Resting-State fMRI: Current Research, Methodological Issues and Its Applications

严超赣

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Outline

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

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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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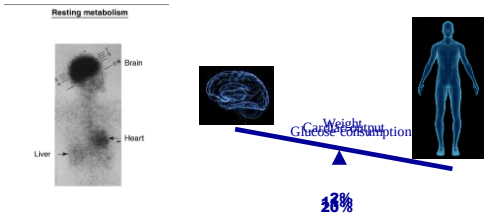
Resting-State fMRI: Principles



Raichle et al., 2010. Trends Cogn Sci

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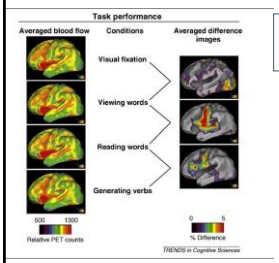
Resting-State fMRI: Principles



Task evoked increases

<5%

Resting-state energy consumption

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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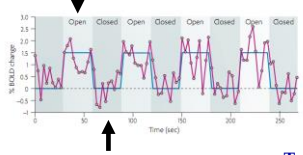
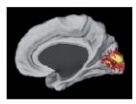
Resting-State fMRI: Principles

Task



Baseline



• Traditional fMRI analysis

Noise?

Activities in the baseline state (usually resting-state)

Fox and Raichle, 2007. Nat Rev Neurosci

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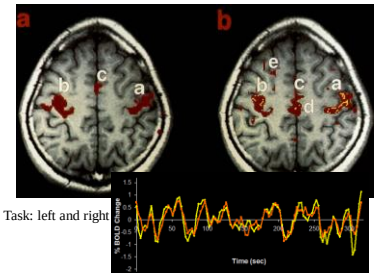
Resting-State fMRI: Principles

- **Temporal synchrony of spontaneous fluctuations**



Task: left and right

Biswal et al., 1995. Magn Reson M.. I

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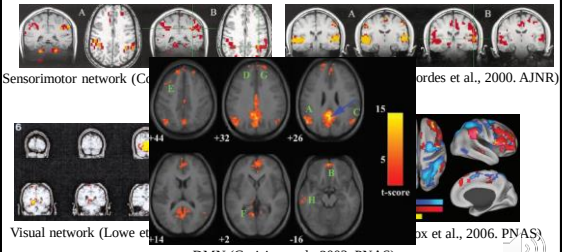
Resting-State fMRI: Principles

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



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

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

DMN (Greicius et al., 2003. PNAS)

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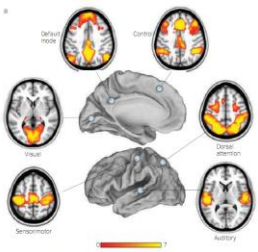
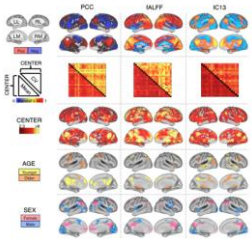
Resting-State fMRI: Principles



Zhang and Raichle, 2010. Nat Rev Neurol



Biswal et al., 2010. PNAS

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Resting-State fMRI: Principles

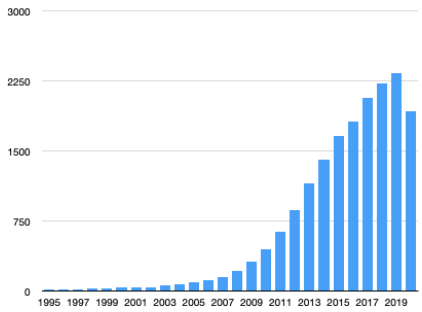

Figure 1. Number of R-fMRI related studies in PubMed (key words: "resting+state+fmri").

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Outline

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

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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)
- ....

