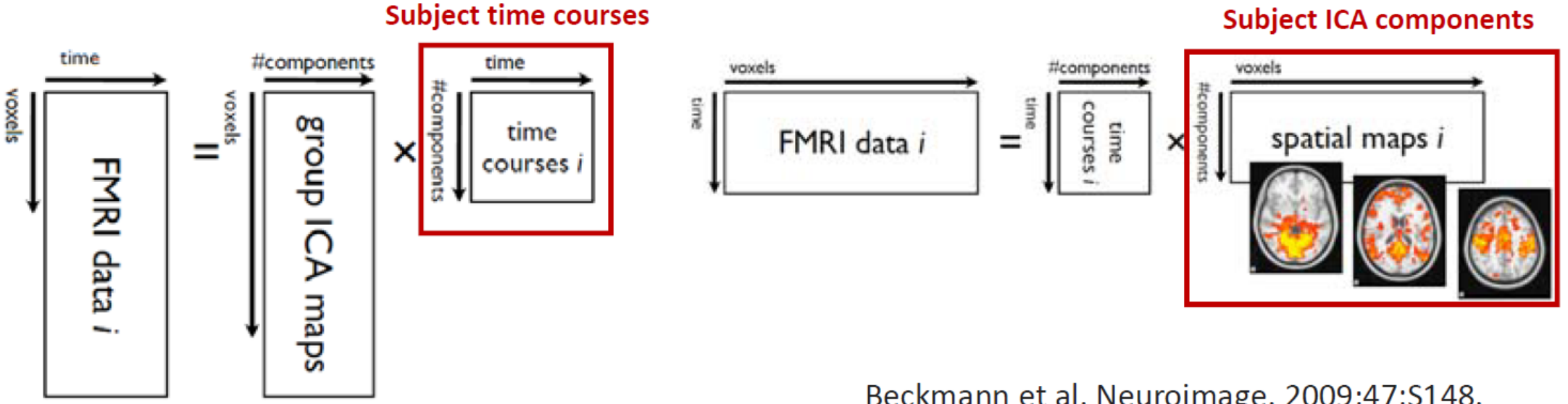


ICA基本原理

- Dual Regression OR Back Reconstruction

Using the group-level spatial maps as a set of spatial regressors in a GLM, to find temporal dynamics associated with each group-level map.

Using these time courses as a set of temporal regressors in a GLM, to find subject specific maps (still associated with the group-level spatial maps).

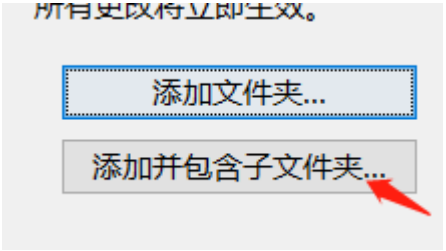


Beckmann et al. Neuroimage. 2009;47:S148.

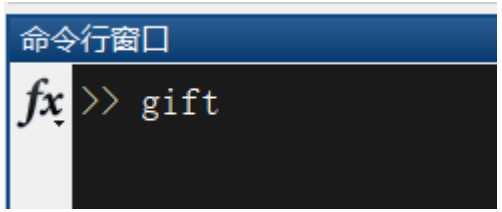
图片来源于盧家鋒老师的课件https://www.ym.edu.tw/~cflu/CFLu_course_fMRIana.html

ICA实际操作

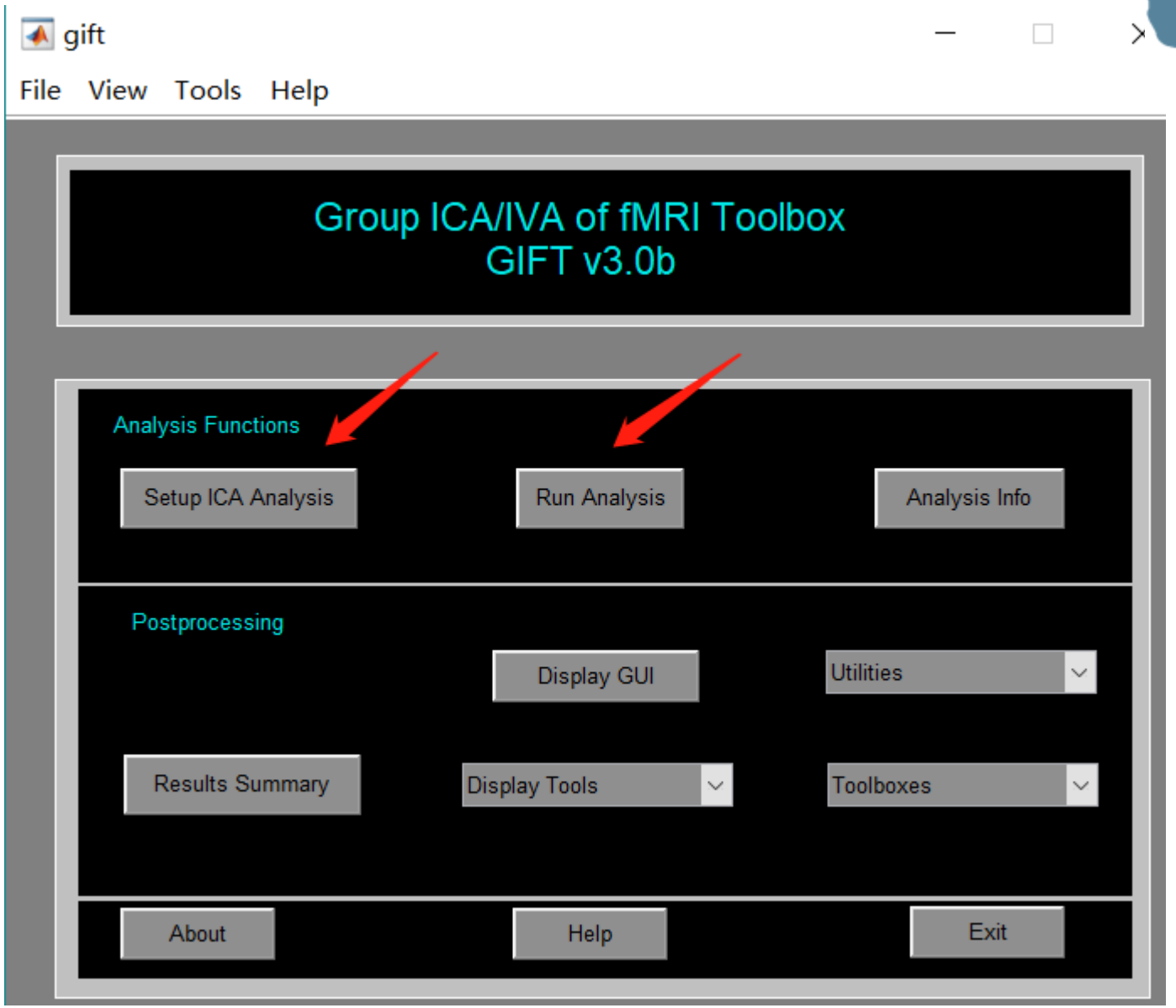
- 加载GIFT软件到MATLAB搜索目录：添加并包含子文件夹



- 启动GIFT：在matlab命令框输入gift



ICA实际操作


gift
File View Tools Help
Group ICA/IVA of fMRI Toolbox
GIFT v3.0b
Analysis Functions
Setup ICA Analysis
Run Analysis
Analysis Info
Postprocessing
Display GUI
Utilities
Results Summary
Display Tools
Toolboxes
About
Help
Exit

ICA实际操作

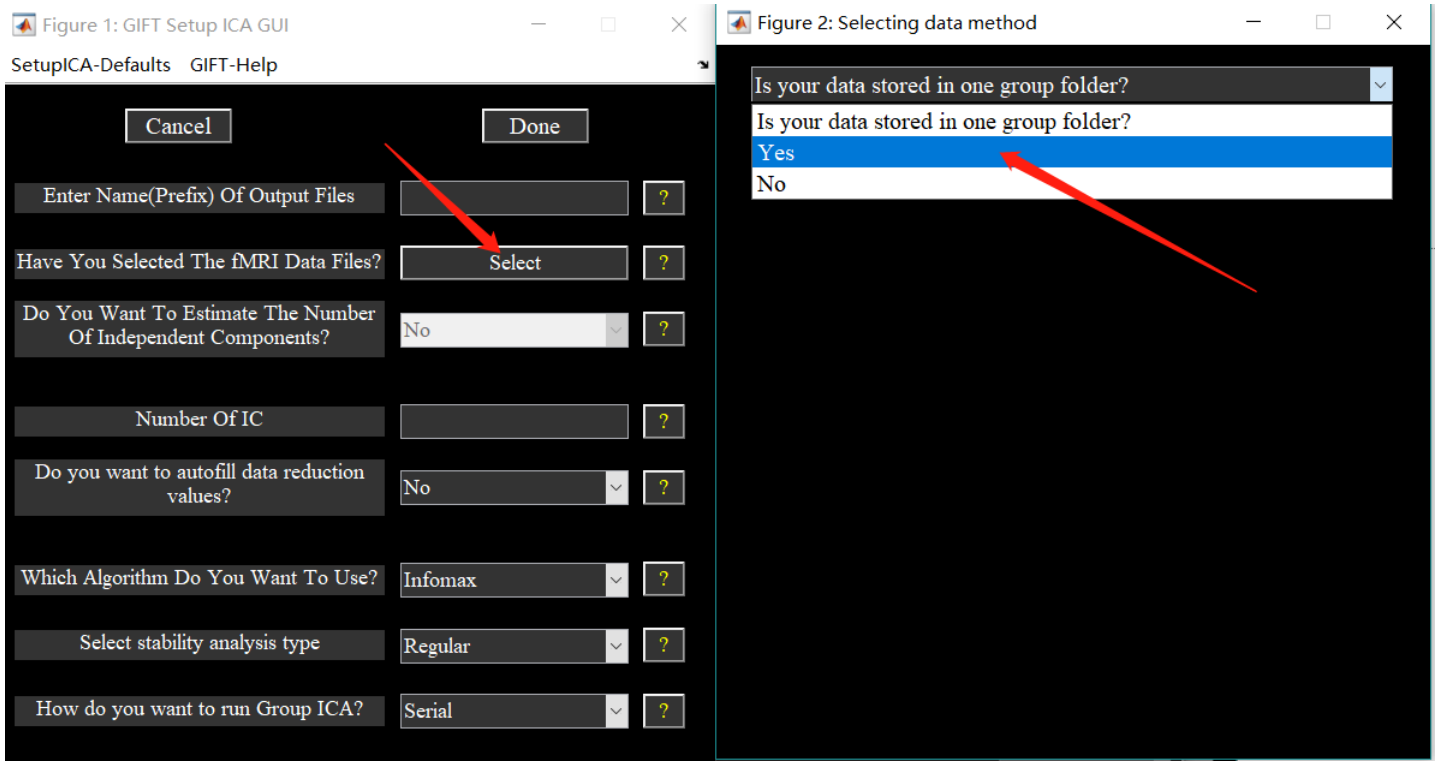


Figure 1: GIFT Setup ICA GUI
SetupICA-Defaults GIFT-Help
Cancel
Done
Enter Name(Prefix) Of Output Files
Have You Selected The fMRI Data Files?
Select
Do You Want To Estimate The Number Of Independent Components?
No
Number Of IC
Do you want to autofill data reduction values?
No
Which Algorithm Do You Want To Use?
Infomax
Select stability analysis type
Regular
How do you want to run Group ICA?
Serial
?

