

Brain Network: Current Research, Methodological Issues and Its Applications

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Outline

- • Principles & Computational Algorithms
- Methodological Issues & Computational Platform
- Applications to Brain Disorders

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Brain Network: Principles

World-wide airport network

Social network

Brain network

Duncan J. Watts

Hilgetag et al., 2000. Trans R Soc Lond B Biol Sci

Achard et al., 2006. J Neurosci

Bassett et al., 2006. PNAS

Stam et al., 2007. Cereb Cortex

Hagmann et al., 2007. PLoS ONE

He et al., 2007. Cereb Cortex

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Brain Network: Principles

Tract-tracing

Functional MRI

Diffusion MRI

MEG

EEG

Structural MRI

Hilgetag et al., 2000. Trans R Soc Lond B Biol Sci

Achard et al., 2006. J Neurosci

Hagmann et al., 2007. PLoS ONE

He et al., 2007. Cereb Cortex

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Brain Network: Principles

- Brain hubs

A

scan 1 participant A

scan 2 participant B

participant C

participant D

participant E

B

4 or 5 patients

2 patients

0 or 1 patient

C

core number (0-10)

core number (0-10)

Hagmann et al., 2008. PLoS Biol

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Brain Network: Principles

- Brain hubs

A

Lateral view

Medial view

Top view

● Global hubs

● Non-hubs

B

Node betweenness

C

Degree

He et al., 2009. PLoS ONE

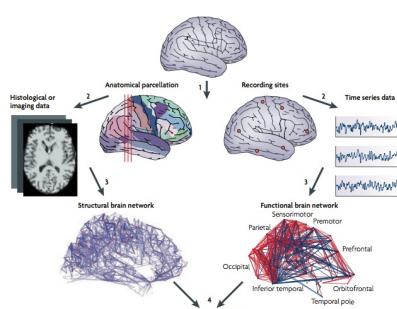
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Computational Methodology

Graph theoretical analysis

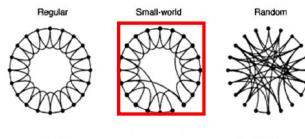
Bullmore and Sporns, 2009



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Computational Methodology

Graph theoretical analysis



Watts and Strogatz, 1998. Nature

Regular: high C_p , high L_p

Small-world: high C_p , low L_p

Random: low C_p , low L_p

Node: brain region
Link: connection

Small-world networks contain many local links and a few long-distance links (so-called "shortcuts").

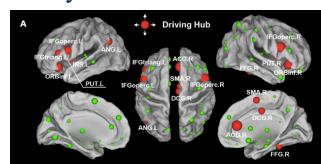
C_p : average clustering of a network
 L_p : average shortest path length of a network

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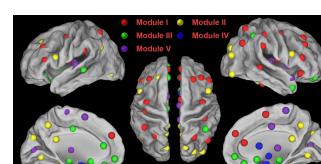
Computational Methodology

Graph theoretical analysis

Hub



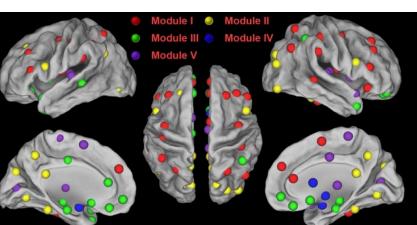
Module



Yan et al., 2011. PLoS ONE

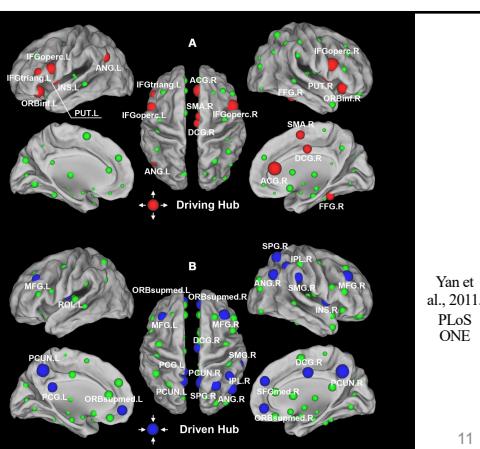
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Computational Methodology