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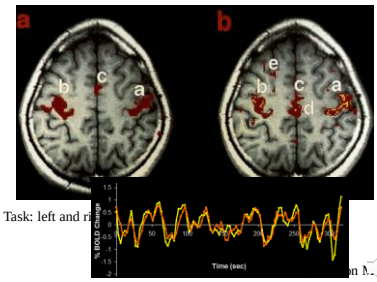
Computational Methodology

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



Task: left and ri

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Computational Methodology

The "Resting" Brain

Courtesy of Dr. Daniel Margulies

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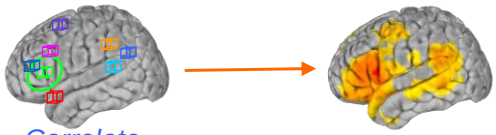
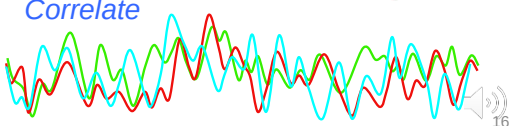
Computational Methodology

How do we detect organized patterns of intrinsic activity?

Resting State Functional Connectivity



Correlate



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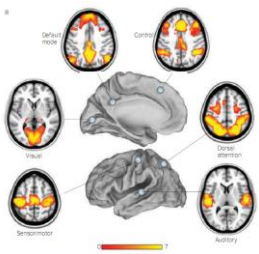
Computational Methodology

- **Correlation**



Zhang and Raichle, 2010. Nat Rev Neurol

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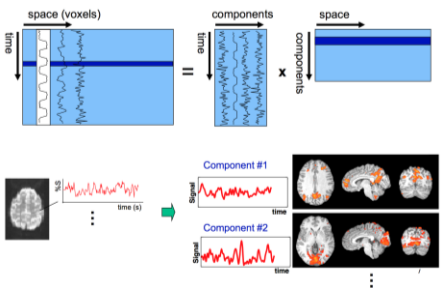
Computational Methodology

- **Independent Component Analysis**



Birn 2015

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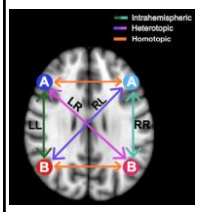
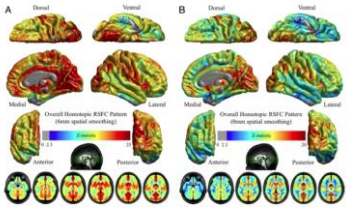
Computational Methodology

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





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

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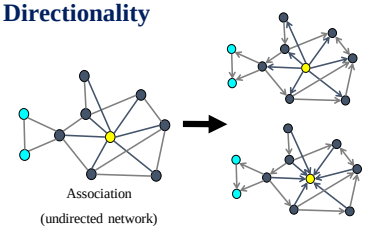
Computational Methodology

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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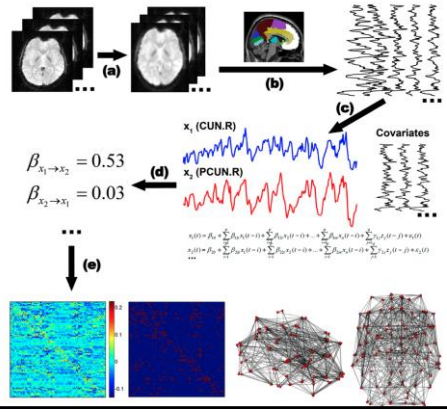

Yan et al., 2011. PLoS ONE

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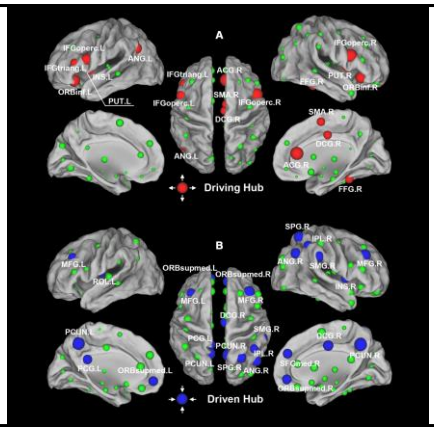

Yan et al., 2011. PLoS ONE

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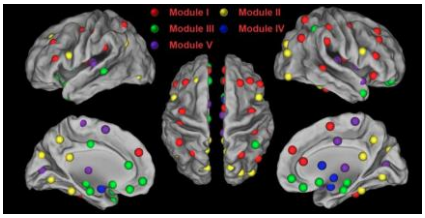
Computational Methodology



Yan et al., 2011. PLoS ONE

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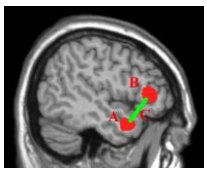
Computational Methodology

Regional approach

"Integrative" is really good, but:



Decreased

functional connectivity

Question: Is A, B, C, or……abnormal?

