Verification of Reproducibility of R-fMRI Metrics and Reproducible Network Underpinnings of Rumination

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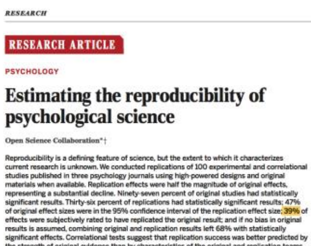
Outline

- **Verification of Reproducibility of R-fMRI Metrics**
- Reproducible Network Underpinnings of Ruminaiton

Introduction

"Reproducibility Crisis"


RESEARCH

RESEARCH ARTICLE

PSYCHOLOGY

Estimating the reproducibility of psychological science

Open Science Collaboration*†

Reproducibility is a defining feature of science, but the extent to which it characterizes current research is unknown. We conducted replications of 100 experimental and correlational studies published in three psychology journals using high-powered designs and original materials when available. Replication effects were half the magnitude of original effects, representing a substantial decline. Ninety-seven percent of original studies had statistically significant results. Thirty-six percent of replications had statistically significant results; 47% of original effect sizes were in the 95% confidence interval of the replication effect size; 39% of effects were subjectively rated to have replicated the original result; and if no bias in original results is assumed, combining original and replication results left 68% with statistically significant effects. Correlational tests suggest that replication success was better predicted by the strength of original evidence than by characteristics of the original and replication teams.

Open Science Collaboration, 2015. Science

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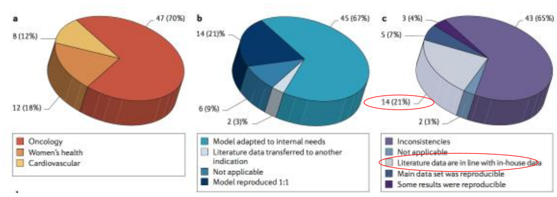
Introduction

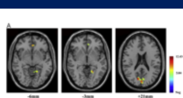
False findings may be the majority majority of published research claims



Analysis of the reproducibility of published data in 67 in - house projects

Prinz et al., 2011. Nat Rev Drug Discov 4

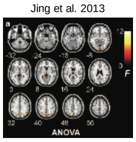
Introduction



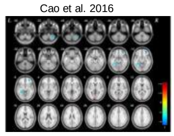
Jing et al. 2013

Cao et al. 2016

ALFF

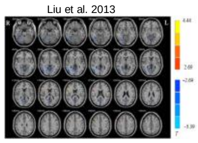


Liu et al. 2014



Liu et al. 2013

fALFF



ReHo

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Introduction


ANALYSIS

Power failure: why small sample size undermines the reliability of neuroscience

Button et al., 2013. Nat Rev Neurosci


ANALYSIS

Scanning the horizon: towards transparent and reproducible neuroimaging research

Poldrack, et al., 2017. Nat Rev Neurosci

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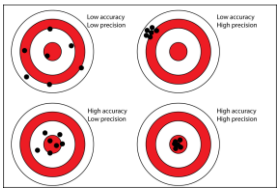
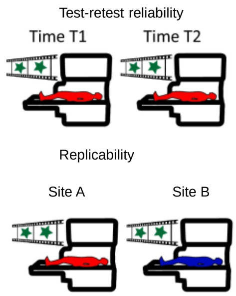
Introduction

Defining reproducibility





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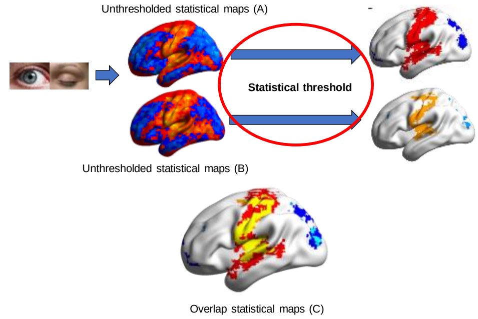
Introduction

Defining reproducibility



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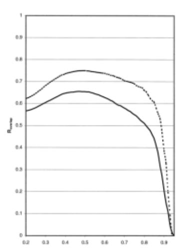
Introduction

Statistical thresholds

Reproducibility is highly sensitive to the statistical threshold used to define significance



Rombouts et al., 1998

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Introduction

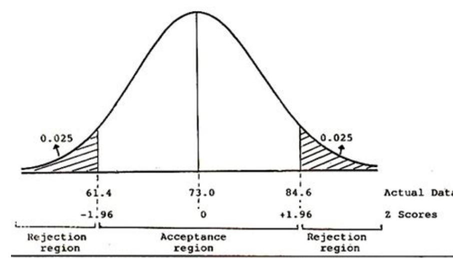

Figure. Critical region for the test of significance.

