

连接组计算系统第1次课程班

# Connectome Computation System

中国科学院心理研究所

行为科学重点实验室

磁共振成像研究中心

人脑功能连接组及其发展实验室

## 系统功能概述

CCS

左西年

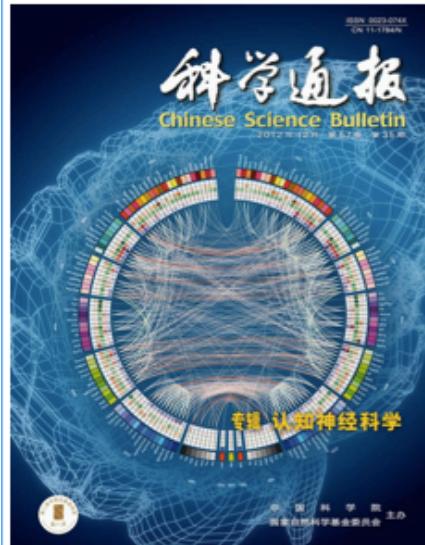
2014年8月7日

# 人脑功能连接组学

科学通报

2012年 57卷 35期

刊出日期：2012-12-19



人脑是如何在不同尺度上将自身极度复杂的网络整合特性与形形色色认知、心理和行为建立起关联的？人类大脑功能连接组图谱的绘制对于人类理解各种日常心理和行为特质的神经科学机制具有决定性作用，将在系统神经科学(即全脑)框架内，帮助研究人员回答这个长期以来极具神秘色彩的问题——心脑关联。封面图片显示的是与人类全基因组图谱颇为类似的人类大脑功能连接组图谱，是基于175名中国大学生被试的磁共振图像绘制而成，与北京的“六环路架构”类似，展现了人类大脑165个区域之间的功能连接全貌。它的六环交通结构蕴藏着极为丰富的信息：最外环(即六环)显示了每一个大脑区域的名称以及它们属于的大脑解剖结构；五到三环则依次表示灰质体积、皮层表面大小和皮层厚度，颜色越深代表其相对更高；二环和最内环则表示全局和局部功能连接上区域的重要性(交通枢纽)。与此同时，人脑连接组的功能连接绘制在图谱中央，线条越粗代表功能连接越强，最强的功能连接存在于大脑半球间(红色)。基于人脑连接组图谱的人脑功能连接组学不同于基因组图谱，更接近宏观心理行为表现，将在基因组和人类行为之间架起对话的桥梁，极有可能革命性地改变目前心理学的研究模式，为揭示心-脑关联神经机制、建立人脑功能连接组常模、探索神经退行性和精神疾病脑机制提供重要理论与方法学基础。详见左西年等人文(p3399)。封面图谱绘制者为中国科学院心理研究所左西年研究员。

# 提纲

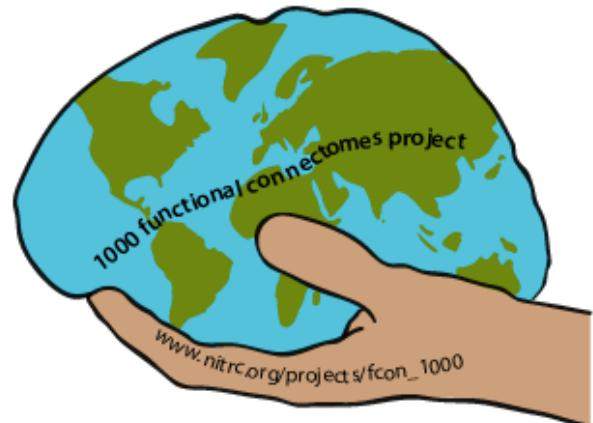
- 开发历史
- 基本功能
- 扩展功能
- 图形界面
- 应用实例
- 未来服务

# 开发历史

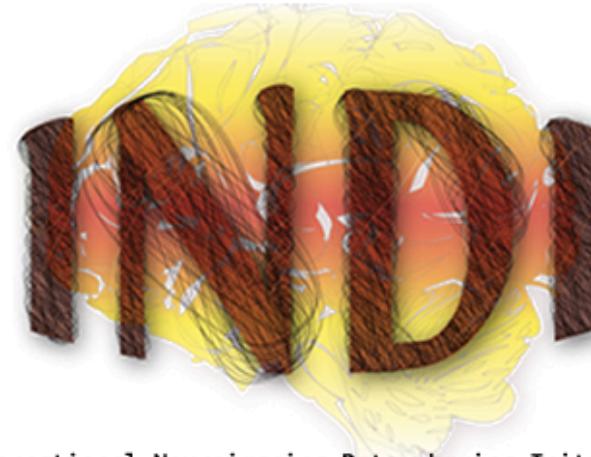
# 1000 Functional Connectomes Project



[http://fcon\\_1000.projects.nitrc.org](http://fcon_1000.projects.nitrc.org)



*FCP Classic Collection*



International Neuroimaging Data-sharing Initiative

Learn more

Request Access



How-To's

Prospective



FCP Scripts

Retrospective

# Toward discovery science of human brain function

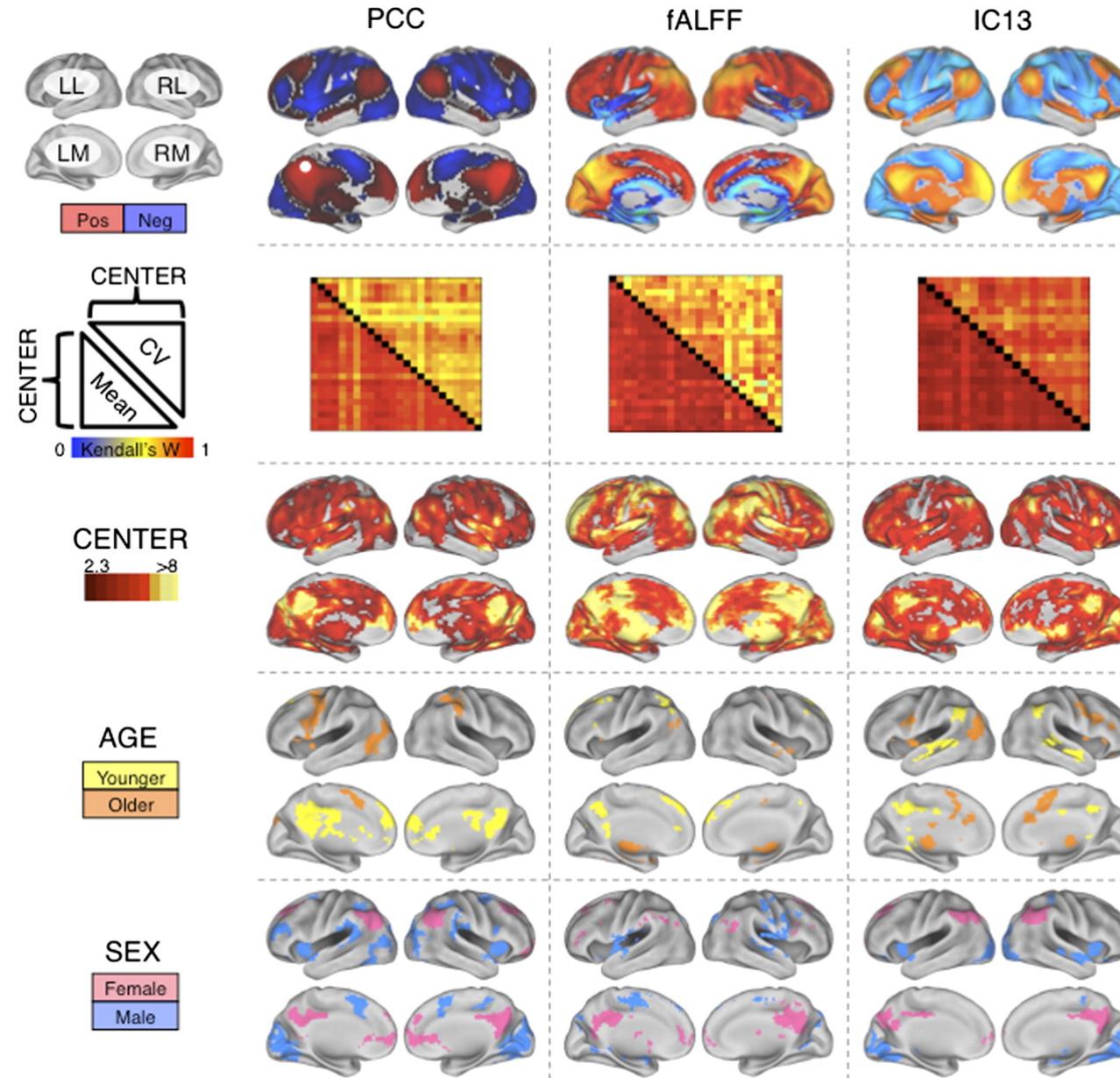
Bharat B. Biswal<sup>a</sup>, Maarten Mennes<sup>b</sup>, Xi-Nian Zuo<sup>b</sup>, Suril Gohel<sup>a</sup>, Clare Kelly<sup>b</sup>, Steve M. Smith<sup>c</sup>, Christian F. Beckmann<sup>c</sup>, Jonathan S. Adelstein<sup>b</sup>, Randy L. Buckner<sup>d</sup>, Stan Colcombe<sup>e</sup>, Anne-Marie Dogonowski<sup>f</sup>, Monique Ernst<sup>g</sup>, Damien Fair<sup>h</sup>, Michelle Hampson<sup>i</sup>, Matthew J. Hoptman<sup>j</sup>, James S. Hyde<sup>k</sup>, Vesa J. Kiviniemi<sup>l</sup>, Rolf Kötter<sup>m</sup>, Shi-Jiang Li<sup>n</sup>, Ching-Po Lin<sup>o</sup>, Mark J. Lowe<sup>p</sup>, Clare Mackay<sup>c</sup>, David J. Madden<sup>q</sup>, Kristoffer H. Madsen<sup>f</sup>, Daniel S. Margulies<sup>r</sup>, Helen S. Mayberg<sup>s</sup>, Katie McMahon<sup>t</sup>, Christopher S. Monk<sup>u</sup>, Stewart H. Mostofsky<sup>v</sup>, Bonnie J. Nagel<sup>w</sup>, James J. Pekar<sup>x</sup>, Scott J. Peltier<sup>y</sup>, Steven E. Petersen<sup>z</sup>, Valentin Riedl<sup>aa</sup>, Serge A. R. B. Rombouts<sup>bb</sup>, Bart Rypma<sup>cc</sup>, Bradley L. Schlaggar<sup>dd</sup>, Sein Schmidt<sup>ee</sup>, Rachael D. Seidler<sup>ff,u</sup>, Greg J. Siegle<sup>gg</sup>, Christian Sorg<sup>hh</sup>, Gao-Jun Teng<sup>ii</sup>, Juha Veijola<sup>jj</sup>, Arno Villringer<sup>ee,kk</sup>, Martin Walter<sup>ll</sup>, Lihong Wang<sup>q</sup>, Xu-Chu Weng<sup>mm</sup>, Susan Whitfield-Gabrieli<sup>nn</sup>, Peter Williamson<sup>oo</sup>, Christian Windischberger<sup>pp</sup>, Yu-Feng Zang<sup>qq</sup>, Hong-Ying Zhang<sup>ii</sup>, F. Xavier Castellanos<sup>b,j</sup>, and Michael P. Milham<sup>b,1</sup>

Package: scripts  38 Subscribers

Release	Date					
		Filename	Size	D/L	Arch	Type
<b>Development and support of the scripts is discontinued; superseded by CPAC project</b>	<b>2014-02-06 03:07</b>					
		C-PAC on <a href="#">github</a> (url)	278	Any	URL	
<b>fcon_1000_scripts_ver1.1 - Development Discontinued</b>	<b>2010-03-10 11:52</b>					
		<a href="#">fcon_1000_scripts_ver1.1.tar.gz</a> (url)	5.55 MB	3,272	Any	URL
<b>fcon_1000_scripts_ver1.1-beta - Development Discontinued</b>	<b>2010-03-03 12:16</b>					
		<a href="#">fcon_1000_scripts_ver1.1b.tar.gz</a>	31 KB	764	Any	Source .gz