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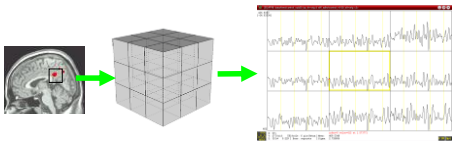
Computational Methodology

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)

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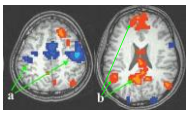
Computational Methodology

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)

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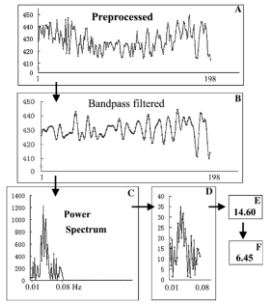
Computational Methodology

Amplitude of low frequency fluctuations



Zang et al., 2007

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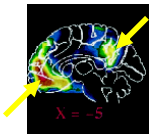
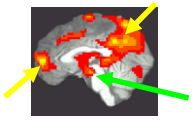
Computational Methodology

ALFF



PET

(Raichle et al., 2001)



ALFF

(Zang et al., 2007)

noise

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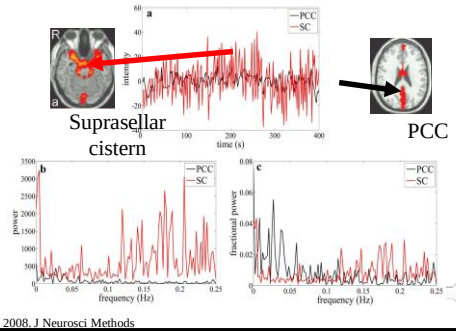
Computational Methodology

Improvement: fractional ALFF



Zou et al., 2008. J Neurosci Methods

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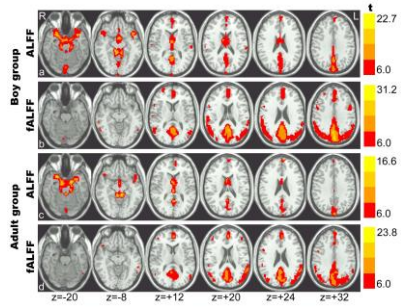
Computational Methodology

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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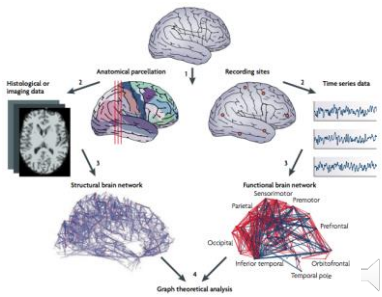
Computational Methodology

Graph theoretical analysis

Bullmore and Sporns, 2009



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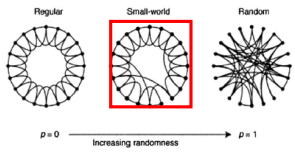
Computational Methodology

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").

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

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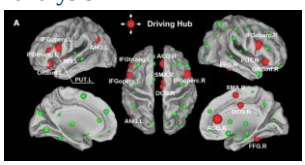
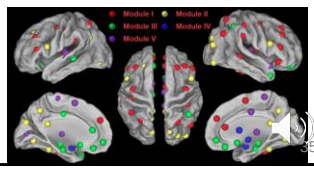
Computational Methodology

Graph theoretical analysis

Hub



Module



Yan et al., 2011. PLoS ONE

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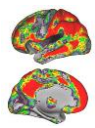
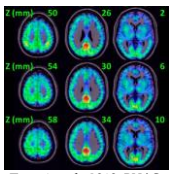
Computational Methodology

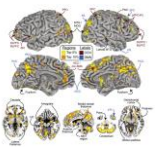
Degree centrality



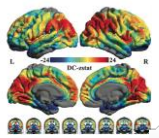
Buckner et al., 2009. J Neurosci



Tomasi et al., 2010. PNAS



Cole et al., 2010. Neuroimage



Zuo et al., 2011. Cereb Cortex

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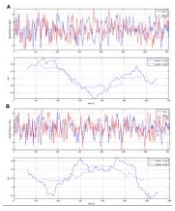
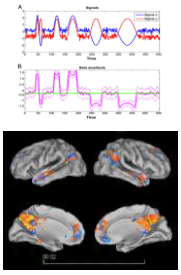
Computational Methodology

