认知心理学进阶第十一讲：
静息态功能磁共振数据分析

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Outline

- Principles & Computational Algorithms
- Methodological Issues & Computational Platform
- DPARSFA Usage

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Resting-State fMRI: Principles

All of the human high mental functions such as thinking, emotion and consciousness rely on brain, an extremely complex system (Singer, 1999)

http://psychcentral.com/news/2010/11/03/new-insights-on-brains-internal-wiring/20500.html

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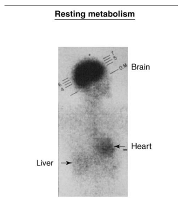
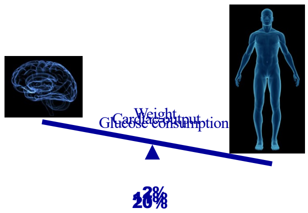
Resting-State fMRI: Principles





Raichle et al., 2010. Trends Cogn Sci

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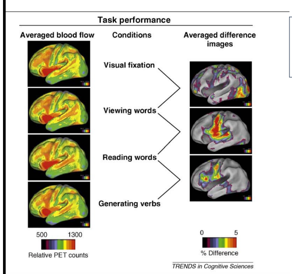
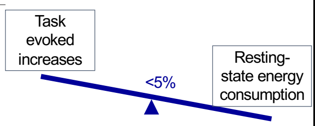
Resting-State fMRI: Principles





There are very important activities in the brain during resting-state (Fox and Raichle, 2007; Zhang and Raichle, 2010)

Raichle et al., 2010. Trends Cogn Sci

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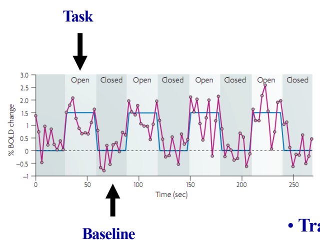
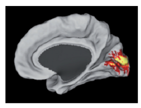
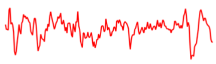
Resting-State fMRI: Principles





- Traditional fMRI analysis



Noise?

Activities in the baseline state (usually resting-state)

Fox and Raichle, 2007. Nat Rev Neurosci

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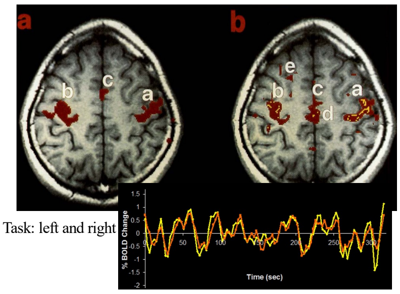
Resting-State fMRI: Principles

- Temporal synchrony of spontaneous fluctuations



Task: left and right

Biswal et al., 1995. Magn Reson Med

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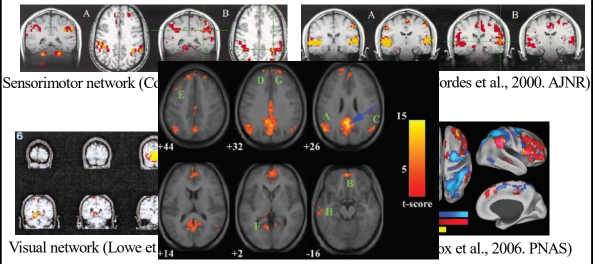
Resting-State fMRI: Principles

- Functional networks identified by functional connectivity with resting-state fMRI (RS-fMRI)



Sensorimotor network (C... ...ordes et al., 2000. AJNR)

Visual network (Lowe et... ...ox et al., 2006. PNAS)

DMN (Greicius et al., 2003. PNAS)

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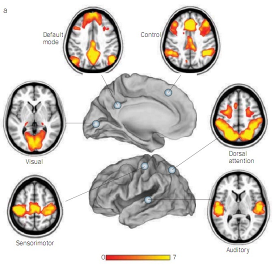
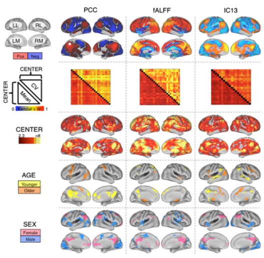
Resting-State fMRI: Principles



Zhang and Raichle, 2010. Nat Rev Neurol



Biswal et al., 2010. PNAS

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Resting-State fMRI: Principles

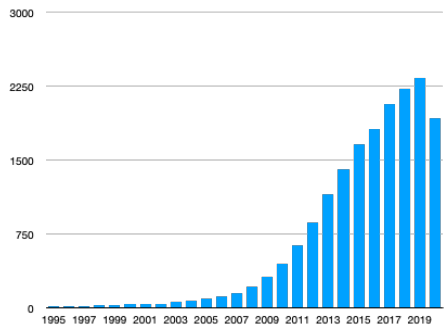

Figure 1. Number of R-fMRI related studies in PubMed (key words: "resting+state+fmri").

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Outline

- **Resting-State fMRI: Principles**
- **Data Analysis: Computational Algorithms**
- **Data Analysis: Methodological Issues**
- **Data Analysis: Computational Platform**
- **DPARSF Usage**

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Computational Methodology

- Integration approach
- Regional approach
- Graphical approach

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Computational Methodology

Integration approach

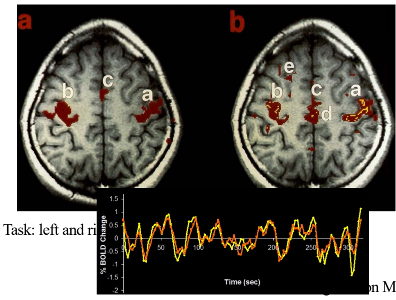
- Functional Connectivity
-

a

- Effective Connectivity: (Friston et al., 2002)
- Hierarchical Clustering: (Cordes et al., 2000; Salvador et al., 2005)
- Self Organization Map: (Peltier et al., 2003)
- ....

Computational Methodology

- **Correlation: Temporal synchrony of spontaneous fluctuations**



Task: left and ri

n Med

Computational Methodology

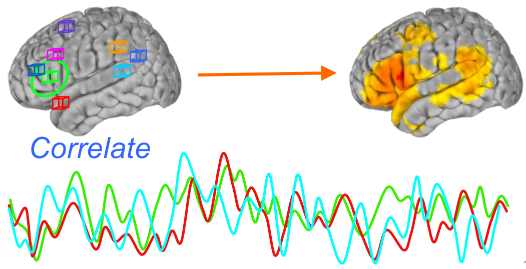
The "Resting" Brain

Courtesy of Dr. Daniel Margulies

Computational Methodology

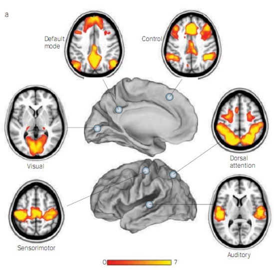
How do we detect organized patterns of intrinsic activity?

Resting State Functional Connectivity



Computational Methodology

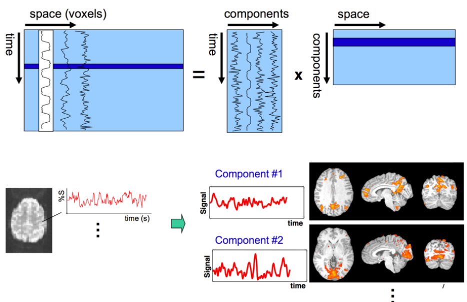
- **Correlation**



Zhang and Raichle, 2010. Nat Rev Neurol

Computational Methodology

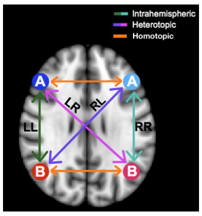
- **Independent Component Analysis**

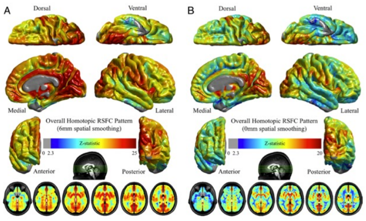


Birn 2015

Computational Methodology

• **Voxel-mirrored homotopic connectivity (VMHC)**





Gee et al., 2011 **Zuo et al., 2010**

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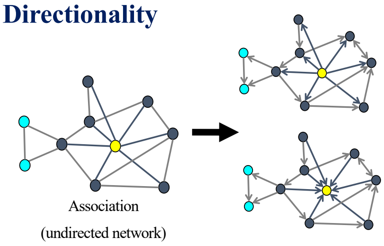
Computational Methodology

Directionality



Association
(undirected network)

Directionality
Causality
(directed network)

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Computational Methodology

Directionality

- Statistical techniques
  - Structural Equation Modeling (McIntosh and Gonzalez-Lima, 1994)
  - Dynamic Causal Modeling (Friston et al., 2003)
  - Granger Causality Analysis (GCA) (Granger, 1969; Goebel et al., 2003)
  - ....
- Lesion studies
- Brain stimulation

Craddock, , Yan et al., 2013. Nat Methods

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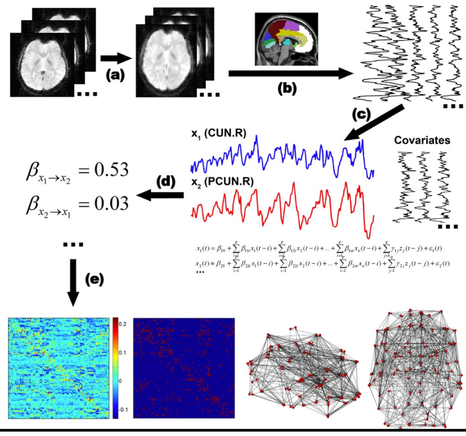

Yan et al., 2011. PLoS ONE

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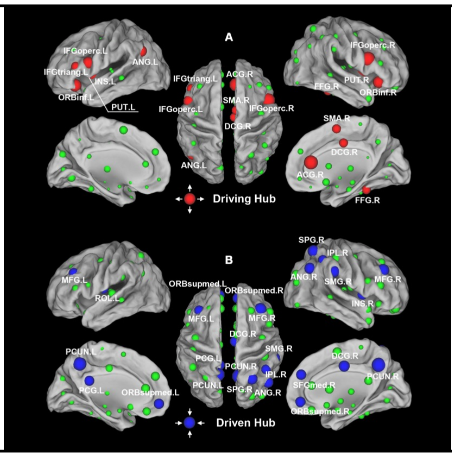

Yan et al., 2011. PLoS ONE

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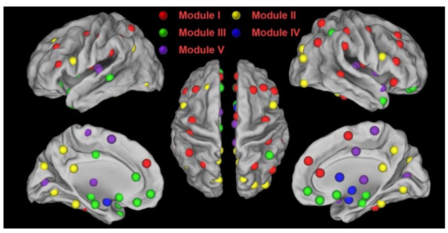
Computational Methodology



Yan et al., 2011. PLoS ONE

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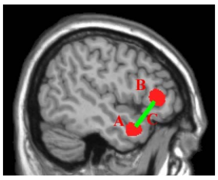
Computational Methodology

Regional approach

“Integrative” is really good, but:



Decreased

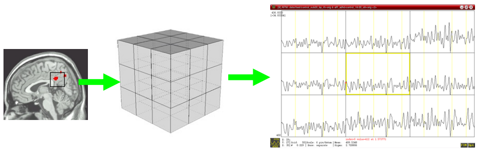
functional connectivity

Question: Is A, B, C, or……abnormal?

