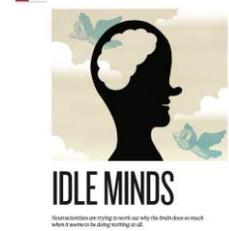





## Temporal Dynamic Analysis

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 The R-fMRI Lab  
 Institute of Psychology, Chinese Academy of Sciences

### Introduction



RESTING-STATE ACTIVITY IS IMPORTANT,  
IF THE AMOUNT OF ENERGY DEVOTED  
TO IT IS ANY INDICATION.

Smith, 2012, Nature

### Introduction

#### Computational Methods

- Regional characteristics of a single voxel
- Relational characteristics among multiple voxels

Zuo and Xing, 2014, Neurosci Biobehav Rev

### Introduction

#### Regional characteristics of a single voxel

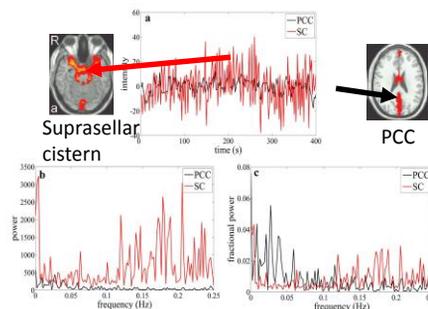
Amplitude measures. For a given frequency:

- RMS: root mean square (Biswal et al., 1995)
- RSFA: standard deviation (Kannurpatti et al. 2008)
- ALFF: amplitude of low-frequency fluctuations (Zang et al., 2007)
- fALFF: fractinal ALFF (Zou et al., 2008)

Zuo and Xing, 2014, Neurosci Biobehav Rev

### Introduction

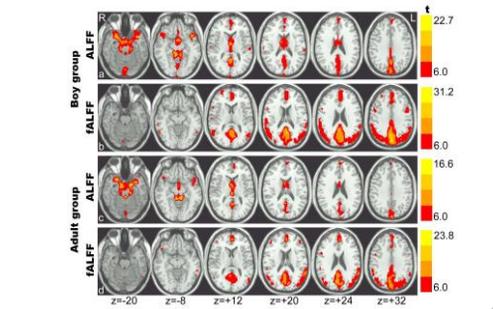
#### Improvement: fractional ALFF



Zou et al., 2008, J Neurosci Methods

### Introduction

#### ALFF vs. fALFF



Zou et al., 2008, J Neurosci Methods

### Introduction

**Regional characteristics of a single voxel**

- Degree of power-law fitting (Kiviniemi et al., 2000)
- Fractal dimension or Hurst exponent (Maxim et al., 2005; Wink et al., 2008)
- Multi-scale or approximate entropy (Smith et al., 2014; Liu et al., 2013a)
- Lyapunov exponent (Xie et al., 2008)

Zuo and Xing, 2014, Neurosci Biobehav Rev

### Introduction

**Relational characteristics among multiple voxels**

- Functional Connectivity
- Effective Connectivity

### Introduction

How do we detect organized patterns of intrinsic activity? Resting State Functional Connectivity

Correlate

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### Introduction

- Correlation

Zhang and Raichle, 2010, Nat Rev Neurol

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### Introduction

- ICA

Beckmann et al., 2005; Birn, 2015

### Introduction

**Regional Homogeneity (ReHo)**

Similarity or coherence of the time courses within a functional cluster

$$W = \frac{\sum(R_i)^2 - n(\bar{R})^2}{12K^2(n^3 - n)}$$

Zang et al., 2004, Neuroimage  
Or COSLOF, Li et al., 2002

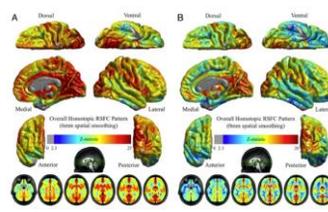
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### Introduction