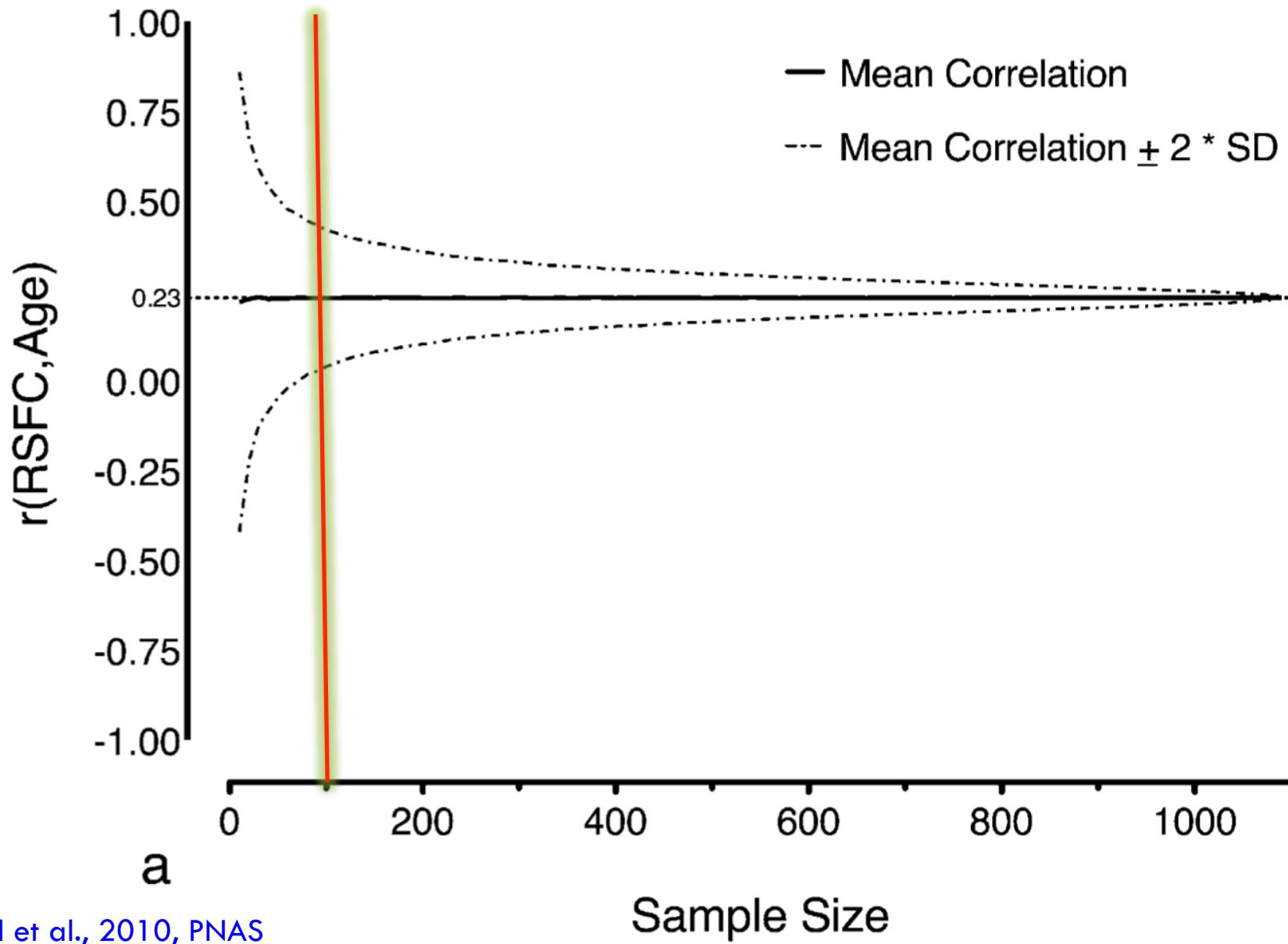
Package: fcon\_1000  50 Subscribers

# KFC主要发现

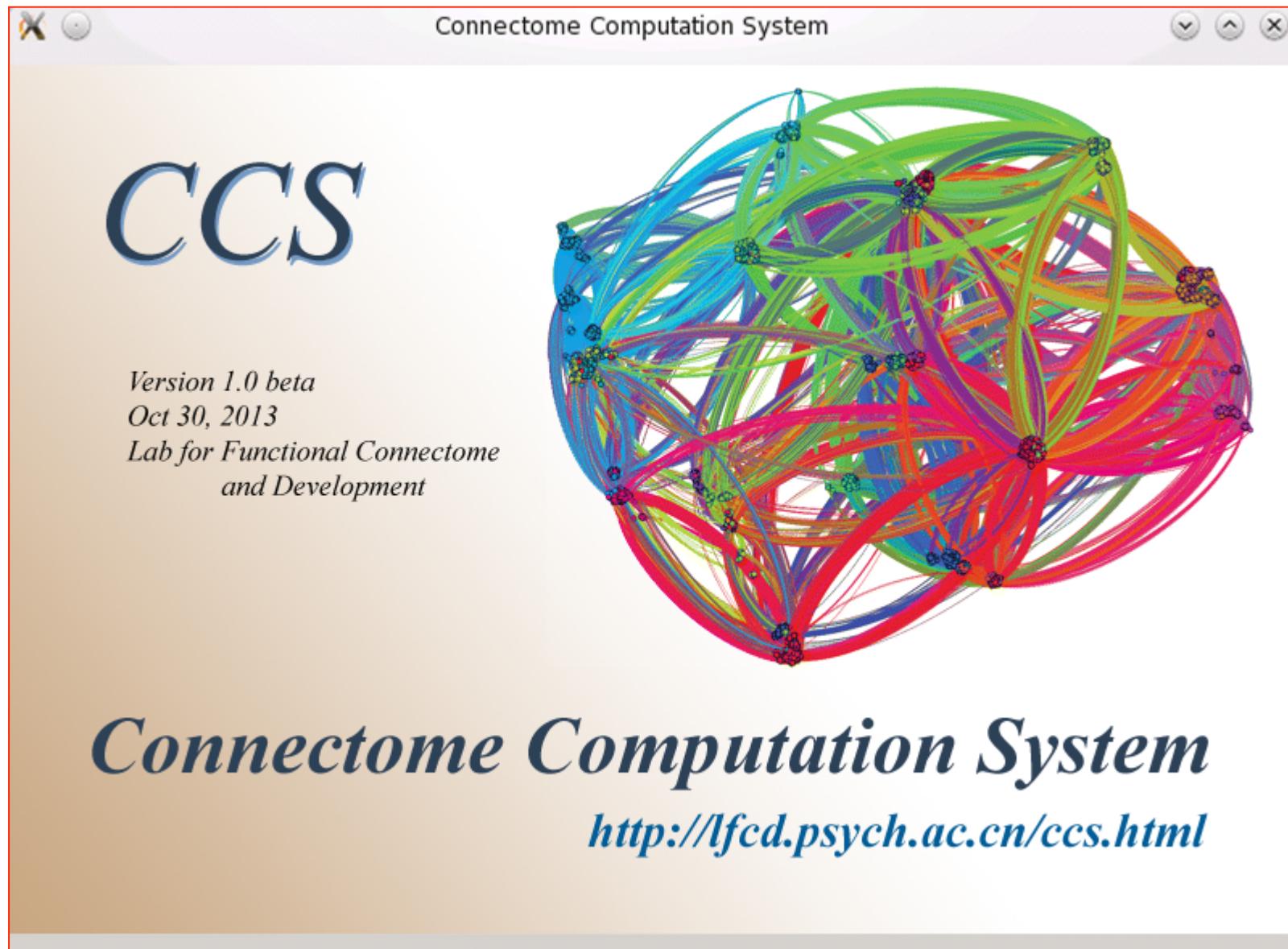


Biswal et al.,  
2010, PNAS

# KFC主要发现

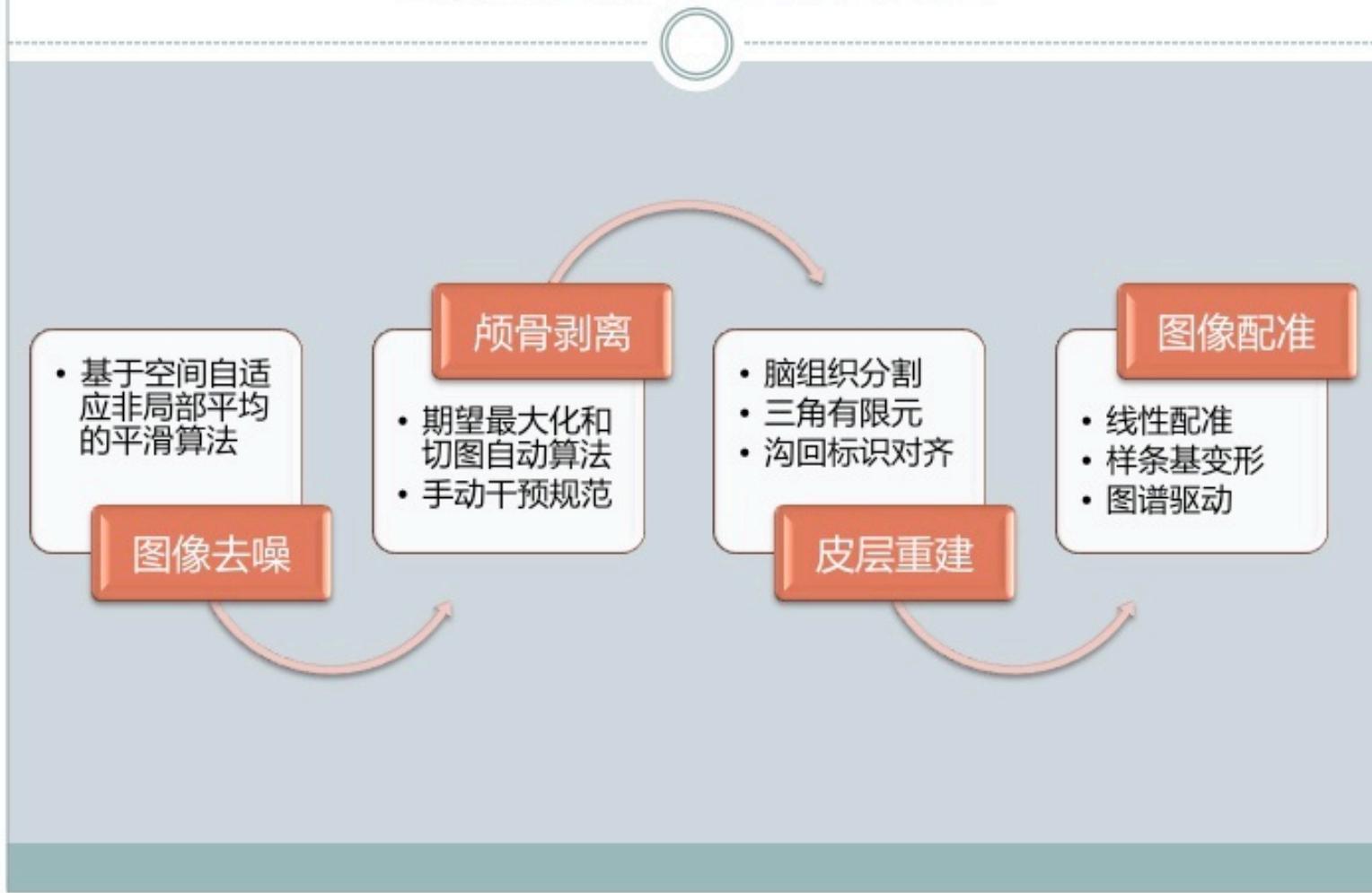


# 改进FCP脚本系统

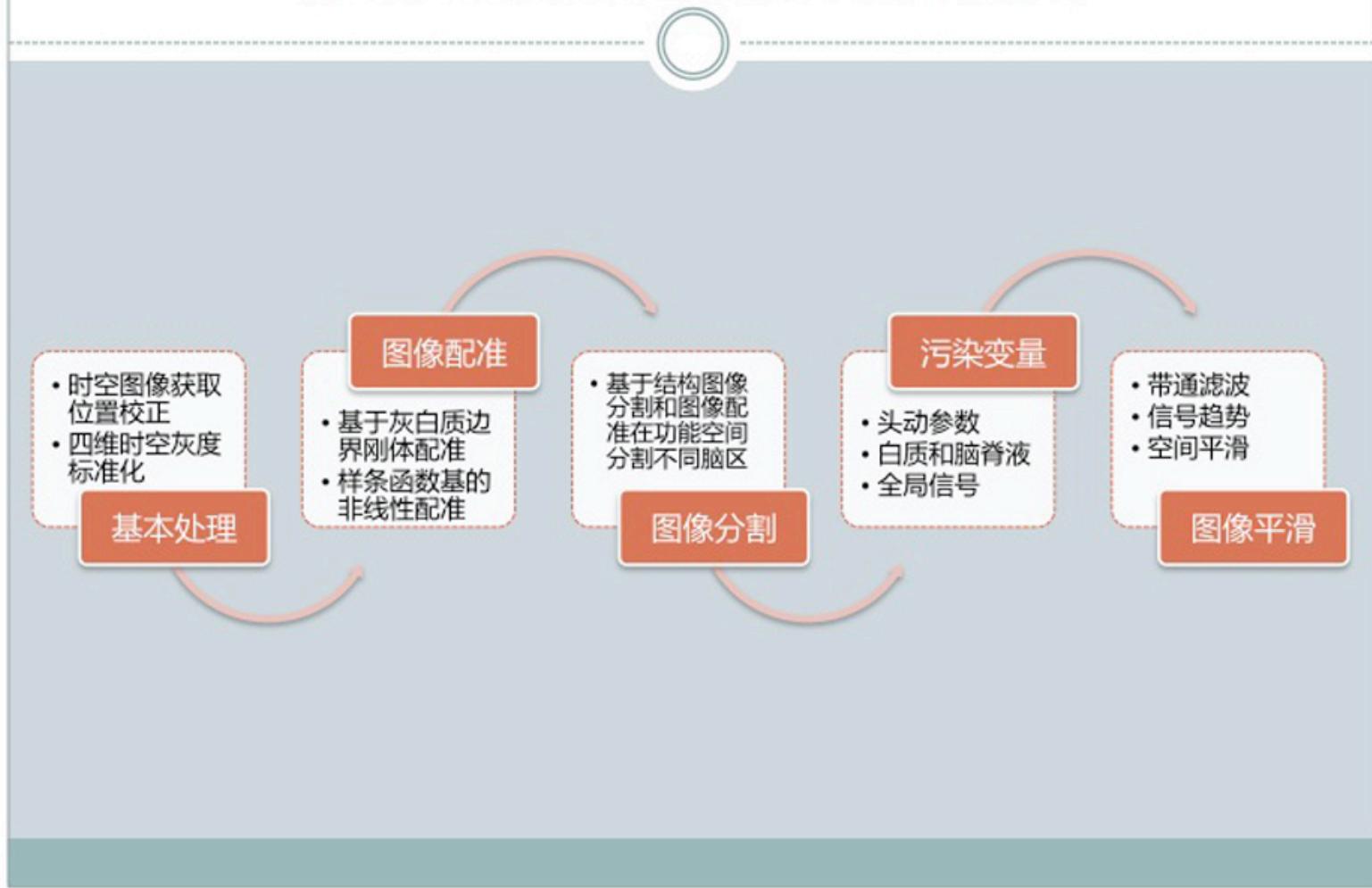


