



## DPABI: Quality Control, Statistical Analysis and Results Viewing

Chao-Gan YAN, Ph.D.

严超轶

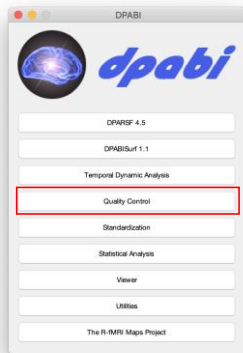
ycg.yan@gmail.com

<http://rfmri.org>

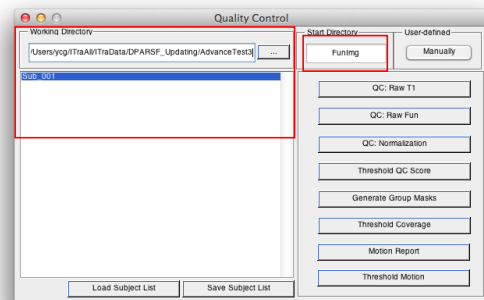
Institute of Psychology, Chinese Academy of Sciences

## Outline

- ➔ • Quality Control
- Statistical Analysis
- Results Viewing

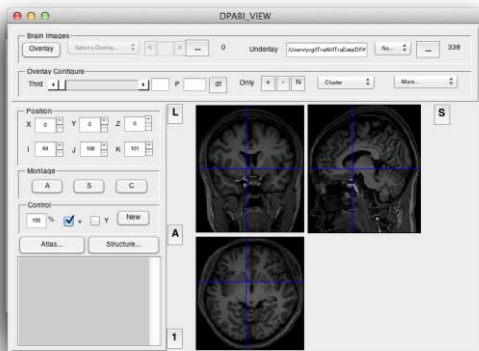


## Quality Control



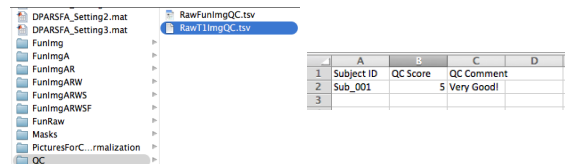
4

## Quality Control

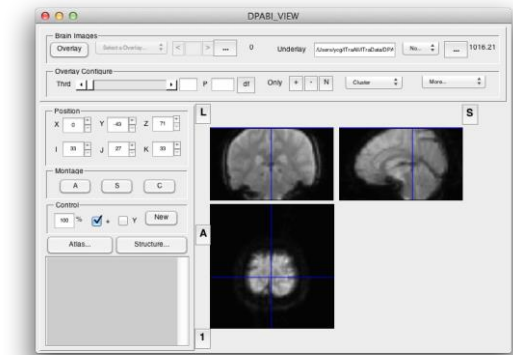


5

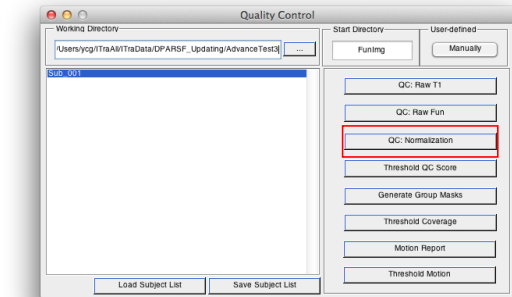
## Quality Control



Quality Control

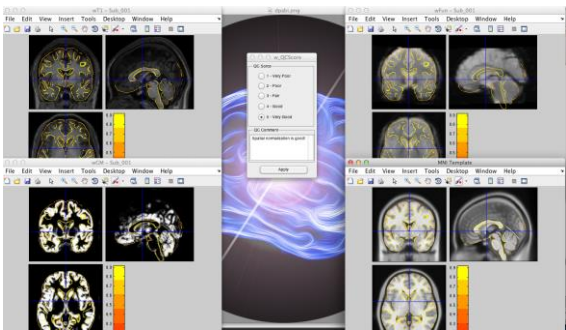


Quality Control

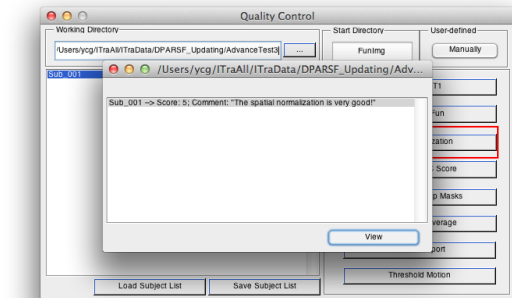


8

Quality Control

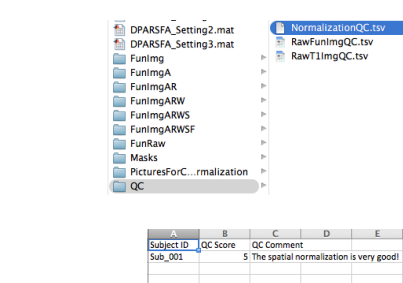


Quality Control

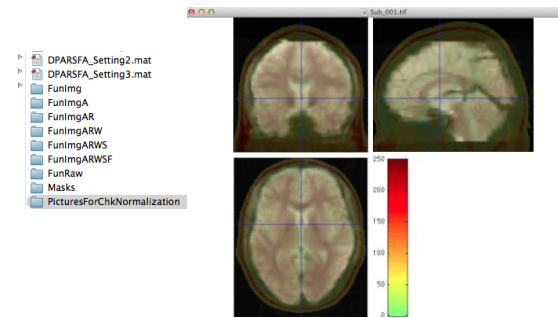


10

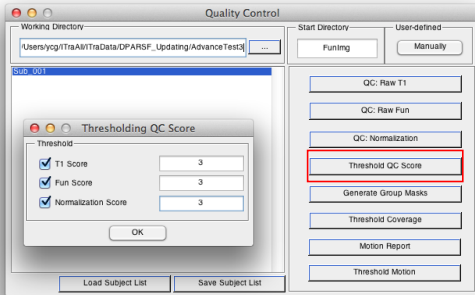
Quality Control



Quality Control

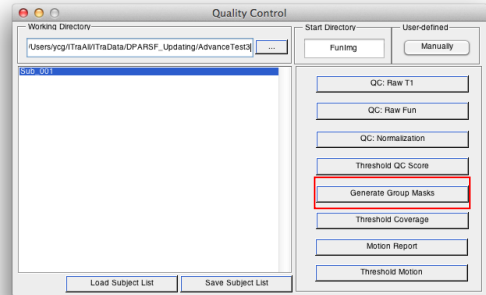


## Quality Control



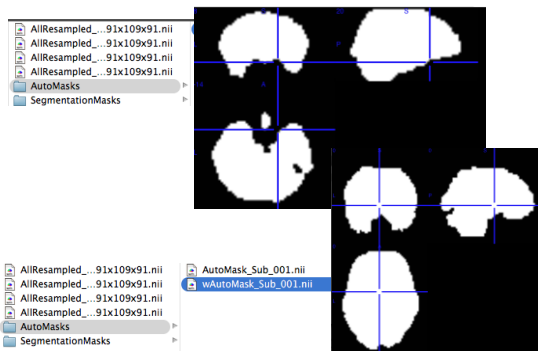
13

## Quality Control

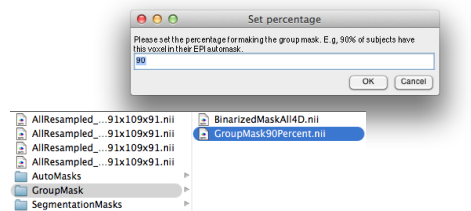


14

## Quality Control

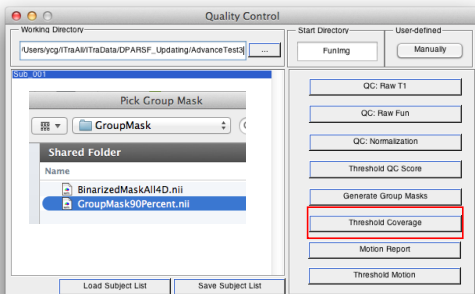


## Quality Control



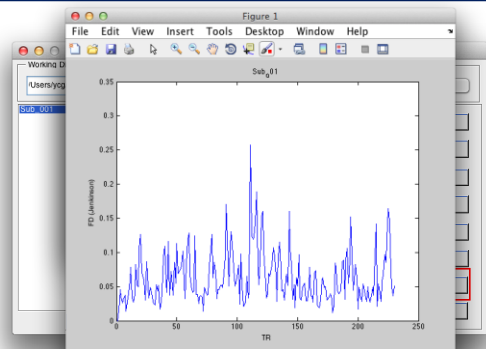
This mask is very important for group statistical analysis!!!

## Quality Control



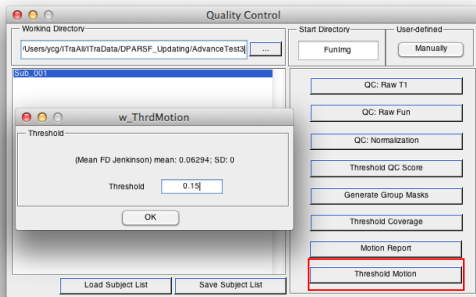
17

## Quality Control



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## Quality Control



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## Quality Control

- Using the visual inspection step within DPARSF, subjects showing severe head motion in the T1 image and subjects showing extremely poor coverage in the functional images, as well as subjects showing bad registration were excluded
- Subjects with overlap with the group mask (voxels present at least 90% of the participants) less than  $2*SD$  under the group mean overlap (threshold: 92.2%) were excluded
- Subjects with motion (Mean FD Jenkinson greater than  $2*SD$  above the group mean motion (threshold: 0.192) were excluded