Computational Methodology

Regional Homogeneity (ReHo)

Similarity or coherence of the time courses within a functional cluster

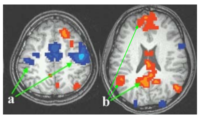


$$W = \frac{\Sigma(R_i)^2 - n(\bar{R})^2}{\frac{1}{12}K^2(n^3 - n)}$$

(Zang et al., 2004)

Computational Methodology

ReHo: motor task state vs. pure resting state



Rest > Motor

Motor > Rest

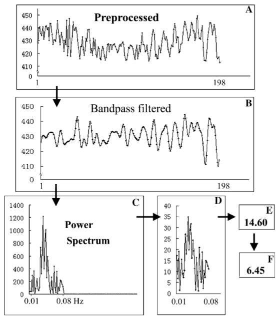
a) Higher ReHo in bilateral primary motor cortices during motor task

b) Higher ReHo in default mode network (PCC, MPFC, IPL) during rest *(Raichle et al., 2001; Greicius et al., 2003)*

(Zang et al., 2004)

Computational Methodology

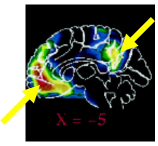
Amplitude of low frequency fluctuations



Zang et al., 2007

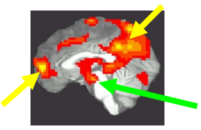
Computational Methodology

ALFF



PET

(Raichle et al., 2001)



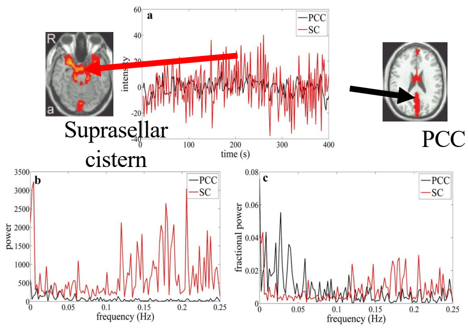
ALFF

(Zang et al., 2007)

noise

Computational Methodology

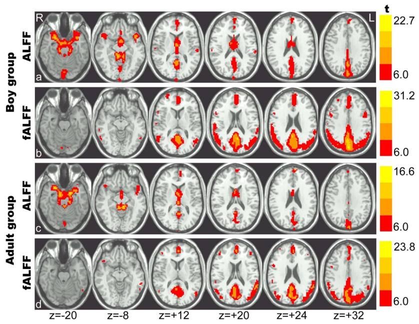
Improvement: fractional ALFF



Zou et al., 2008, J Neurosci Methods

Computational Methodology

Improvement: fractional ALFF



Zou et al., 2008. J Neurosci Methods

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Computational Methodology

Graphical approach

- Graph theoretical analysis: (Salvador et al., 2005, Bullmore and Sporns, 2009)
  - Degree connectivity, functional connectivity density, degree centrality: (Buckner et al., 2009; Tomasi et al., 2010; Cole et al., 2010; Zuo et al., 2012)
- …

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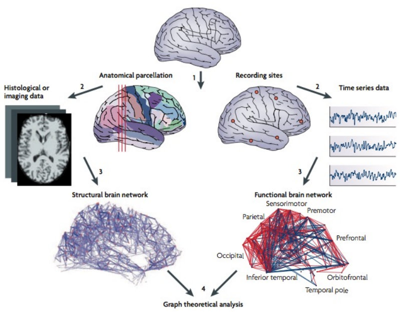
Computational Methodology

Graph theoretical analysis

Bullmore and Sporns, 2009



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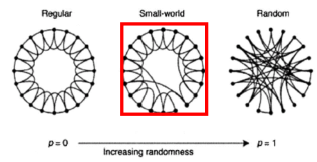
Computational Methodology

Graph theoretical analysis



Watts and Strogatz, 1998. Nature

Node: brain region
Link: connection

Regular:	Small-world:	Random:
high C_p	high C_p	low C_p
high L_p	low L_p	low L_p

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

Cp: average clustering of a network
Lp: average shortest path length of a network

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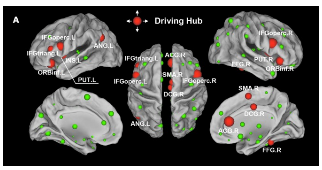
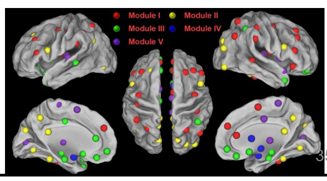
Computational Methodology

Graph theoretical analysis

Hub



Module



Yan et al., 2011. PLoS ONE

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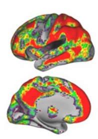
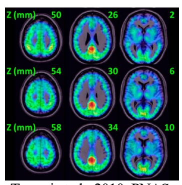
Computational Methodology

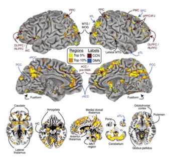
Degree centrality



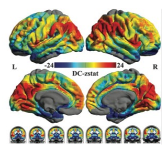
Buckner et al., 2009. J Neurosci



Tomasi et al., 2010. PNAS



Cole et al., 2010. Neuroimage



Zuo et al., 2011. Cereb Cortex

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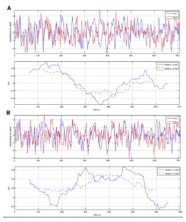
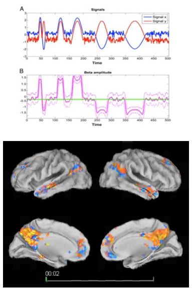
Computational Methodology

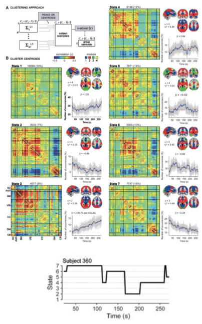
Dynamic perspective



Chang and Glover, 2010. Neuroimage



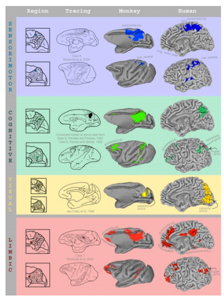
Kang, , Yan et al., 2011. Neuroimage



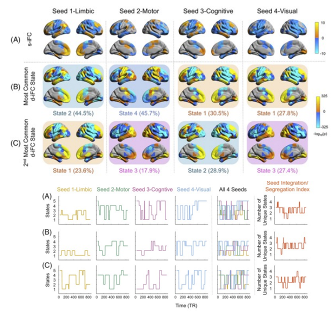
Allen et al., 2013. Cereb Cortex

Computational Methodology

Dynamic perspective



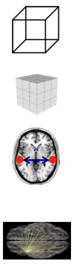
Margulies et al., 2009. PNAS



Yang, , Yan, Milham, 2014. Neuroimage

Computational Methodology

A Growing Range of R-fMRI Indices for Intrinsic Brain Function

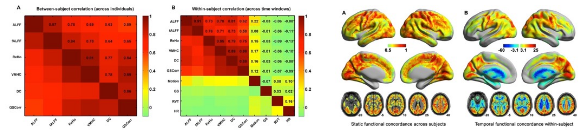


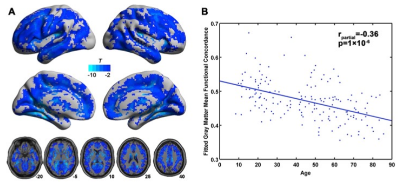
- Voxel strength: ALFF/fALFF
- Regional synchronization: ReHo
- Homotopic connectivity: VMHC
- Global connectivity: Degree Centrality

- Global Signal Correlation

Computational Methodology

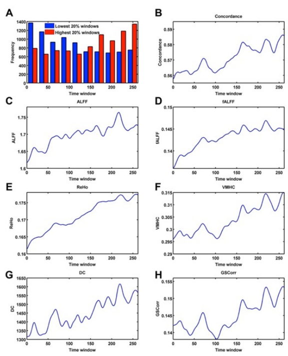
Concordance Among Indices of Intrinsic Brain Function





Yan et al., 2017. Science Bulletin

Computational Methodology



Yan et al., 2017. Science Bulletin

Outline

- Resting-State fMRI: Principles
- Data Analysis: Computational Algorithms
- Data Analysis: Methodological Issues
- Data Analysis: Computational Platform
- DPARSF Usage

Methodological Issues

- Head motion — *Yan et al., 2013a. Neuroimage; Yan et al., 2013. Front Hum Neurosci*
- Standardization — *Yan et al., 2013b. Neuroimage*
- Multiple-comparison correction — *Chen, Lu, Yan*, 2017. Human Brain Mapping*
- And many many more…

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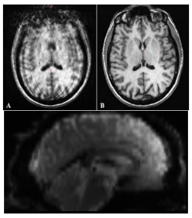
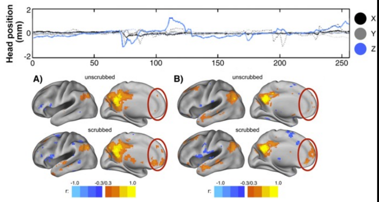
Methodological Issues: Head Motion





Power et al, 2012. Neuroimage
Van Dijk et al, 2012. Neuroimage

Head motion is a critical factor in R-fMRI data processing.