Yan et al., 2011. PLoS ONE

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Yan et al., 2011. PLoS ONE

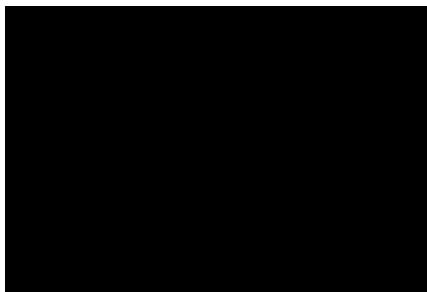
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Yan et al., 2011. PLoS ONE

Computational Methodology

The “Resting” Brain



Courtesy of Dr. Daniel Margulies

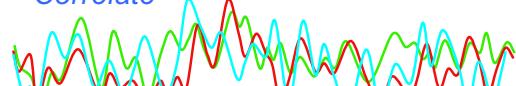
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Computational Methodology

How do we detect
organized patterns of
intrinsic activity?



Correlate



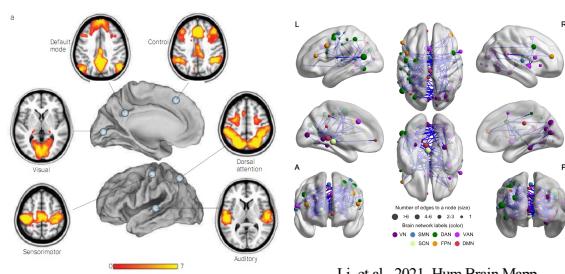
Resting State Functional
Connectivity

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Computational Methodology

• Correlation



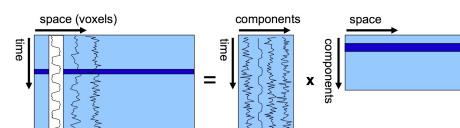
Zhang and Raichle, 2010. Nat Rev Neurol

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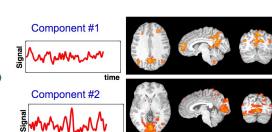
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Computational Methodology

• Independent Component Analysis



Bim
2015

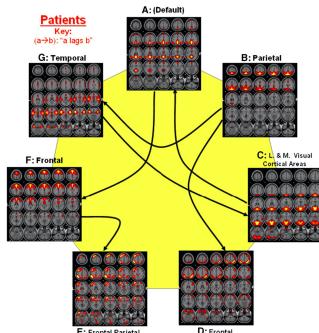


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Computational Methodology

• Functional network connectivity



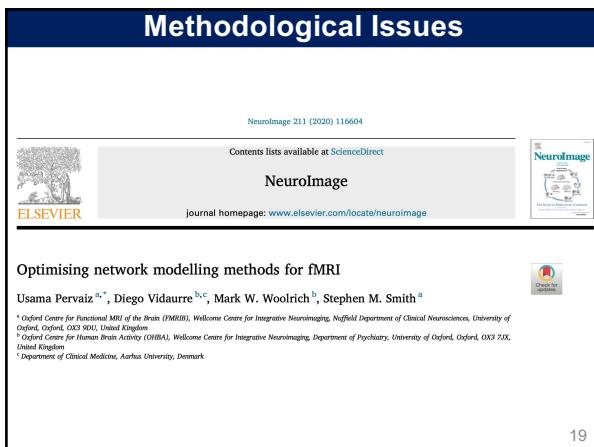
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Outline

- Resting-State fMRI: Principles
- Data Analysis: Computational Algorithms
- Data Analysis: Methodological Issues
- Data Analysis: Computational Platform
- Applications to Brain Disorders