Figure 2: Selecting data method
Is your data stored in one group folder?
Is your data stored in one group folder?
Yes
No

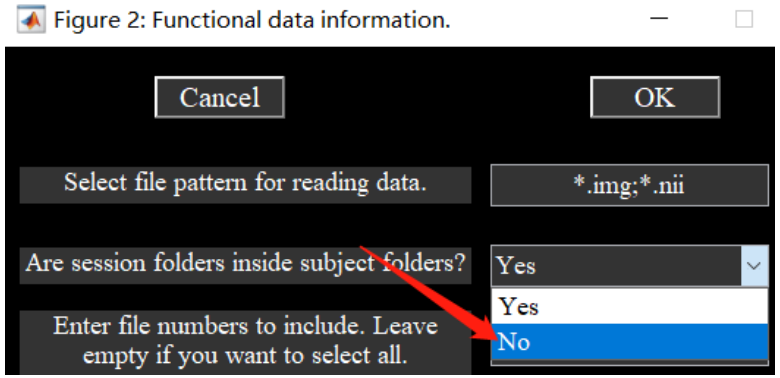
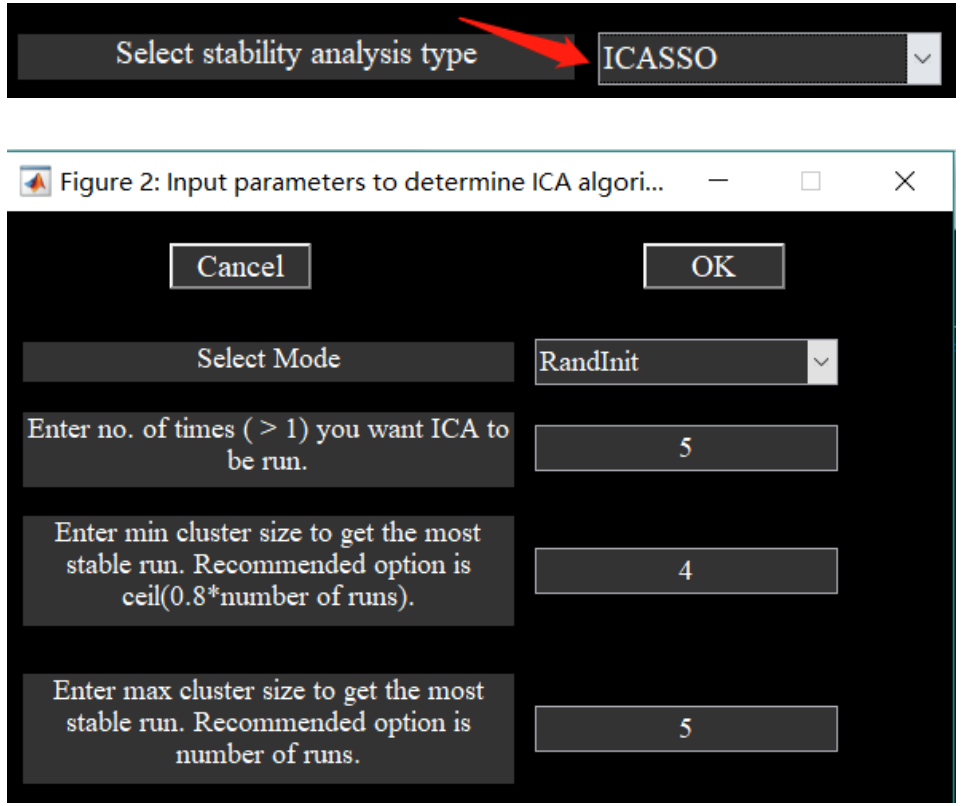


Figure 2: Functional data information.
Cancel
OK
Select file pattern for reading data.
.img;.nii
Are session folders inside subject folders?
Yes
Yes
No
Enter file numbers to include. Leave empty if you want to select all.

ICA实际操作

- 'Which Group ICA Analysis You Want To Use?' Options are 'Regular', 'ICASSO' and 'MST'. When you select 'ICASSO' or 'MST', ICA is run several times and the best estimate for each component is used (See Section 3.13.1). Please note that algorithms like JADE OPAC, Constrained ICA (Spatial), GIG-ICA and IVA-GL don't work with ICASSO. If you want to run stability analysis on IVA-GL algorithm, select 'MST'. When you select 'MST', best run is selected using the highest correlation between the selected component estimates and *t*-maps obtained using all ICA/IVA runs. Please see (W. Du, S. Ma, G-S. Fu, V. Calhoun, and T. Adalı, 2014) for more information.

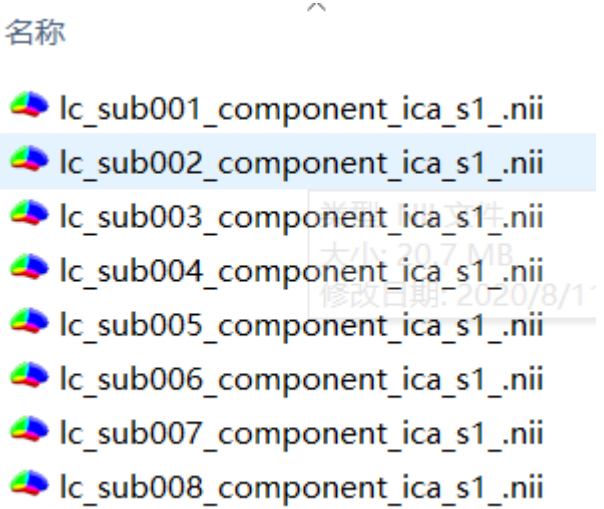


独立成分的筛选与提取

所有结果参数

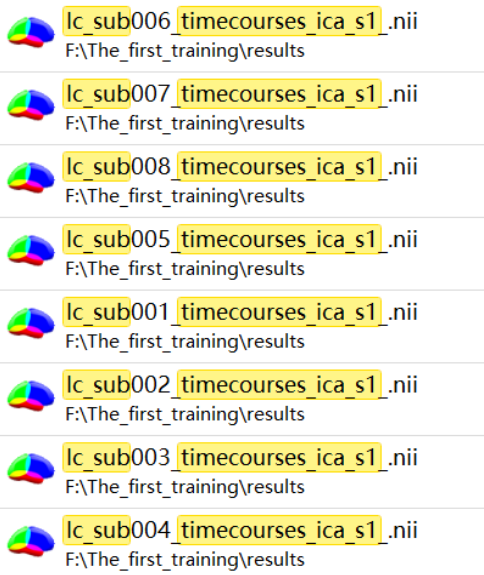
```
Parameter Infomation Stored as Matlab File in:
    lc_ica_parameter_info
Data Reduction Results Stored as Matlab File in:
    lc_pca_r
ICA Results Stored as Matlab File in:
    lc_ica
Back Reconstructed Results Stored as Matlab File in:
    lc_ica_br
Calibrated Components Stored as Matlab File in:
    lc_ica_c
Mean Component for all Subjects and Sessions Stored as:
    lc_mean_component_ica_s_all_.nii
Mean Component Results for Session 1 Stored as:
    lc_mean_component_ica_s1_.nii
TMap Component Results for Session 1 Stored as:
    lc_tmap_component_ica_s1_.nii
Std Component Results for Session 1 Stored as:
    lc_std_component_ica_s1_.nii
Subject 1 Component Results for Session 1 Stored as:
    lc_sub001_component_ica_s1_.nii
```