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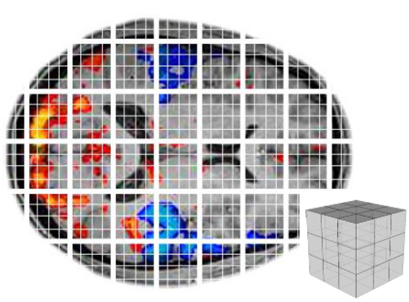
Reproducibility and Multiple Comparison Correction



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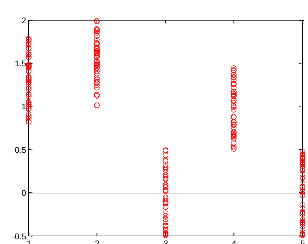

P=0.05	P=0.05	P=0.05	P=0.05	P=0.05
0.95	0.95	0.95	0.95	0.95
Probability of not getting a false positive result:	Probability of not getting a false positive result:	Probability of not getting a false positive result:	Probability of not getting a false positive result:	Probability of not getting a false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

$0.95^5=0.774$

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Reproducibility and Multiple Comparison Correction

Multiple Comparisons

Bonferroni correction

The Bonferroni correction rejects the null hypothesis for each $p_i \leq \alpha/m$, thereby controlling the FWER at $\leq \alpha$

$$\mathrm{FWER} = P\left\{\bigcup_{i=1}^{m_0}\left(p_i \leq \frac{\alpha}{m}\right)\right\} \leq \sum_{i=1}^{m_0}\left\{P\left(p_i \leq \frac{\alpha}{m}\right)\right\} = m_0\frac{\alpha}{m} \leq m\frac{\alpha}{m} = \alpha.$$

Carlo Emilio Bonferroni

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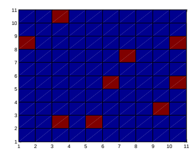
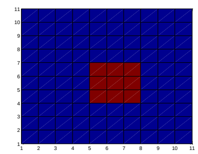
Reproducibility and Multiple Comparison Correction

Multiple Comparisons

Gaussian Random Field Theory Correction

Monte Carlo simulations (AlphaSim)





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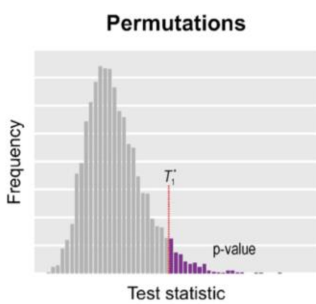
Reproducibility and Multiple Comparison Correction

Permutation Test



Ronald Aylmer Fisher

Winkler et al., 2016. Neuroimage

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Reproducibility and Multiple Comparison Correction

Threshold-Free Cluster Enhancement (TFCE)

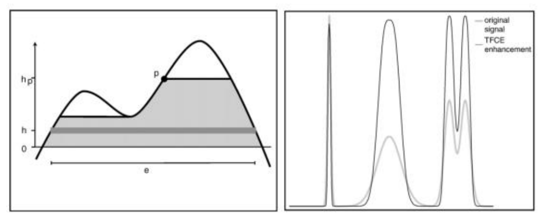

Fig. 1. Illustration of the TFCE approach. Left: the TFCE score at voxel p is given by the sum of the scores of all incremental supporting sections (one such is shown as the dark-grey band) within the area of "support" of p (light grey). The score for each section is a simple function of its height h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

PNAS

CrossMark

Cluster failure: Why fMRI inferences for spatial extent have inflated false-positive rates

Anders Eklund[a,b,c,1], Thomas E. Nichols[d,e], and Hans Knutsson[a,c]

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Edited by Emery N. Brown, Massachusetts General Hospital, Boston, MA, and approved May 17, 2016 (received for review February 12, 2016)

Technology

15 years of brain research has been invalidated by a software bug, say Swedish scientists

Up to 70% of fMRI analyses produce at least one false positive, challenging the validity of over 40,000 studies.

Eklund et al., 2016. PNAS

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Reproducibility and Multiple Comparison Correction

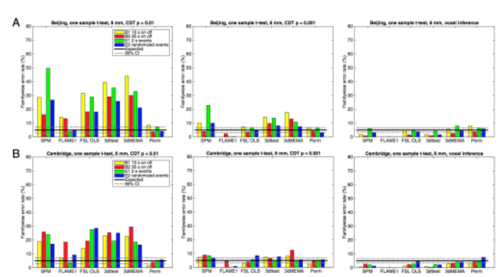

Fig. 1. Results for one-sample t test, showing estimated FWE rates for (*A*) Beijing and (*B*) Cambridge data analyzed with 6 mm of smoothing and four different activity paradigms (B1, B2, E1, and E2), for SPM, FSL, AFNI, and a permutation test. These results are for a group size of 20. The estimated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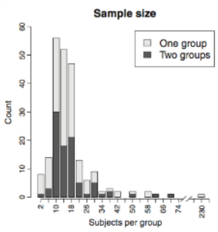
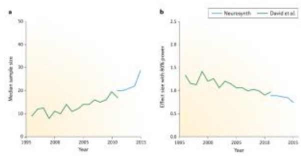
Introduction

Small samples in neuroscience





Median sample size: 15 for one group studies and 14.75 per group for two group studies (Carp, 2012)