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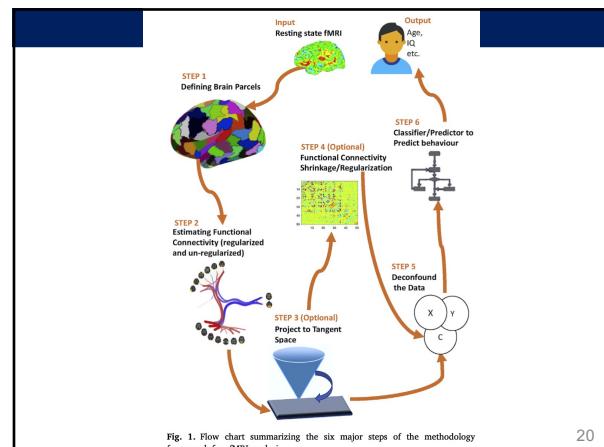
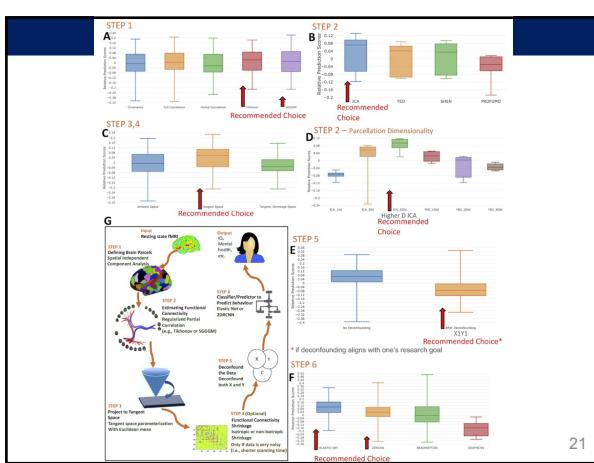


Fig. 1. Flow chart summarizing the six major steps of the methodology framework for fMRI analysis.

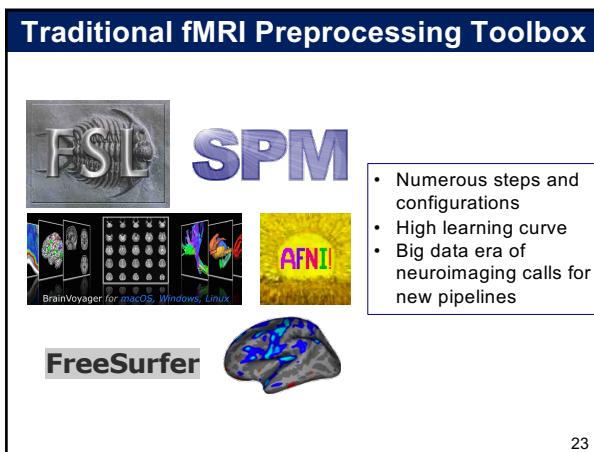
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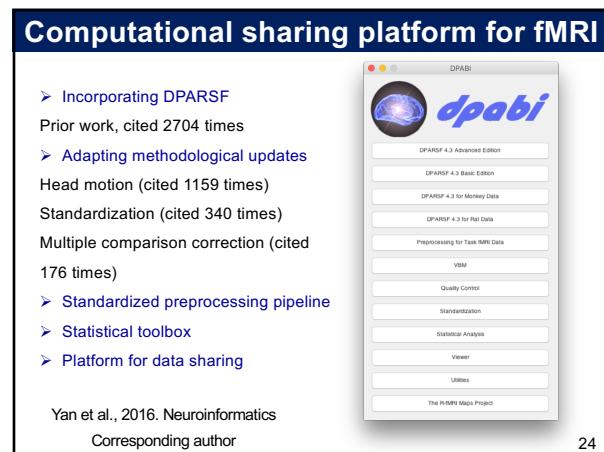
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- ## Outline
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Peer Evaluation