每个被试的4D成分图

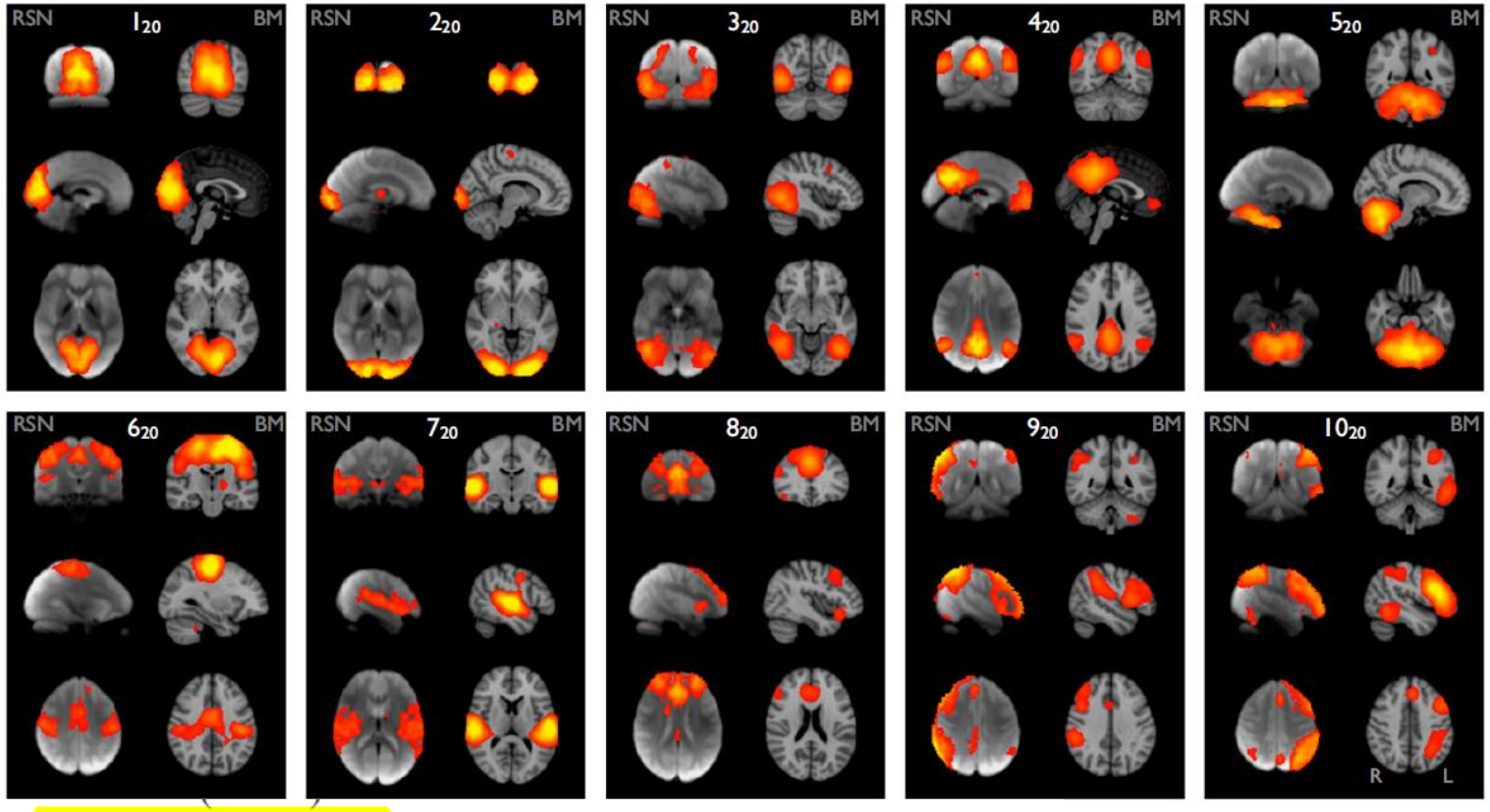


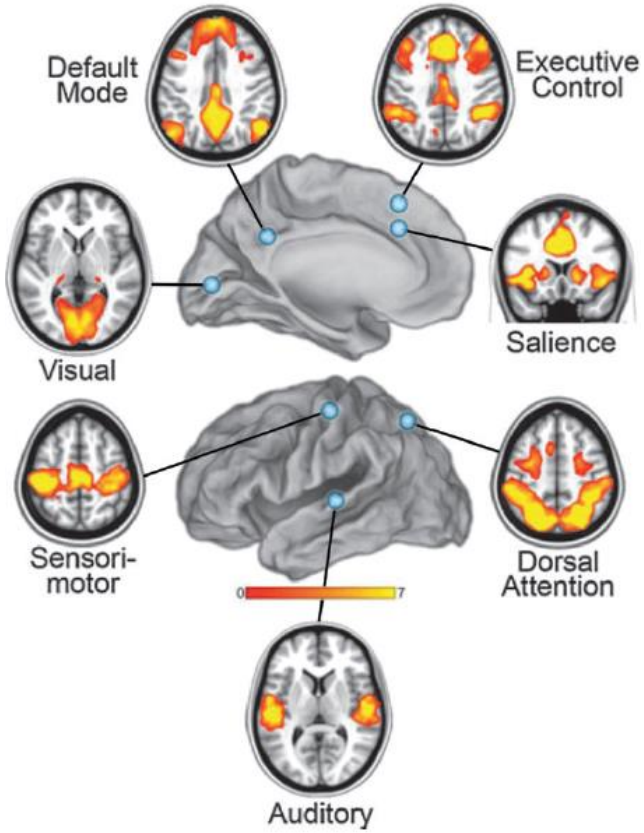
N_row * N_column * N_layer * N_components

每个被试成分的2D时间序列



N_volume * N_components





Maps 1_{20}, 2_{20} and 3_{20} ("visual") correspond to medial, occipital pole, and lateral visual areas. The explicitly visual behavioral

Map 4_{20} ("default mode network") includes medial parietal (precuneus and posterior cingulate), bilateral inferior–lateral–parietal and ventromedial frontal cortex. This is often referred

Map 5_{20} ("cerebellum") covers the cerebellum.

Map 6_{20} ("sensorimotor") includes supplementary motor area, sensorimotor cortex, and secondary somatosensory cortex.

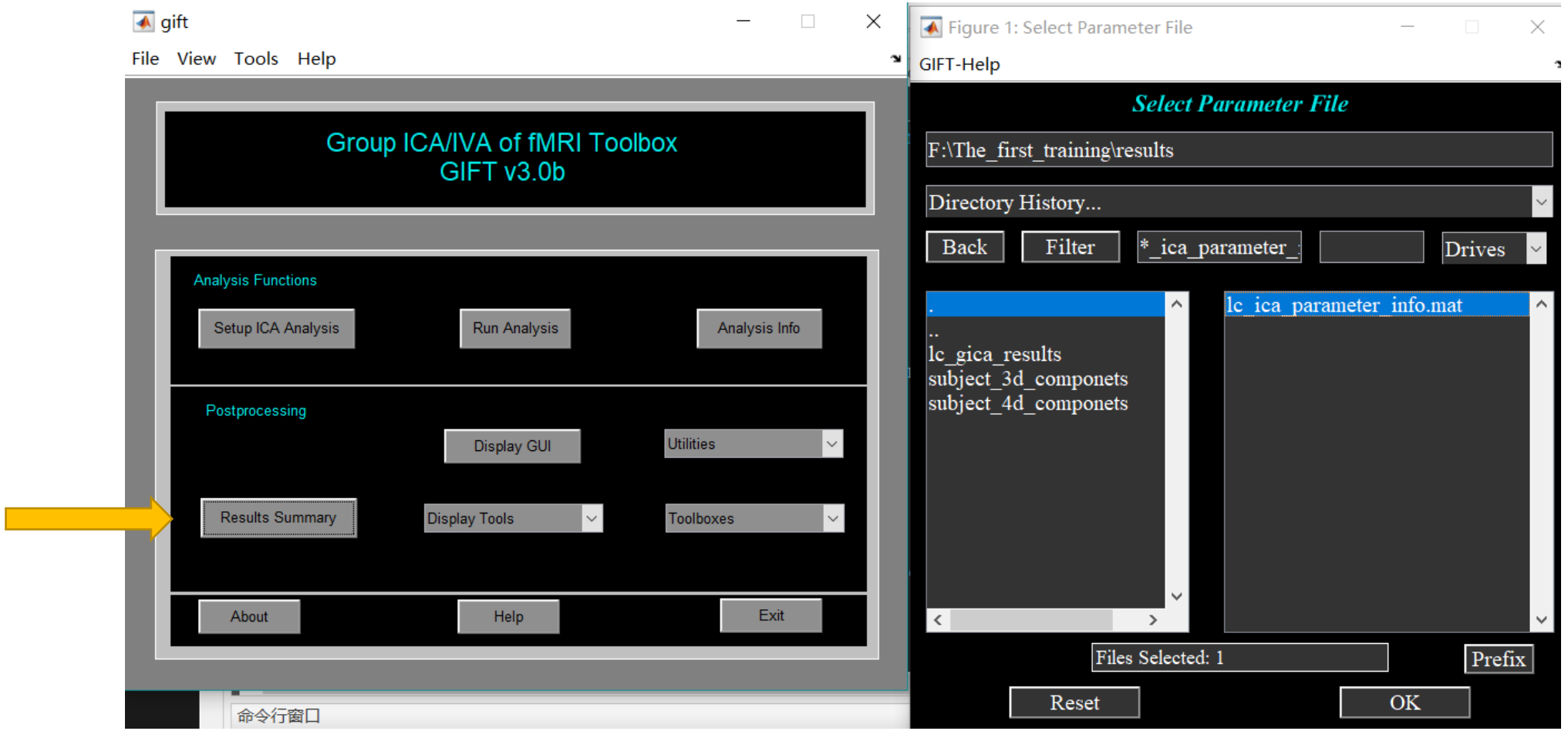
Map 7_{20} ("auditory") includes the superior temporal gyrus, Heschl's gyrus, and posterior insular. It includes primary and association auditory cortices. This corresponds most strongly to

Map 8_{20} ("executive control") covers several medial–frontal areas, including anterior cingulate and paracingulate. This cor-

Maps 9_{20} and 10_{20} ("frontoparietal") cover several frontoparietal areas. These are the only maps to be strongly lateralized, and are largely left–right mirrors of each other. They correspond

1.www.pnas.orgcgidoi10.1073pnas.0905267106
2.Resting-State Functional MR Imaging: A New Window to the Brain

独立成分的筛选与提取

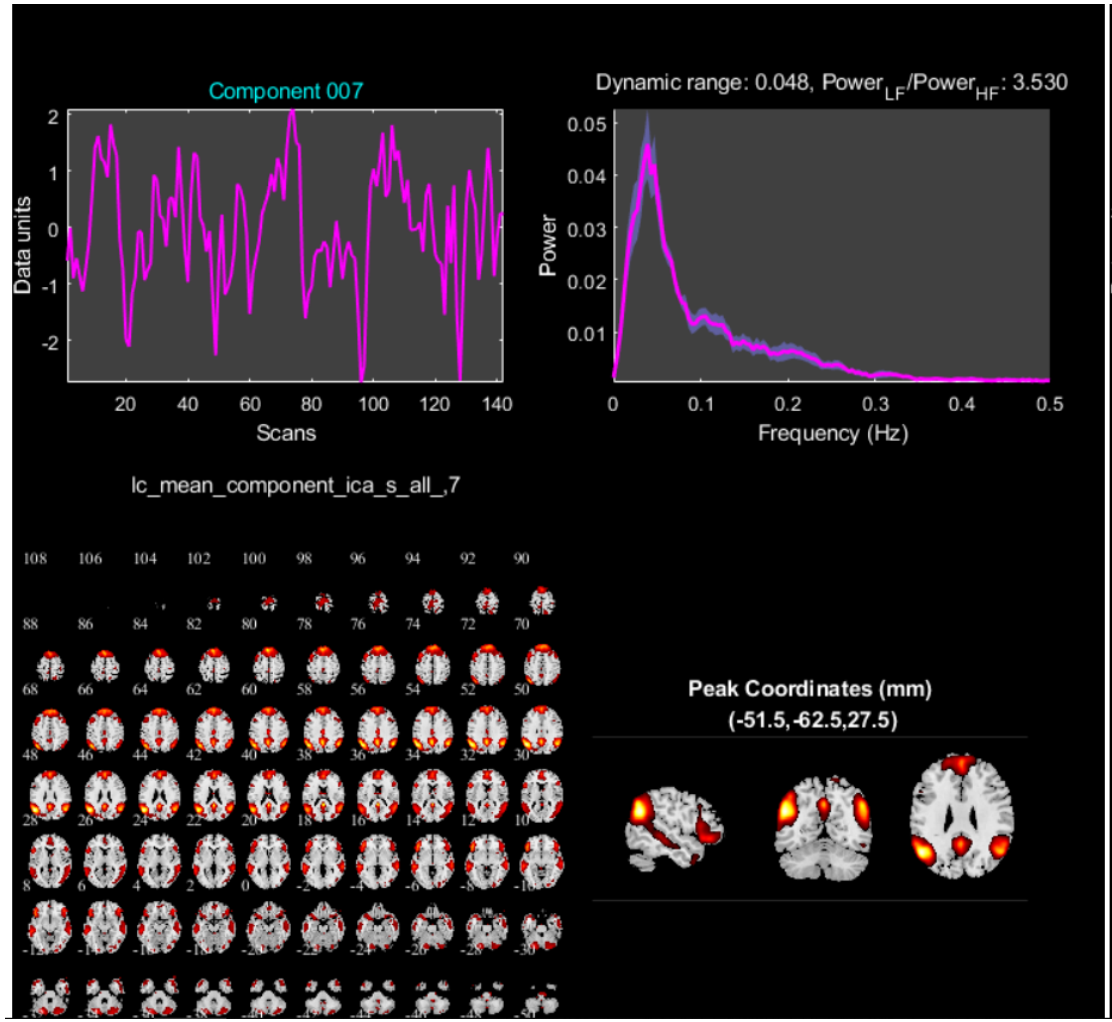

gift
File View Tools Help
Group ICA/IVA of fMRI Toolbox
GIFT v3.0b
Analysis Functions
Setup ICA Analysis
Run Analysis
Analysis Info
Postprocessing
Display GUI
Utilities
Results Summary
Display Tools
Toolboxes
About
Help
Exit
命令行窗口
Figure 1: Select Parameter File
GIFT-Help
Select Parameter File
F:\The_first_training\results
Directory History...
Back
Filter
*_ica_parameter_
Drives
.
..
lc_gica_results
subject_3d_componets
subject_4d_componets
lc_ica_parameter_info.mat
Files Selected: 1
Prefix
Reset
OK