# 基本功能

# 结构图像处理流程图



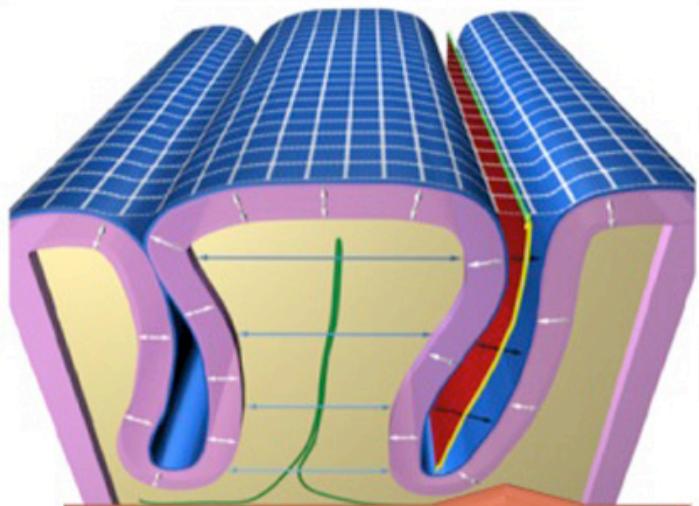
# 静息态功能图像处理流程图



# 扩散张量图像处理流程图

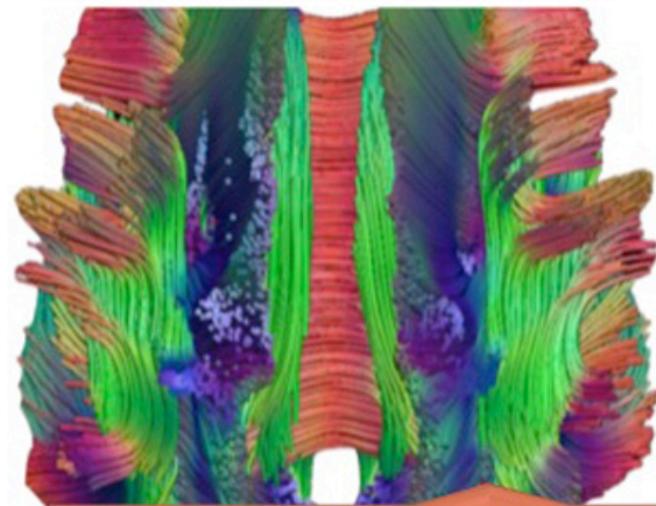


# 脑结构图谱



形态学图谱

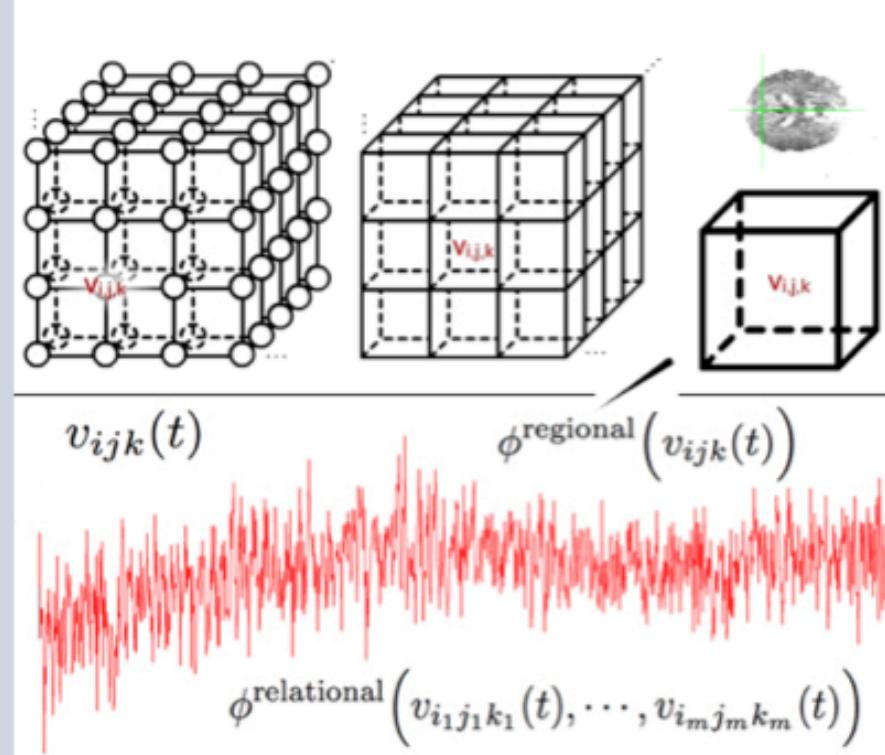
- 皮层厚度
- 皮层表面积
- 高斯曲率



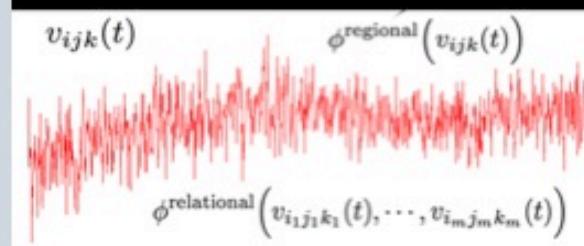
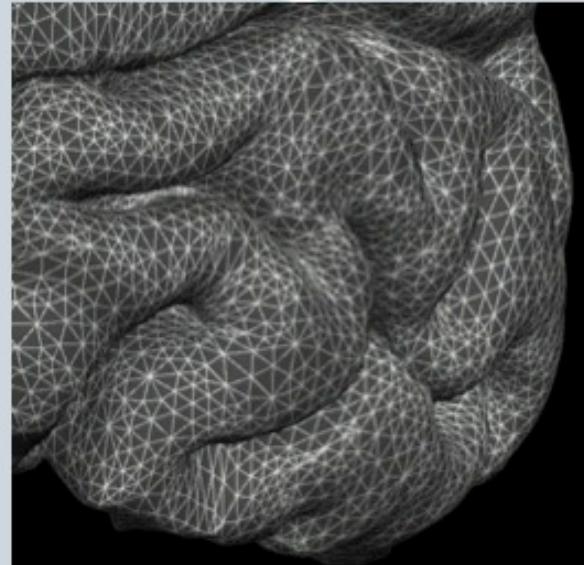
白质纤维图谱