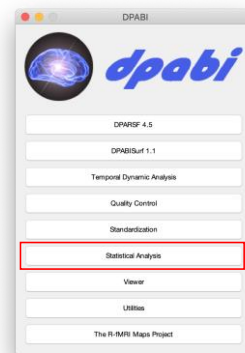
Yan et al., 2013, NeuroImage  
 Standardizing the intrinsic brain: Towards robust measurement of inter-individual variation in 1000 functional connectomes  
 Chao-Gan Yan <sup>1,2,3</sup>, K. Cameron Craddock <sup>4,5</sup>, Xi-Nian Zuo <sup>6</sup>, Yu-Feng Zang <sup>7</sup>, Michael P. Milham <sup>1,3,8</sup>

20

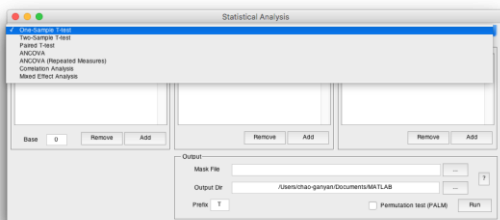
## Outline

- Quality Control
- ➔ • Statistical Analysis
- Results Viewing

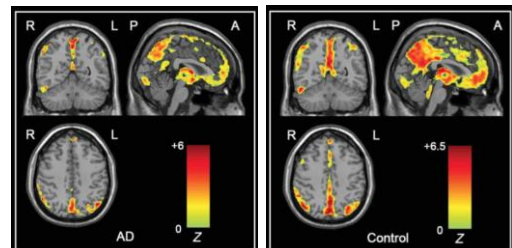
21



## Statistical Analysis



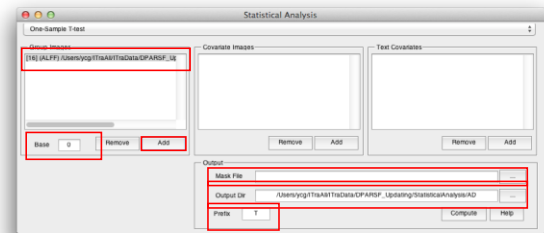
## One-Sample T-Test



Wang<sup>a</sup>, Yan<sup>a</sup> et al., 2011, Hum Brain Mapp

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## One-Sample T-Test

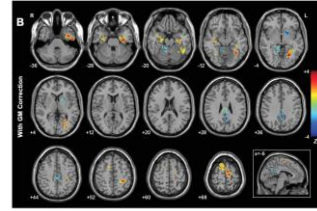


0 for z\* images  
1 for m\* images

T Statistic Image

Group Mask

## Two-Sample T-Test

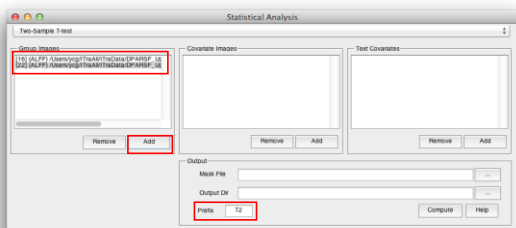


**Figure 3.** Z-statistical difference maps between the AD patients and healthy elderly (without GPR correction). The AD patients showed significantly decreased ALFF in the bilateral PCC/PCu, left LNI, left CING, and right ALC, and increased ALFF in the bilateral PFC, lateral and medial STG. For the details of the regions, see Table 2. Z-statistical difference maps between the AD patients and healthy elderly (with GPR correction). The AD patients showed significantly decreased ALFF in the bilateral PCC/PCu, left LNI, and right ALC, and increased ALFF in the bilateral PFC, lateral and medial STG. For the details of the regions, see Table 2. The statistical threshold was set at  $p < 0.05$  (FDR) and cluster size  $> 100$  voxels, which corresponded to a corrected  $p < 0.05$ . Of note, we showed the two-sample t-test results within a mask showing significant group difference in the ANCOVA analysis (Fig. 3A). R, right; L, left. [Color figure can be viewed in the online issue, which is available at [www.intellect.com](http://www.intellect.com).]