Need an effective motion correction strategy!

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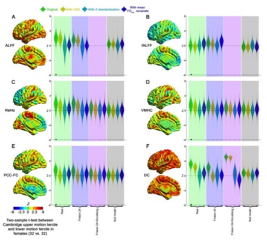
Methodological Issues: Head Motion



Yan et al., 2013a. Neuroimage

Proposed an effective head motion correction strategy

- **Individual-level correction with the Friston-24 model**
- **Group-level correction with head motion covariate**

- Cited: 1456 times
- ESI Top 0.1% highly cited paper

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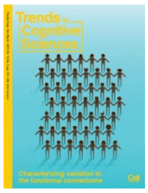
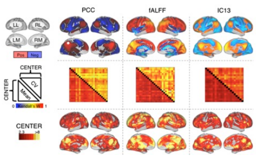
Methodological Issues: Standardization





Biswal et al., 2010, PNAS

Table 1. Factors can introduce unintended variations in fMRI measurement.

Category	Factor
1. Acquisition-related variations	Scanner make and model (Friedman and Glover, 2006b), sequence type (spiral vs. echo planar; single-echo vs. multi-echo) (Klarhofer et al., 2002), parallel vs. conventional acquisition (Feinberg et al., 2010; Lin et al., 2005), coil type (surface vs. volume, number of channels, orientation), repetition time, number of repetitions, flip angle, echo time, and acquisition volume (field of view, voxel size, slice thickness/gaps, slice prescription) (Friedman and Glover, 2006a)
2. Experimental-related variations	Participant instructions (Hartstra et al., 2011), eyes-open/eyes-closed (Yan et al., 2009; Yang et al., 2007), visual displays, experiment duration (Fang et al., 2007; Van Dijk et al., 2010)
3. Environment-related variations	Sound attenuation measures (Cho et al., 1998; Elliott et al., 1999), attempts to improve participant comfort during scans (e.g., music, videos) (Cullen et al., 2009), head-motion restraint techniques (e.g., vacuum pad, foam pad, bite-bar, plaster cast head holder) (Edward et al., 2000; Menon et al., 1997), room temperature and moisture (Vanhoutte et al., 2006).
4. Participant-related variations	Circadian cycle (Shannon et al., 2012), prandial (Haase et al., 2009), caffeine (Rack-Gomer et al., 2009), and nicotine status (Tanabe et al., 2011), sleepiness / arousal (Horovitz et al., 2008), sleep deprivation (Samann et al., 2010), scanner anxiety (de Bie et al., 2010), and menstrual cycle status (for women) (Protopopescu et al., 2005).

Yan et al., 2013b. Neuroimage

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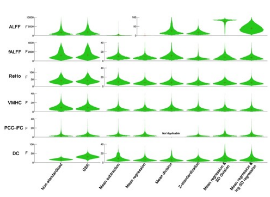
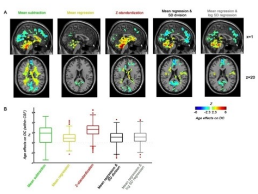
Methodological Issues: Standardization



The Impact of Standardization Procedures on Confound Variables: Site Effects



The Impact of Standardization Procedures on Variables of Interest: Age Effects

Proposed an effective standardization strategy

Mean regression + SD division

- Cited: 428 times
- ESI Top 1% highly cited paper

Yan et al., 2013b. Neuroimage

47

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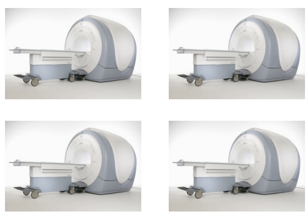
Methodological Issues

Standardization

Collaborate with Dr. Xi-Nian Zuo @ IPCAS
Dr. Jia-Hong Gao @ PKU



National Natural Science Foundation of China (81671774) (PI: Yan)
Beijing Municipal Science & Technology Commission (Z161100000216152) (PI: Gao)
National Basic Research (973) Program (2015CB351702) (Co-I: Zuo)

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Eklund et al., 2016. PNAS

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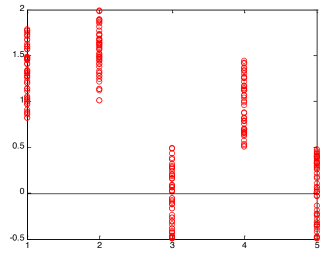

P=0.05 P=0.05 P=0.05 P=0.05 P=0.05

0.95 0.95 0.95 0.95 0.95

$0.95^5=0.774$

Probability of not getting a false positive result: 1 - 0.05 = 0.95

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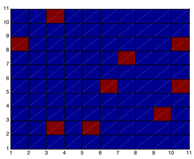
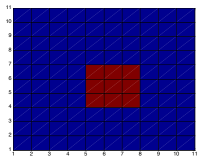
Reproducibility and Multiple Comparison Correction

Multiple Comparisons

Gaussian Random Field Theory Correction

Monte Carlo simulations (AlphaSim)





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Reproducibility and Multiple Comparison Correction

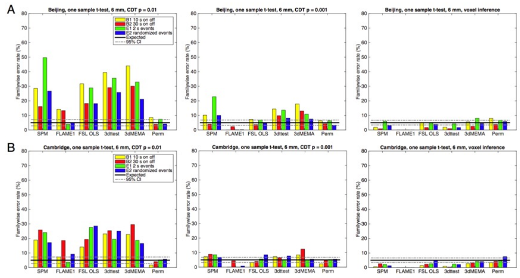

Fig. 1. Results for one-sample t test, showing estimated FWE rates for (A) Beijing and (B) Cambridge data analyzed with 6 mm of smoothing and four different activity paradigms (B1, B2, E1, and E2), for SPM, FSL, AFNI, and a permutation test. These results are for a group size of 20. The estimated FWE rates are simply the number of analyses with any significant group activation divided by the number of analyses (1,000). From Left to Right: Cluster inference using a cluster-defining threshold (CDT) of P = 0.01 and a FWE-corrected threshold of P = 0.05, cluster inference using a CDT of P = 0.001 and a FWE-corrected threshold of P = 0.05, and voxel inference using a FWE-corrected threshold of P = 0.05. Note that the default CDT is P = 0.001 in SPM and P = 0.01 in FSL (AFNI does not have a default setting).

Eklund et al., 2016. PNAS

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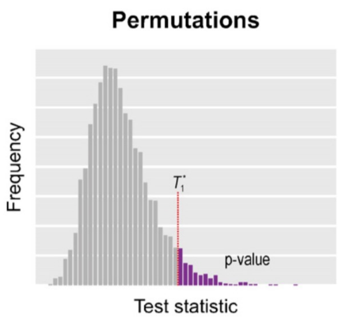
Reproducibility and Multiple Comparison Correction

Permutation Test



Winkler et al., 2016. Neuroimage

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Reproducibility and Multiple Comparison Correction

Threshold-Free Cluster Enhancement (TFCE)

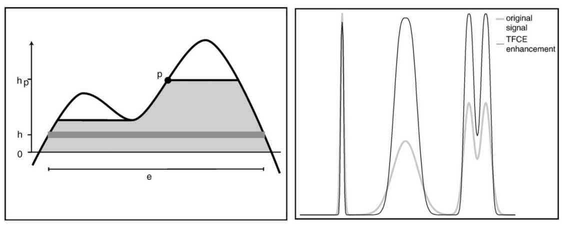

Fig. 1. Illustration of the TFCE approach. Left: the TFCE score at voxel p is given by the sum of the scores of all incremental supporting sections (one such is shown as the dark-grey band) within the area of "support" of p (light grey). The score for each section is a simple function of its height h and extent e. Right: example input image and TFCE-enhanced output. The input contains a focal, high signal, a much more spatially extended, lower, signal and a pair of overlapping signals of intermediate extent and height. The TFCE output has the same maximal values for all three cases, and preserves the distinct local maxima in the third case.

Smith et al., 2009. Neuroimage

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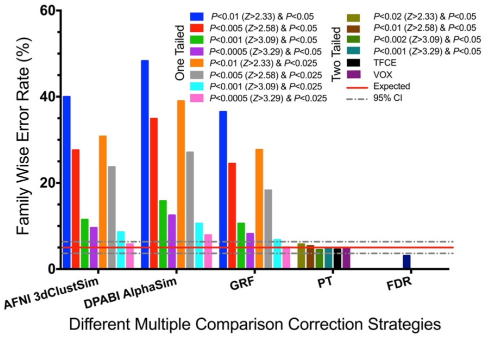
Family wise Error Rate



20 vs. 20 Permutation 1000 times

Chen, Lu, Yan*, 2018. Human Brain Mapping

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Family wise Error Rate

TABLE I. FWER and cluster size of ALFF (smoothness: 7.94 × 7.31 × 6.86) without GSR under corrections of GRF Theory, AFNI 3dClustSim, and DPABI AlphaSim

(One-tailed twice)		AFNI 3dClustSim		DPABI AlphaSim		GRF	
Voxel threshold	Cluster threshold	FWER	Cluster size	FWER	Cluster size	FWER	Cluster size
$P < 0.01$ ($Z > 2.33$)	$P < 0.05$	40.0%	66.05 ± 0.73	48.3%	60.24 ± 1.68	36.5%	69.35 ± 1.09
$P < 0.005$ ($Z > 2.58$)	$P < 0.05$	27.6%	43.59 ± 0.42	34.9%	39.45 ± 1.13	24.5%	46.70 ± 0.75
$P < 0.001$ ($Z > 3.09$)	$P < 0.05$	11.5%	19.98 ± 0.34	15.8%	18.40 ± 0.61	10.6%	21.29 ± 0.46
$P < 0.0005$ ($Z > 3.29$)	$P < 0.05$	9.6%	14.53 ± 0.25	12.5%	13.93 ± 0.54	8.2%	15.82 ± 0.39
$P < 0.01$ ($Z > 2.33$)	$P < 0.025$	30.8%	74.50 ± 1.14	39.0%	67.72 ± 2.36	27.7%	78.96 ± 1.24
$P < 0.005$ ($Z > 2.58$)	$P < 0.025$	23.7%	47.01 ± 0.59	27.1%	44.48 ± 1.60	18.3%	53.48 ± 0.85
$P < 0.001$ ($Z > 3.09$)	$P < 0.025$	8.6%	22.63 ± 0.25	10.6%	21.00 ± 0.87	6.8%	24.94 ± 0.41
$P < 0.0005$ ($Z > 3.29$)	$P < 0.025$	5.8%	17.33 ± 0.22	7.9%	16.03 ± 0.71	5.1%	18.51 ± 0.50