Cited by 1532 times, ESI Top 1% top cited paper and hot paper

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RESEARCH ARTICLE

WILEY

Estimation of vocational aptitudes using functional brain networks

Yul-Wan Sung¹ | Younseok Kang² | Uh-Su Choi² | Daehan Kang¹ | Chikro Abel¹ | Yuki Ono³ | Seiji Ogawa¹

pants, we used the data processing assistant for a part of resting-state fMRI preprocessing software known as DPABI (Chao-Gan & Yu-Feng 2010; Yan et al., 2016). The preprocessing included slice-scan time cor-

Seiji Ogawa
Inventor of fMRI BOLD

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DPARSF

Data Organization

ProcessingDemoData.zip

FunRaw

Sub_001
Sub_002
Sub_003

Functional DICOM data

T1Raw

Sub_001
Sub_002
Sub_003

Structural DICOM data

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Resting State fMRI Data Processing

Data Processing Assistant for Resting-State fMRI Advanced Edition DPARSF 4

Working Directory: J:\yulw\yog\Tran\IT\ITData\DPARSF_Updating\DPARSFTest

Participants: Sub_002
Sub_003

Time Points: 0
TR (sec): 0

Template Parameters

- Calculate Optimal Brain Lesion by DARTEL
- Calculate INTRASUB-Space (Lesion by DARTEL)
- Calculate INTRASUB-Space (Lesion from unified segmentation)
- Calculate INTRASUB-Space (Lesion from unified segmentation)
- Calculate in MNI Space - TRADITIONAL order
- Task fMRI data preprocessing
- VBM (New Segment and DARTEL)
- Unified Segmentation
- Blank

Filter (Hz): 0.01 ~ 0.08

Normal: Bounding Box: [-40 -120 -72; 30] Voxel Size: [2x3x3]
Normalize by using EPI template: Normalize by using T1 image unified segmentation: Normalize by DARTEL

Smooth: Smooth by DARTEL: FWHM: 4x4x4
ALFF-HALFF: Band (Hz): 0.01 ~ 0.08
Scrubbing: Reho: Cluster: 7 P < 27 voxels: Smooth Rmtc: Nuisance Covariates Regression: Degree Centrality: Extract ROI time courses: Define ROI: Define ROI Interactive: CWAS: Normalize to Symmetric Template: VMC: Smooth Derivatives: Smooth Derivatives

Parallel Workers #: 0 Functional Sessions #: 1 Starting Directory Name: FunRaw

Help Save Load Utilities Quit Run

Template Parameters

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DPABI

Yan et al., 2016. Neuroinformatics

ESI Top 0.1% Highly Cited Paper

DPARSF 4.3 Advanced Edition
DPARSF 4.3 Basic Edition
DPARSF 4.3 for Monkey Data
DPARSF 4.3 for Rat Data
Preprocessing for Task fMRI Data
VBM
Quality Control
Standardization
Statistical Analysis
Viewer
Utilities
The R-fMRI Maps Project

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DPABISurf

DPABISurf 4.5
DPABISurf 1.0beta
Temporal Dynamic Analysis
Quality Control
Standardization
Statistical Analysis
Viewer
Utilities
The R-fMRI Maps Project

DPARSF Advanced Edition
DPARSF Basic Edition
DPARSF for Monkey Data
DPARSF for Rat Data
Preprocessing for Task fMRI Data
VBM