Wang<sup>†</sup>, Yan<sup>†</sup> et al., 2011, Hum Brain Mapp

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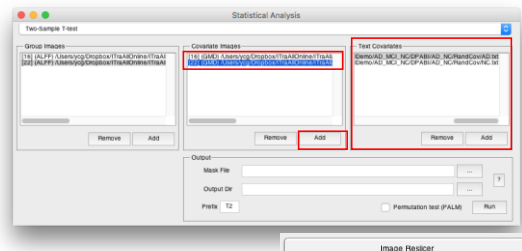
## Two-Sample T-Test



T Statistic Image: positive corresponds to the mean of Group 1 is greater than the mean of Group 2

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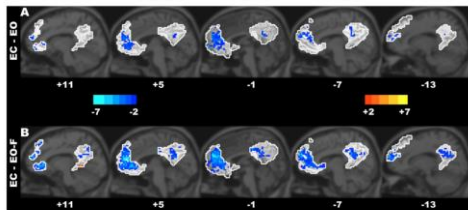
## Two-Sample T-Test



Two-Sample T-Test with covariates: e.g. gray matter proportion images (see Table 2 for details), between the group images and the covariate images (e.g. gray matter proportion, age, sex etc.)

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## Paired T-Test

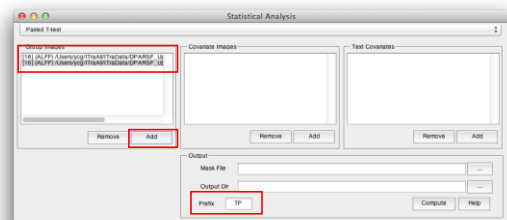


**Figure 3.** The between-condition differences of the ALFF within the DMN. The ALFF differences were found between the EC and EO conditions (A), and between the EC and ED conditions (B). The areas in the white contours denote the ROIs within the DMN. The numbers below the images refer to the x coordinates in the Talairach and Tournoux space. The statistical threshold was set at  $p < 0.05$  (FDR) and cluster size  $> 100$  voxels, which corresponds to a corrected  $p < 0.05$ . doi:10.1371/journal.pone.0005748.g003

Yan et al., 2009, PLoS ONE

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## Paired T-Test



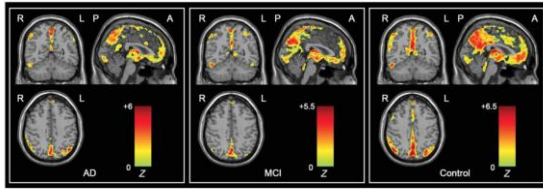
T Statistic Image

Condition 1 - Condition 2

Please make sure the correspondence

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## ANOVA or ANCOVA

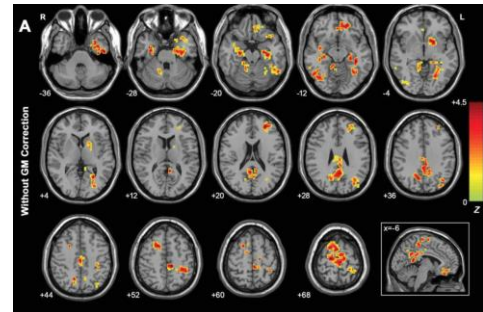


**Figure 1.** Within-group ALFF maps within the AD, MCI, and healthy elderly control groups. Visual inspection indicated that the PCC and adjacent PCu had the highest ALFF values within each group and had different strengths among the three groups. The statistical threshold was set as  $Z > 3.09$  ( $P < 0.001$ ) and cluster size  $> 189$  mm<sup>3</sup>, which corresponded to a corrected  $P < 0.001$ . R, right; L, left; P, posterior; A, anterior. [Color figure can be viewed in the online issue, which is available at [www.intellecta.com](http://www.intellecta.com).]

Wang<sup>a</sup>, Yan<sup>a</sup> et al., 2011, Hum Brain Mapp

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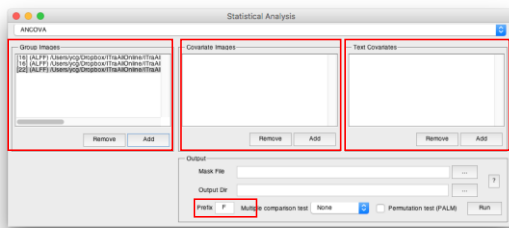
## ANOVA or ANCOVA



Wang<sup>a</sup>, Yan<sup>a</sup> et al., 2011, Hum Brain Mapp

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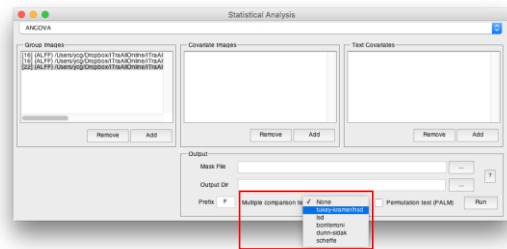
## ANOVA or ANCOVA



ANCOVA: e.g. gray matter proportion images (Oakes et al., 2007). Please make sure the correspondence between the statistical image and the covariate images (e.g. age, brain size, IQ, etc.).

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## ANOVA or ANCOVA



Post-hoc procedures: the corrected p values under a given control procedure for comparing group means of any pairs were calculated (e.g., through Studentized Range statistic for Tukey-Kramer correction) with the same route as MATLAB command `multcompare`. The p maps were then converted to Z maps according to the Normal inverse cumulative distribution function (`norminv`), with the sign of group mean differences applied.