20 vs. 20 Permutation 1000 times

Chen, Lu, Yan*, 2018. Human Brain Mapping

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Family wise Error Rate

TABLE II. FWER under correction of three kinds of cluster-based correction with the strictest threshold, 6 versions of PT-based correction as well as FDR correction

	Voxel threshold	Cluster threshold	FWER: ALFF	fALFF	ReHo	DC	VMHC	ALFF with GSR	fALFF with GSR	ReHo with GSR	DC with GSR	VMHC with GSR	ALFF (8 mm smoothed)
Smoothness (mm, x×y×z)			7.94 × 7.31 × 6.86	7.34 × 7.42 × 7.20	9.36 × 8.72 × 8.39	7.86 × 7.97 × 7.81	6.31 × 6.87 × 6.61	7.99 × 7.31 × 6.84	7.32 × 7.41 × 7.19	9.24 × 8.56 × 8.18	8.06 × 8.16 × 8.09	6.11 × 6.61 × 6.37	11.88 × 11.53 × 11.68
AFNI 3dClustSim (one-tailed)	$P < 0.0005$ ($Z > 3.29$)	$P < 0.025$	5.8%	6.1%	7.3%	8.5%	6.0%	5.3%	6.6%	6.9%	6.8%	6.4%	5.5%
DPABI AlphaSim (one-tailed)			7.9%	8.3%	8.5%	10.2%	9.0%	7.8%	7.7%	7.8%	8.3%	9.6%	6.9%
GRF (one-tailed)			5.1%	5.5%	4.9%	7.4%	5.2%	4.8%	5.9%	5.3%	5.1%	6.4%	4.4%
PT cluster extent correction (two-tailed)	$P < 0.02$ ($Z > 2.33$)	$P < 0.05$	5.8%	3.6%	5.8%	4.6%	5.2%	4.8%	3.9%	5.5%	5.2%	4.3%	5.3%
	$P < 0.01$ ($Z > 2.58$)	$P < 0.05$	5.4%	4.0%	5.7%	4.6%	5.5%	5.3%	3.8%	5.3%	5.0%	4.5%	5.4%
	$P < 0.002$ ($Z > 3.09$)	$P < 0.05$	4.5%	4.1%	5.3%	4.8%	4.2%	4.5%	5.0%	5.1%	4.7%	4.3%	4.4%
	$P < 0.001$ ($Z > 3.29$)	$P < 0.05$	4.8%	4.5%	4.5%	4.9%	3.4%	4.3%	4.8%	5.4%	4.2%	3.9%	4.1%
PT TFCE			4.6%	3.9%	5.7%	5.0%	4.3%	5.3%	4.2%	5.5%	4.7%	4.8%	4.6%
PT VOX			4.9%	4.9%	5.7%	3.9%	4.7%	6.0%	4.5%	5.6%	4.0%	4.6%	3.9%
FDR correction			3.1%	3.4%	4.4%	2.4%	3.9%	4.1%	2.8%	3.6%	2.4%	3.5%	1.6%

The smoothness in the second row is the estimated effective smoothness of the final metric maps feed to statistical analysis, and was different form the applied smoothness (4 mm FWHM) in pre-processing. The effective smoothness was used in 3 versions of cluster-based correction (i.e., GRF theory correction, AFNI 3dClustSim and DPABI AlphaSim)

20 vs. 20 Permutation 1000 times

Chen, Lu, Yan*, 2018. Human Brain Mapping

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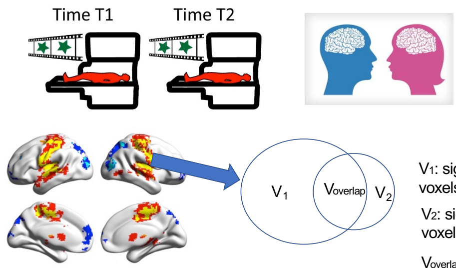
Test-retest Reliability

Test-retest reliability

Sex differences in test and retest



V_1: significant voxels in test

V_2: significant voxels in retest

$V_{overlap}$: voxels significant in both test and retest

Statistical significant voxels

$$Dice = \frac{2 \times V_{overlap}}{V_1 + V_2}$$

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Test-retest Reliability

TABLE III. Test–retest reliability of sex differences for all R-fMRI metrics with and without GSR under correction of three kinds of cluster-based correction with the strictest threshold, six kinds of PT-based correction and FDR correction, calculated between the first and second sessions in the CORR dataset

	Voxel threshold	Cluster threshold	Test–retest reliability (dice coefficient): ALFF	fALFF	ReHo	DC	VMHC	ALFF with GSR	fALFF with GSR	ReHo with GSR	DC with GSR	VMHC with GSR
AFNI 3dClustSim (one-tailed)	$P < 0.0005$ ($Z > 3.29$)	$P < 0.025$	0.65	0.51	0.50	0.34	0.39	0.64	0.48	0.44	0.28	0.24
DPABI AlphaSim (one-tailed)			0.65	0.51	0.49	0.34	0.39	0.64	0.48	0.45	0.27	0.27
GRF (one-tailed)			0.64	0.51	0.50	0.35	0.39	0.65	0.48	0.43	0.28	0.24
PT cluster extent correction (two-tailed)	$P < 0.02$ ($Z > 2.33$)	$P < 0.05$	0.65	0.70	0.56	0.45	0.40	0.62	0.68	0.45	0.30	0.40
	$P < 0.01$ ($Z > 2.58$)	$P < 0.05$	0.67	0.66	0.52	0.32	0.33	0.60	0.63	0.46	0.27	0.32
	$P < 0.002$ ($Z > 3.09$)	$P < 0.05$	0.63	0.55	0.51	0.36	0.38	0.63	0.52	0.47	0.23	0.32
	$P < 0.001$ ($Z > 3.29$)	$P < 0.05$	0.64	0.51	0.48	0.37	0.38	0.64	0.48	0.44	0.28	0.26
PT TFCE			0.68	0.75	0.54	0.48	0.44	0.66	0.74	0.44	0.31	0.42
~~PT VOX~~			~~0.66~~	~~0.34~~	~~0.48~~	~~0.37~~	~~0.22~~	~~0.65~~	~~0.31~~	~~0.38~~	~~0.11~~	~~0.14~~
FDR correction			0.64	0.67	0.54	0.39	0.37	0.63	0.64	0.47	0.23	0.29

For test–retest reliability for all the 31 kinds of multiple comparison correction strategies, please see Supporting Information Table S13

- Moderate test-retest reliability
- ALFF, fALFF, ReHo are better than DC and VMHC

212 M vs. 208 F × 2 times

Chen, Lu, Yan*, 2018. Human Brain Mapping

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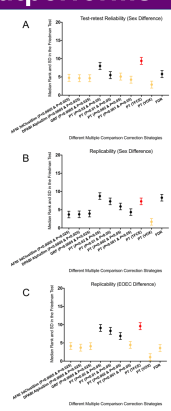
PT with TFCE outperforms

Permutation test TFCE, a strict multiple comparison correction strategy, reached the best balance between family-wise error rate (under 5%) and test-retest reliability / replicability



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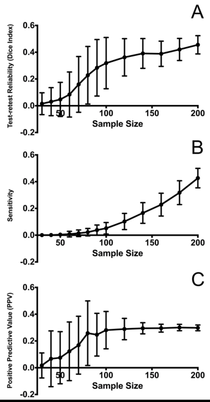
Sample Size Matters

Randomly draw k subjects from the "SWU 4" site in the CORR dataset, which has two sessions of 116 males and 105 females



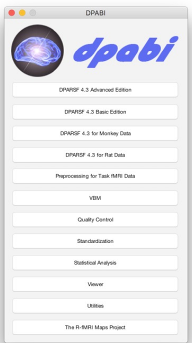
Chen, Lu, Yan*, 2018. Human Brain Mapping

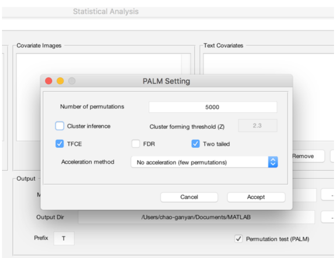
Reproducibility of R-fMRI Metrics on the Impact of Different Strategies for Multiple Comparison Correction and Sample Sizes

- Permutation test with TFCE reached the best balance between FWER and reproducibility
- Although R-fMRI indices attained moderate reliabilities, they replicated poorly in distinct datasets (replicability < 0.3 for between-subject sex differences, < 0.5 for within-subject EOEC differences)
- For studies examining effect sizes similar to or even less than those of sex differences, results from a sample size <80 (40 per group) should be considered preliminary, given their low reliability (< 0.23), sensitivity (< 0.02) and PPV (< 0.26).
  - Cited 96 times
  - ESI Top 1% highly cited

Chen, Lu, Yan*, 2018. Human Brain Mapping

Permutation Test with TFCE



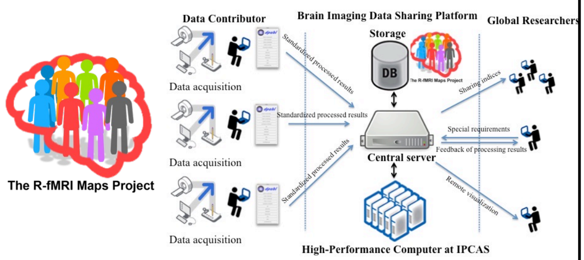


Integrated from PALM
(Winkler et al. 2016. Neuroimage)

Yan* et al., 2016. Neuroinformatics

ESI Top 0.1% highly cited (>3007 times)

The R-fMRI Maps Project



Part of the Human Brain Data Sharing Initiative (HBDSI), IPCAS

The R-fMRI Maps Project

Shared data of 4770 subjects:

1. Amplitude of low frequency fluctuations (ALFF)
2. Fractional ALFF (fALFF)
3. Regional Homogeneity (ReHo)
4. Voxel-mirrored homotopic connectivity (VMHC)
5. Degree Centrality (DC)
6. Functional Connectivity Matrices
   a. Automated Anatomical Labeling (AAL) atlas
   b. Harvard-Oxford atlas
   c. Craddock's clustering 200 ROIs
   d. Zalesky's random parcelations
   e. Dosenbach's 160 functional ROIs

In addition, gray matter, white matter and CSF density and volume files were shared

Downloaded by 593 researchers

Outline

- Resting-State fMRI: Principles
- Data Analysis: Computational Algorithms
- Data Analysis: Methodological Issues
- **Data Analysis: Computational Platform**
- DPARSF Usage

静息态功能磁共振数据处理平台

frontiers in SYSTEMS NEUROSCIENCE — METHODS ARTICLE

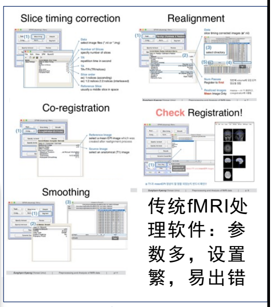
DPARSF: a MATLAB toolbox for "pipeline" data analysis of resting-state fMRI

Yan and Zang, 2010. Front Syst Neurosci.