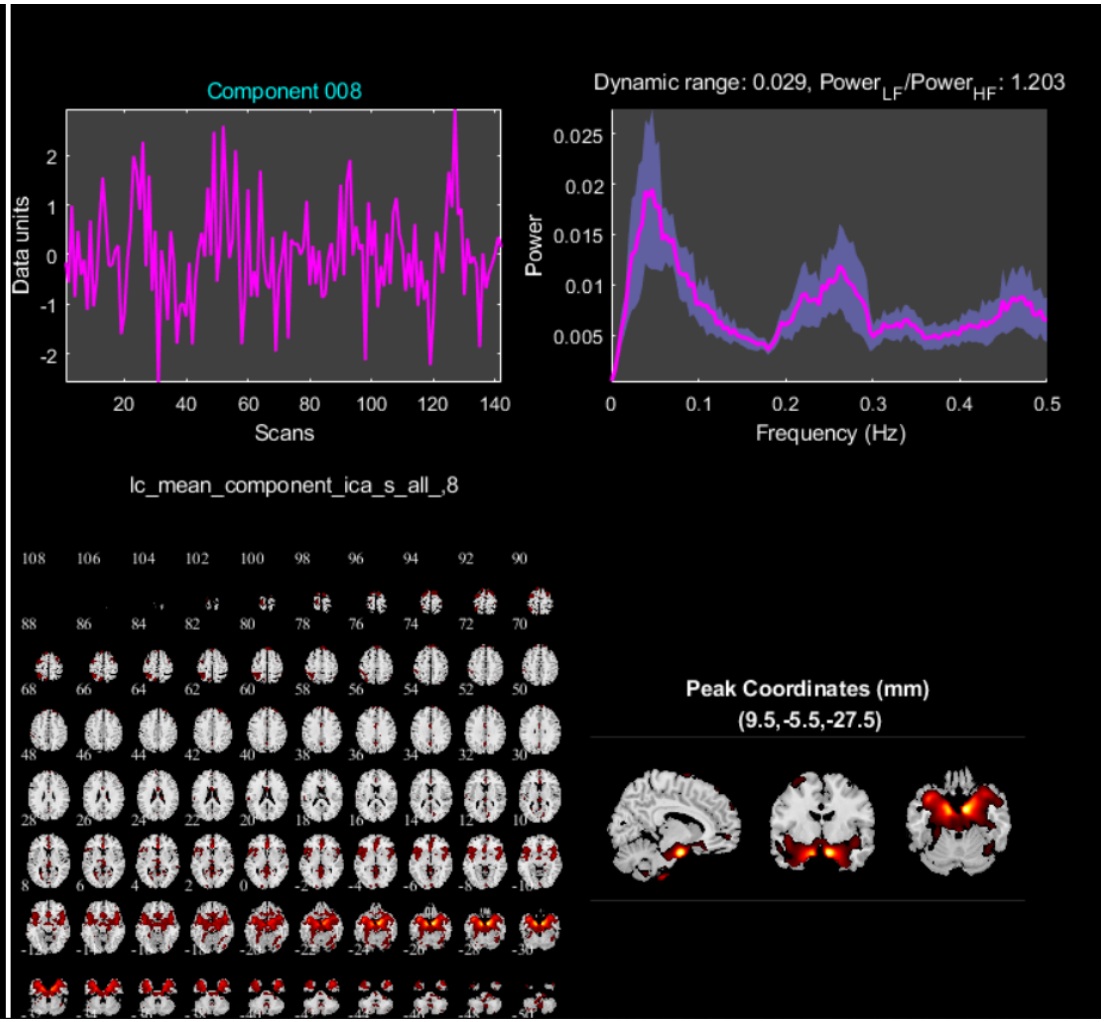
独立成分的筛选与提取

低频的振幅大，高频振幅小，提示是神经信号

部分高频的振幅也大，提示非神经信号

icatb_gica_html_report.html





独立成分的筛选与提取

Here, all ICs were evaluated based on the group IC maps according to the following criteria [Beckmann et al., 2005; Cohn et al., 2015; Cordes et al., 2000; Damoiseaux et al., 2006; Zuo et al., 2010]: the RSNs exhibited peak activations in gray matter, had time courses dominated by low-frequency fluctuations (based on a frequency analysis of the spectra of the estimated ICs), and showed low spatial overlap with known white matter structures, vascular, ventricles, motion and susceptibility artifacts.

DOI: 10.1002/hbm.23430

独立成分的筛选与提取

使用这个脚本提取每个成分的信号

extract_componets.m	2020/8/17 22:01	M 文件	2 KB
lc_glm_dfnc.m	2020/8/17 19:10	M 文件	6 KB
lc_glm_metrics.m	2020/8/17 9:56	M 文件	5 KB

lc_split_mean_4dcomponets_to_3dcomponets

```
1   % This script is used to extract components. Transform 4d to 3d.
2   % ================================================================
3
4   % Inputs
5   input_dir = 'F:\The_first_training\results\subject_4d_componets';
6   out_dir = 'F:\The_first_training\results\subject_3d_componets';
7
```

只需要修改第5和第6行!

先将所有被试的4D成分文件整理到该文件夹，方便程序处理

提取后可以进行常规的统计分析

独立成分之间的动态连接

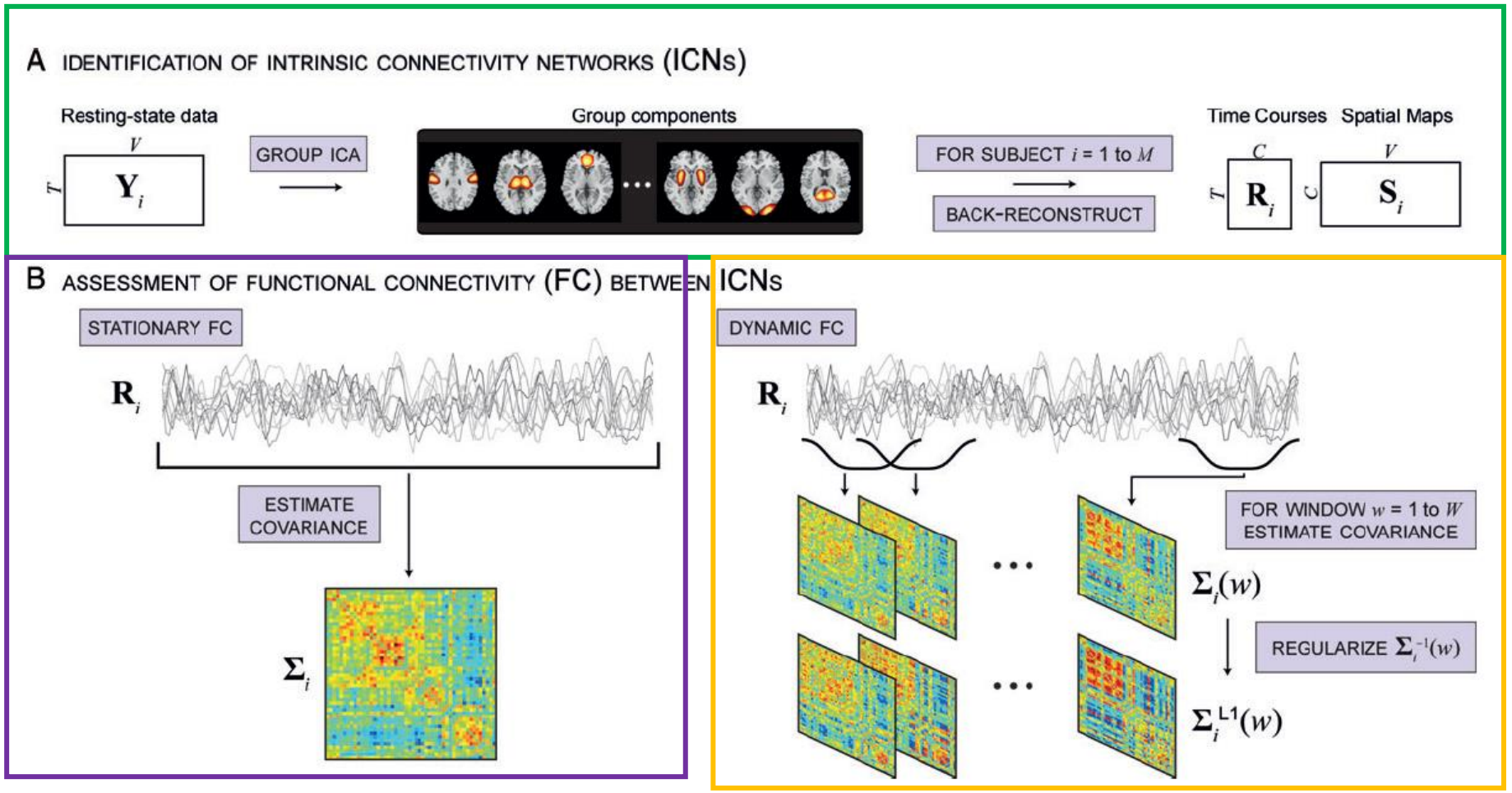
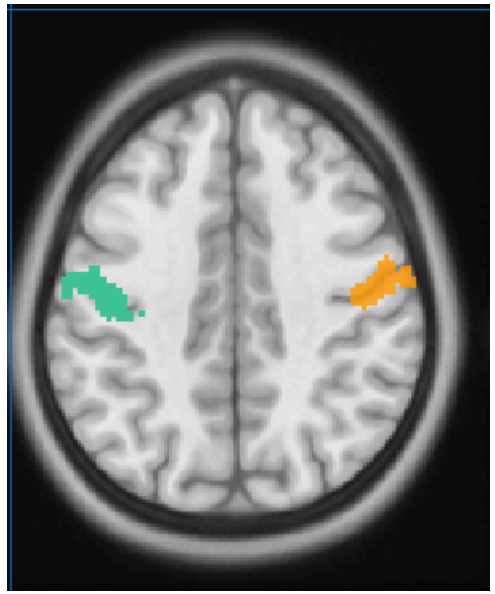
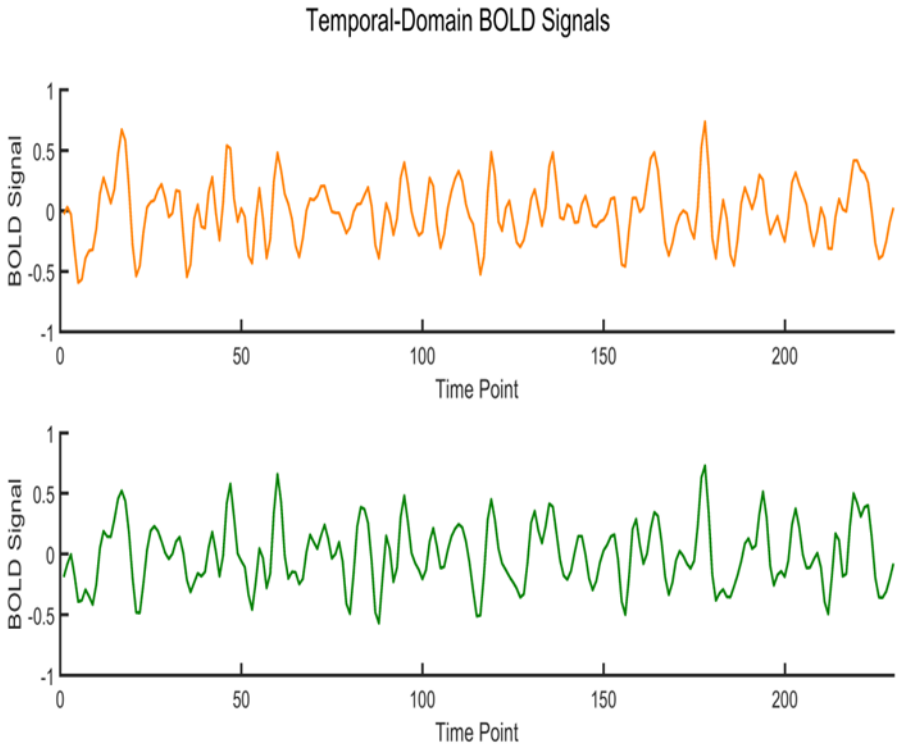