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## ANOVA or ANCOVA



ANOVA F image

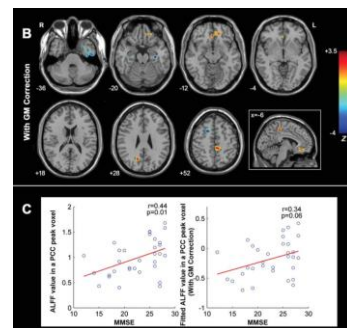
The difference of mean between groups

The corrected p of difference between groups

The corrected Z values of difference between groups, can be forwarded to further multiple comparison correction

Yan et al., 2016. Neuroinformatics

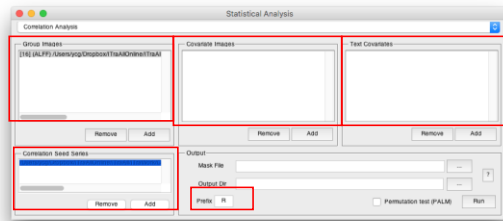
## Correlation Analysis



Wang<sup>a</sup>, Yan<sup>a</sup> et al., 2011, Hum Brain Mapp

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## Correlation Analysis

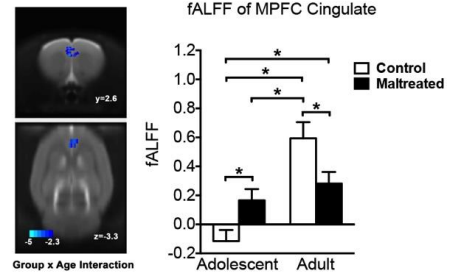


The imaging measure:  
ALFF maps

Traits: e.g.  
MMSE.txt  
19  
15  
...

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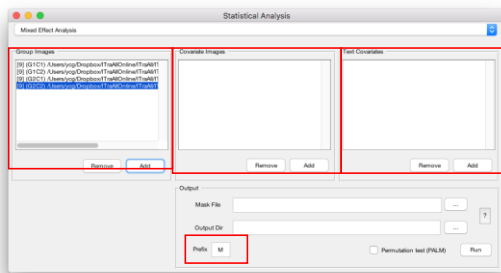
## Mixed Effect Analysis



Yan et al., 2016. Translational  
Psychiatry

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## Mixed Effect Analysis



The imaging measure  
should be:

Group1Condition1  
Group1Condition2  
Group2Condition1  
Group2Condition2

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## Mixed Effect Analysis

- \* **\_ConditionEffect\_T.nii** - the T values of condition differences (corresponding to the first condition minus the second condition) (WithinSubjectFactor)
- \* **\_Interaction\_F.nii** - the F values of interaction (BetweenSubjectFactor by WithinSubjectFactor)
- \* **\_Group\_TwoT.nii** - the T values of group differences (corresponding to the first group minus the second group). Of note: the two conditions will be averaged first for each subject. (BetweenSubjectFactor)

## Statistical Analysis

```
function [b_OLS_brain, t_OLS_brain, TF_FarContrast_brain, r_OLS_brain, Header] = y_GroupAnalysis_Image(DependentVolume, Predictor, OutputName,
% Function [b_OLS_brain, t_OLS_brain, TF_FarContrast_brain, r_OLS_brain, Header] = y_GroupAnalysis_Image(DependentVolume, Predictor, OutputName)
% Perform regression analysis
% Input:
%   DependentVolume - 4D data matrix (DimXDimXDimXDim) or the directory of 3D image data file or the filename of one 4D
%   Predictor - the Predictors M (subjects) by N (traits). SHOULD INCLUDE the CONSTANT column if needed. The program will not add constant 0
%   OutputName - the output name. Should not have extension such as .img, .nii
%   MaskFile - the mask file.
%   ContrastVolume - 4D data matrix (DimXDimXDimXDim) or the directory of image covariates, in which the files should be
%   Contrast - Contrast for T-test for F-test. 1xNcol matrix.
%   TF_Flag (optional) - 'T' or 'F'. Specify if T-test or F-test need to be performed for the contrast
%   IsOutputResidual (optional) - 1: output the 4D residuals.
%   % 0: don't output the 4D residuals.
%   Header (optional) - If DependentVolume is given as a 4D Brain matrix, then Header should be designated.
% Output:
%   OutputName_b.nii, OutputName_t.nii - beta and t value files results
%   OutputName_Residual.nii (optional) - Residual files
% Written by YIM Chan-Gan 120822.
% The Nathan Kline Institute for Psychiatric Research, 140 Old Orangeburg Road, Orangeburg, NY 10962, USA
% Child Mind Institute, 445 Park Avenue, New York, NY 10022, USA
% The Phyllis Green and Randolph Cowen Institute for Pediatric Neuroscience, New York University Child Study Center, New York, NY 10010, USA
% ycg.yimg@gmail.com
```

{DPABI\_Dir}/StatisticalAnalysis/y\_GroupAnalysis\_Image.m

## Statistical Analysis



## Statistical Analysis

```
function [b_OLS_brain, t_OLS_brain, TF_FarContrast_brain, r_OLS_brain, Header] = y_GroupAnalysis_Image(DependentVolume, Predictor, OutputName, I)
% Function [b_OLS_brain, t_OLS_brain, TF_FarContrast_brain, r_OLS_brain, Header] = y_GroupAnalysis_Image(DependentVolume, Predictor, OutputName, I)
% Perform regression analysis
% Input:
%   DependentVolume - 4D data matrix (Dim1xDim2xDim3xDim4) or the directory of 3D image data file or the filename of one 4D
%   Predictor - 1xN Predictors M (subjects) by N (traits), SHOULD INCLUDE the CONSTANT column if needed. The program will not add constant 0
%   OutputName - the output name, (should not have extension such as .img, .nii)
%   MaskFile - the mask file.
%   Covolume - optional - 4D data matrix (Dim1xDim2xDim3xDim4) or the directory of image covariates, in which the files should be
%   Contrast - optional - Contrast for T-test for F-test, incolex matrix.
%   TF_Flag - optional - 't' or 'f', Specify if T-test or F-test need to be performed for the contrast
%   IsOutputResidual - optional - 1: output the 4D residuals.
%   Header - optional - If DependentVolume is given as a 4D Brain matrix, then Header should be designated.
% Output:
%   OutputName_b.nii, OutputName_t.nii - beta and t value files results
%   OutputName_Residual.nii (optional) - Residual files
% Written by YHM Chao-Gan 120823.
% The Nathan Kline Institute for Psychiatric Research, 140 Old Orangeburg Road, Orangeburg, NY 10962, USA
% Child Mind Institute, 400 Park Avenue, New York, NY 10022, USA
% The Phyllis Green and Randolph Cowen Institute for Pediatric Neuroscience, New York University Child Study Center, New York, NY 10016, USA
% ycg-yong@gmail.com
```

(DPABI\_Dir)/StatisticalAnalysis/y\_GroupAnalysis\_Image.m

Smoothness estimation based on the 4D residual is built in this function!!!