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DPABISurf

DPABISurf Pipeline

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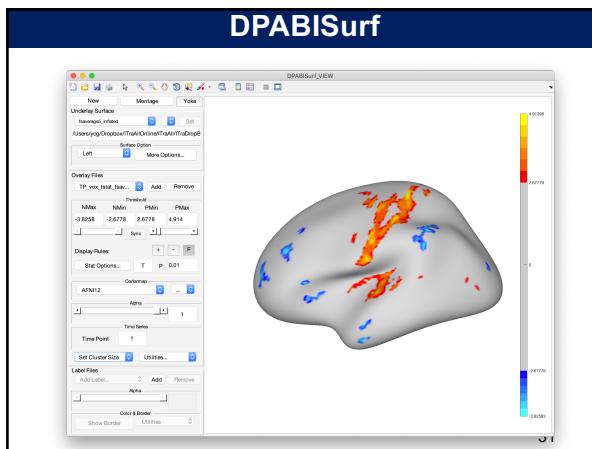
Template Parameters: Convert to BIDS: Preprocess w/ Dropshot: Low Memory Mode: Normalize by Voxel Size: ICA-AROMA: Bile Tracing: Slice Number: 0: Slice Order: 1 2 3 4 5 6 7 8 9 10: Reference Size: 0: ICA-AROMA: Mask: Scrubbing: Averaging Dropshot: ...: Shutter: Using Dropshot: ...: Volume: Averaging Dropshot: ...: Head Motion Model: Rigid-body 6: Derivative 12: Derivative 24: Head motion scrubbing regressions: Advance regressor NW, CSF, Global: Other covariates: Add Invert Back: FWHM for Surface: 10: FWHM for Volume: 8 ~ 6: Scrubbing: ALFF-HALFF: Band (Hz): 0.01 ~ 0.1: Filter (Hz): 0.01 ~ 0.1: Surface Neglect: 0 ~ 2 voxels: Volume Cluster: 7 P < 27 voxels: Surface Dropshot: Averaging Dropshot: ...: Shutter: Using Dropshot: ...: SurRF: Using Dropshot: ...: Degree Centrality: Functional Connectivity: Extract ROI time courses: Define ROI: Smooth Derivatives