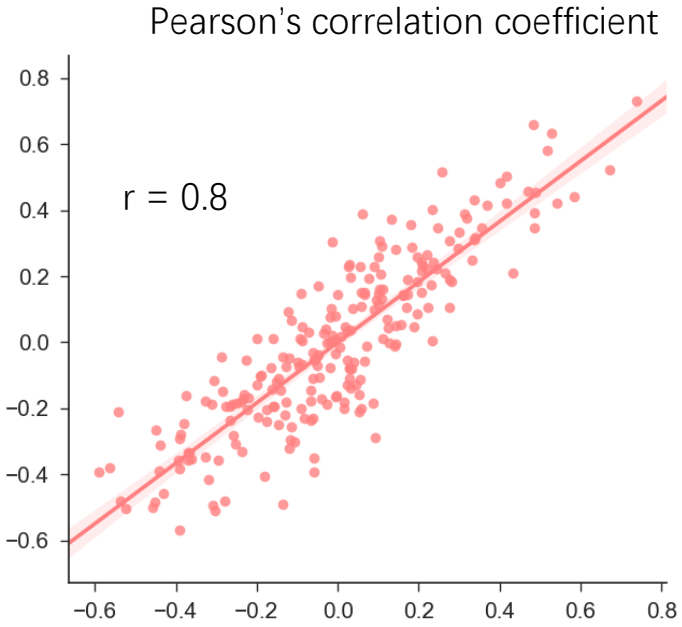
Figure 1. Illustration of analysis steps. (*A*) Group ICA decomposes resting-state data from $M = 405$ subjects into $C = 100$ components, $C_1 = 50$ of which are identified as intrinsic connectivity networks (ICNs). GICA1 back reconstruction is used to estimate the TCs ($\mathbf{R}_i$) and SMs ($\mathbf{S}_i$) for each subject. (*B*) Stationary FC between components (left, $\sum_i$) is estimated as the covariance of $\mathbf{R}_i$. Dynamic FC (right, $\sum_i^{L1}(w)$) is estimated as the series of regularized covariance matrices from windowed portions of $\mathbf{R}_i$.

doi:10.1093/cercor/bhs352

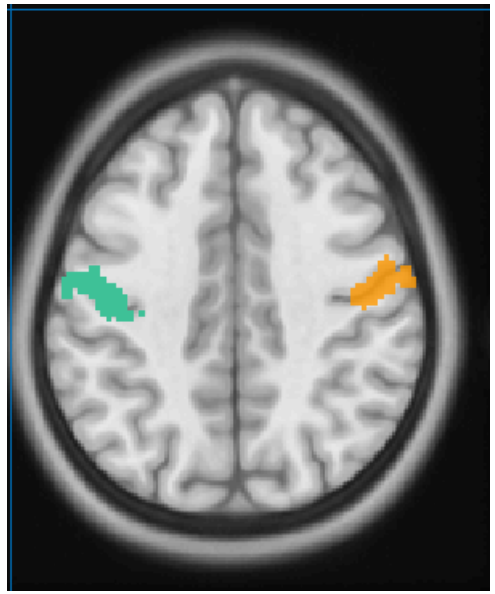
独立成分之间的动态连接

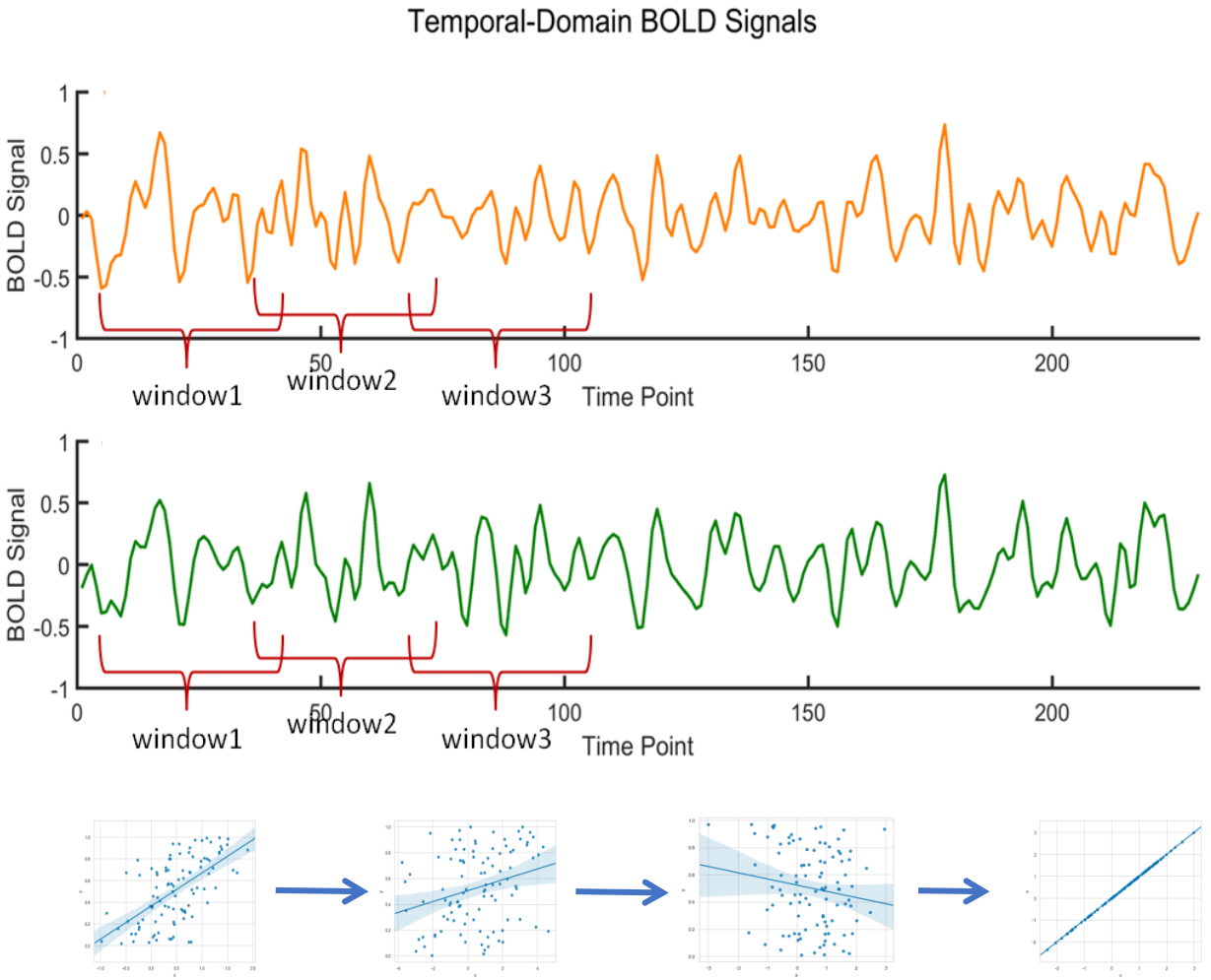






独立成分之间的动态连接





独立成分之间的动态连接

…

一生整体的相关系数R = 0.8

两人一生的关系很亲密

独立成分之间的动态连接


R = 1　　R = -0.3　　R = 0.3　　•••　　R = 1

1. 两人一生的关系总体很亲密
2. 但是两人关系不是很稳定
3. 同时两人一生中经历了4种状态：热恋，吵架，分手，相濡以沫

独立成分之间的动态连接

名称

- lc_3Datlas_to_4Datlas.m
- lc_calc_var.m
- lc_dfnc_input.m
- lc_extract_componets.m
- lc_glm_dfnc.m
- lc_glm_metrics.m
- lc_icatb_plot_connectogram.m
- lc_icatb_plot_connectogram_base.m
- lc_split_mean_4dcomponets_to_3dcomponets.m

```
%% Output directory to place results
outputDir = 'F:\The_first_training\results_
%% ICA parameter file
ica_param_file = 'F:\The_first_training\resu
%% Cell array of dimensions number of networ
% network names
comp_network_names = {'DMN', [3,7,10];
                      'AUD', 13;
                      'VIS',[18,19];
                      'LFPN',4;
                      'RFPN',6;
                      'DorsAttn',9;
                      'SMN',11;
                      'CEN',20
                      };
```

```
%% TR of the experiment
TR = 2;
```

```
dfnc_params.wsize = 30;
```

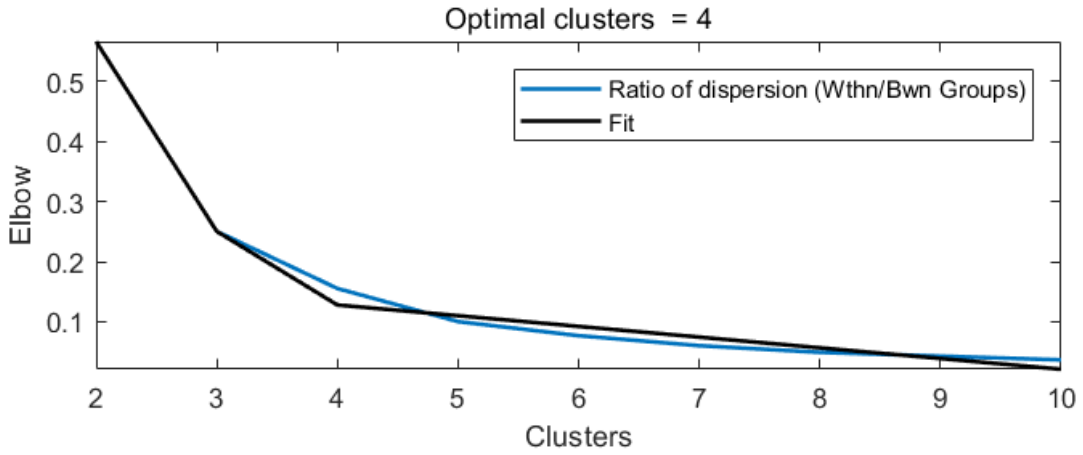
```
postprocess.estimate_clusters = 'yes';
```