## Statistical Analysis

<http://fmri.org/DemoData>

(Download)/ProcessingDemoData/StatisticalDemo/AD\_MCI\_NC/

ALFF: AD – NC Two Sample T Test:

- Applied smooth kernel in preprocessing: [4 4 4]
- Smooth kernel estimated on 4D residual: [6.77 6.88 6.71]
- Smooth kernel estimated on statistical image (T to Z, as in easythresh): [6.90 7.33 6.94]

ReHo: AD – NC Two Sample T Test:

- Applied smooth kernel in preprocessing: [4 4 4]
- Smooth kernel estimated on 4D residual: [8.10 8.50 7.93]
- Smooth kernel estimated on statistical image (T to Z, as in easythresh): [8.33 8.94 8.24]

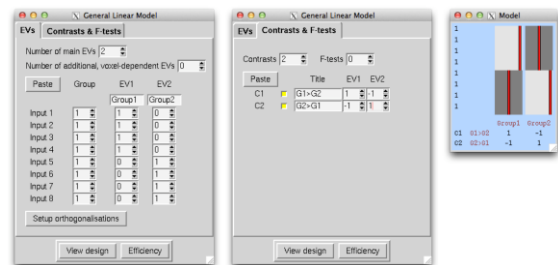
Thus, only using smooth kernel applied in preprocessing is NOT sufficient!!!



## Statistical Analysis

```
function [b_OLS_brain, t_OLS_brain, TF_FarContrast_brain, r_OLS_brain, Header] = y_GroupAnalysis_Image(DependentVolume, Predictor, OutputName, I)
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% Perform regression analysis
% Input:
%   DependentVolume - 4D data matrix (Dim1xDim2xDim3xDim4) or the directory of 3D image data file or the filename of one 4D
%   Predictor - 1xN Predictors M (subjects) by N (traits), SHOULD INCLUDE the CONSTANT column if needed. The program will not add constant 0
%   OutputName - the output name, (should not have extension such as .img, .nii)
%   MaskFile - the mask file.
%   Covolume - optional - 4D data matrix (Dim1xDim2xDim3xDim4) or the directory of image covariates, in which the files should be
%   Contrast - optional - Contrast for T-test for F-test, incolex matrix.
%   TF_Flag - optional - 't' or 'f', Specify if T-test or F-test need to be performed for the contrast
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% Output:
%   OutputName_b.nii, OutputName_t.nii - beta and t value files results
%   OutputName_Residual.nii (optional) - Residual files
% Written by YHM Chao-Gan 120823.
% The Nathan Kline Institute for Psychiatric Research, 140 Old Orangeburg Road, Orangeburg, NY 10962, USA
% Child Mind Institute, 400 Park Avenue, New York, NY 10022, USA
% The Phyllis Green and Randolph Cowen Institute for Pediatric Neuroscience, New York University Child Study Center, New York, NY 10016, USA
% ycg-yong@gmail.com
```

## Statistical Analysis



<http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/GLM>

## Statistical Analysis



<http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/GLM>

## Statistical Analysis



**Multiple Comparison Correction**



## Multiple Comparison Correction



Eklund

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## Multiple Comparison Correction

... I estimate about 15,000 papers use cluster size inference with correction for multiple testing; of these, around 3,500 use a CDT of  $P=0.01$ ... So, are we saying 3,500 papers are "wrong"? It depends....

-- Thomas Nichols  
July 06, 2016

### Correction

**NEUROSCIENCE, STATISTICS**  
Correction for "Cluster failure: Why fMRI inferences for spatial extent have inflated false-positive rates," by Anders Eklund, Thomas E. Nichols, and Håkan Knutsson, which appeared in issue 28, July 12, 2016, of *Proc. Natl. Acad. Sci. USA* (113:7900–7905; first published June 28, 2016; 10.1073/pnas.1602413113).

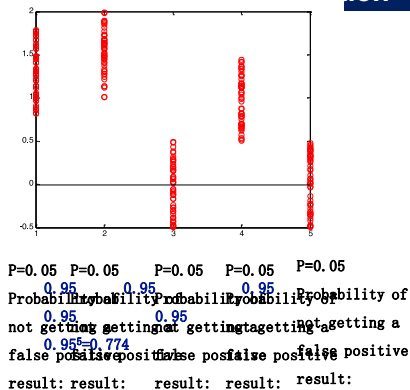
The authors note that on page 7900, in the Significance Statement, lines 3–4, "These results question the validity of some 40,000 fMRI studies and may have a large impact on the interpretation of neuroimaging results" should instead appear as, "These results question the validity of a number of fMRI studies and may have a large impact on the interpretation of weakly significant neuroimaging results."

Additionally, the authors note that on page 7904, left column, fifth full paragraph, lines 1–3, "It is not feasible to redo 40,000 fMRI studies, and lamentable archiving and data-sharing practices mean most could not be reanalyzed either" should instead appear as "Due to lamentable archiving and data-sharing practices, it is unlikely that problematic analyses can be redone."

These errors do not affect the conclusions of the article. The online version has been corrected.

[www.pnas.org/doi/10.1073/pnas.1612031113](https://www.pnas.org/doi/10.1073/pnas.1612031113)

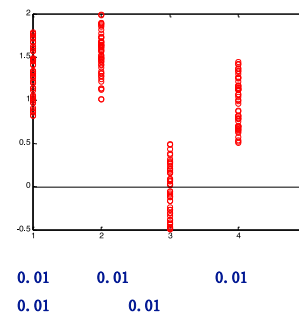
## Multiple Comparison Correction



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## Multiple Comparison Correction

Bonferroni correction:  $p=0.05/5=0.01$



## Multiple Comparison Correction

- False Discovery Rates (FDR) correction
- Family-Wise Error (FWE) correction
  - Bonferroni correction:  $0.05/5=0.01$
  - Gaussian Random Field theory correction
  - Monte Carlo simulations (AlphaSim)
  - Threshold-Free Cluster Enhancement
  - Permutation test

## FDR Theory

Number of errors committed when testing  $m$  null hypotheses

	Declared non-significant	Declared significant	Total
True null hypotheses	U	V	$m_0$
Non-true null hypotheses	T	S	$m - m_0$
	$m - R$	R	$m$

- False discovery rate

$$Q_0 = E(V/(V+S)) = E(V/R)$$

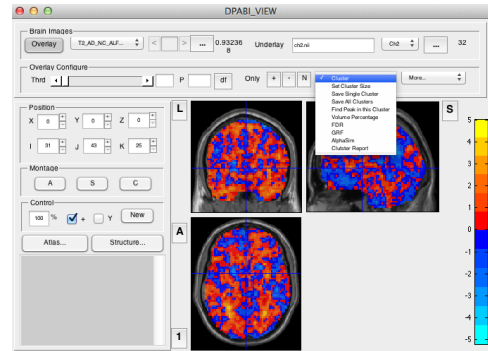
Benjamini and Hochberg, 1995, Journal of the Royal Statistical Society

## FDR Theory

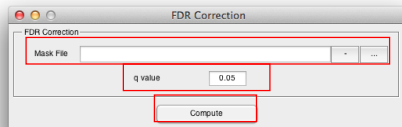
• Let  $H_1, \dots, H_m$  be the null hypotheses and  $P_1, \dots, P_m$  their corresponding p-values. Order these values in increasing order and denote them by  $P_{(1)}, \dots, P_{(m)}$ . For a given  $q$ , find the largest  $k$  such that  $P_{(k)} \leq kq/m$ .