- 各向异性分数
- 平均扩散度
- 最大特征值

## 个体功能图谱（三维）

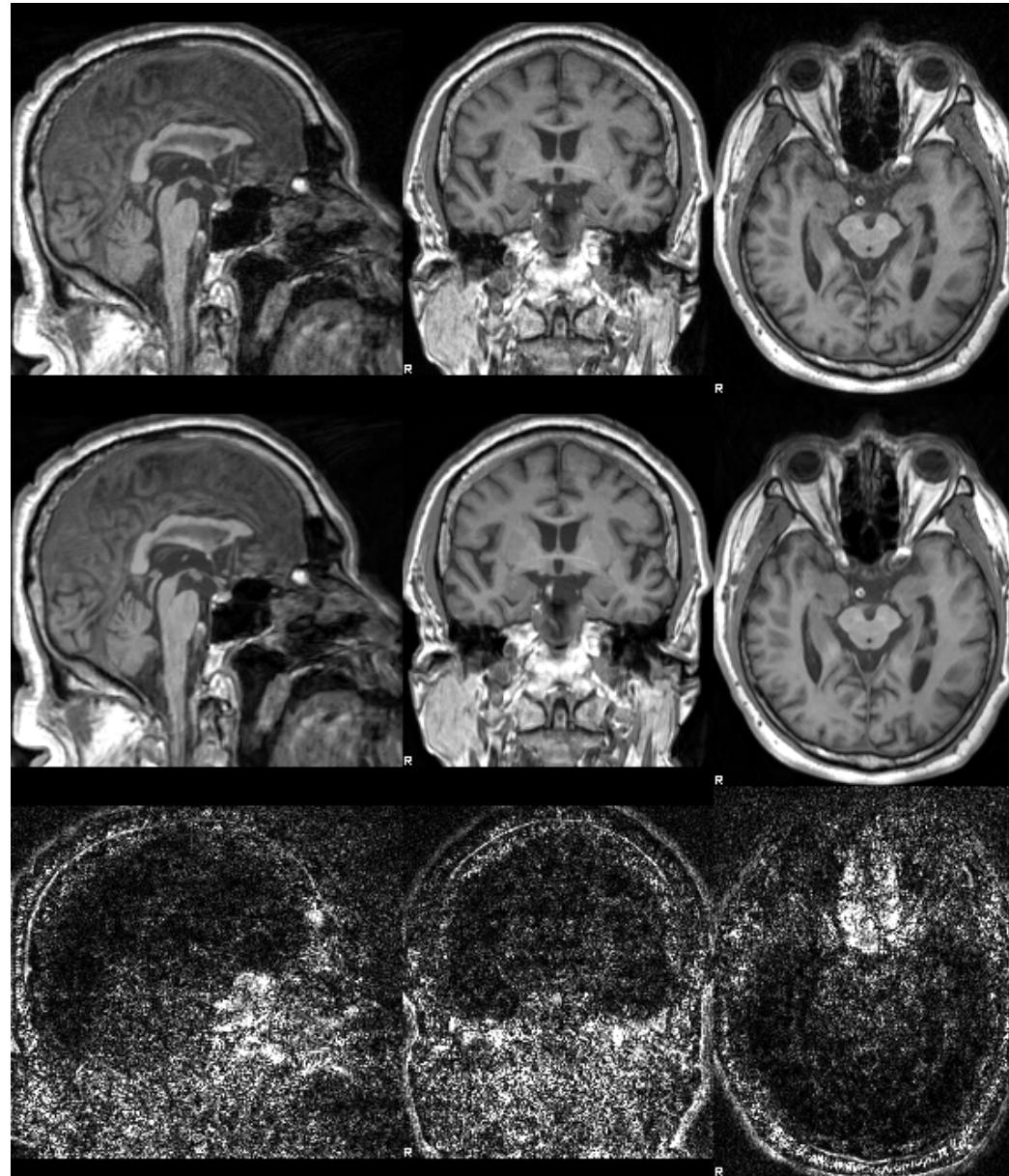


## 个体功能图谱 (二维)

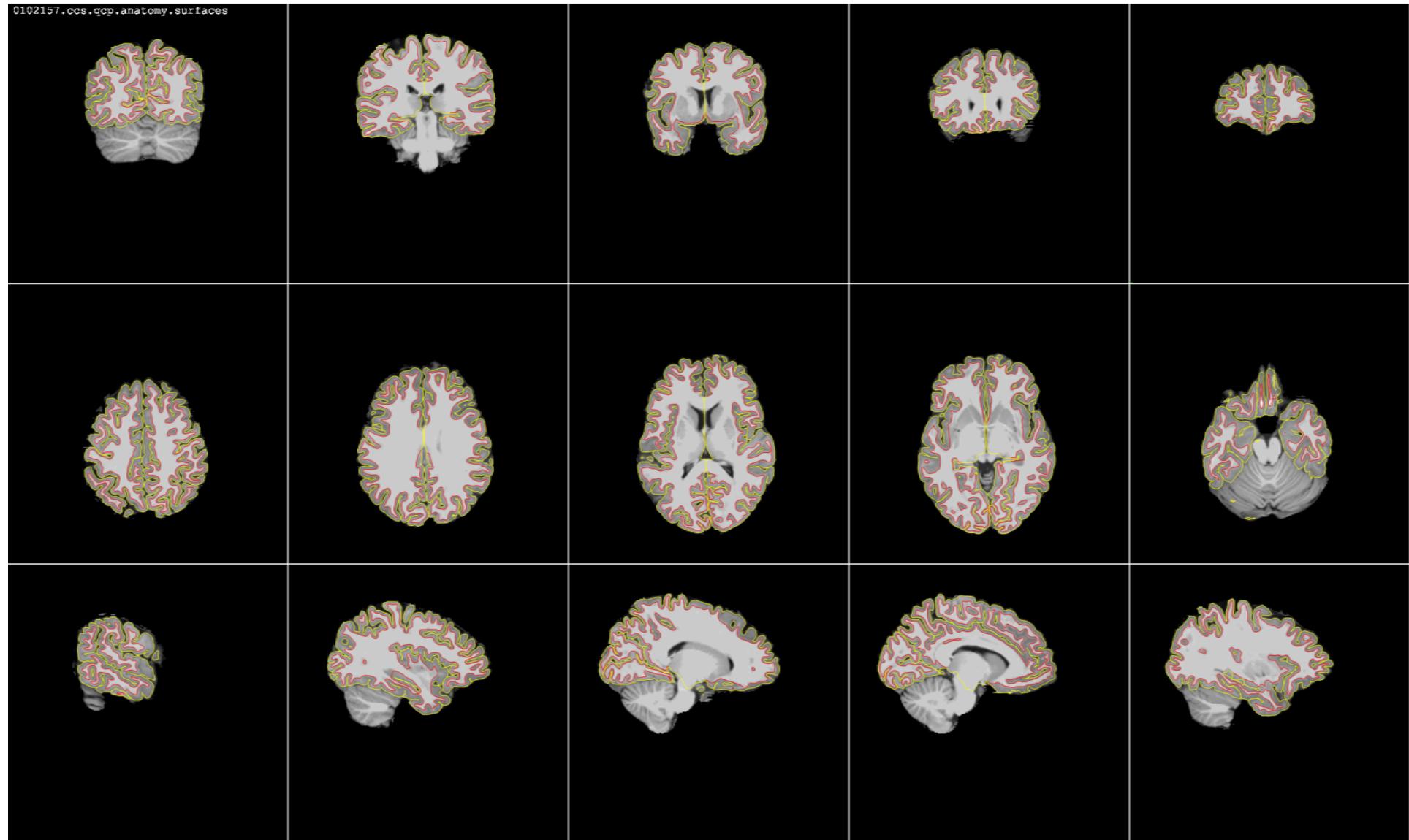


# 扩展功能

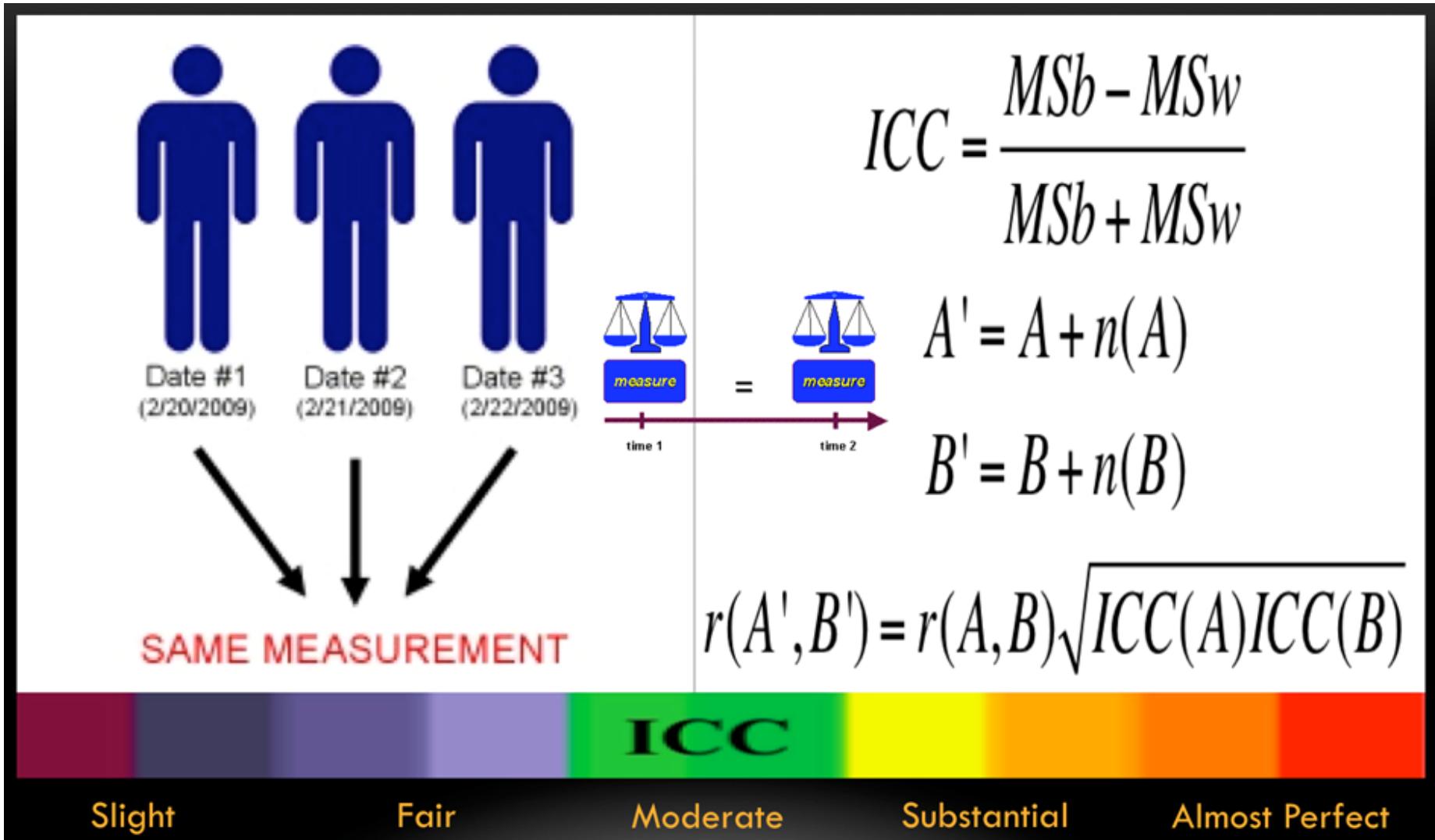
# 质量控制模块



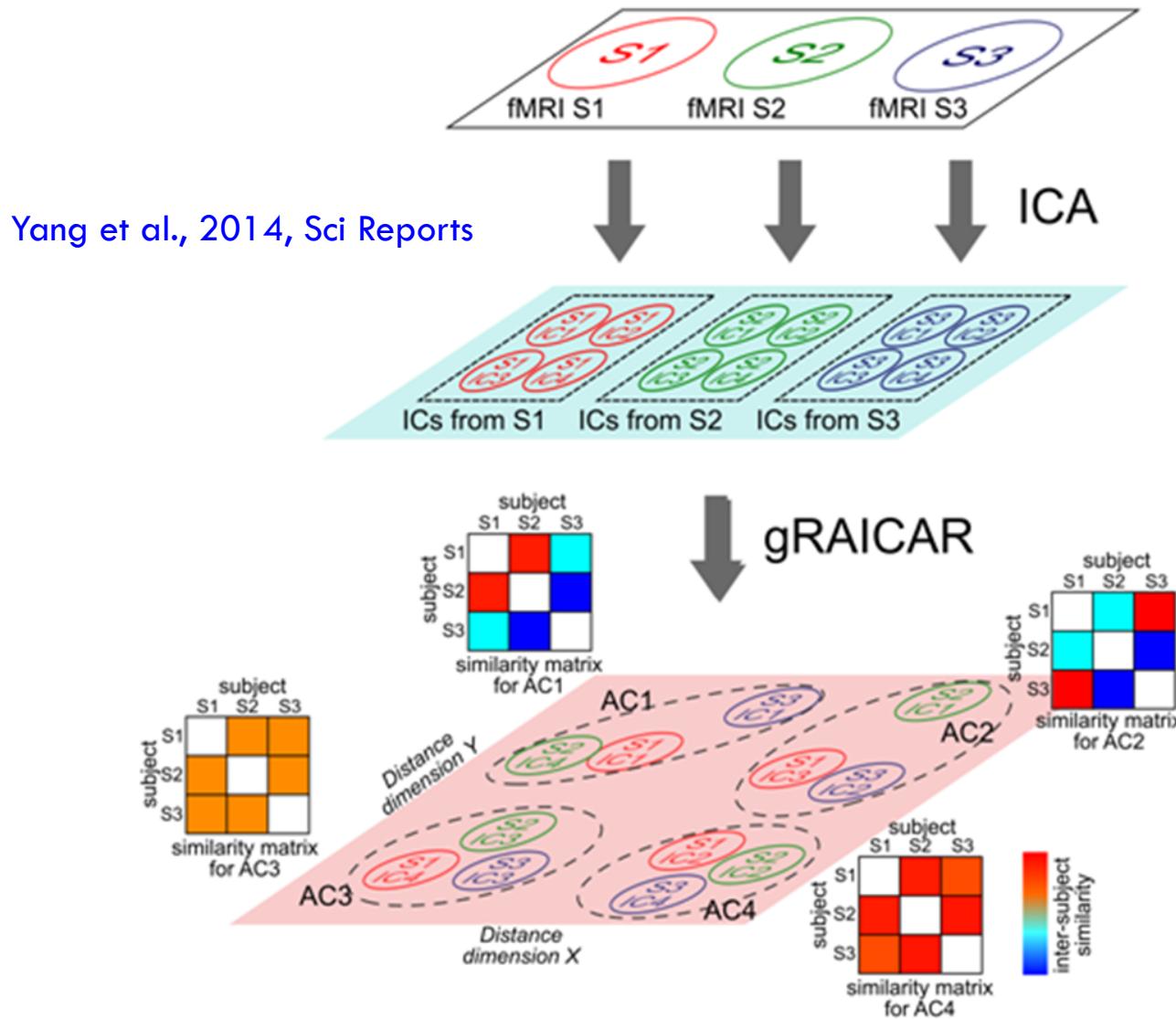
# 质量控制模块



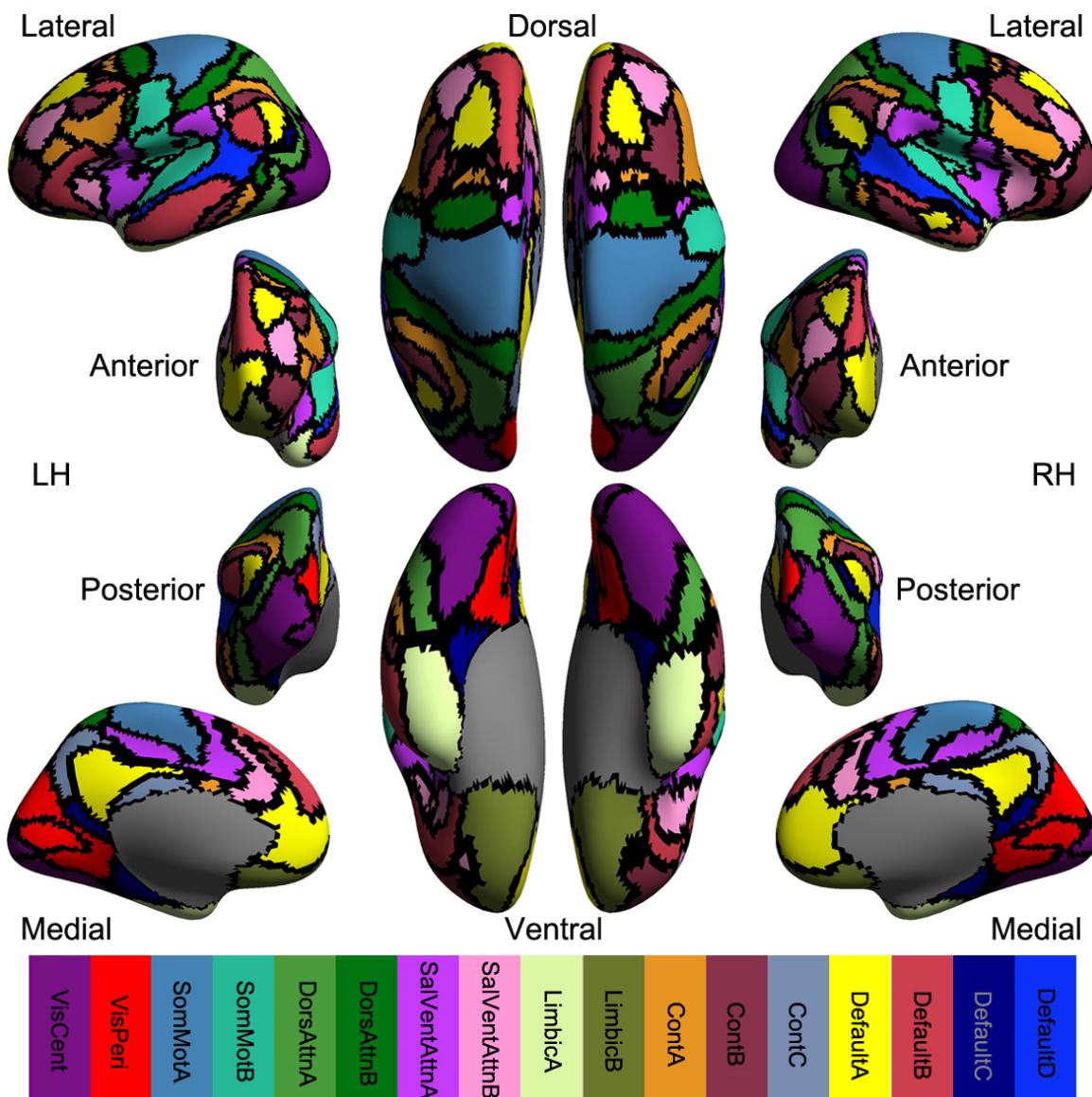
# 重测信度模块



# 连接组关联模块

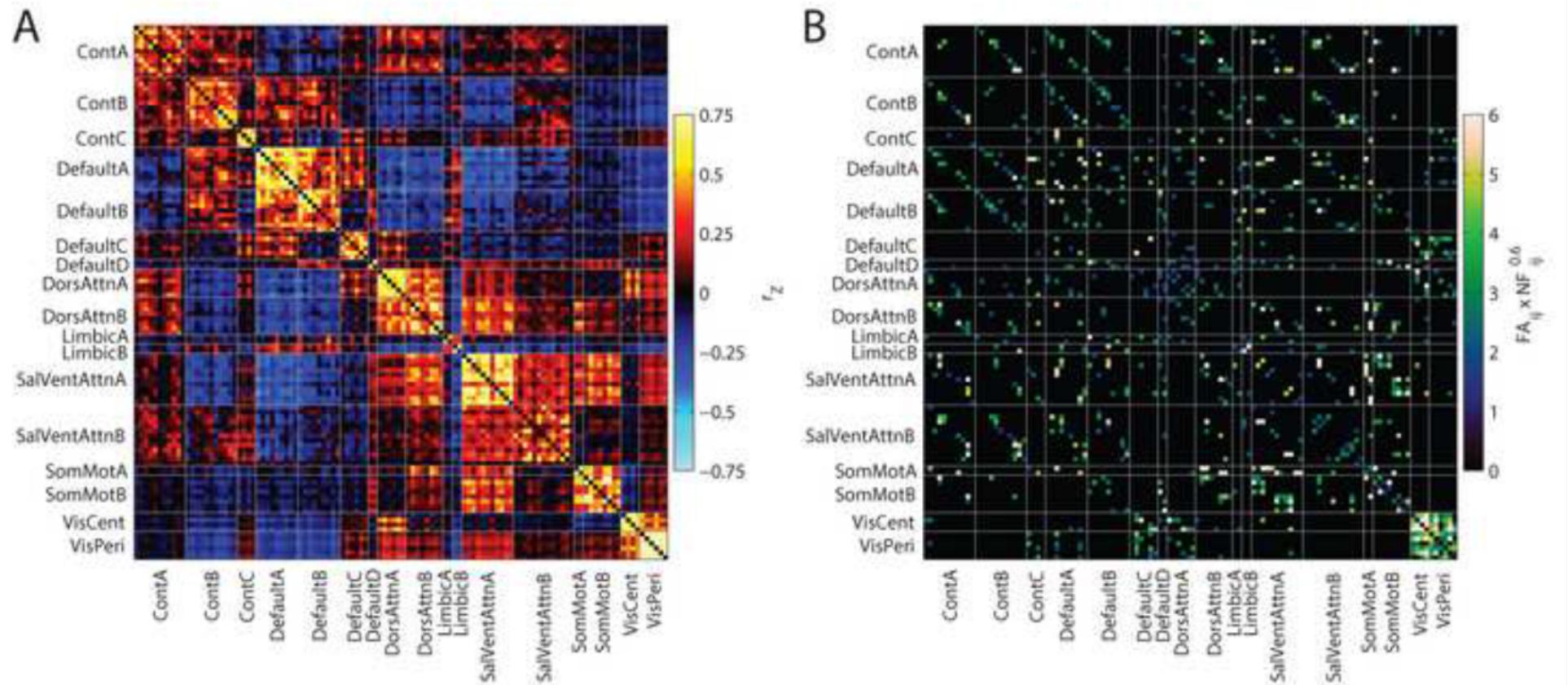


# 多模态整合模块



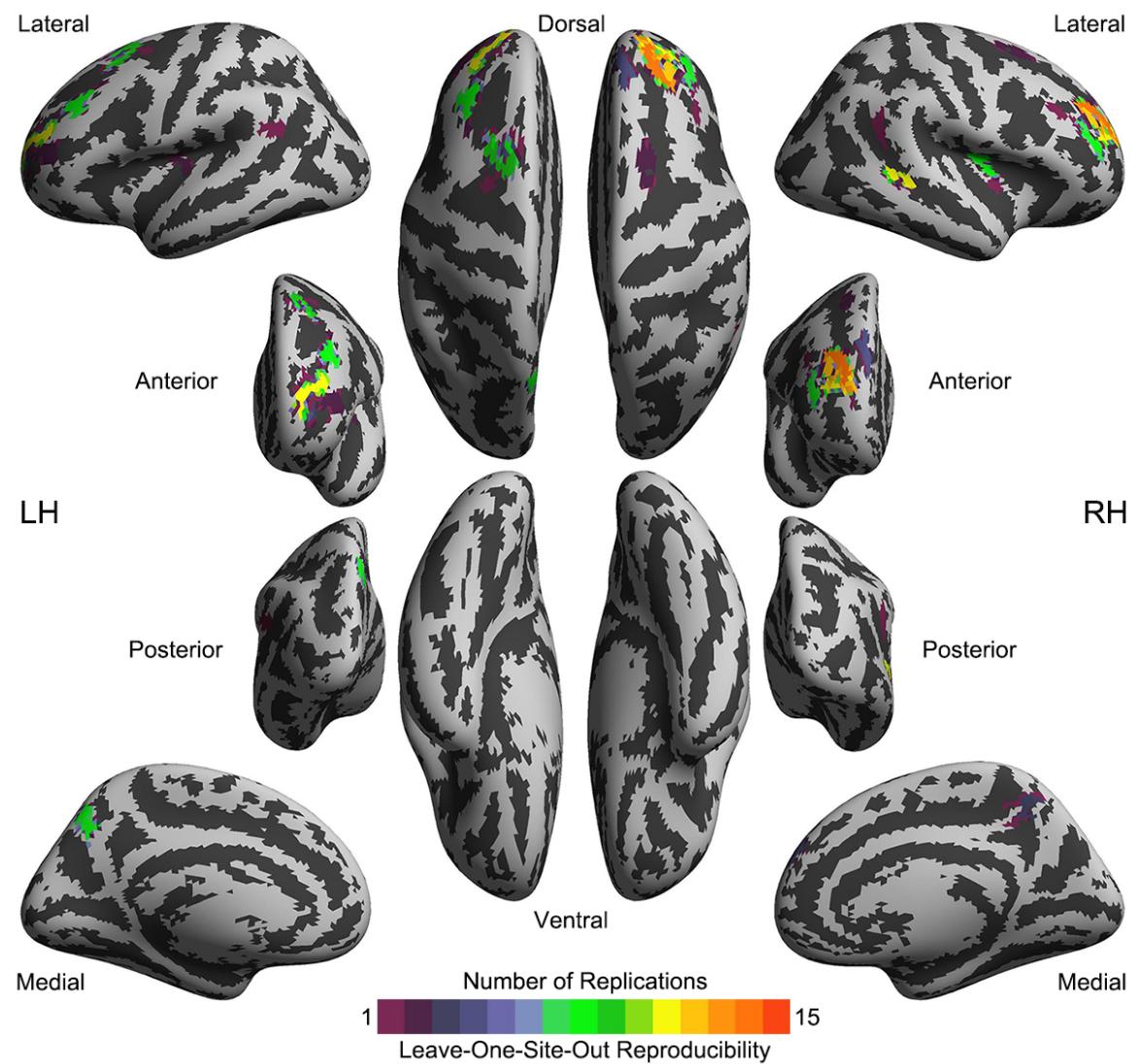
Yeo et al., 2011, J Neurophysiol

# 多模态整合模块



Betzel et al., 2014, Neuroimage

# 可视化模块



# 图形界面

Connectome Computation System

Analysis Directory /Users/yuexiaolin/Desktop/coursedata ... check\_anatfnirt.list

Main Pre-Configure Skull Strip Anat Process Func Process Post-Configure Post Process

Configure File s/yuexiaolin/Desktop/coursedata/scripts/preconfigure.txt Load Save Default

Anatomical Process

Anat Directory	anat	Scans Number	1	<input checked="" type="checkbox"/> Denoised
Anat Filename	mprage	<input checked="" type="checkbox"/> Freesufer "Gcut" Option <input type="checkbox"/> Use GPU		

Head Template applications/lfcd\_app/fsl/data/standard/MNI152\_T1\_2mm.nii.gz ...