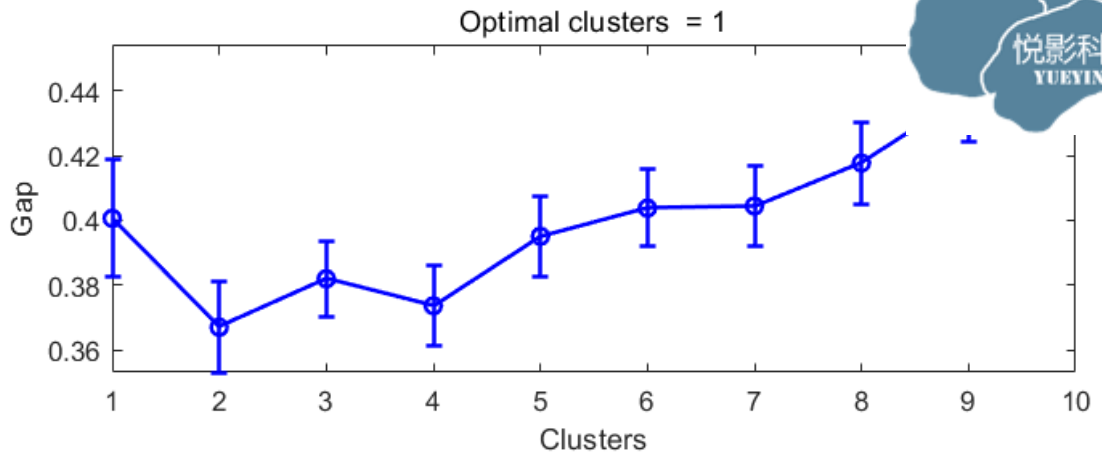
***
根据下张PPT中所有聚类评价标准得到的最佳K的均值，自动估计聚类数目
***

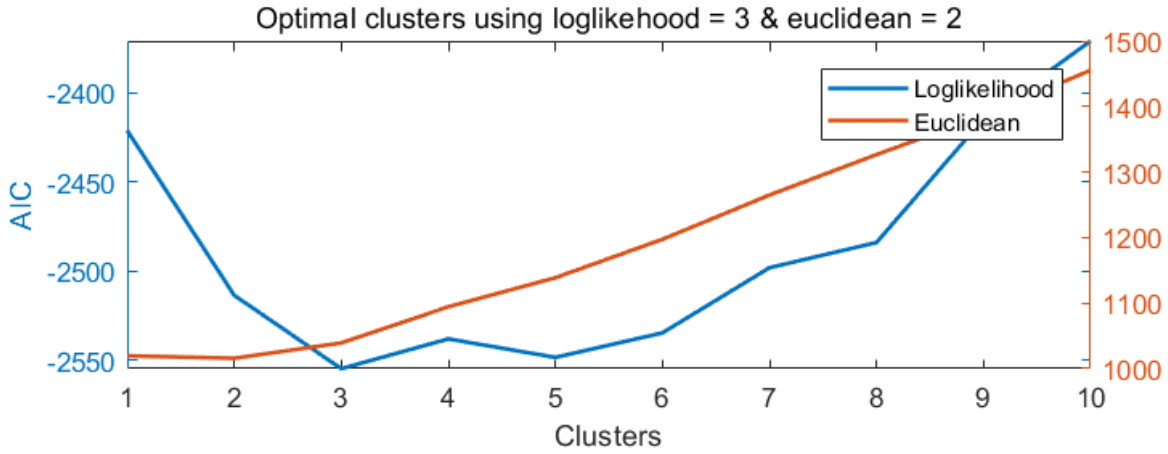
最后运行右图所示的代码

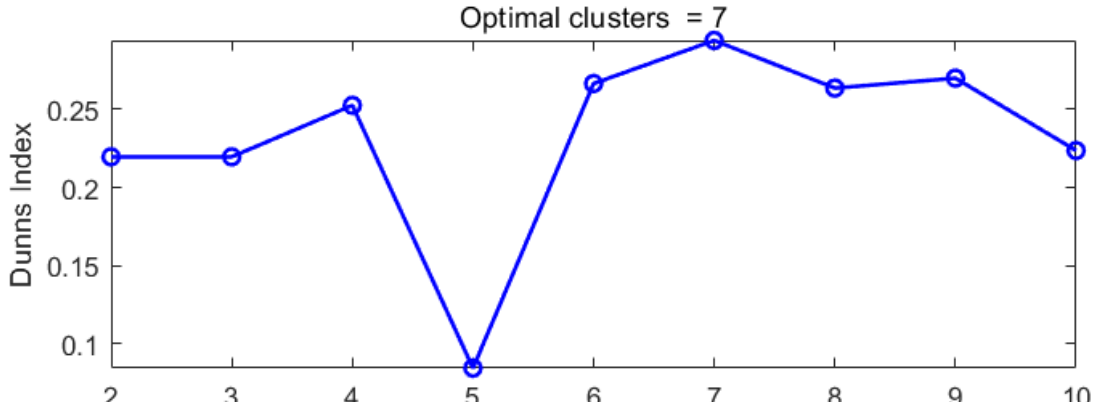
```
icatb_dfnc_batch('lc_dfnc_input.m')
```

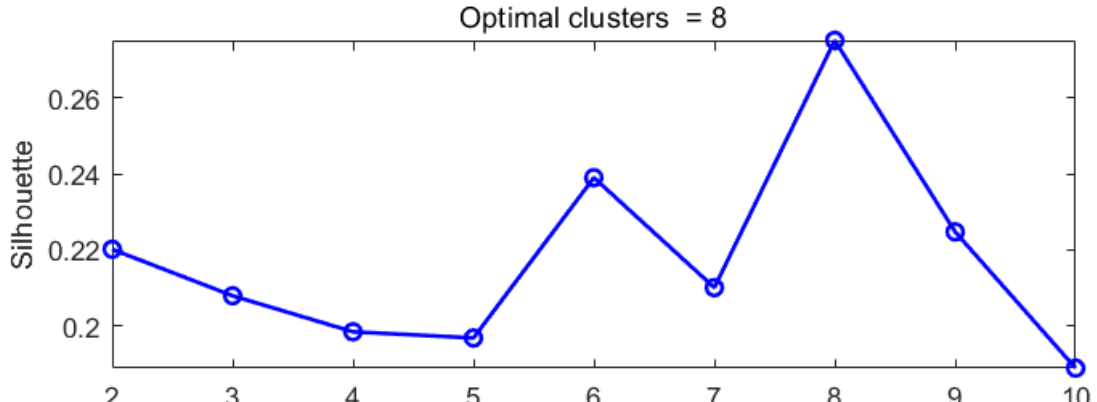
```
66 —    postprocess.estimate_clusters = 'yes';
```