• Then reject (i.e. declare positive) all  $H_{(i)}$  for  $i = 1, \dots, k$ .

## FDR Theory

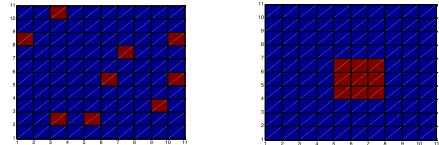


## FDR Theory



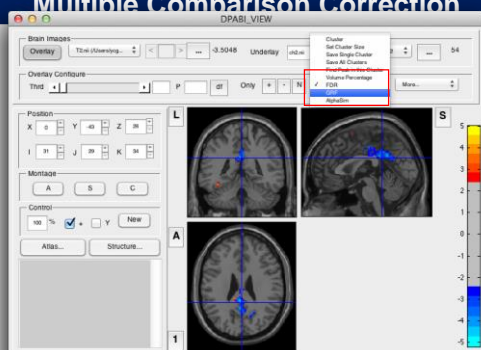
## Multiple Comparison Correction

Gaussian Random Field Theory Correction  
Monte Carlo simulations (AlphaSim)

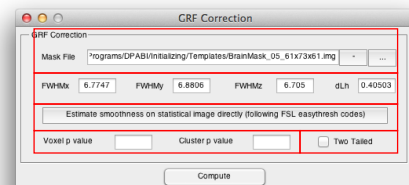


?

## Multiple Comparison Correction

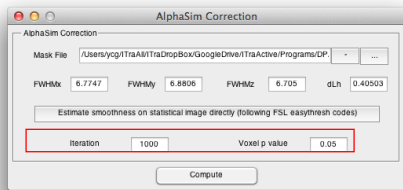


## Multiple Comparison Correction



Voxel  $Z > 2.3$ , Cluster  $P < 0.05$ , Two One-Tailed Corrections:  
equivalent to  
Voxel  $P < 0.0214$ , Cluster  $P < 0.1$ , Two Tailed.

## Multiple Comparison Correction



## Multiple Comparison Correction

CI Size	Frequency	Cum Prop	p/Voxel	Max Freq	Alpha
1	235971	0.619898	0.009613	0	1.000000
2	76150	0.819945	0.006282	0	1.000000
3	32297	0.904789	0.004131	0	1.000000
4	15940	0.946664	0.002763	0	1.000000
5	8476	0.968930	0.001863	0	1.000000
6	4786	0.981503	0.001265	1	1.000000
7	2767	0.988772	0.000860	19	0.999000
8	1606	0.992991	0.000586	51	0.980000
9	1011	0.995647	0.000405	127	0.929000
10	585	0.997184	0.000276	132	0.802000
11	391	0.998211	0.000194	172	0.670000
12	236	0.998831	0.000133	146	0.498000
13	164	0.999262	0.000093	107	0.352000
14	98	0.999519	0.000063	78	0.245000
15	69	0.999701	0.000043	61	0.167000
16	37	0.999798	0.000029	30	0.106000
17	22	0.999856	0.000020	22	0.076000
18	22	0.999913	0.000015	21	0.054000
19	11	0.999942	0.000010	11	0.033000
20	7	0.999961	0.000007	7	0.022000
21	5	0.999974	0.000005	5	0.015000
22	5	0.999987	0.000003	5	0.010000
23	4	0.999997	0.000002	4	0.005000
24	1	1.000000	0.000000	1	0.001000

## Threshold-Free Cluster Enhancement (TFCE)

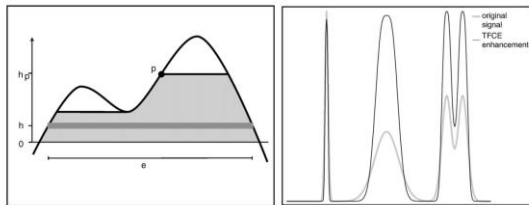
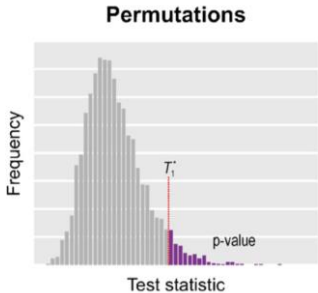


Fig. 1. Illustration of the TFCE approach. Left: the TFCE score at voxel  $p$  is given by the sum of the scores of all incremental supporting sections (see such as shown as the dark-grey band) within the area of 'support' of  $p$  (light grey). The score for each section is a simple function of its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

## Permutation Test



Winkler et al., 2016. Neuroimage

## Multiple Comparison Correction

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

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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)

Eklund et al., 2016. PNAS

## Multiple Comparison Correction

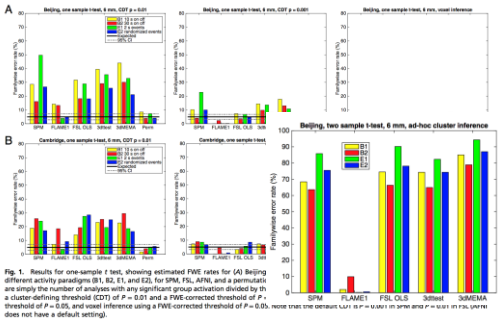


Fig. 1. Results for one-sample t test, showing estimated FWE rates for (A) Beijing different activity paradigms (B1, B2, E1, and E2, for SPM, FSL, AFNI, and a permutation test) and (B) the same paradigms with a cluster-defining threshold (CDT) of  $P = 0.01$  and a FWE-corrected threshold of  $P = 0.05$ , and voxel inference using a FWE-corrected threshold of  $P = 0.05$ , where one voxel is significant only if  $P = 0.05$  in both SPM and FSL, and one voxel is not significant in any of the three methods.