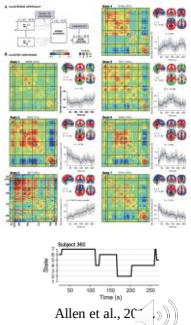
Dynamic perspective



Chang and Glover, 2010. Neuroimage



Kang, , Yan et al., 2011. Neuroimage



Allen et al., 20[illegible] Cereb Cortex

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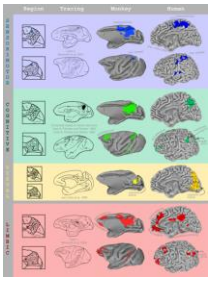
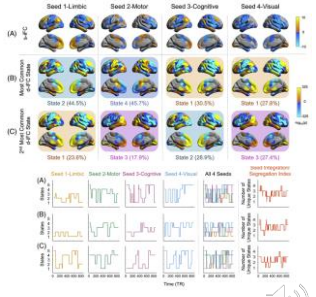
Computational Methodology

Dynamic perspective



Margulies et al., 2009. PNAS



Yang, , Yan, Milham, 2014. Neuroimage

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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

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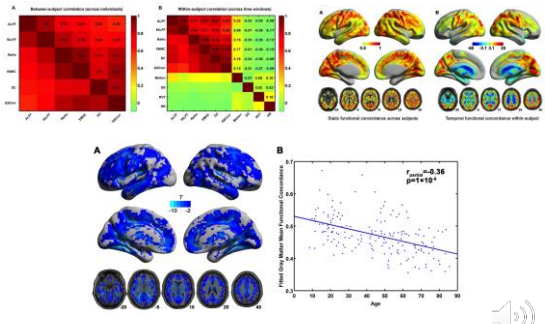
Computational Methodology

Concordance Among Indices of Intrinsic Brain Function



Yan et al., 2017. Science Bulletin

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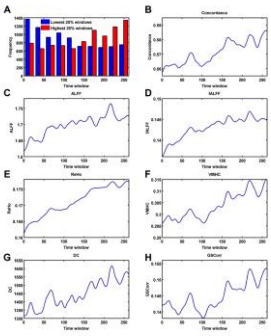
Computational Methodology



Yan et al., 2017. Science Bulletin

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- **Resting-State fMRI: Principles**
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- **Applications to Brain Disorders**

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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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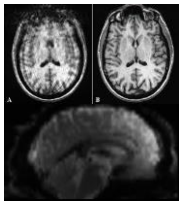
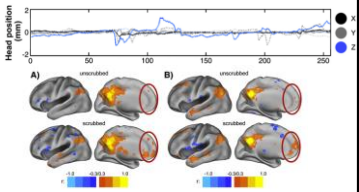
Methodological Issues: Head Motion





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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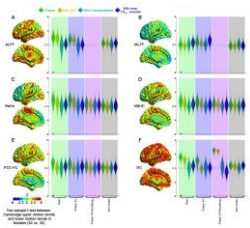
Methodological Issues: Head Motion



Proposed an effective head motion correction strategy

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

- Cited: 970 times
- ESI Top 0.1% highly cited paper

Yan et al., 2013a. Neuroimage

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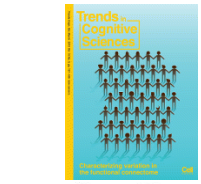
Methodological Issues: Standardization



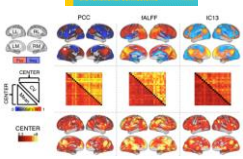


Table 1. Factors can introduce unintended variations in fMRI measurement.

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-Gomar 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., 2006).