Poldrack et al., 2017

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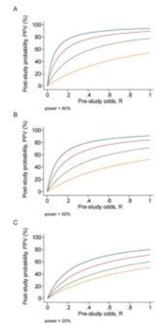
Introduction

Low power studies are unlikely reflecting a true effect



John P. A. Ioannidis


Why Most Published Research Findings Are False

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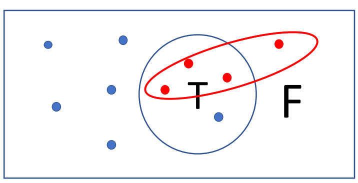
Introduction



Positive Predictive Value, PPV
After a research finding has been claimed based on achieving formal statistical significance, the post-study probability that it is true

$PPV = (1 - \beta)R/(R - \beta R + \alpha)$

Table 1. Research Findings and True Relationships

Research Finding	True Relationship Yes	No	Total
Yes	$c(1-\beta)R/(R+1)$	$c\alpha/(R+1)$	$c(R+\alpha-\beta R)/(R+1)$
No	$c\beta R/(R+1)$	$c(1-\alpha)/(R+1)$	$c(1-\alpha+\beta R)/(R+1)$
Total	$cR/(R+1)$	$c/(R+1)$	c

DOI: 10.1371/journal.pmed.0020124.t001

Introduction

Summary

- The impact of multiple comparison correction strategy (considering FWER) on reproducibility (test-retest reliability and replicability)
- The impact of sample size on reproducibility (test-retest reliability)

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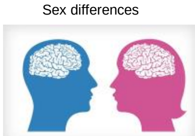
Introduction

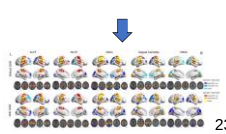
Defining reproducibility

We sought to propose a quantitative method to calculate reproducibility of R-fMRI metrics

Sex differences



Eyes open eyes closed (EOEC) differences



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Materials and Methods

Participants and Imaging Protocols

CORR
CONSORTIUM FOR RELIABILITY AND REPRODUCIBILITY

Consortium for Reliability and Reproducibility (CORR)

1000 Functional Connectomes Project (FCP)

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Materials and Methods

CORR dataset

Sample size: 420 (212 M vs. 208 F)
Scanned 2 times
Inclusion criteria (from 549):
Age between 18 and 32
No extreme head motion
No poor T1 or functional images, low quality normalization or inadequate brain coverage

Beijing EOEC1 dataset

Sample size: 48
Eyes-open vs. eyes-closed
Same Inclusion criteria

1000 Functional Connectomes Project (FCP) dataset

Sample size: 716 (296 M vs. 420 F)
Same inclusion criteria

Beijing EOEC2 dataset

Sample size: 20
Eyes-open vs. eyes-closed
Same inclusion criteria

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

Materials and Methods

Preprocessing

1. The first 10 volumes were discarded
2. Slice-timing correction
   shifted to the slice at the mid-point of each TR
3. Realignment
   six-parameter (rigid body) linear transformation
   two-pass procedure
4. Co-registration and segment
   six degree-of-freedom linear transformation without re-sampling
5. Transformation from native space to MNI space
   Diffeomorphic Anatomical Registration Through Exponentiated Lie algebra tool (DARTEL)

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Materials and Methods

Nuisance Regression

A General Linear Regression Model including: $Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_{p-1} X_{i,p-1} + \varepsilon_i$

1. Head motion
   Friston 24-parameter model and mean FD
2. Global Signal Regression (GSR)
   Results both with and without GSR were evaluated
3. Other sources of spurious variance
   WM and CSF signals
4. Linear trends

Temporal bandpass filtering (0.01–0.1 Hz)
   All time series except for ALFF and fALFF analyses

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Materials and Methods

A Broad Array of R-fMRI Metrics

ALFF:
The mean of amplitudes within a specific frequency domain (here, 0.01–0.1Hz) from a fast Fourier transform of a voxel's time course

fALFF:
A normalized version of ALFF and represents the relative contribution of specific oscillations to the whole detectable frequency range

ReHo:
A rank-based Kendall's coefficient of concordance that assesses the synchronization among a given voxel and its nearest neighbors' (here, 26 voxels) time courses

Degree Centrality:
The number or sum of weights of significant connections for a voxel. The weighted sum of positive correlations with a threshold of r>0.25

VMHC:
The functional connectivity between any pair of symmetric inter-hemispheric voxels