## Voxel Mirrored Homotopic Connectivity (VMHC)



Gee et al., 2011

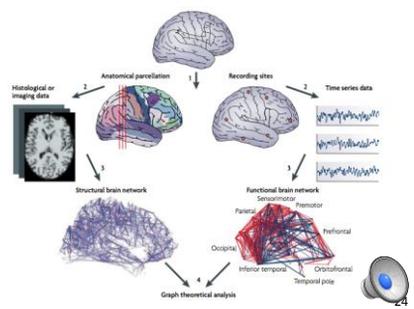



Zuo et al., 2010

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### Introduction

## Graph theoretical analysis

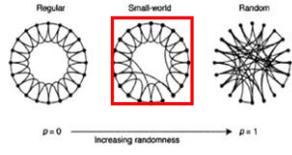


Bullmore and Sporns, 2009

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### Introduction

## Graph theoretical analysis



Watts and Strogatz, 1998. Nature

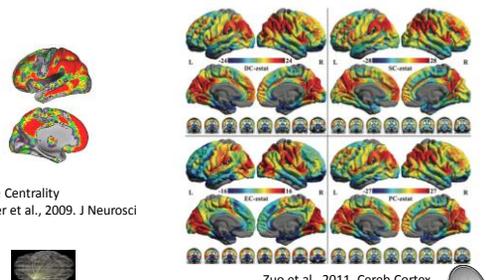
<p><b>Regular:</b> high <math>C_p</math> high <math>L_p</math></p>	<p><b>Small-world:</b> high <math>C_p</math> low <math>L_p</math></p>	<p><b>Random:</b> low <math>C_p</math> low <math>L_p</math></p>	<p>Small-world networks contain many local links and a few long-distance links (so-called "shortcuts").</p>
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$C_p$ : average clustering of a network  
 $L_p$ : average shortest path length of a network

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### Introduction

## Voxel-wise network centrality metrics



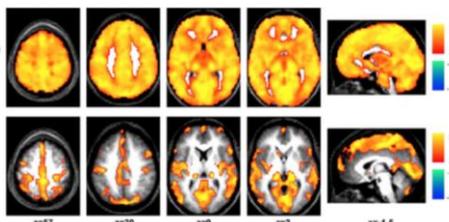
Buckner et al., 2009. J Neurosci

Zuo et al., 2011. Cereb Cortex

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### Introduction

## Global Signal Correlation



Fox et al., 2009. J Neurophysiol

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### Introduction

-  Voxel strength: ALFF/fALFF
-  Regional synchronization: ReHo
-  Homotopic connectivity: VMHC
-  Global connectivity: Degree Centrality

GSCorr

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### Introduction

**Head motion control**  
Yan et al., 2013a. Neuroimage

**Standardization**  
Yan et al., 2013b. Neuroimage

### Introduction

**Clusters of Regional Connectivity**

**Clusters of Connectivity**

**Intrinsic activity in Autism**  
Di Martino, Yan et al., 2014. Mol Psychiatry

**Intrinsic brain indices of verbal working memory capacity**  
Yang, Yan et al., 2015. Dev Cogn Neurosci

### Introduction

#### Interdependencies among different intrinsic brain function measures

- How concordant differing indices are with respect to their variation across voxels
- How concordant different indices are with respect to their variation from one individual to the next
- How concordant differing indices are with respect to their variation over time

### Introduction

**RelTo vs. DC**

**RelTo vs. FALFF**

**FALFF vs. DC**

Yuan et a., 2013. Magn Reson Imaging

Aiello et a., 2015. Neuroimage

### Introduction

Yang et al., 2016. Brain Struct Funct

### Introduction

#### Temporal Dynamic Perspective

Chang and Glover, 2010. Neuroimage

Allen et al., 2013. Cereb Cortex

Kang, Yan et al., 2011. Neuroimage

Yang, Yan et al., 2014. Neuroimage

## Introduction

The goal of the present work is to provide a comprehensive understanding of interdependencies among different intrinsic brain activity measures within and across individuals.