Brain Template ons/lfcd\_app/fsl/data/standard/MNI152\_T1\_2mm\_brain.nii.gz ...

Refine Template ...

Functional Process

Func Directory	func	TR	Dropped Volumes	5
Func Filename	rest	TPattern	alt+z	Band 0.01 - 0.1

Surface Template fsaverage5

Connectome Computation System

Analysis Directory /Users/yuexiaolin/Desktop/coursedata ... subject.list

Main | Pre-Configure | Skull Strip | Anat Process | Func Process | Post-Configure | Post Process

Configure File Load Save Default

Post-process

Volume-based ( 3D )

ALFF (0.01 – 0.1) / fALFF (0.01 – 0.1) / Slow 4    ReHo    VMHC

DC    EC    BC    PC   p value ( DC / EC / BC / PC ) 0.001

FC /Applications/lfcdd\_app/ccs/bin/masks/AH2010\_DMN/DMN\_PCC\_2mm.nii.gz ...

Surface-based ( 2D )

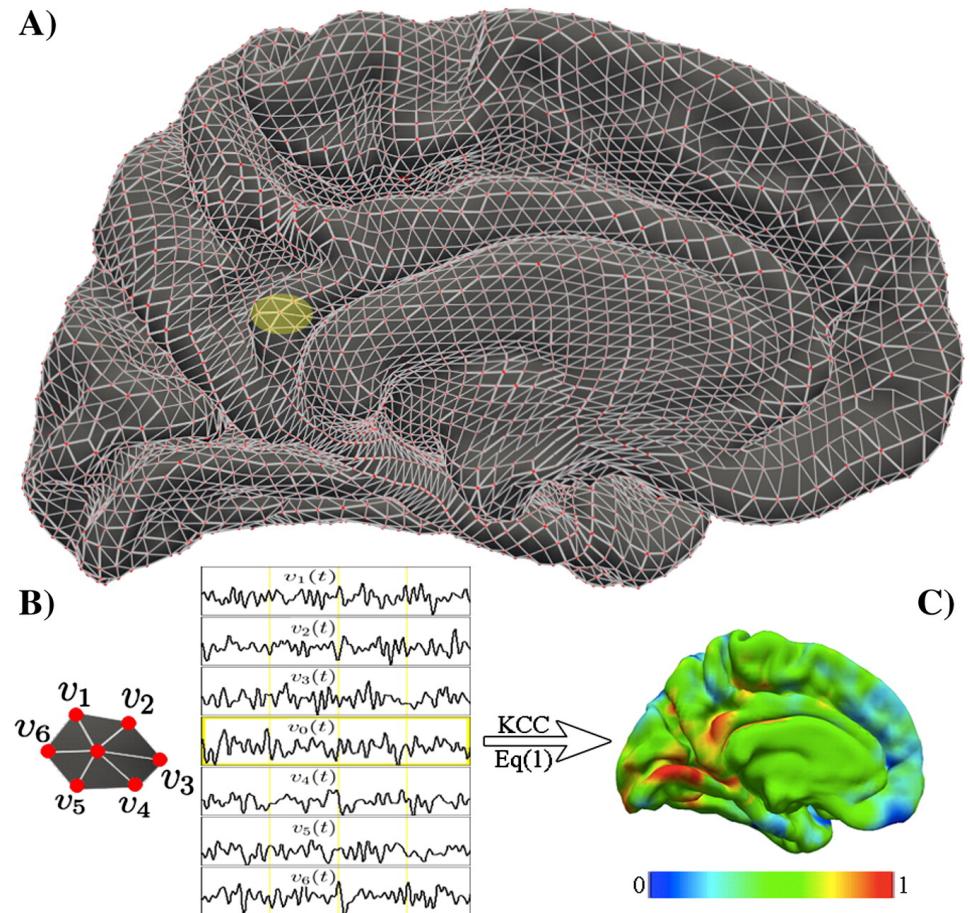
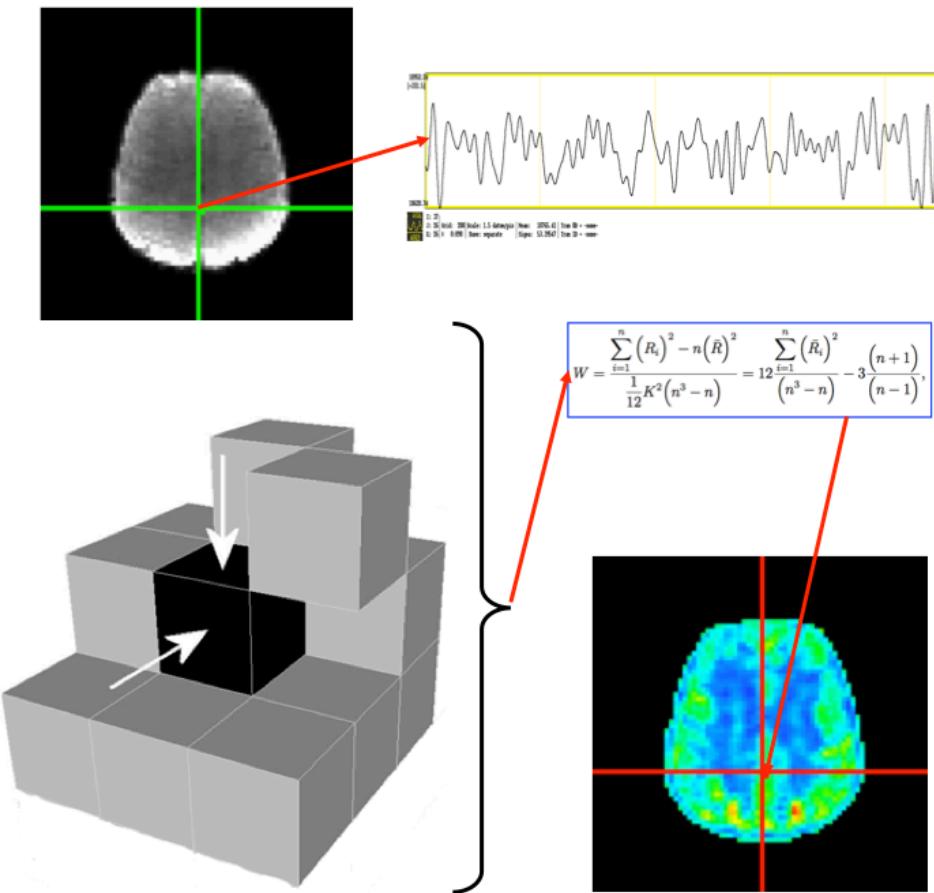
ALFF (0.01 – 0.1) / fALFF (0.01 – 0.1) / Slow 4    ReHo    VMHC

DC    EC    BC    PC   p value ( DC / EC / BC / PC ) 0.001

FC G\_precuneus ( lh )