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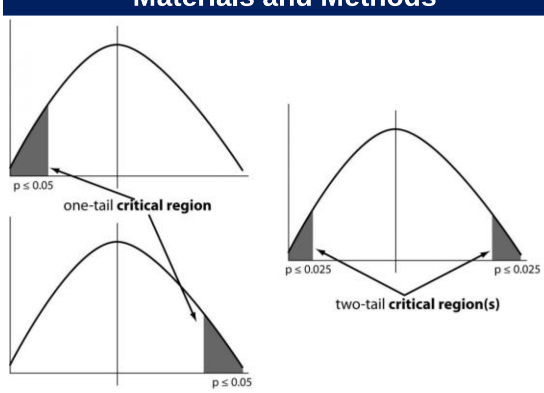
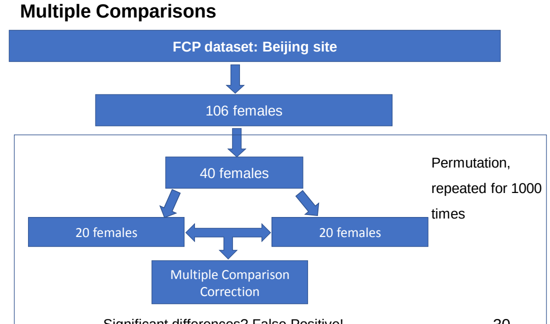
Materials and Methods



Materials and Methods

Evaluating FWER of Different Strategies to Correct for Multiple Comparisons



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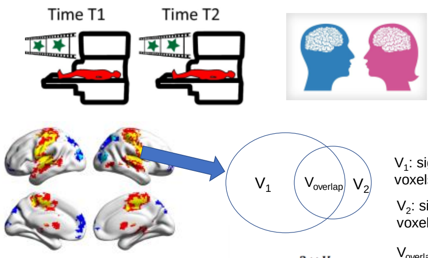
Materials and Methods

Test-retest reliability

Sex differences in test and retest



Statistical significant voxels

V_1: significant voxels in test

V_2: significant voxels in retest

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

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

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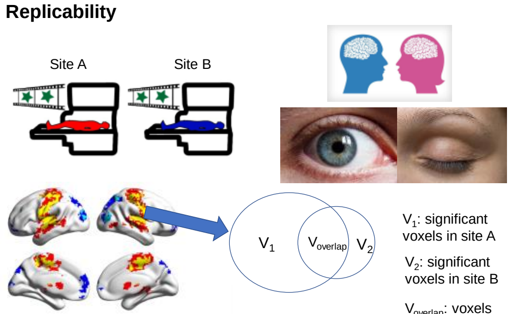
Materials and Methods

Replicability



Statistical significant voxels

V_1: significant voxels in site A

V_2: significant voxels in site B

$V_{overlap}$: voxels significant in both site A and B

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

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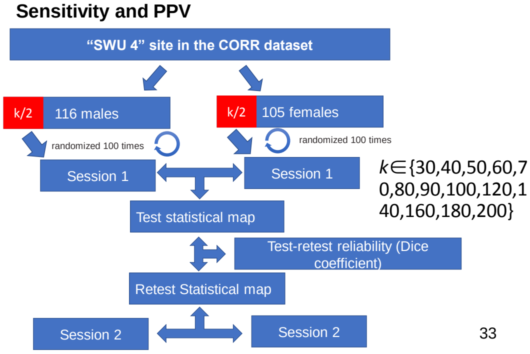
Materials and Methods

Influences of Sample Size on Test–Retest Reliability, Sensitivity and PPV



$k \in \{30,40,50,60,70,80,90,100,120,140,160,180,200\}$

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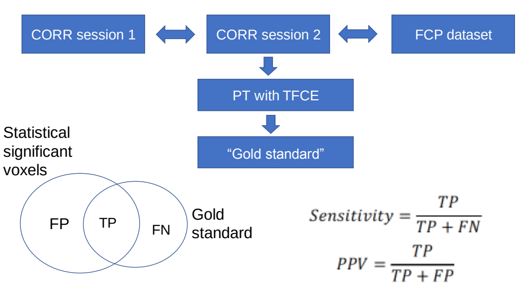
Materials and Methods

Influences of Sample Size on Test–Retest Reliability, Sensitivity and PPV



$$Sensitivity = \frac{TP}{TP + FN}$$

$$PPV = \frac{TP}{TP + FP}$$

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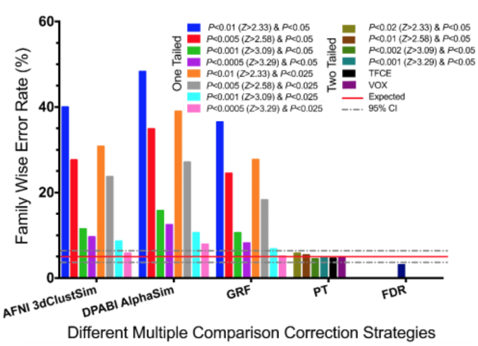
Results



FWER calculated with ALFF without GSR (4mm FWHM smoothing kernel)