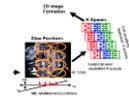


## Materials and Methods



Enhanced Nathan Kline Institute - Rockland Sample

173 neurotypical individuals ages between ages 8 and 86 with quality pass datasets (mean age: 44.5; 117 females)



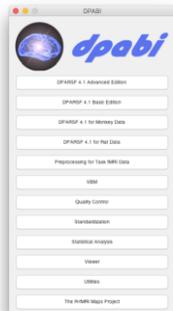
MultiBand EPI  
TR = 0.645s

Nooner et al., 2012



## Materials and Methods

Preprocessing



Yan et al., 2016. Neuroinformatics



## Materials and Methods

R-fMRI Indices



Voxel strength: ALFF/fALFF



Regional synchronization: ReHo



Homotopic connectivity: VMHC



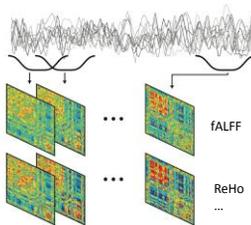
Global connectivity: Degree Centrality

GSCorr



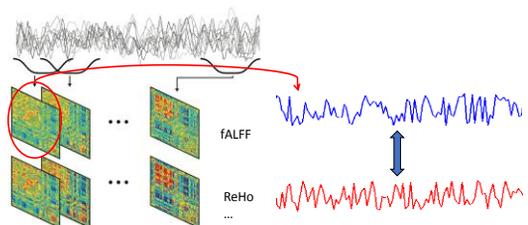
## Materials and Methods

Dynamic R-fMRI Indices



## Materials and Methods

Correlation between Global Mean of R-fMRI Indices



### Materials and Methods

**Voxel-wise Concordance Index**

Kendall's W  $W = \frac{\sum(R_i)^2 - n(\bar{R})^2}{\frac{1}{12}K^2(n^3 - n)}$

### Materials and Methods

**Volume-wise Concordance Index**

Kendall's W  $W = \frac{\sum(R_i)^2 - n(\bar{R})^2}{\frac{1}{12}K^2(n^3 - n)}$

### Materials and Methods

**Age Effects**

A given measure =  $b_0 + b_1 \times \text{Age} + b_2 \times \text{Sex} + b_3 \times \text{meanFD} + \text{error}$