Parallel Workers #: 0 Functional Sessions #: 1 Starting Directory Name: FunRaw

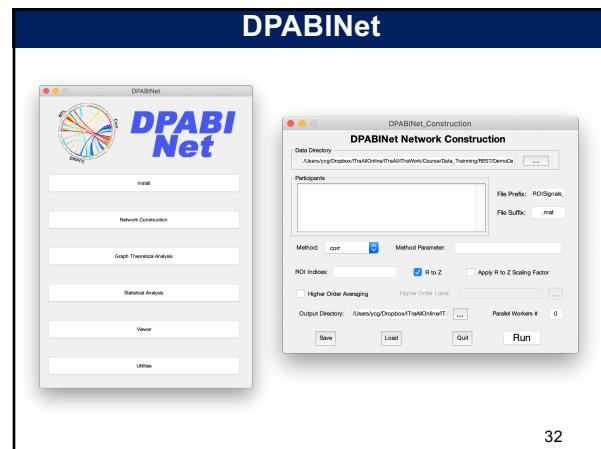
Save Load Utilities Run

Yan et al., 2021. Science Bulletin

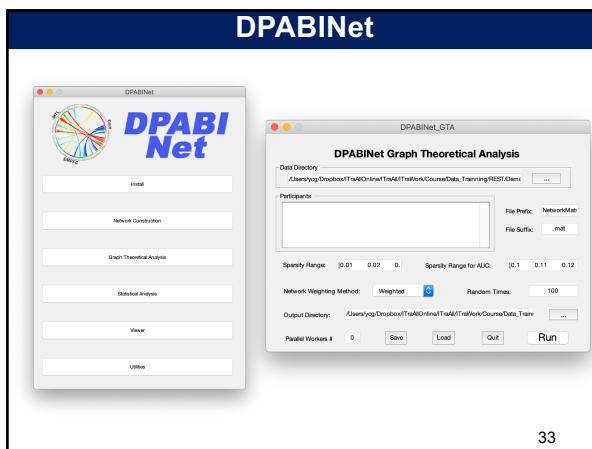
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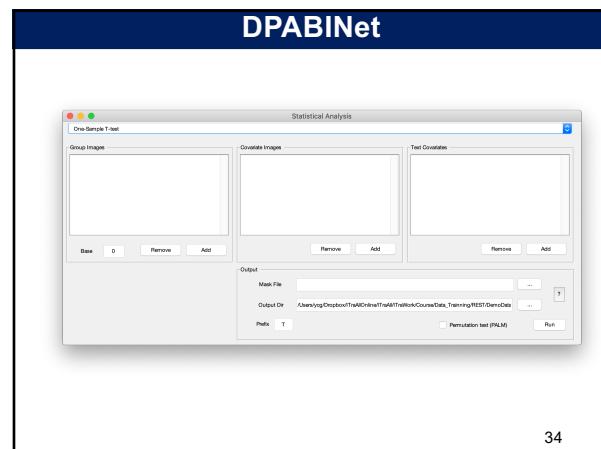
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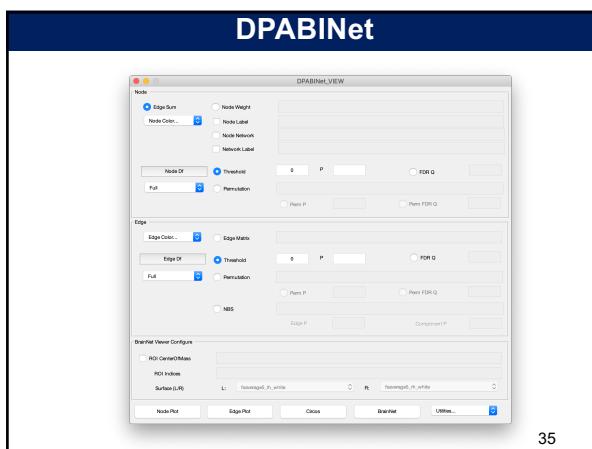
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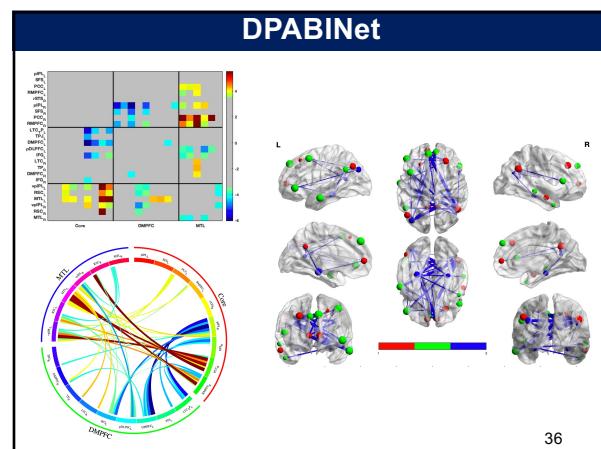
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Future Directions

- R-fMRI methodology
- Mechanism of R-fMRI: electrophysiology/fMRI recording
- Modulation and intervention: medication and brain stimulation
- Application to brain disorders

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Further Help



The R-fMRI Course V3.0

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<http://rfmri.org>

The R-fMRI Lab

International Big-Data Center for Depression Research

Institute of Psychology, Chinese Academy of Sciences



<http://rfmri.org/Course>



The R-fMRI Wiki

Configurations for EPARSFA_001

You can see EPARSFA_001 independently from the ECR to process your data. Because the ECR is smaller, the raw data are processed by the ECR instead of the ECR. The process time will be shorter.

[Log in or register](#) | [Logout](#)

<http://rfmri.org/wiki>

<http://rfmri.org/wiki>



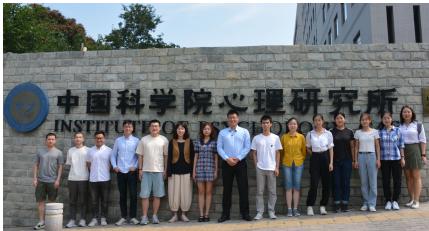
The R-fMRI Journal Club



Official Account: RFMRILab

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Acknowledgments



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Thanks for your attention!

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