# 应用实例

# 局部功能一致性



# 局部功能一致性

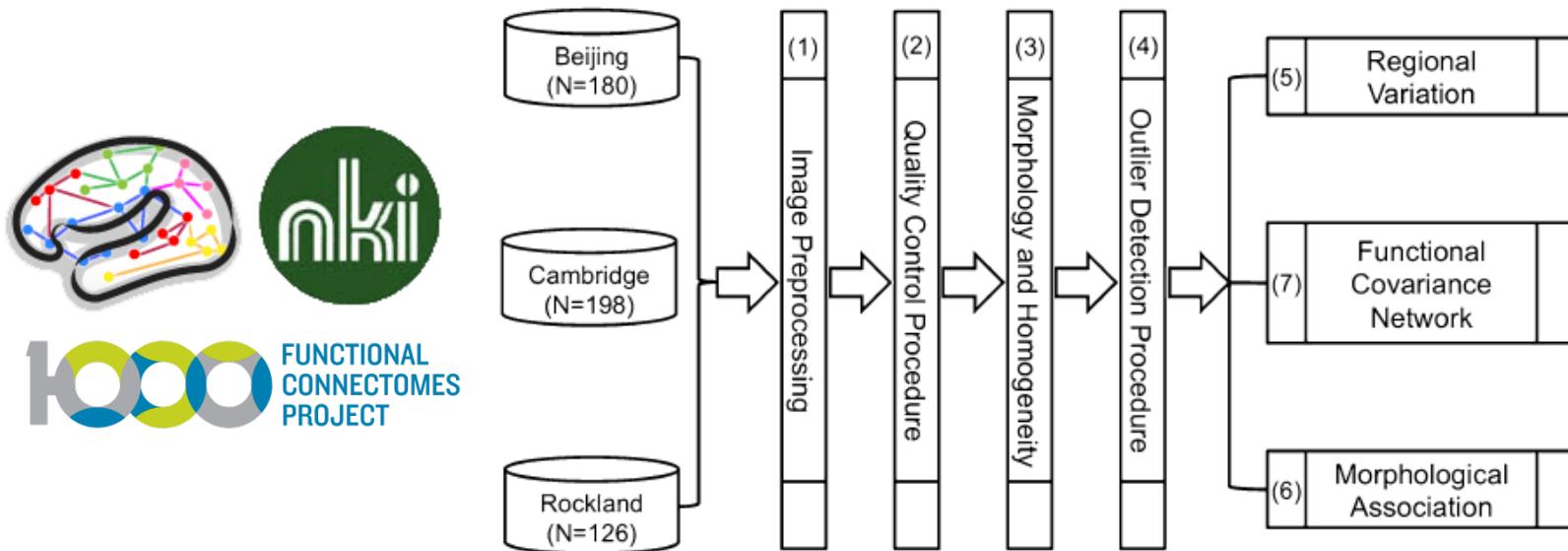


Table 2 Basic information for participants with usable datasets

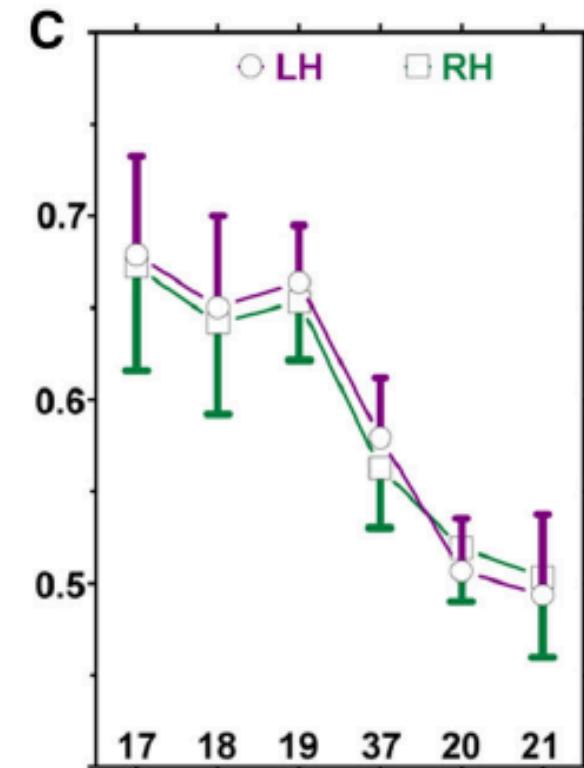
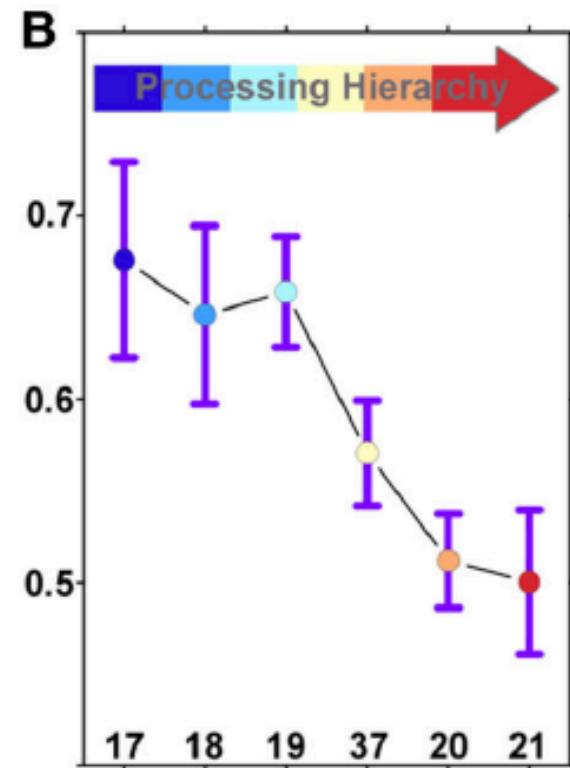
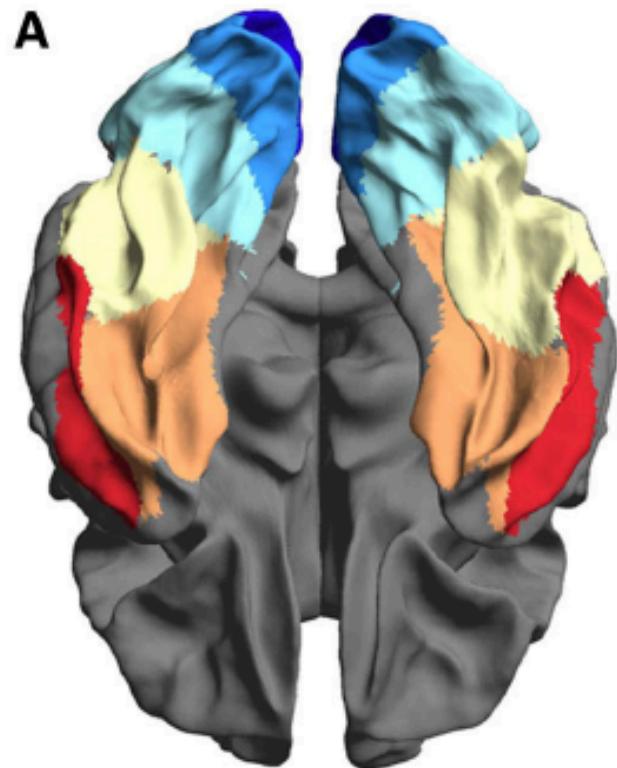
	Beijing (N = 132)	Cambridge (N = 159)	Rockland (N = 111)	Combined (N = 402)
Age (Years)	$21.3 \pm 2.05$	$21.0 \pm 2.24$	$37.1 \pm 20.80$	$25.5 \pm 13.15$
Age range (Years)	18.0–28.0	18.0–30.0	8.0–85.0	8.0–85.0
Gender (Males)	47	55	61	163
ICV <sup>a</sup> (Liter)	$1.1 \pm 0.14$	$1.2 \pm 0.17$	$1.2 \pm 0.20$	$1.2 \pm 0.17$
mcBBR <sup>b</sup>	$0.5 \pm 0.04$	$0.4 \pm 0.05$	$0.5 \pm 0.05$	$0.5 \pm 0.06$
meanFD <sup>c</sup> (mm)	$0.04 \pm 0.023$	$0.04 \pm 0.021$	$0.08 \pm 0.039$	$0.05 \pm 0.0317$

<sup>a</sup> ICV is the intracranial volume

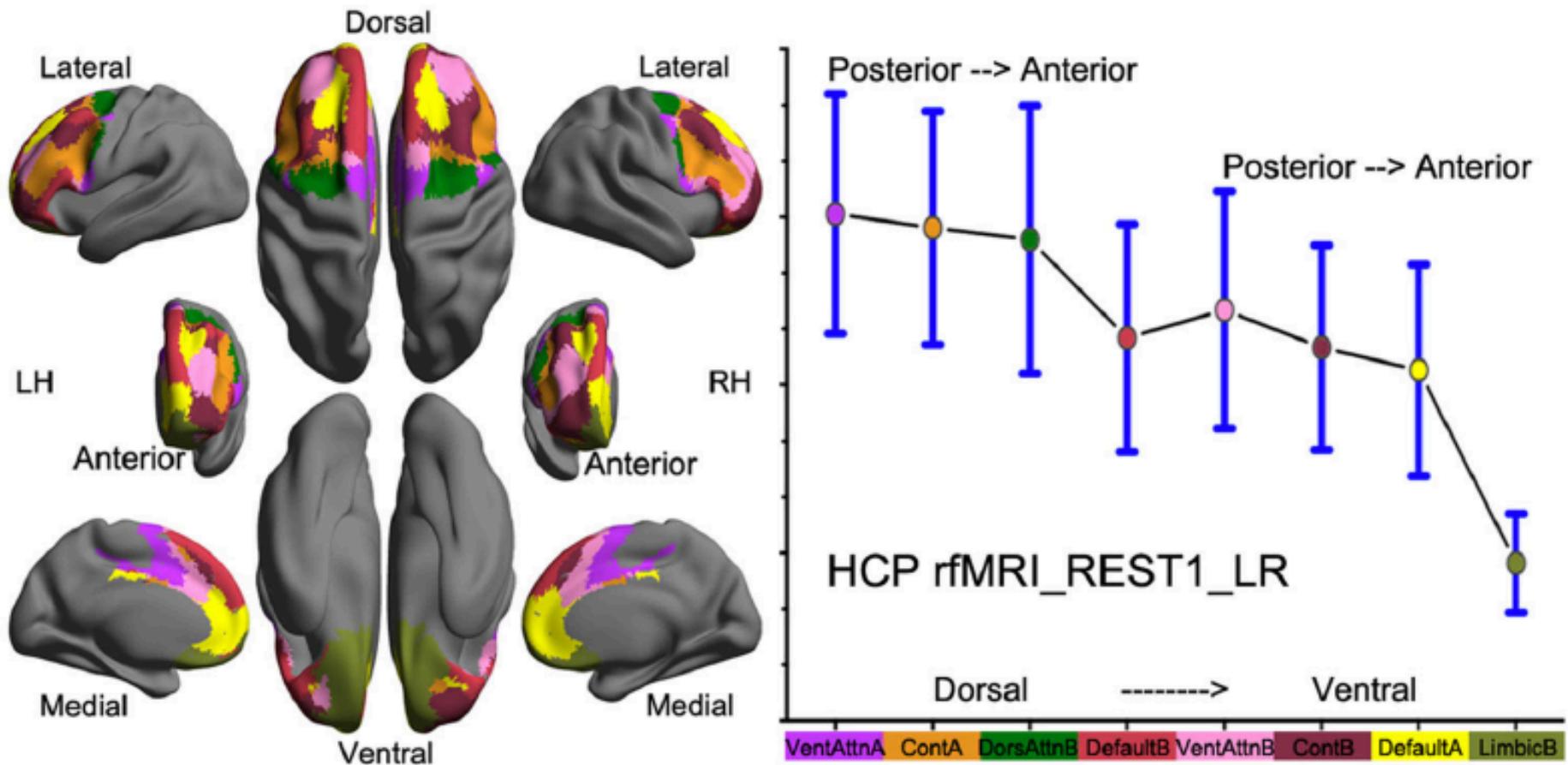
<sup>b</sup> mcBBR is the minimal cost of the intra-subject co-registration with the boundary-based registration

<sup>c</sup> meanFD is the mean frame-wise displacement for in-scanner head motion