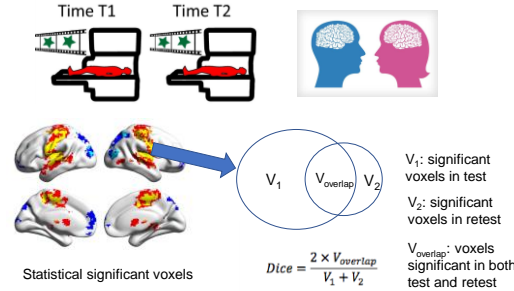
Eklund et al., 2016. PNAS



Test-retest Reliability

Test-retest reliability

Sex differences in test and retest



Statistical significant voxels

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

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 PTA-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
CBF (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
	$P < 0.01$ ( $Z > 2.58$ )		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
	$P < 0.003$ ( $Z > 3.29$ )	$P < 0.05$	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-VOL			0.66	0.54	0.48	0.37	0.35	0.65	0.53	0.36	0.24	0.34
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

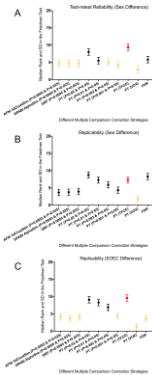
> Moderate test-retest reliability  
> ALFF, fALFF, ReHo are better than DC and VMHC  
Chen, Lu, Yan\*, 2018. Human Brain Mapping

212 M vs. 208 F × 2 times

74

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

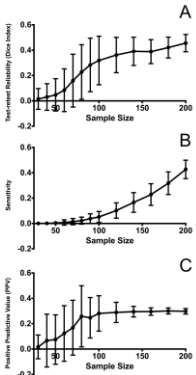


Chen, Lu, Yan\*, 2018. Human Brain Mapping

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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

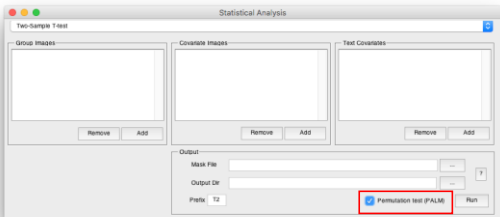
76

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).

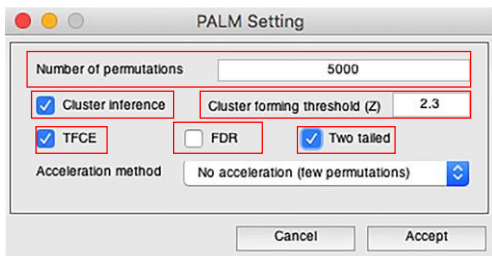
77

Permutation Test



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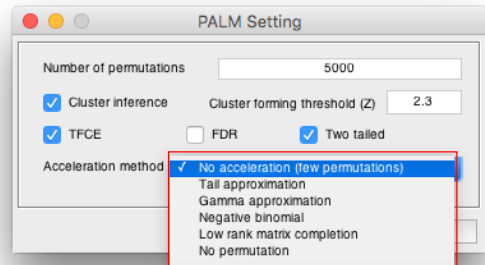
## Permutation Test



Based on PALM: Winkler, A.M., Ridgway, G.R., Douaud, G., Nichols, T.E., Smith, S.M., 2016. Faster permutation inference in brain imaging. Neuroimage 141, 502-516.

79

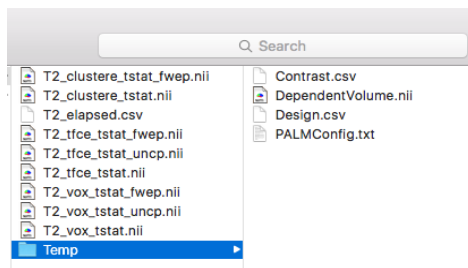
## Permutation Test



Based on PALM: Winkler, A.M., Ridgway, G.R., Douaud, G., Nichols, T.E., Smith, S.M., 2016. Faster permutation inference in brain imaging. Neuroimage 141, 502-516.

80

## Permutation Test

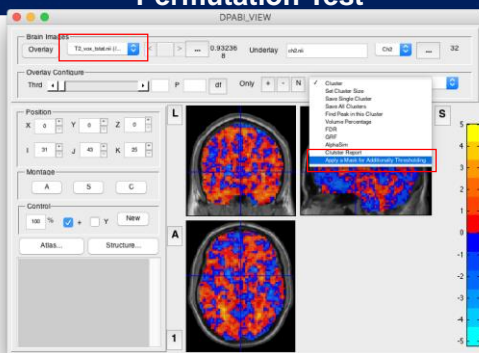


Based on PALM: Winkler, A.M., Ridgway, G.R., Douaud, G., Nichols, T.E., Smith, S.M., 2016. Faster permutation inference in brain imaging. Neuroimage 141, 502-516.

## Permutation Test

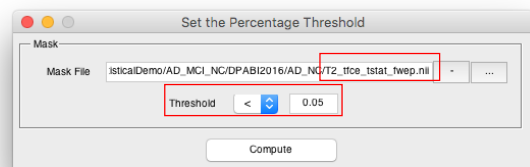
1. `_vox_tstat.nii` is the T value of a voxel.
2. `_vox_tstat_uncp.nii` is the p value corresponds to the rank of the observed T value within the permutations FOR A GIVEN VOXEL (the null distribution is the permuted T values of that given voxel). Computing the rank is one of the ways in which the p-value can be obtained (it's then divided by the number of permutations).
3. `_vox_tstat_fwep.nii` is the p value corresponds to the rank of the observed T value within the permutations of maximum T values across all the voxels (the null distribution is composed by the maximum T value across all the voxels for each permutation). For the corrected, the distribution of the maximum is used as reference, and the rank (or quantile) of a given voxel in relation to that distribution is used to obtain p-values.
4. `_clustere_tstat.nii` is simply the size (in voxels) of the cluster. This number acts as the test statistic.
4. `_clustere_tstat_fwep.nii`: p-values computed in the same way as 3, i.e., using the distribution of the maximum cluster size.
5. The TFCE maps are similar to Points 1, 2 and 3.