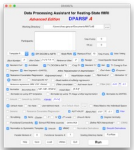
共同通讯作者；持续更新至今

Cited: >2000 times

DPARSF：流水线式fMRI数据处理软件



传统fMRI处理软件：参数多，设置繁，易出错



时间层矫正 → 头动矫正 → 生理噪声回归 → 配准 → 平滑 → 滤波 → 结果

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同行评价及影响

BRAIN CONNECTIVITY
Volume 6, Number 9, 2016
© Mary Ann Liebert, Inc.
DOI: 10.1089/brain.2016.0446

COMMUNICATION

Reporting of Resting-State Functional Magnetic Resonance Imaging Preprocessing Methodologies

Syed Hamza Waheed, Saeedeh Mirbagheri, Shruti Agarwal, Arash Kamali, Noushin Yahyavi-Firouz-Abadi, Ammar Chaudhry, Michael DiGianvittorio, Sachin K. Gujar, Jay J. Pillai, and Haris I. Sair

Twelve different software packages were used in the 100 studies. Many articles utilized the use of multiple software for analysis. The most commonly used software was SPM (56%) followed by DPARSF (29%) and FSL (25%). Other less commonly used software included AFNI and various MATLAB toolboxes, such as the GIFT toolbox and the Conn toolbox.

12种不同的软件…使用得最多的软件是SPM（56%），然后是DPARSF（29%）和FSL（25%）…

Haris I. Sair
约翰·霍普金斯大学教授

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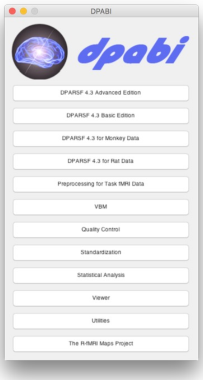
高效脑成像数据处理与共享平台

- 整合DPARSF
  此前工作，被引3590次
- 整合方法学改进
  头动（被引1456次）
  标准化（被引428次）
  多重比较校正（被引302次）
- 处理流程规范化
- 统计分析
- 大数据共享平台

Yan* et al., 2016. Neuroinformatics



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同行评价及影响

序号	WOS号	论文题目
10	WOS:000377813900008	Yan Chaogan* 等. DPABI: Data processing & analysis for (resting-state) brain imaging. Neuroinformatics, 2016, 14(3), 339-351.

2015-2019年中国医学领域论文第十名

软件使用者包括：

Seiji Ogawa
功能磁共振发明人

Bharat Biswal
静息态功能磁共振创始人

来自58个国家/地区的研究者使用DPARSF/DPABI合计发表6000余篇论文

70

70

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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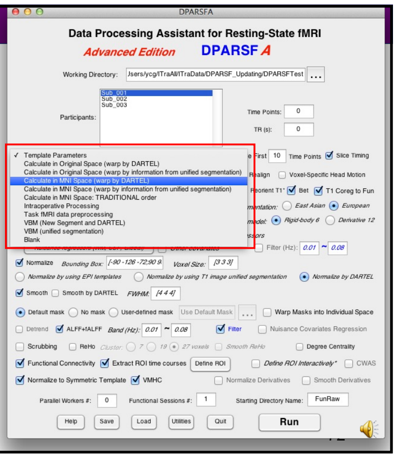
Resting State fMRI Data Processing

Template Parameters



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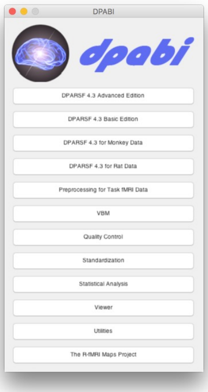
DPABI

Yan et al., 2016. Neuroinformatics

ESI Top 1% Highly Cited Paper



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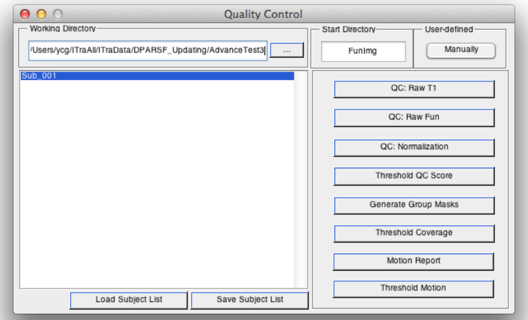
Quality Control



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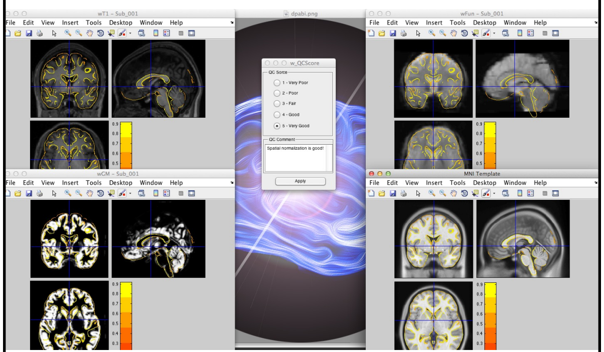
Quality Control



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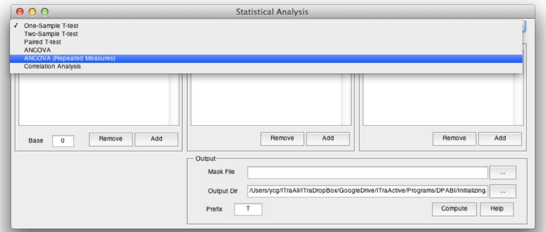
Statistical Analysis



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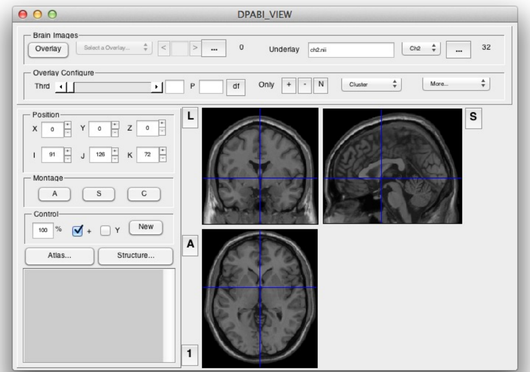
DPABI Viewer



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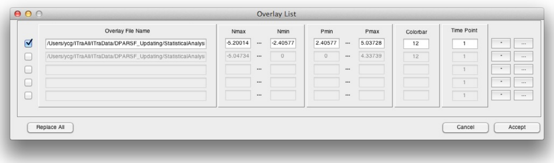
DPABI Viewer



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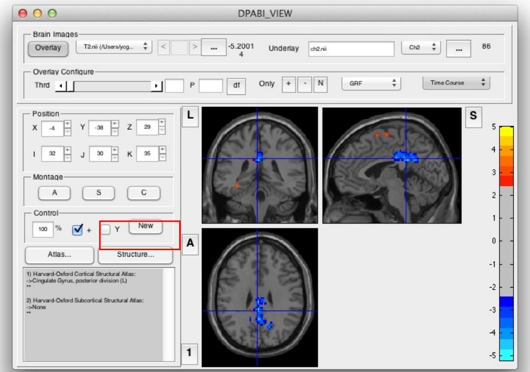
DPABI Viewer



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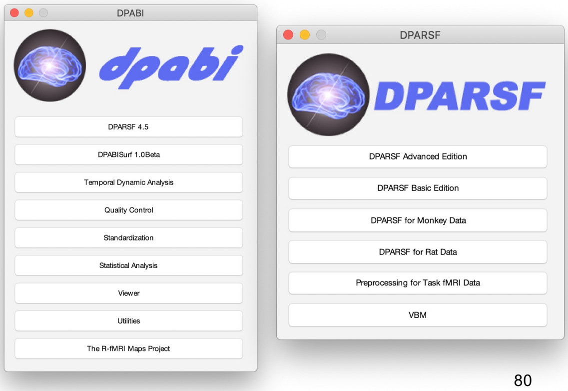
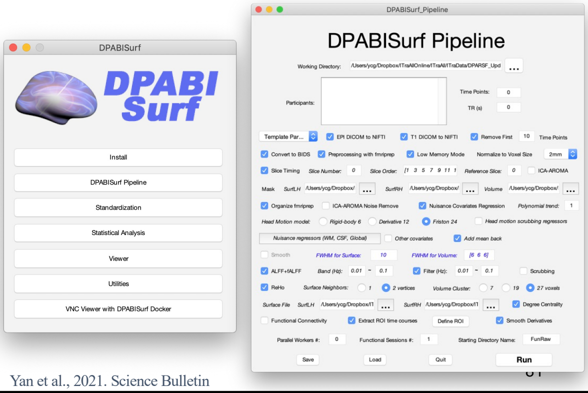
DPABISurf