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Results

(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

	Voxel Threshold	Cluster Threshold	ALFF	fALFF	ReHo	DC	VMHC	ALFF with GSR	fALFF with GSR	ReHo with GSR	DC with GSR	VMHC with GSR	ALFF (8mm smoothed)
			Family Wise Error Rate										
Smoothness (mm, FWHM)			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)	$P < 0.0005$ $(Z > 3.29)$	$P < 0.025$	7.9%	8.3%	8.5%	10.2%	9.0%	7.8%	7.7%	7.8%	8.3%	9.6%	6.9%
Gaussian Random Field (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 Threshold-Free Cluster Enhancement (TFCE)			4.6%	3.9%	5.7%	5.0%	4.3%	5.3%	4.2%	5.5%	4.7%	4.8%	4.6%
PT Voxel-Wise Correction (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%

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Results

Test-retest reliability of between-subject sex difference

	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

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

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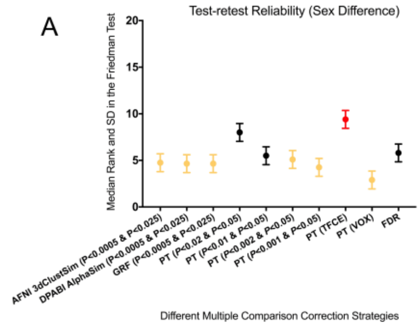
Test-retest Reliability



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

212 M vs. 208 F × 2 times

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Results

Replicability of between-subject sex difference

	Voxel threshold	Cluster threshold	Replicability (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)	$P<0.0005$ $(Z>3.29)$	$P<0.025$	0.12	0.10	0.07	0.07	0.01	0.10	0.11	0.02	0.08	0.02
DPABI AlphaSim (one-tailed)			0.13	0.09	0.07	0.07	0.02	0.10	0.11	0.02	0.08	0.02
GRF (one-tailed)			0.13	0.10	0.07	0.07	0.01	0.10	0.11	0.02	0.08	0.02
PT cluster extent correction (two-tailed)	$P<0.02$ $(Z>2.33)$	$P<0.05$	0.21	0.13	0.14	0.17	0.05	0.21	0.06	0.12	0.22	0.10
	$P<0.01$ $(Z>2.58)$	$P<0.05$	0.19	0.11	0.11	0.16	0.02	0.17	0.09	0.08	0.24	0.08
	$P<0.002$ $(Z>3.09)$	$P<0.05$	0.14	0.10	0.08	0.11	0.02	0.12	0.10	0.03	0.05	0.03
	$P<0.001$ $(Z>3.29)$	$P<0.05$	0.12	0.10	0.07	0.07	0.01	0.10	0.11	0.02	0.08	0.02
PT TFCE			0.25	0.06	0.13	0.20	0.01	0.25	0.03	0.09	0.26	0.02
PT VOX			0.02	0.00	0.01	0.00	0.00	0.01	0.05	0.00	0.00	0.00
FDR correction			0.15	0.06	0.11	0.09	0.02	0.13	0.04	0.05	0.08	0.00

- ◆ Poor replicability

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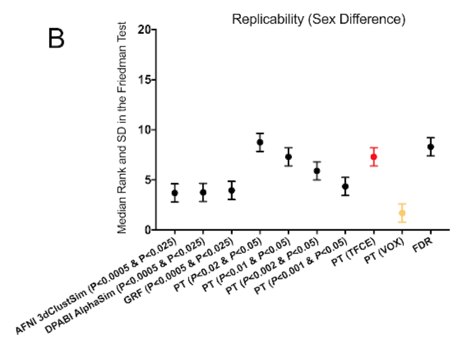
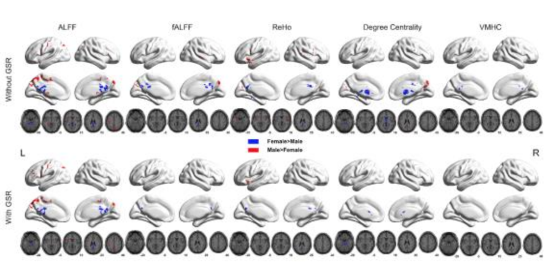
Results



40

Results



- ◆ Female's PCC demonstrate more spontaneous activity than male

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Results

Replicability of within-subject EOEC difference

	Voxel threshold	Cluster threshold	Replicability (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)	$P<0.0005$ $(Z>3.29)$	$P<0.025$	0.15	0.11	0.26	0.03	0.10	0.14	0.11	0.31	0.07	0.10
DPABI AlphaSim (one-tailed)			0.15	0.11	0.26	0.03	0.10	0.14	0.11	0.31	0.07	0.09
GRF (one-tailed)			0.15	0.11	0.27	0.04	0.10	0.14	0.11	0.30	0.05	0.10
PT cluster extent correction (two-tailed)	$P<0.02$ $(Z>2.33)$	$P<0.05$	0.46	0.27	0.44	0.24	0.21	0.41	0.30	0.49	0.28	0.17
	$P<0.01$ $(Z>2.58)$	$P<0.05$	0.39	0.24	0.40	0.20	0.16	0.35	0.21	0.48	0.18	0.21
	$P<0.002$ $(Z>3.09)$	$P<0.05$	0.22	0.16	0.32	0.06	0.14	0.19	0.16	0.35	0.09	0.12
	$P<0.001$ $(Z>3.29)$	$P<0.05$	0.15	0.11	0.27	0.04	0.10	0.14	0.11	0.30	0.05	0.09
PT TFCE)			0.49	0.31	0.45	0.29	0.20	0.46	0.32	0.47	0.30	0.20
PT VOX			0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
FDR Correction			0.09	0.00	0.29	0.03	0.08	0.12	0.00	0.34	0.12	0.10