Yan et al., 2013b. Neuroimage

Biswal et al., 2010, PNAS

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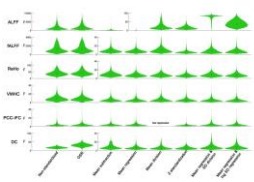
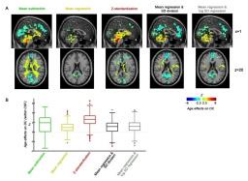
Methodological Issues: Standardization



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: 284 times
- ESI Top 1% highly cited paper

Yan et al., 2013b. Neuroimage

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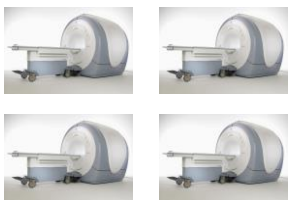
Methodological Issues

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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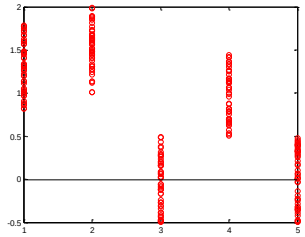


P=0.05 P=0.05 P=0.05 P=0.05 P=0.05

Probability of not getting a false positive result: 0.95

Probability of not getting a false positive result: 0.95

Probability of not getting a false positive result: 0.95

Probability of not getting a false positive result: 0.95

Probability of not getting a false positive result: 0.95

1 - 0.05 = 0.95 $0.95^5 = 0.774$ 1 - 0.05 = 0.95 1 - 0.05 = 0.95 1 - 0.05 = 0.95

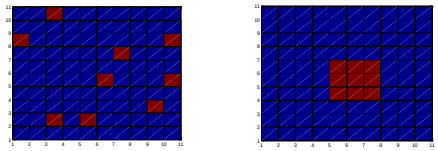
50

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

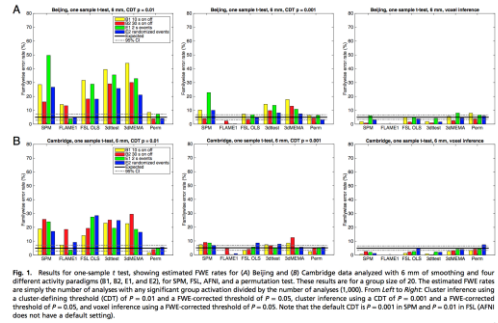

Fig. 1. Results for one-sample *t* test, showing estimated FWE rates for (A) Beijing and (B) Cambridge data analyzed with 6 mm of smoothing and four different activity paradigms (B1, B2, E1, and E2), for SPM, FSL, AFNI, and a permutation test. These results are for a group size of 20. The estimated FWE 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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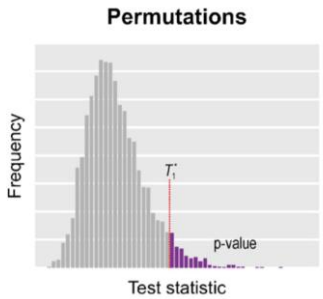
Reproducibility and Multiple Comparison Correction

Permutation Test



Winkler et al., 2016. Neuroimage

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Reproducibility and Multiple Comparison Correction

Threshold-Free Cluster Enhancement (TFCE)

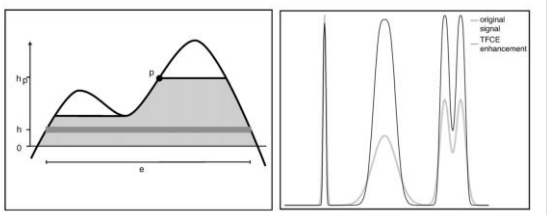

Fig. 1. Illustration of the TFCE approach. Left: the TFCE score at voxel p is given by the sum of the scores of all incremental supporting sections (one such is shown as the dark-grey band) within the area of "support" of p (light grey). The score for each section is a simple function of its height h 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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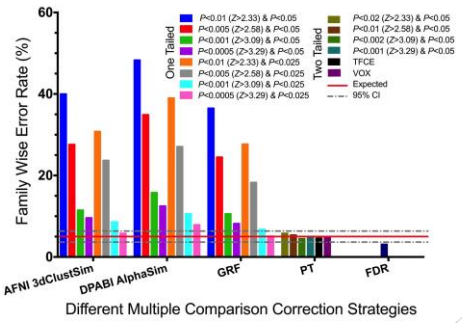
Family wise Error Rate



20 vs. 20 Permutation 1000 times

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

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 × 8.73 × 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%