80

80

DPABISurf



Yan et al., 2021. Science Bulletin

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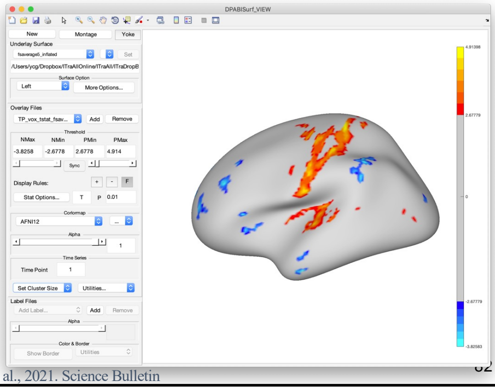
DPABISurf



Yan et al., 2021. Science Bulletin

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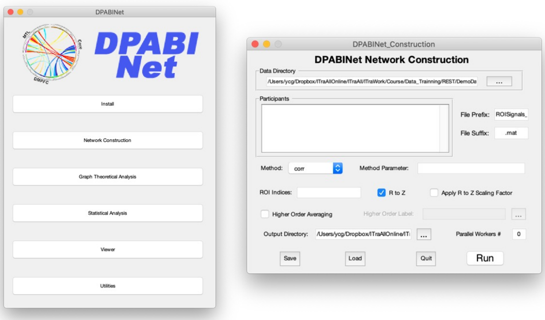
DPABINet



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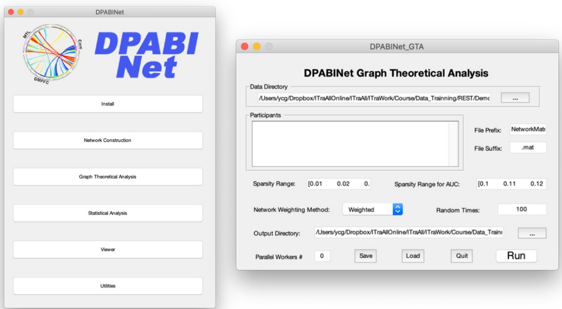
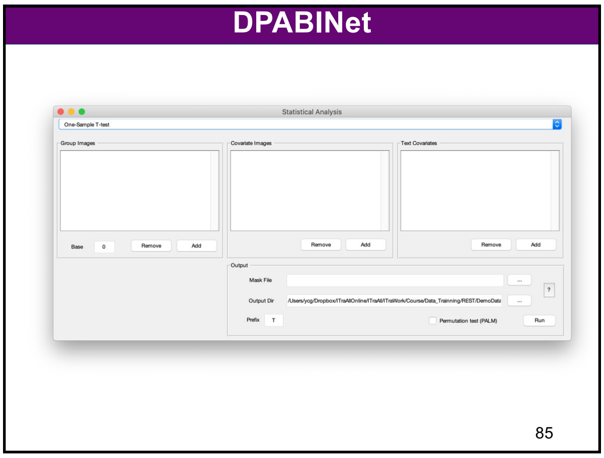
DPABINet

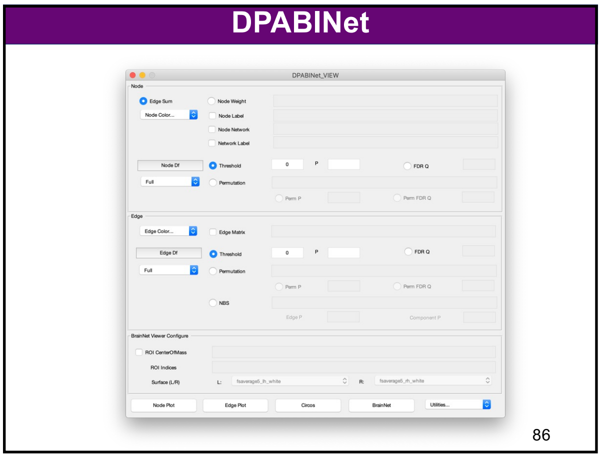


84

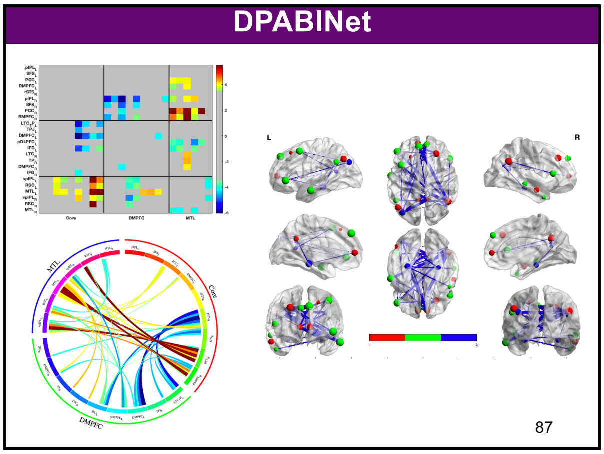
84



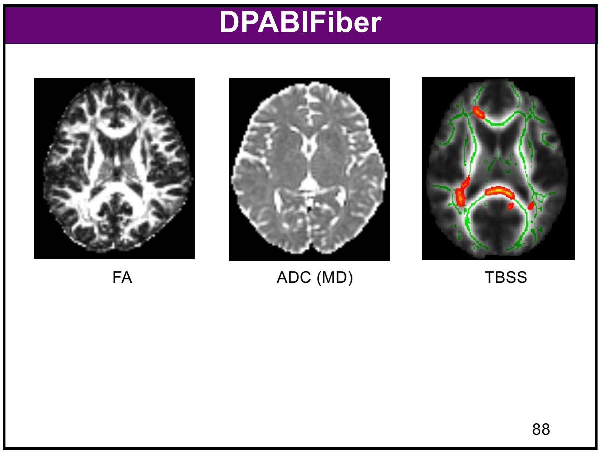
85



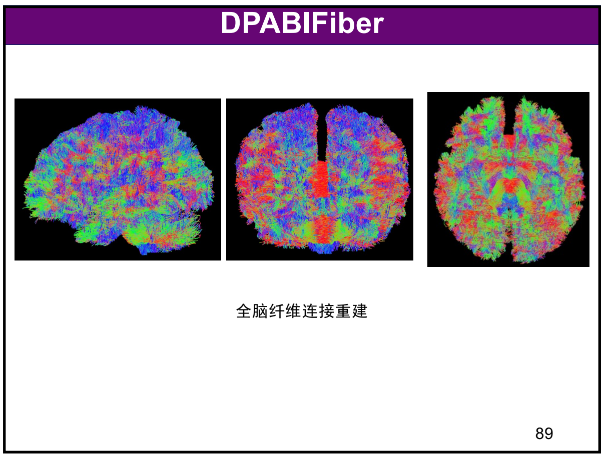
86



87



88



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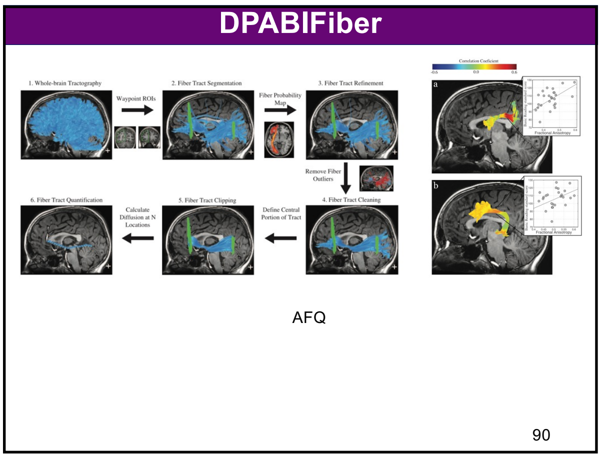

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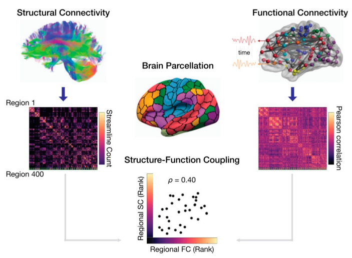
DPABIFiber

结构连接网络分析

结构/功能耦合分析



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Outline

- Resting-State fMRI: Principles
- Data Analysis: Computational Algorithms
- Data Analysis: Methodological Issues
- Data Analysis: Computational Platform
- DPARSF Usage

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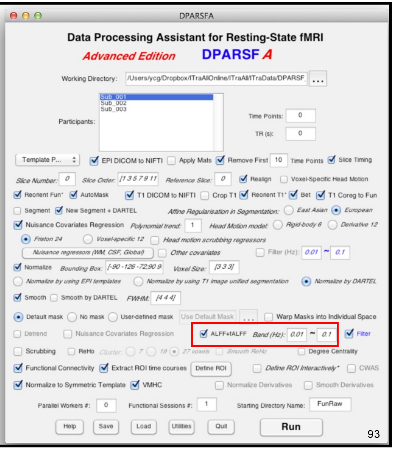
R-fMRI measures Calculation

ALFF and fALFF calculation (Zang et al., 2007; Zou et al., 2008)



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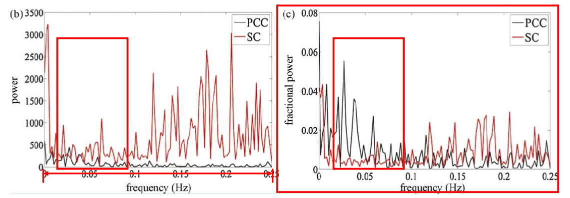
ALFF/fALFF



PCC: posterior cingulate cortex

SC: suprasellar cistern

Zang et al., 2007; Zou et al., 2008

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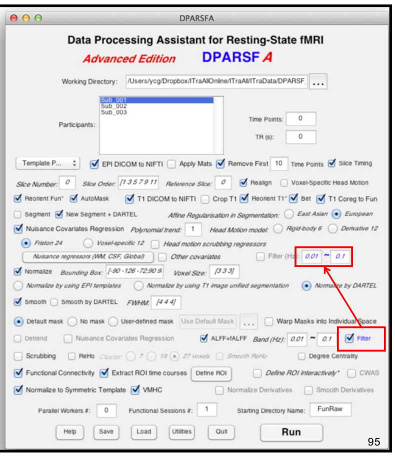
R-fMRI measures Calculation

Filtering

Use the parameters set in the blue edit boxes.