- ◆ Higher than between-subject sex difference but still not moderate

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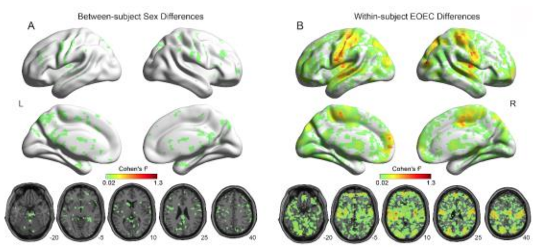
Results



Within-subject design has larger effect size

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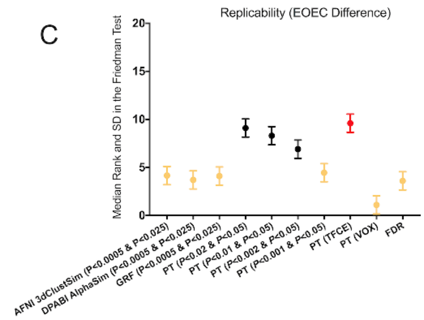
Results



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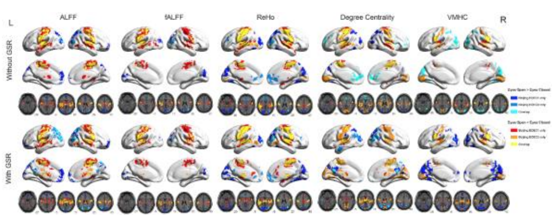
Results



- ◆ Eyes open > Eyes closed in bilateral occipital cortices
- ◆ Eyes open < Eyes closed in bilateral pre- and post-central gyrus

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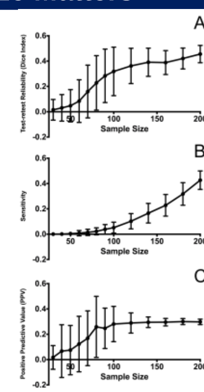
Sample Size Matters

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

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Discussion

Main findings:

- ◆ Liberal correction strategies yield unacceptable high FWERs
- ◆ PT with TFCE reach the best balance between FWER and reproducibility
- ◆ Between-subject design has moderate test-retest reliability but poor replicability
- ◆ Within-subject design has better replicability but still not moderate
- ◆ Larger sample size increases reproducibility, sensitivity as well as PPV

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Discussion

What correction strategy can be used?

According to FWER…

- ◆ GRF correction with strict p values (voxel wise P<0.0005 and cluster wise P<0.025 for each tail)
- ◆ Four kinds of PT with extent thresholding
- ◆ PT with TFCE
- ◆ PT with VOX
- ◆ FDR correction

According to reproducibility…

Strict strategies cannot achieve moderate reproducibility, except PT with TFCE

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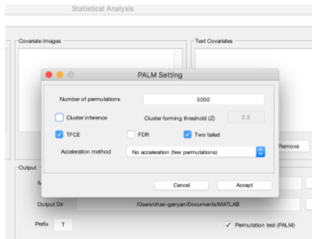
Permutation Test with TFCE



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

Yan* et al., 2016. Neuroinformatics

ESI Top 1% highly cited (>60 times)

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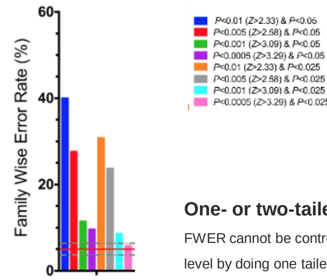
Discussion



One- or two-tailed?

FWER cannot be controlled to the norminal level by doing one tailed correction twice

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Discussion

Sample size (k)	Test–retest reliability (dice index)	Sensitivity	PPV
30	0.02 ± 0.08	0.001 ± 0.004	0.02 ± 0.09
40	0.03 ± 0.11	0.001 ± 0.01	0.07 ± 0.21
50	0.05 ± 0.13	0.004 ± 0.01	0.07 ± 0.19
60	0.08 ± 0.17	0.01 ± 0.02	0.12 ± 0.22
70	0.16 ± 0.21	0.01 ± 0.02	0.17 ± 0.22
80	0.23 ± 0.22	0.02 ± 0.03	0.26 ± 0.24
90	0.28 ± 0.21	0.04 ± 0.04	0.25 ± 0.16
100	0.32 ± 0.19	0.05 ± 0.04	0.28 ± 0.14
120	0.36 ± 0.14	0.10 ± 0.06	0.29 ± 0.08
140	0.39 ± 0.11	0.17 ± 0.08	0.29 ± 0.04
160	0.39 ± 0.09	0.23 ± 0.09	0.30 ± 0.03
180	0.42 ± 0.08	0.32 ± 0.09	0.30 ± 0.02
200	0.46 ± 0.07	0.43 ± 0.07	0.30 ± 0.02