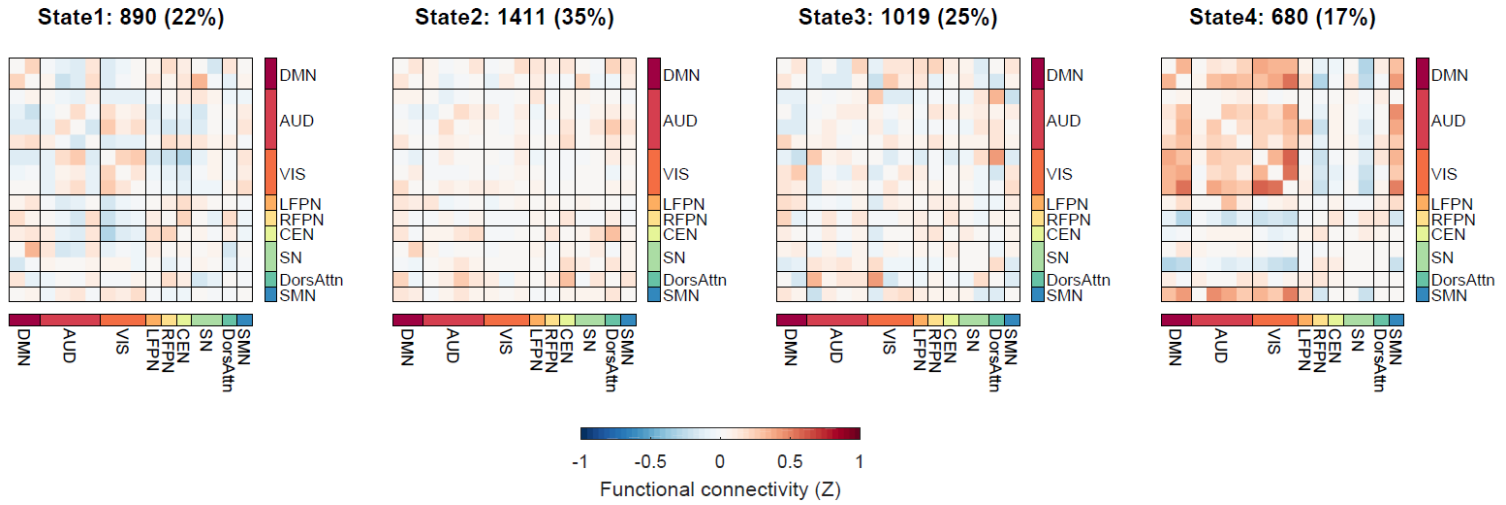




独立成分之间的动态连接

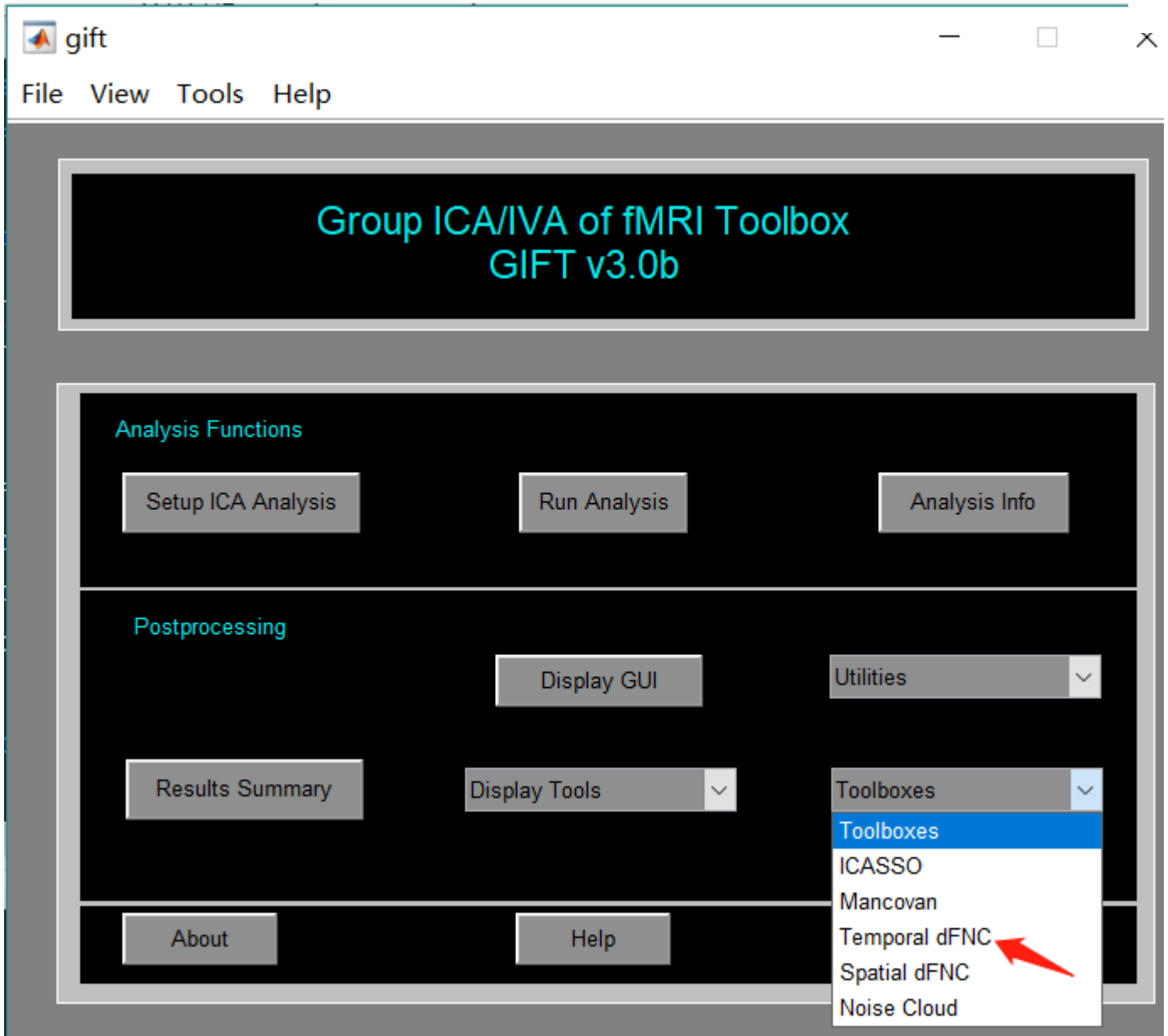
- 显示动态连接状态

lc_rsfmri_tools_matlab
GroupICATv4.0b.zip
lc_3Datlas_to_4Datlas.m
lc_calc_var.m
lc_dfnc_input.m
lc_display_states.m
lc_extract_componets.m
lc_glm_dfnc.m
lc_glm_metrics.m
lc_icatb_plot_connectogram.m
lc_icatb_plot_connectogram_base.m
lc_split_mean_4dcomponets_to_3dcomponets.m