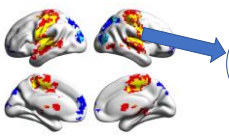
The smoothness in the second row is the estimated effective smoothness of the final metric maps feed to statistical analysis, and was different form the applied smoothness (4 mm FWHM) in pre-processing. The effective smoothness was used in 3 versions of cluster-based correction (i.e., GRF theory correction,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

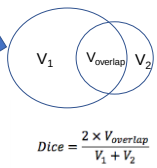
20 vs. 20 Permutation 1000 times

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

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

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

			Test–retest reliability (dice coefficient)									
	Voxel threshold	Cluster threshold	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	0.74	0.48	0.37	0.32	0.65	0.71	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

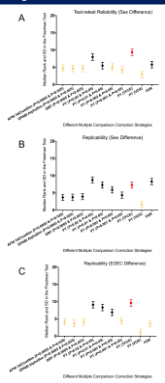
For test-retest reliability for all the 31 kinds of multiple comparison correction strategies, please see Supporting Information Table S13

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

212 M vs. 208 F × 2 times

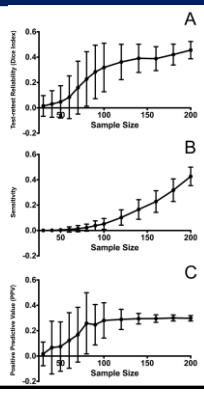
PT with TFCE outperforms

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



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

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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

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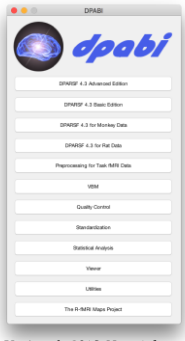
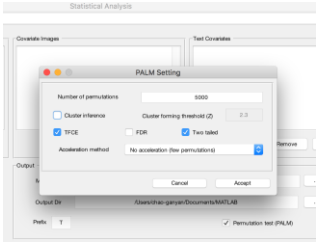
Permutation Test with TFCE





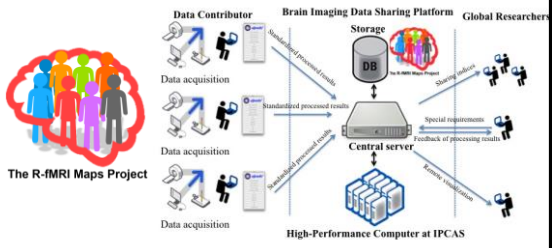
Integrated from PALM (Winkler et al. 2016. Neuroimage)

Yan* et al., 2016. Neuroinformatics

ESI Top 0.1% highly cited (>850 times)

63

The R-fMRI Maps Project



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

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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

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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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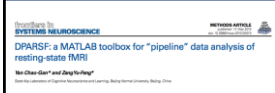
静息态功能磁共振数据处理平台


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

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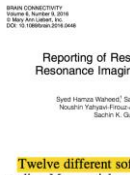
同行评价及影响


COMMUNICATION

Reporting of Resting-State Functional Magnetic Resonance Imaging Preprocessing Methodologies

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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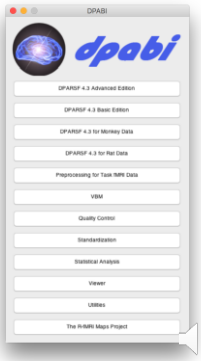
高效脑成像数据处理与共享平台

- 整合DPARSF
  - 此前工作，被引2202次
- 整合方法学改进
  - 头动（被引970次）
  - 标准化（被引284次）
  - 多重比较校正（被引96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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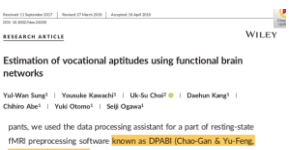
同行评价及影响

引用850次，为ESI Top 1‰高被引论文


RESEARCH ARTICLE
WILEY
Estimation of vocational aptitudes using functional brain networks

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
fMRI BOLD发明人

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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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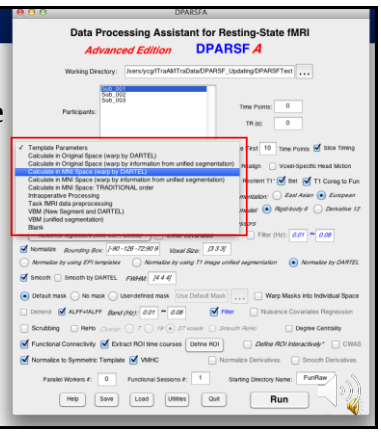
Resting State fMRI Data Processing