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)

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Discussion

All statistical maps have been shared through the R-fMRI Maps project (http://rfmri.org/maps)

Key source code have been shared through (https://github.com/Chaogan-Yan/PaperScripts/tree/master/Chen_2017_HBM)

Thus our findings could be easily reproduced by any researchers

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Outline

•Verification of Reproducibility of R-fMRI Metrics

• **Reproducible Network Underpinnings of Ruminaiton**

Rumination

Rumination

Repetitive thinking about negative personal concerns and/ or about the implications, causes, and meanings of a negative mood

Example:

What do I do to deserve this?

Why these things happened to me?

Features

- Self perpetuate
- Recycled
- Long-lasted

Susan Nolen-Hoeksema
(1959 – 2013)

Nolen-Hoeksema et al., 2008. Perspect Psychol Sci

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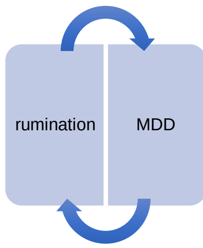
Rumination

Rumination and MDD

Individuals with ruminative traits are prone to suffer MDD when stuck in negative life events

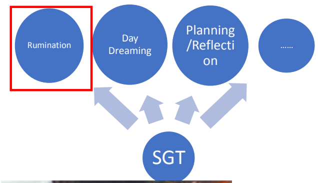


People with depressive symptoms tend to ruminate more

- Rumination is not only a defining feature, but also a risk factor for MDD

Koster et al., 2011. Clinical Psychol Rev

Self-Generated Thoughts

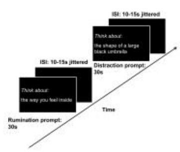


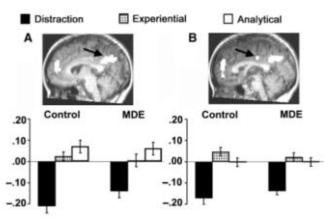
- Resting-state is a complex state
- Focusing on a specific mental state?

Andrews-Hanna et al., 2014. N.Y.Acad.Sci.

Literature Review

Rumination and Task-fMRI：DMN





Rumination

"Think: Why these things happen to me?"

Distraction

"Think: A big black umbrella"

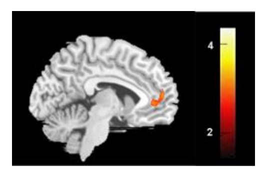
Johnson et al., 2009. SCAN

Literature Review

Correlation studies on trait ruminaiton: DMN

Rumination scale（e.g. RRS）

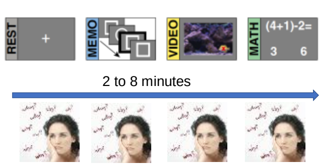
resting/task fMRI metrics



Zhu et al., 2012

Rumination State

"Rumination State"

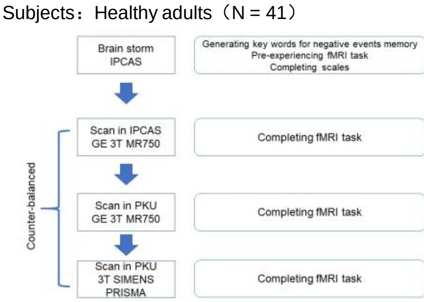


- A subject-driven, relatively long period of mental state
- Continuous and dynamic thinking style following the instructions

Rumination State Task

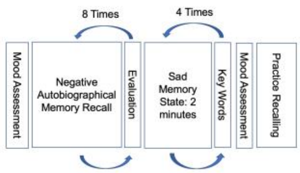
Materials and Methods

Subjects：Healthy adults（N = 41）



Rumination State Task

Brain Storm



Scale

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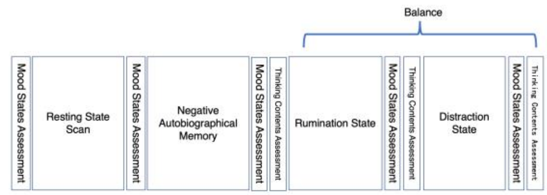
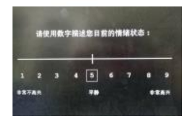
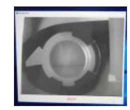
Rumination State Task

MRI Scan







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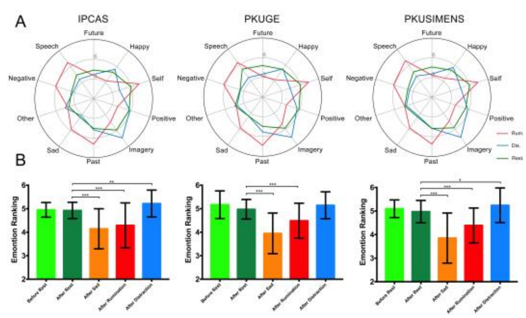
Rumination State



Chen et al., In prep.