### Results and Discussion

**Static and Dynamic R-fMRI Indices**

Yan et al., 2017. Science Bulletin

### Results and Discussion

**Evaluating Concordance among R-fMRI Indices: Global-Level Analyses**

Yan et al., 2017. Science Bulletin

### Results and Discussion

**Evaluating Voxel-wise Concordance among R-fMRI Indices:**

Yan et al., 2017. Science Bulletin

### Results and Discussion

Evaluating Concordance among R-fMRI Indices: Voxel-wise Analyses

Yan et al., 2017. Science Bulletin

### Results and Discussion

Evaluating Spatial Concordance among R-fMRI Indices: Volume-wise Analysis

Yan et al., 2017. Science Bulletin

Fjell et al., 2015. PNAS

### Results and Discussion

Understanding Low/High Concordance

Yan et al., 2017. Science Bulletin

### Results and Discussion

Understanding Low/High Concordance

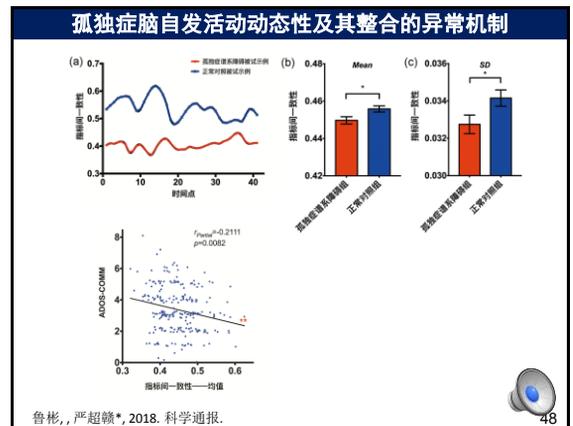
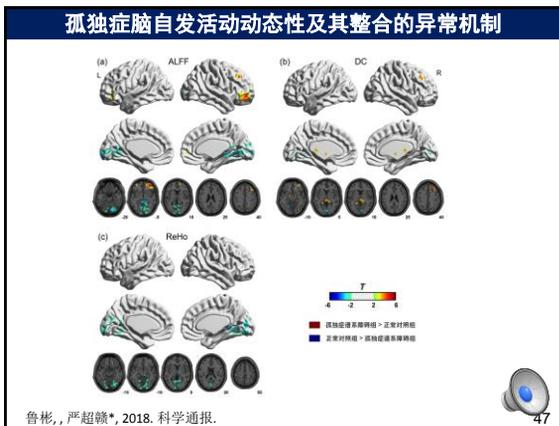
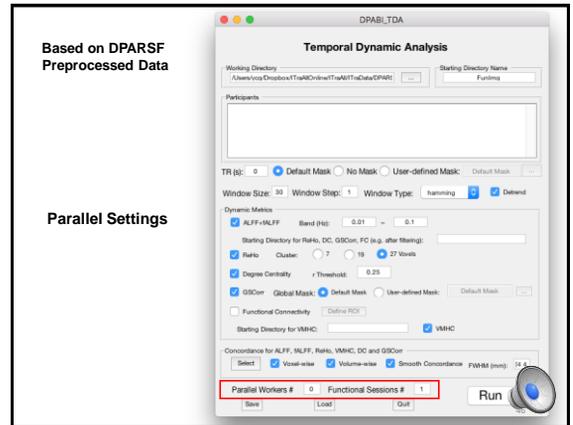
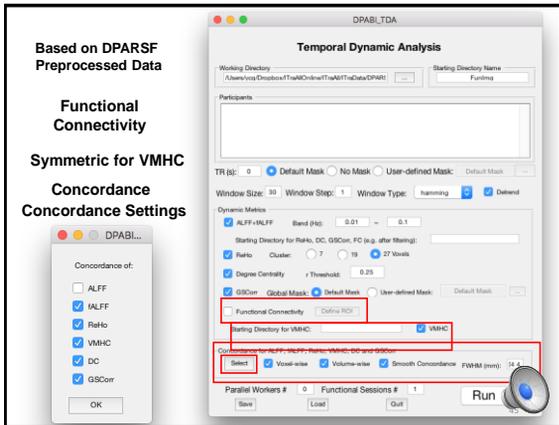
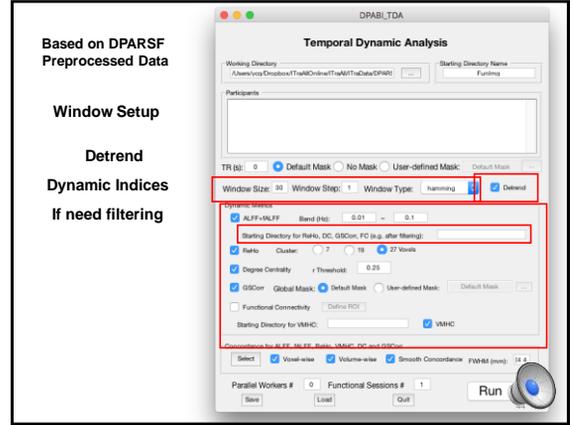
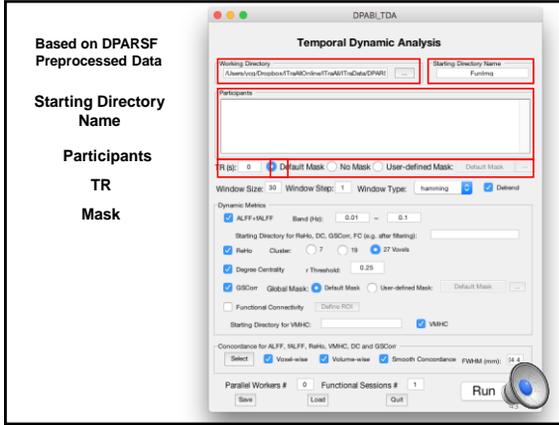
Yan et al., 2017. Science Bulletin