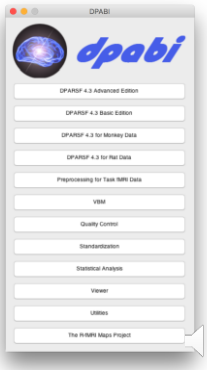
Template Parameters



DPABI

Yan et al., 2016. Neuroinformatics

ESI Top 1% Highly Cited Paper



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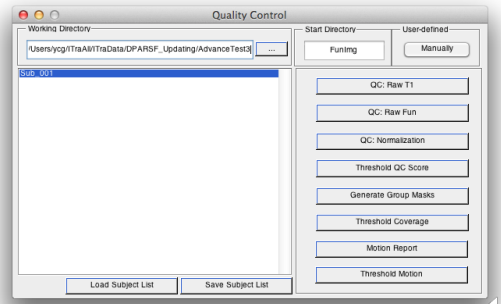
Quality Control



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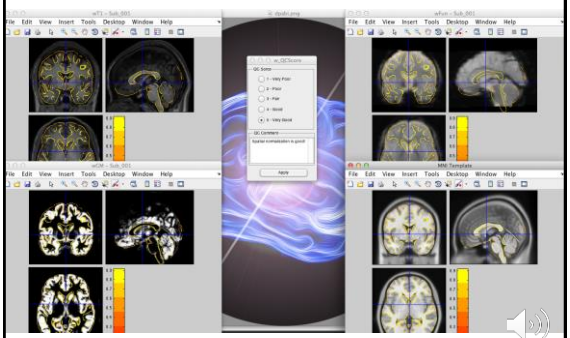
Quality Control



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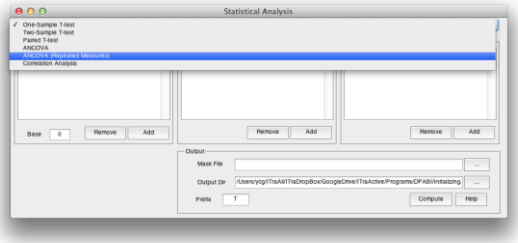
Statistical Analysis



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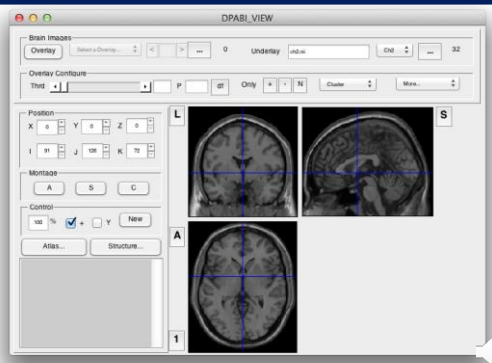
DPABI Viewer



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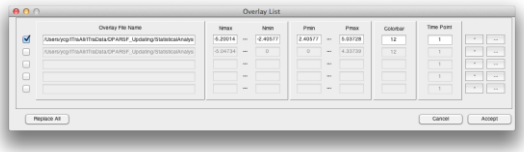
DPABI Viewer



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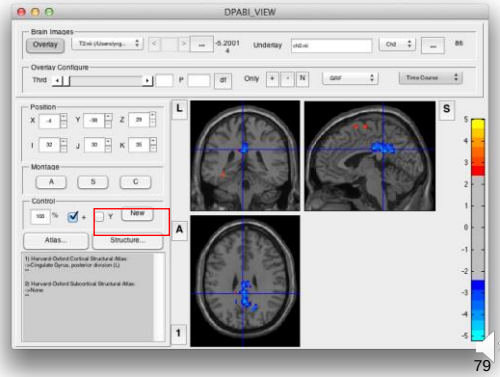
DPABI Viewer