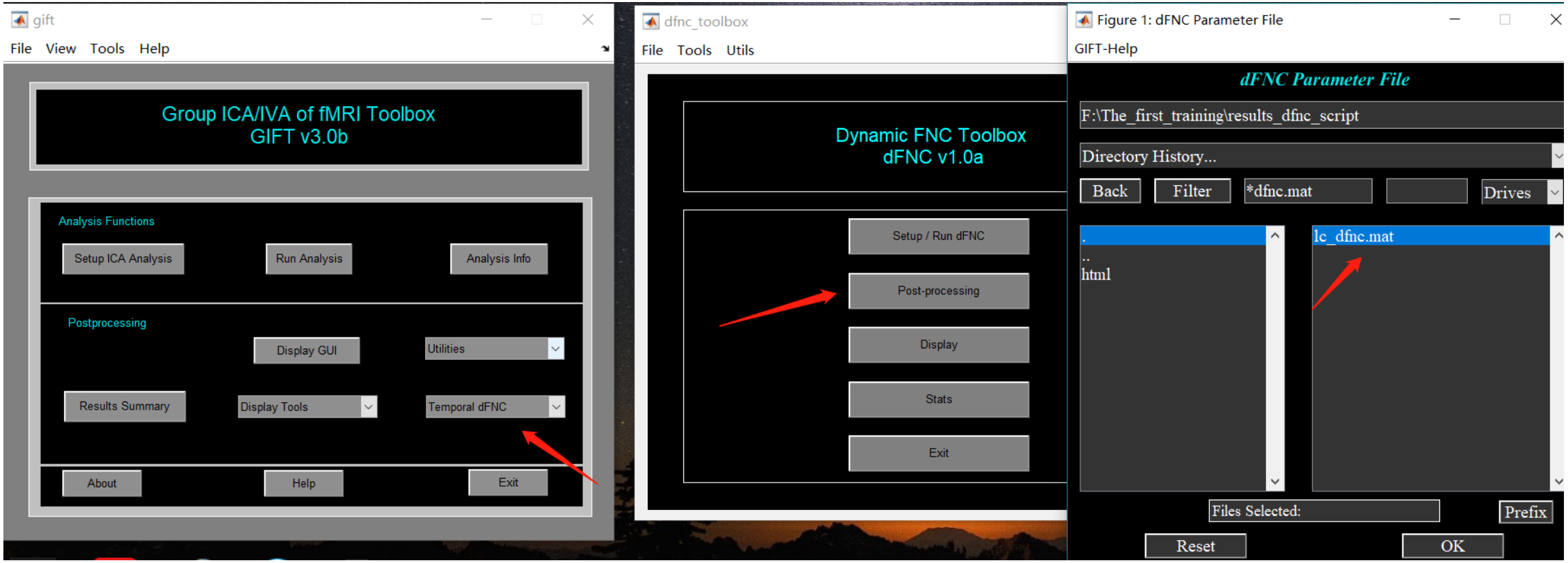
独立成分之间的动态连接

- 通过图形界面
 来计算动态连接并聚类

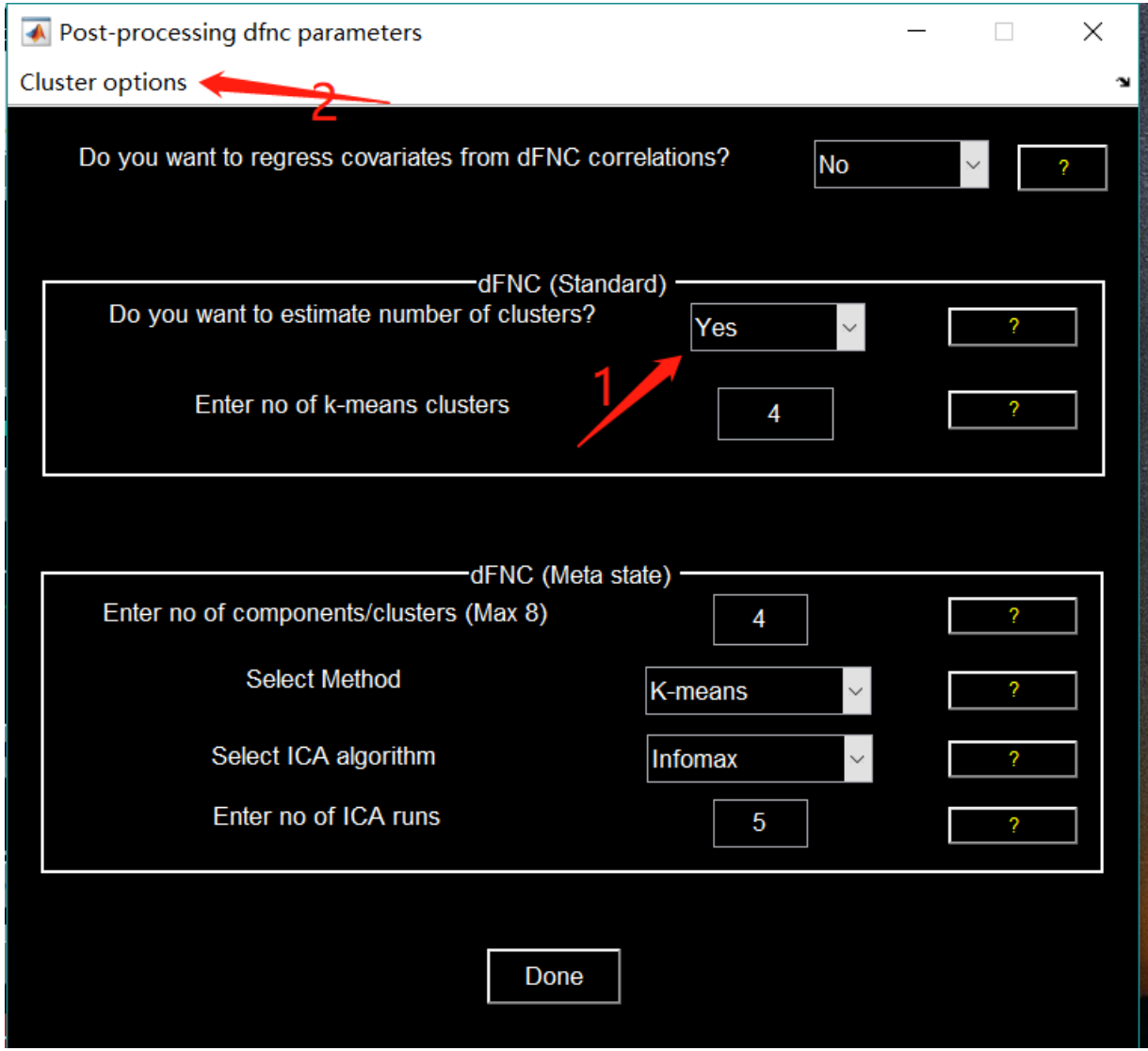


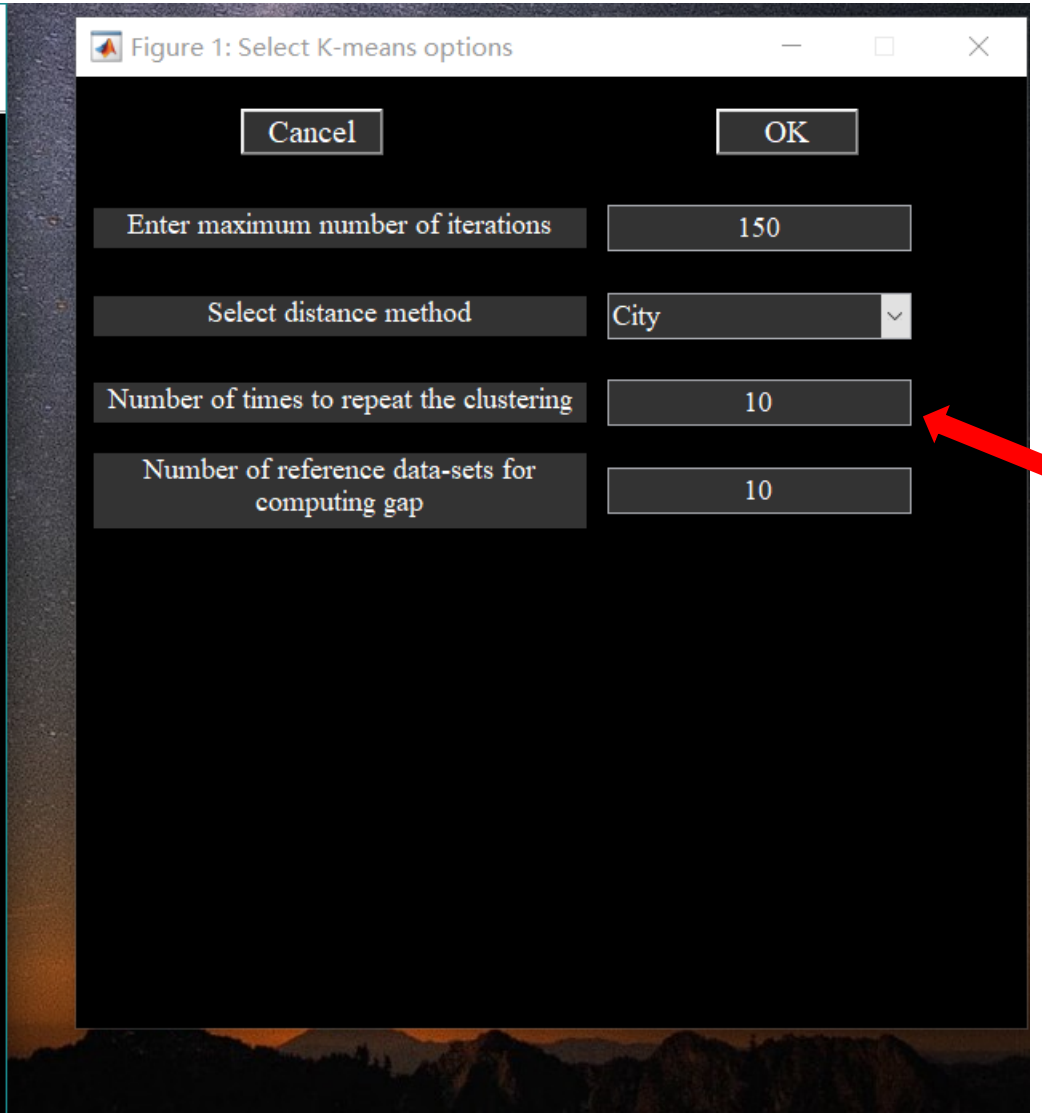
独立成分之间的动态连接

通过图形界面



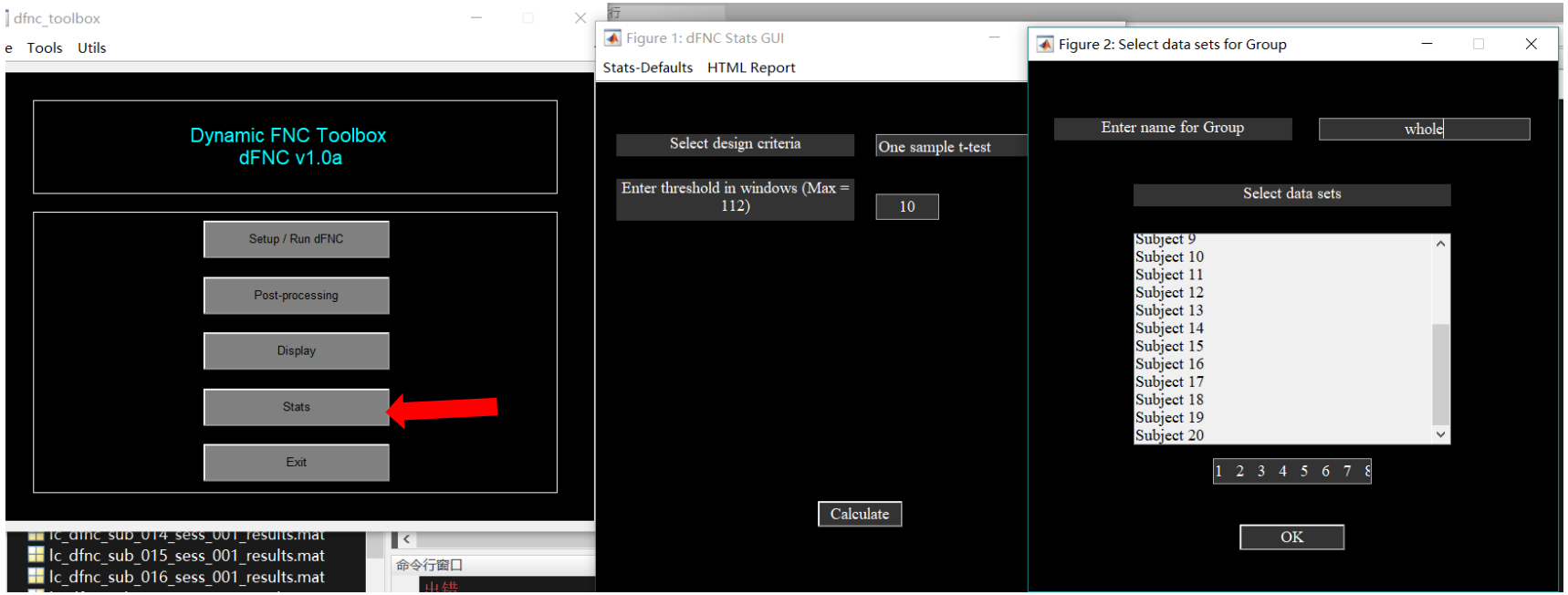
独立成分之间的动态连接





独立成分之间的动态连接

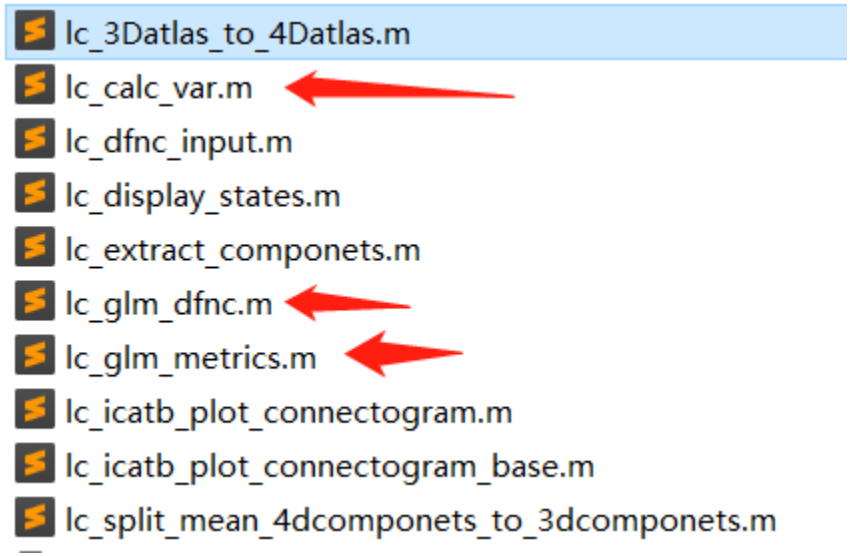
- 运行Stats目的只是为了获得每个被试各个状态的功能连接，方便后续统计



- 运行后会得到一个叫prefix_dfnc_cluster_stats文件，如下所示：

独立成分之间的动态连接

- 以下三个标箭头的代码用来做统计

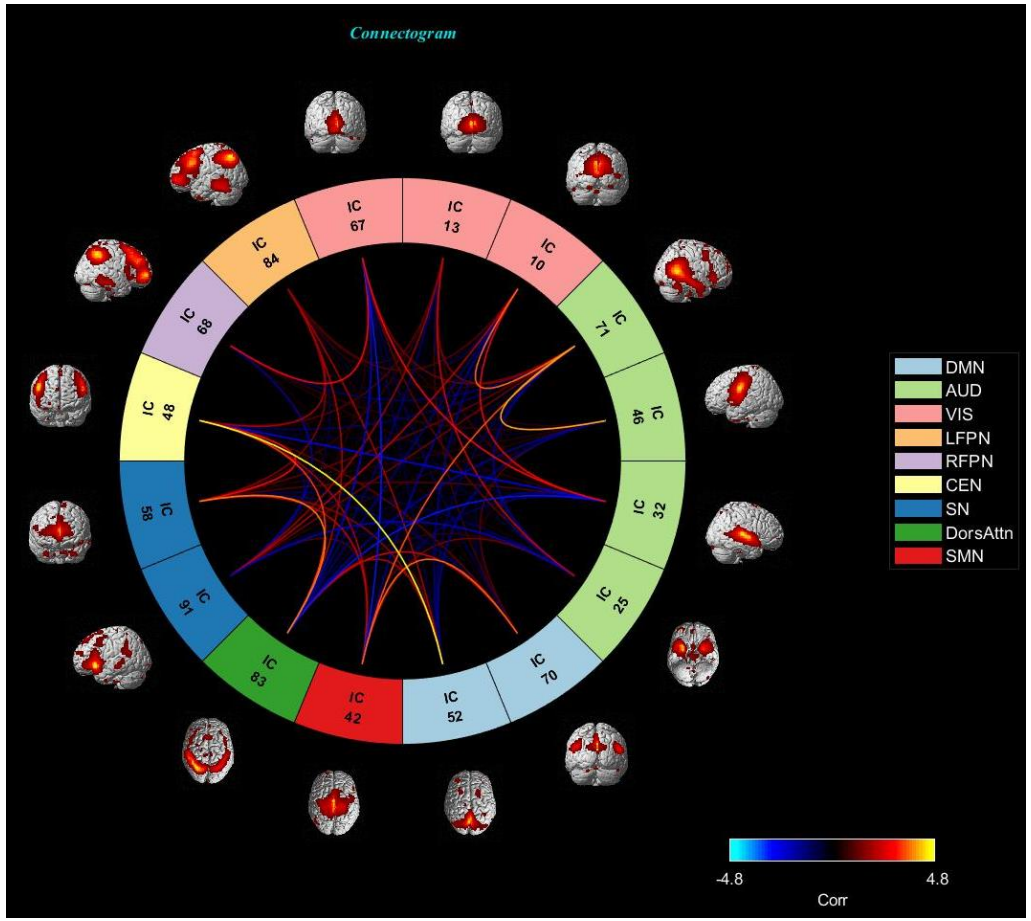


独立成分之间的动态连接

- 被试协变量格式
- ID为每个被试的唯一标识
- Label为被试的诊断
- 此图中的协变量，在独立样本t建议时，contrast为 [1 -1 0 0]

	A	B	C	D
1	ID	label	age	gender
2	Csub1	1	27	1
3	Csub10	1	21	1
4	Csub11	1	35	1
5	Csub12	1	27	2
6	Csub13	1	19	2
7	Csub14	1	40	2
8	Csub15	1	31	1
9	Csub16	1	20	1
10	Csub17	1	27	1
11	Csub18	0	21	1
12	Csub19	0	35	1
13	Csub2	0	27	2
14	Csub20	0	19	2
15	Csub3	0	40	2
16	Csub4	0	31	1
17	Csub5	0	20	1
18	Csub6	0	40	2
19	Csub7	0	31	1
20	Csub8	0	20	1
21	Csub9	0	20	1
22	Psub1	1	27	1
23	Psub10	1	21	1
24	Psub11	1	35	1
25	Psub12	1	27	2
26	Psub13	1	19	2

独立成分之间的动态连接



基于ROI的动态连接分析(额外课程)

- 现场实际操作为主

悦影科技
YUEYING

Thank you~~