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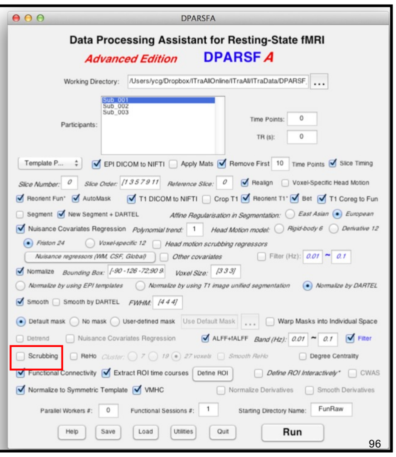
R-fMRI measures Calculation

Scrubbing



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The “bad” time points defined by FD_Power (Power et al., 2012) will be interpolated or deleted as the specified method.

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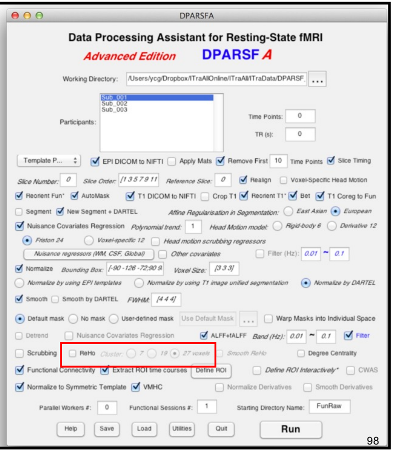
Preprocessing and R-fMRI measures Calculation

Regional Homogeneity (ReHo) Calculation (Zang et al., 2004)



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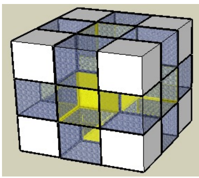
ReHo (Regional Homogeneity)



$$W = \frac{\Sigma(R_i)^2 - n(\overline{R})^2}{\frac{1}{12}K^2(n^3 - n)}$$

Zang et al., 2004

Zang YF, Jiang TZ, Lu YL, He Y, Tian LX (2004) Regional homogeneity approach to fMRI data analysis. Neuroimage 22: 394–400.

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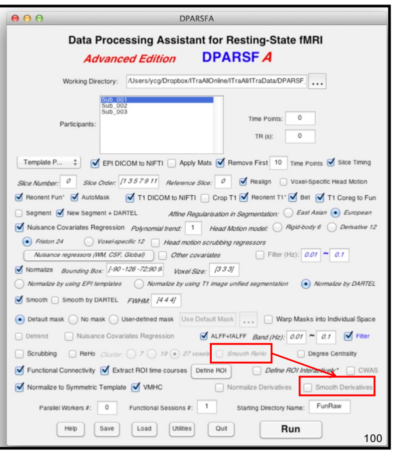
R-fMRI measures Calculation

Regional Homogeneity (ReHo) Calculation (Zang et al., 2004)



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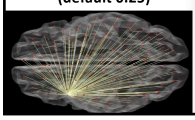
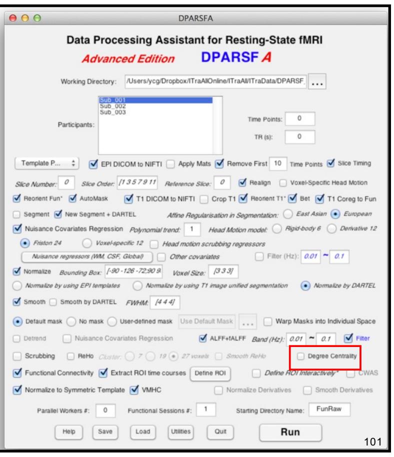
100

R-fMRI measures Calculation

Degree Centrality Calculation (Buckner et al., 2009; Zuo et al, 2012)

> r Threshold (default 0.25)





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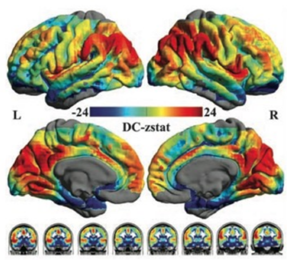
101



Zuo et al., 2012

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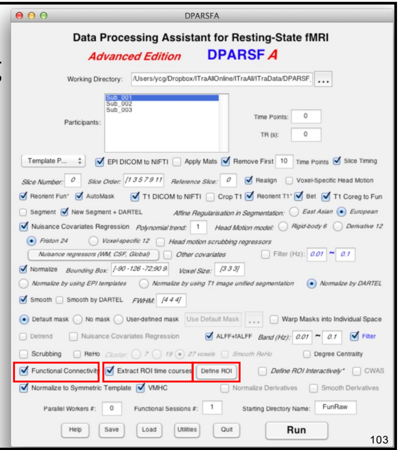
Preprocessing and R-fMRI measures Calculation

Functional Connectivity (voxel-wise seed based correlation analysis)

Extract ROI time courses (also for ROI-wise Functional Connectivity)

Define ROI



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Define ROI

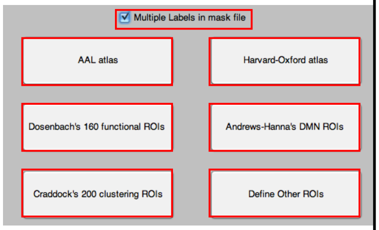
Multiple labels in mask file: each label is considered as one ROI

Dosenbach et al., 2010

Andrews-Hanna et al., 2010

Craddock et al., 2011

Define other ROIs



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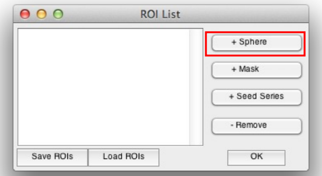
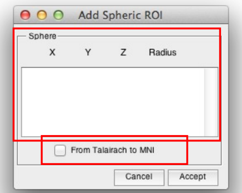
Define ROI



105

105

Define ROI



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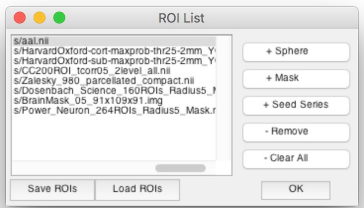
Define ROI



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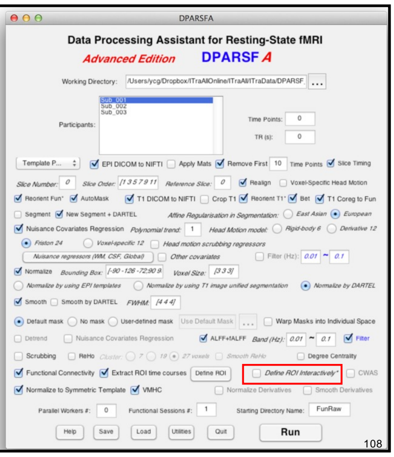
R-fMRI measures Calculation

Define ROI Interactively



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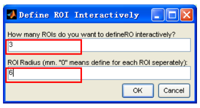
Define ROI



0 means define ROI Radius for each ROI seperately

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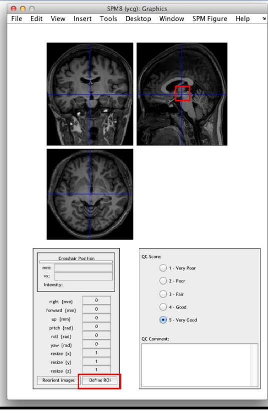
Define ROI



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Functional Connectivity

You will get the Voxel-wise functional connectivity results of each ROI in {working directory}\Results\FC:

zROI1FCMap_Sub_001.img

zROI2FCMap_Sub_001.img

For ROI-wise results, please see {working directory}\Results\FunImgARCW*_ROISignals.

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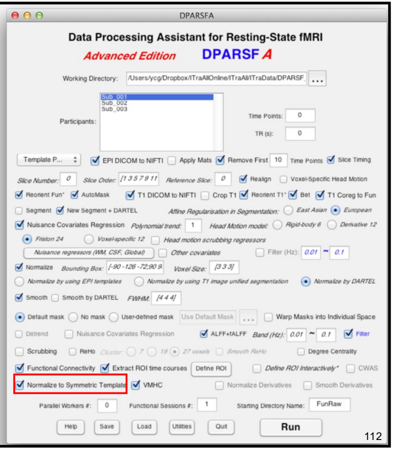
R-fMRI measures Calculation

Voxel-mirrored homotopic connectivity (VMHC) (Zuo et al., 2010)

Prepare for VMHC: Further register to a symmetric template



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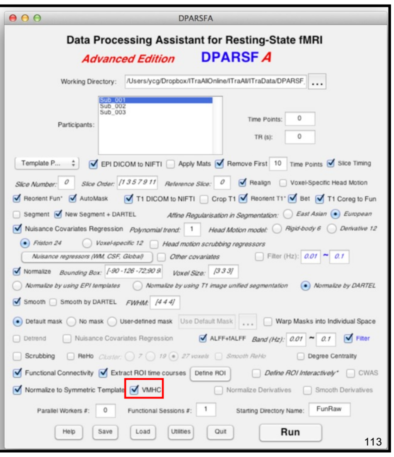
R-fMRI measures Calculation

Voxel-mirrored homotopic connectivity (VMHC) (Zuo et al., 2010)



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VMHC

1) Get the T1 images in MNI space (e.g., wco*.img or wco*.nii under T1ImgNewSegment or T1ImgSegment) for each subject, and then create a mean T1 image template (averaged across all the subjects).

2) Create a symmetric T1 template by averaging the mean T1 template (created in Step 1) with it's flipped version (flipped over x axis).

3) Normalize the T1 image in MNI space (e.g., wco*.img or wco*.nii under T1ImgNewSegment or T1ImgSegment) for each subject to the symmetric T1 template (created in Step 2), and apply the transformations to the functional data (which have been normalized to MNI space beforehand). Please see a reference from Zuo et al., 2010.