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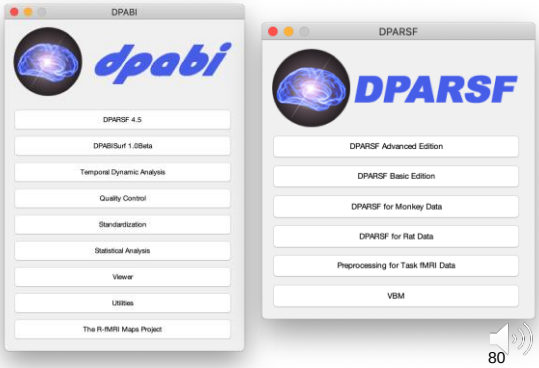
DPABISurf



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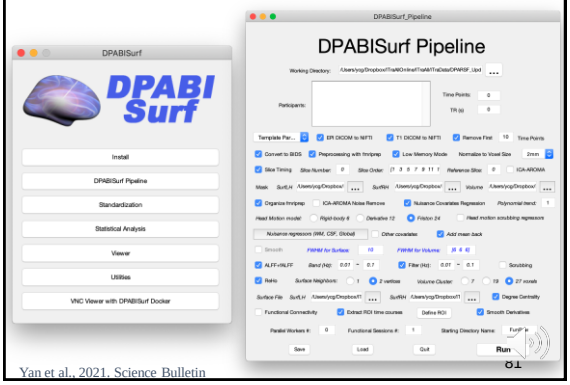
DPABISurf



Yan et al., 2021, Science Bulletin

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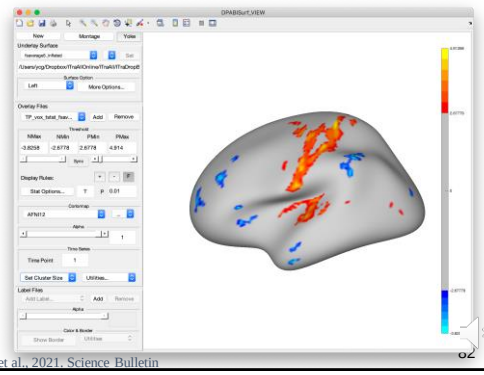
DPABISurf



Yan et al., 2021, Science Bulletin

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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

http://rfmri.org/Course

http://rfmri.org/wiki

The R-fMRI Journal Club

Official Account: RFMRILab

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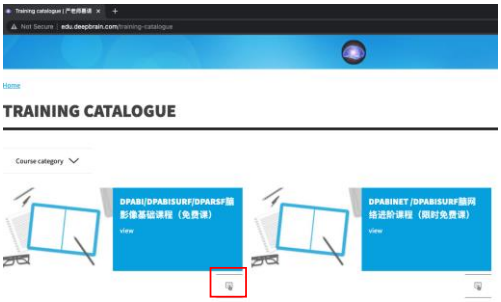
严老师慕课



http://edu.deepbrain.com/

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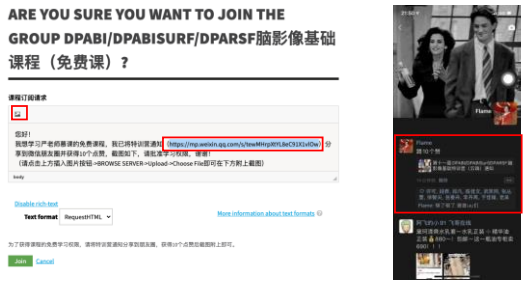
严老师慕课



http://edu.deepbrain.com/

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DPABI/DPABISurf/DPARSF特训营

第十一届DPABI/DPABISurf/DPARSF脑影像基础特训营（云端）通知
2021.11.20～11.22

第三届DPABISurf/DPABINet脑网络进阶特训营（北京现场+线上可选）通知
2022.1.8～1.10

定期举办，请关注http://rfmri.org

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DPABISurf皮层数据预处理业务

特训营学员：99元/例次

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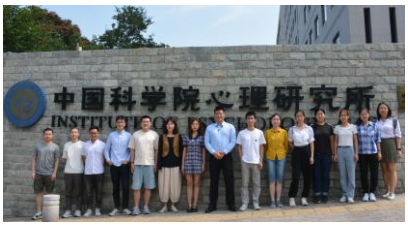
The R-fMRI Lab

WeChat Official Account: RFMRILab

微信添加**rfmriorg2**为好友，加入The R-fMRI Journal Club微信群

Acknowledgments



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Thanks for your attention!

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