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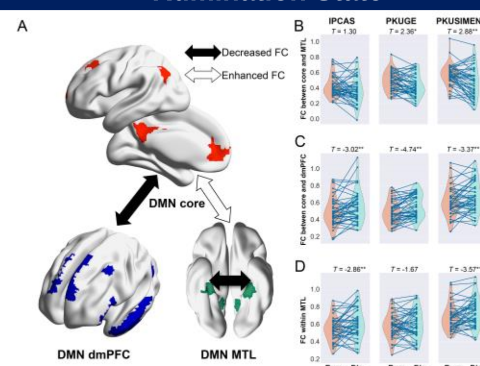
Rumination State



Chen et al., In prep.

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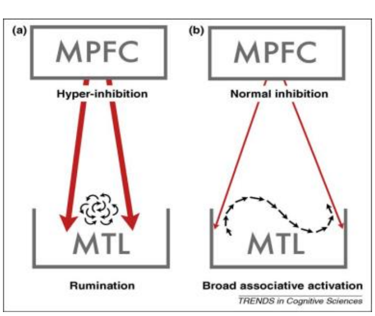
Discussion



Moshe Bar

Bar, 2009. Trends in cognitive sciences

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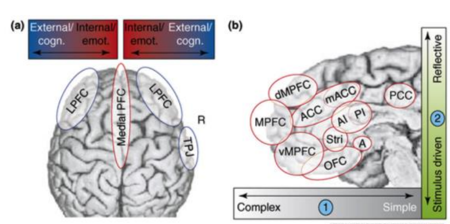
Discussion



Andreas Olsson

- Ventral MPFC: Emotional “hot” psychological process
- Dorsal MPFC：Cognitive “cold” psychological process

Olsson and Ochsner, 2007. Trends in cognitive sciences

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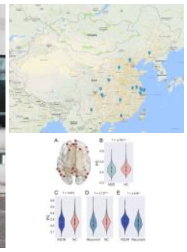
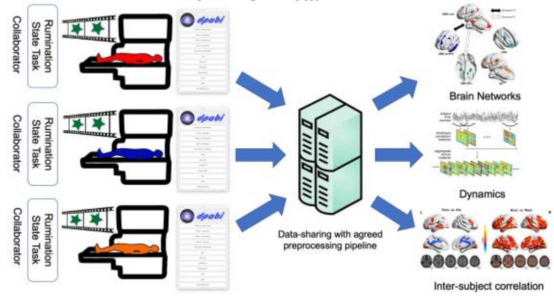
Future Work

REST-meta-MDD Project

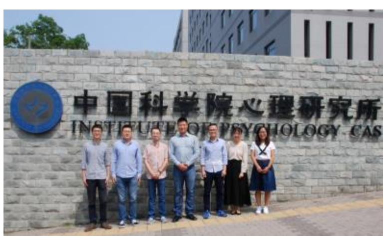


Future Work

Multi-sited rumination state research based on REST-meta-MDD



Acknowledgements

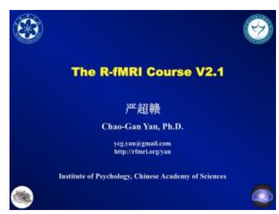


Funding

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

NYU Child Study Center
F. Xavier Castellanos

Further Help



http://rfmri.org/Course

http://rfmri.org/wiki

The R-fMRI Journal Club

Official Account: RFMRILab

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

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DPABI工作站

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2.	DPABI计算工作站 (Linux/Windows) DPABI Computational Core	塔式服务器 20核40线程英特尔至强4114 2.2G *2,9.6GT/s 2UPI,14M ,Turbo, HT(85W), 4*16GB RDIMM, 64G内存, 2666MT/s, 4*4TB 7.2K RPM NLSAS，16TB硬盘, 冗余电源，RAID卡：H330，DVD-RW 双电 三年服务	¥59999
3.	DPABI移动工作站 (Windows) DPABI Mobile Core Windows	15.6英寸移动图形工作站 八代六核十二线程i7-8750H, 16G内存, 256G固态硬盘+1T机械硬盘, P1000 4G独立显卡	¥24999
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DPABI计算工作站

2.	DPABI计算工作站 (Linux/Windows) DPABI Computational Core	塔式服务器 20核40线程英特尔至强4114 2.2G *2,9.6GT/s 2UPI,14M ,Turbo, HT(85W), 4*16GB RDIMM, 64G内存, 2666MT/s, 4*4TB 7.2K RPM NLSAS，16TB硬盘, 冗余电源，RAID卡：H330，DVD-RW 双电 三年服务	¥59999

http://deepbrain.com/DPABICore

DPABISurf 并行计算:

每天完成 **20** 个被试的皮层计算!!!

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The R-fMRI Lab

WeChat Official Account: RFMRILab

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Thanks for your attention!

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