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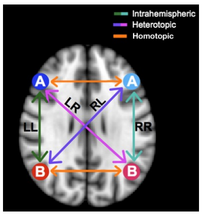
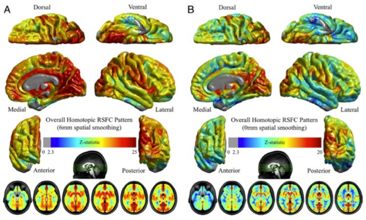


Gee et al., 2011



Zuo et al., 2010

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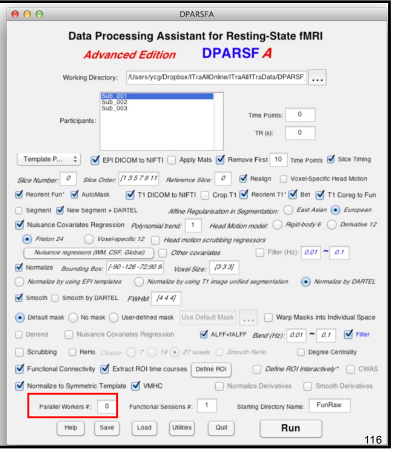
R-fMRI measures Calculation

Parallel Workers (if parallel computing toolbox is installed)

Each subject is distributed into a different worker. (Except DARTEL-Create Template)



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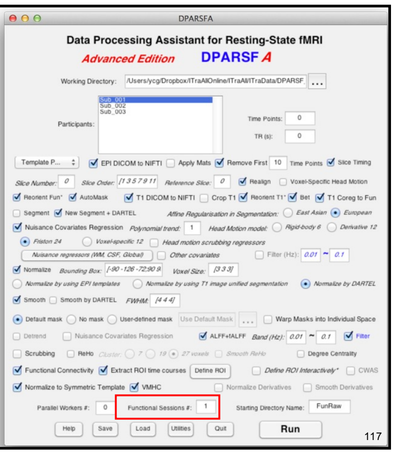
R-fMRI measures Calculation

Multiple functional sessions

1st session: FunRaw
2nd session: S2_FunRaw
3rd session: S3_FunRaw
…



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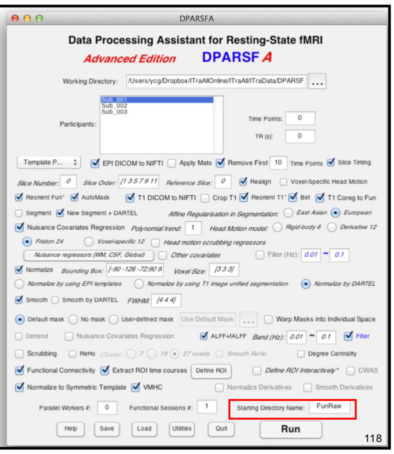
Starting Directory Name

If you do not start with raw DICOM images, you need to specify the **Starting Directory Name.**

E.g. "**FunImgARW**" means you start with images which have been slice timed, realigned and normalized.

Abbreviations:
A - Slice Timing
R - Realign
W - Normalize
S - Smooth
D - Detrend
F - Filter
C - Covariates Removed
B - ScruBBing



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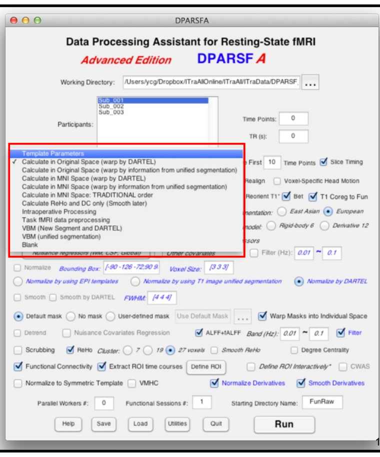
Resting State fMRI Data Processing

Template Parameters



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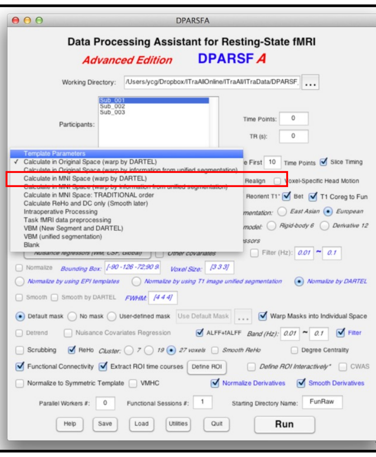
Resting State fMRI Data Processing

Calculate in MNI space

Calculate in Original space



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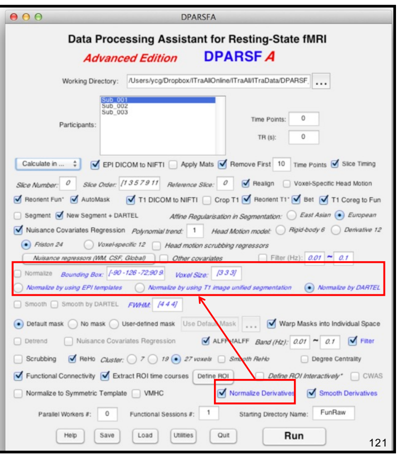
Preprocessing and R-fMRI measures Calculation

Normalize measures (derivatives) calculated in original space into MNI space

Use the parameters set in the upper section.



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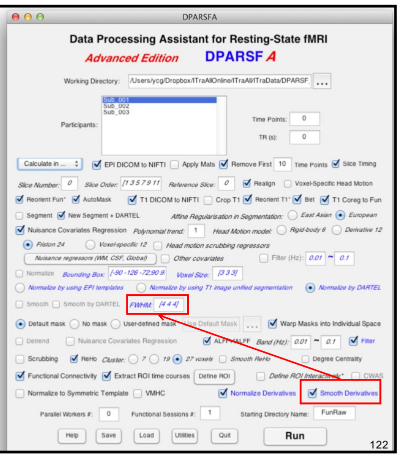
Preprocessing and R-fMRI measures Calculation

Smooth R-fMRI measures (derivatives)

Use the parameters set in the upper section.



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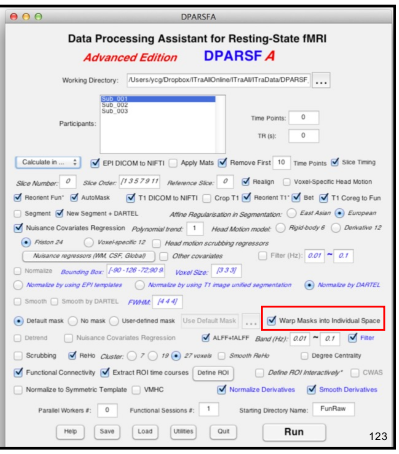
Preprocessing and R-fMRI measures Calculation

Warp masks into original space



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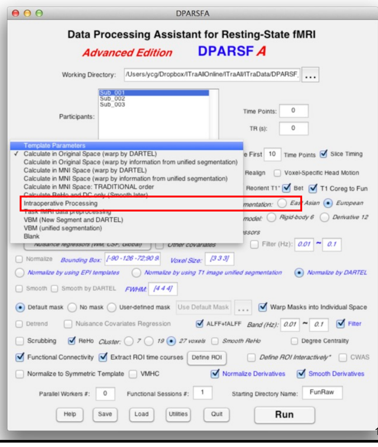
Resting State fMRI Data Processing

Intraoperative Processing



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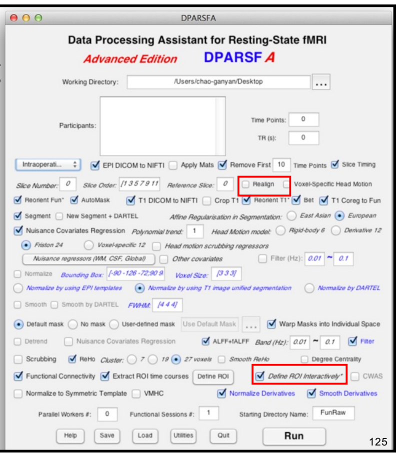
Preprocessing and R-fMRI measures Calculation

No realign since there is no head motion. DPARSFA will generate the mean functional images automatically.

Define ROI Interactively



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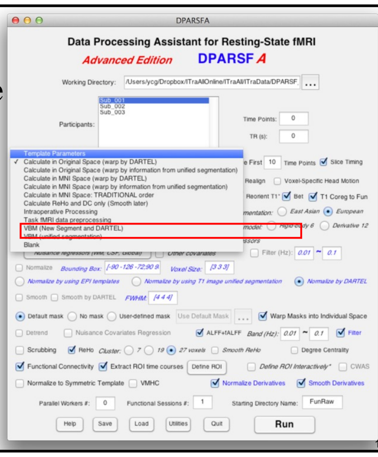
Resting State fMRI Data Processing

VBM



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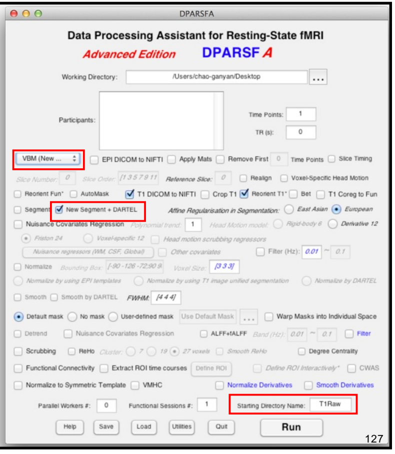
VBM

Only New Segment + DARTEL is checked

Define the Starting Directory Name as T1Raw



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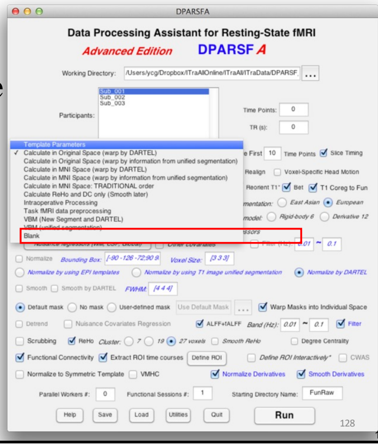
127

Resting State fMRI Data Processing

Blank



128

128

Blank

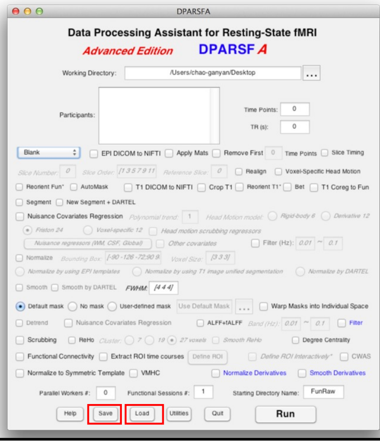
129

129

Save and Load Parameters

Save parameters to *.mat

Load parameters from *.mat



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Thanks for your attention!

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