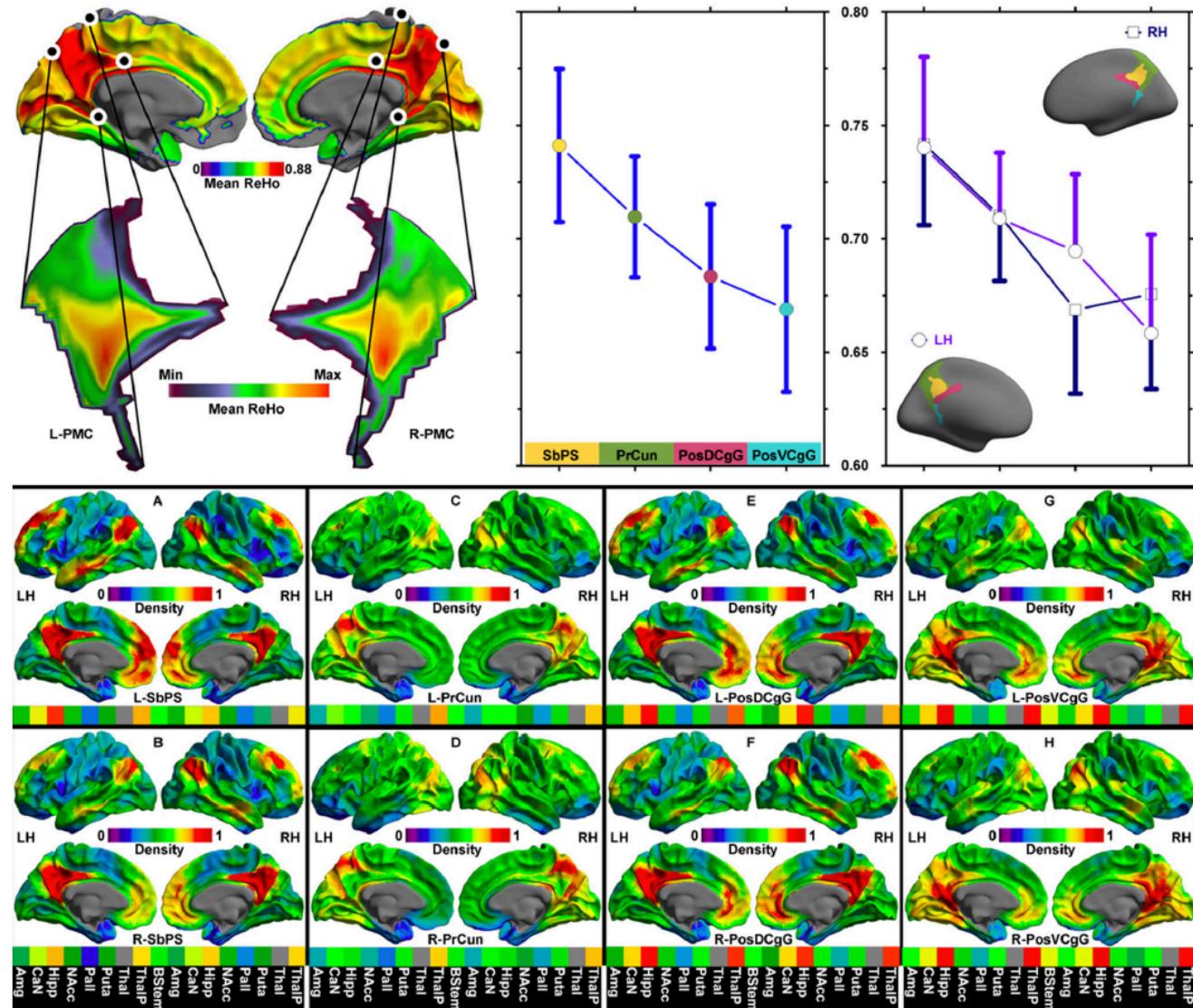
# 局部功能一致性



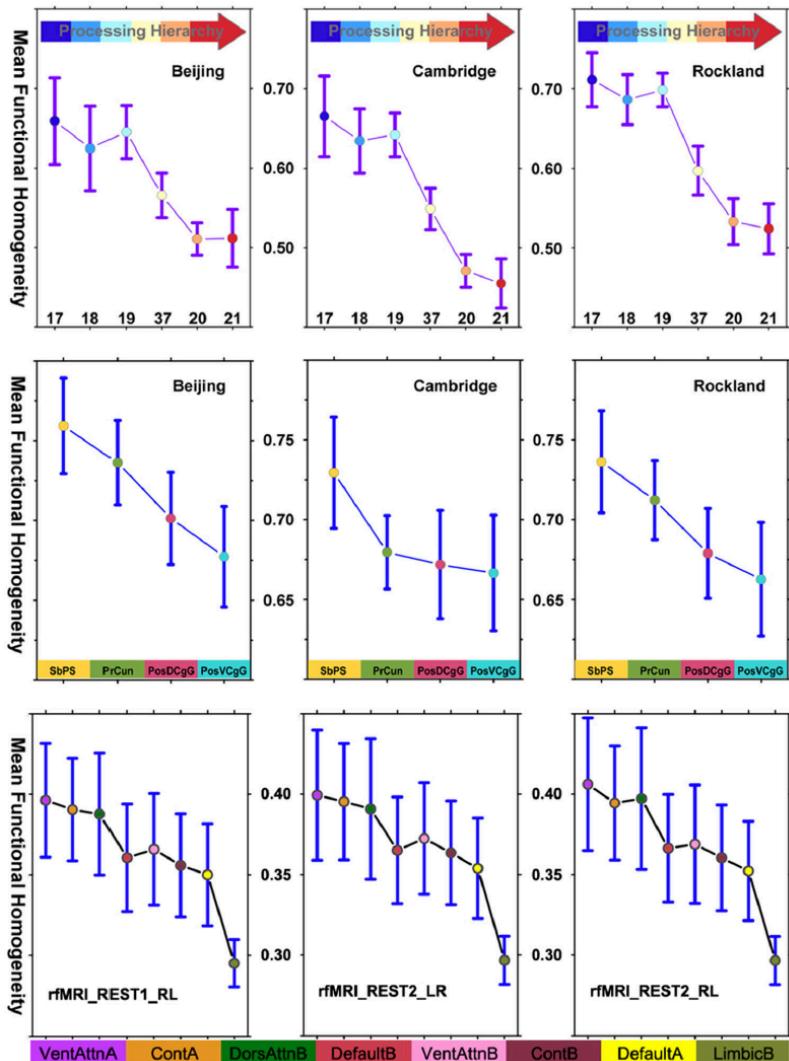
# 局部功能一致性



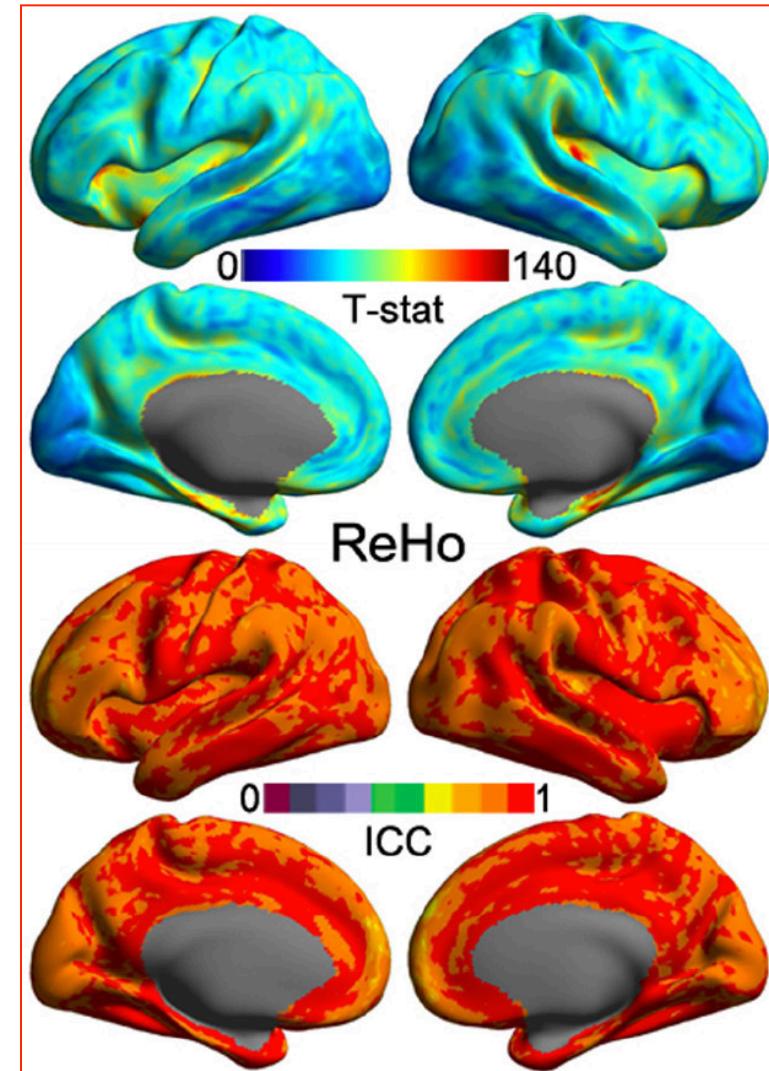
# 局部功能一致性



# 局部功能一致性



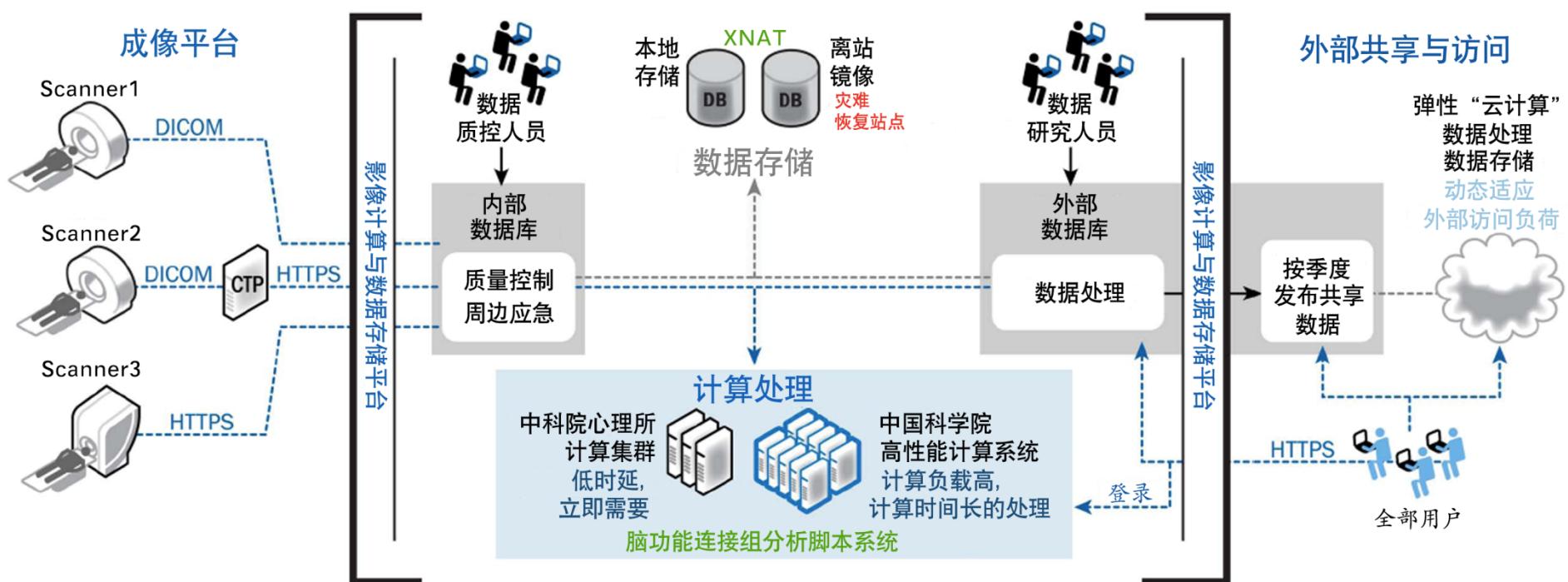
Jiang et al., 2014, Brain Struct Func



Zuo & Xing, 2014, Neurosci Biobehav Rev

# 未来服务

# 数据共享与处理



# 数据共享与处理



# 网站与论坛

The Connectome Functionally Plays the Music of Brain Oscillators!

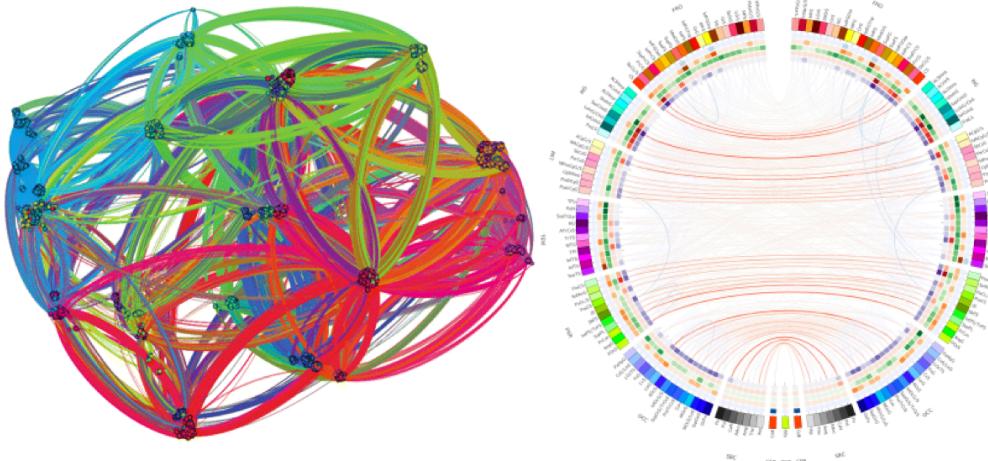
## CCS Brief

Here is a wiki to share knowledge about the Connectome Computation System (CCS) among members from the Laboratory for Functional Connectome and Development (<http://lfcd.psych.ac.cn>) at the Institute of Psychology (<http://www.psych.ac.cn>), Chinese Academy of Sciences (<http://www.cas.ac.cn>). It provides a common platform for multimodal brain connectome analysis by integrating the functionality of AFNI (<http://afni.nimh.nih.gov/afni>), FSL (<http://fsl.fmrib.ox.ac.uk/fsl>), and FreeSurfer (<http://surfer.nmr.mgh.harvard.edu>), extending the utility of 1000 Functional Connectomes Projects (FCP) scripts (<http://www.nitrc.org/frs/downloadlink.php/2628>) and by integrating the brain surface information reconstructed by FreeSurfer. This part of CCS description was borrowed from the paper we recently published in *NeuroImage* (Zuo et al., 2013: <http://www.sciencedirect.com/science/article/pii/S1053811912010208>). We are currently working on a **CCS manual** and a manuscript - **PyCCS: A Connectome Computation System GUled by Python**.

## CCS Processed Datasets

CCS has run its full functions for NYU test-retest (NYU TRT: [http://www.nitrc.org/projects/nyu\\_trt](http://www.nitrc.org/projects/nyu_trt)), enhanced NKI test-retest (eNKI TRT: [http://fcon\\_1000.projects.nitrc.org/indi/pro/eNKI\\_RS\\_TRT/FrontPage.html](http://fcon_1000.projects.nitrc.org/indi/pro/eNKI_RS_TRT/FrontPage.html)), Beijing and Cambridge sites from 1000 Functional Connectomes Projects (FCP: [http://www.nitrc.org/projects/fcon\\_1000](http://www.nitrc.org/projects/fcon_1000)), the initial NKI-RS lifespan datasets ([http://fcon\\_1000.projects.nitrc.org/indi/pro/nki.html](http://fcon_1000.projects.nitrc.org/indi/pro/nki.html)) as well as ADHD200 ([http://fcon\\_1000.projects.nitrc.org/indi/adhd200](http://fcon_1000.projects.nitrc.org/indi/adhd200)) datasets. More coming for those from CMI Summer of Sharing (<http://www.childmind.org/en/summer-sharing/>). All these preprocessed data will serve as the basis of LFCD members' first-stage projects and training courses of using CCS. Here is an demonstration for the analyses of lifespan cortical thickness changes based upon the initial NKI-RS lifespan data.

## The Human Functional Connectome Map



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