### Underst

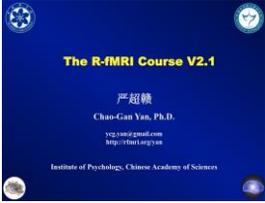
Yan et al., 2017. Science Bulletin

### DPABI\_TDA

Yan et al., 2017. Science Bulletin



## Further Help



**The R-fMRI Course V2.1**  
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132296@gmail.com  
http://rfmri.org/yan

Institute of Psychology, Chinese Academy of Sciences

<http://rfmri.org/Course>



<http://rfmri.org/wiki>

 The R-fMRI Journal Club

 Official Account: RfMRIlab

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## Preprints of the R-fMRI Network



Preprints of the R-fMRI Network (PRN) is a preprint, open-access, free-submission, open-discussion, community funded Preprints of R-fMRI related research. The goal of PRN is to supplement the peer-reviewed journal publication system – by more rapidly communicating the latest research achievements across the global.

**F1000Research** F1000Research 2018, 3:1313 | doi:10.1093/f1000r/21/AUG/2019

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click for updates

**SOFTWARE TOOL ARTICLE**  
**REVISED** **PRN: a preprint service for catalyzing R-fMRI and neuroscience related studies [v2; ref status: indexed, http://f1000r.es/5qy]**

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中国科技论文预发布平台

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## 数据分析与深度培训



**静息态功能磁共振成像深度数据分析**

功能磁共振成像越来越成为一种主题的科研手段,然而功能磁共振的数据分析却是一项具有高度挑战性的工作。海量的原始数据,复杂的分析步骤,复杂的分析方法都让研究者们无所适从。恰当的分析方法可以从最原始的数据中挖掘出富有创新性的结果,而不恰当的分析则可能让精心收集的数据黯然失色。深度大脑公司联合中国科学院 The R-fMRI Lab 的专业功能磁共振研究团队提出一站式功能磁共振数据分析解决方案,帮助您从容应对功能磁共振数据带来的挑战。

<http://deepbrain.com>



**静息态功能磁共振成像数据处理深度特训**

从您见到这条消息开始,您将有机会与中国科学院 The R-fMRI Lab 的静息态功能磁共振专家团队共同探索大脑的奥秘!课程组特设期间,您将亲身体验:

- 数据处理 专家指导下高效学习静息态功能磁共振成像数据处理
- 思路设计 与国际知名专家讨论形成研究思路
- 论文撰写 系统的 SCI 论文写作训练

<http://deepbrain.com>

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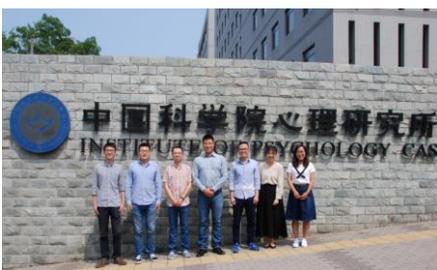
## The R-fMRI Lab



 WeChat Official Account: RfMRIlab

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## Acknowledgments



Chinese Academy of Sciences  
Xi-Nian Zuo  
Hangzhou Normal University  
Yu-Feng Zang  
NYU Child Study Center  
F. Xavier Castellanos

Child Mind Institute  
Michael P. Milham

**Funding**

- National Natural Science Foundation of China
- National Key R&D Program of China
- Chinese Academy of Sciences

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## Thanks for your attention!

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