## Permutation Test

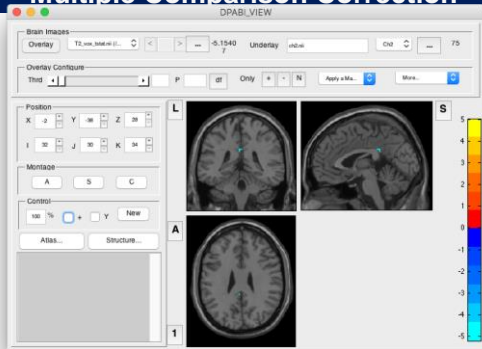


83

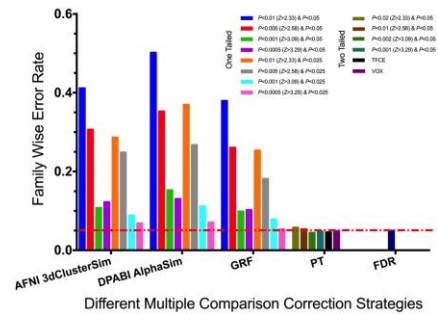
## Permutation Test



## Multiple Comparison Correction



## Multiple Comparison Correction



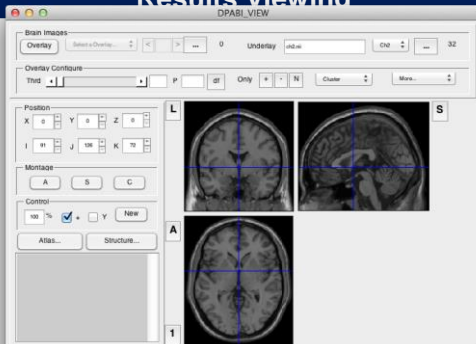
Chen, Lu, Yan\*, Human brain mapp. 2017. 20 vs. 20 Permutation 1000 times

## Outline

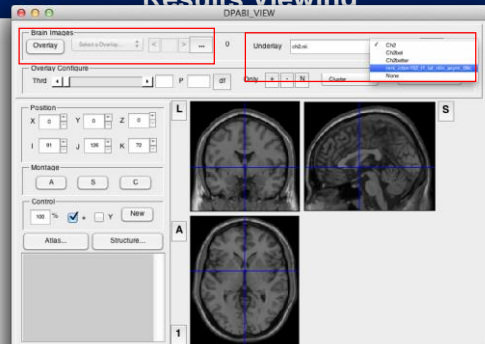
- **Quality Control**
- **Statistical Analysis**
- **Results Viewing**



## Results Viewing

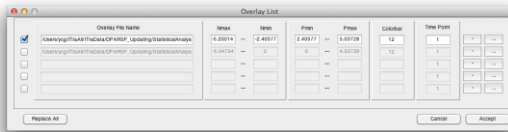


## Results Viewing

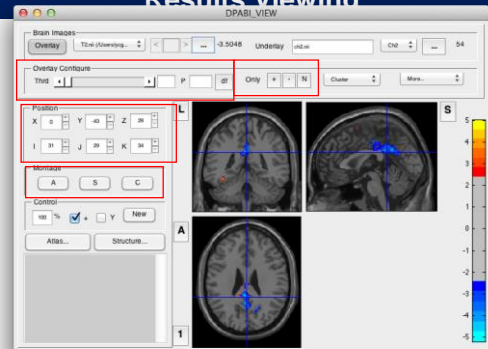




## Results Viewing

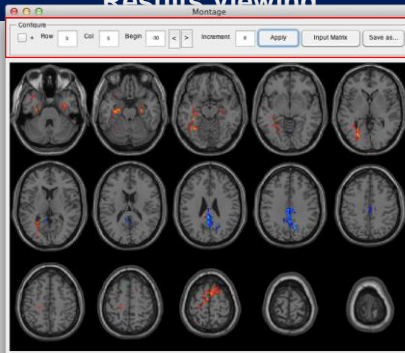


## Results Viewing



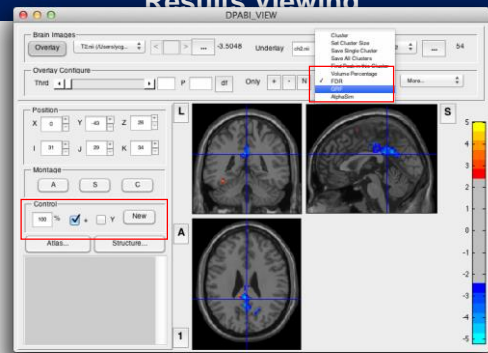
92

## Results Viewing



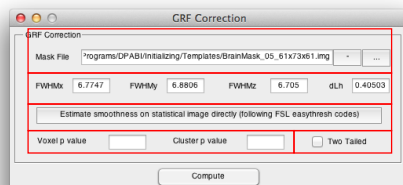
93

## Results Viewing



94

## Results Viewing



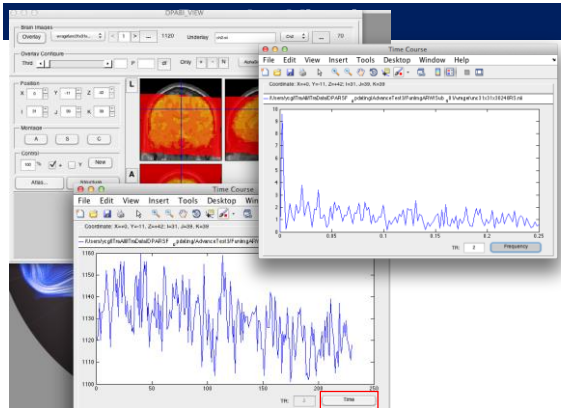
Voxel  $Z > 2.3$ , Cluster  $P < 0.05$ , Two One-Tailed Corrections:  
equivalent to  
Voxel  $P < 0.0214$ , Cluster  $P < 0.1$ , Two Tailed.

95

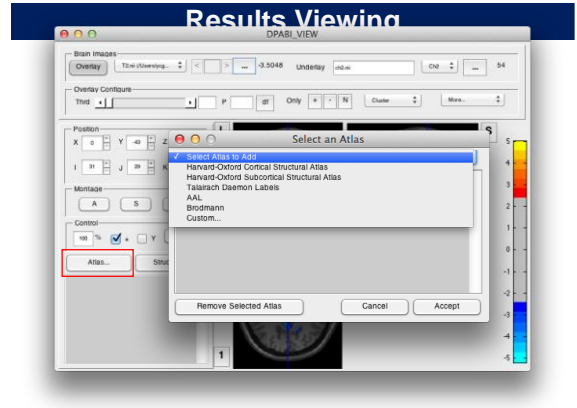
## Results Viewing



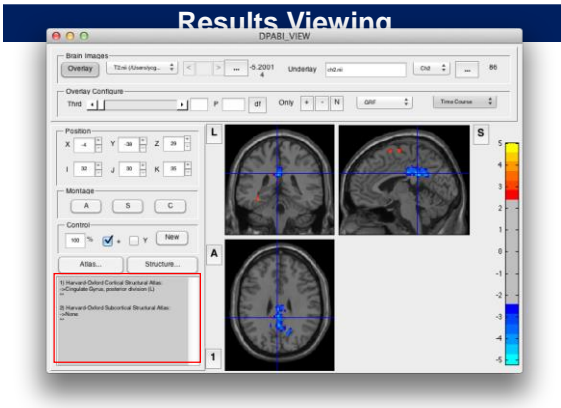




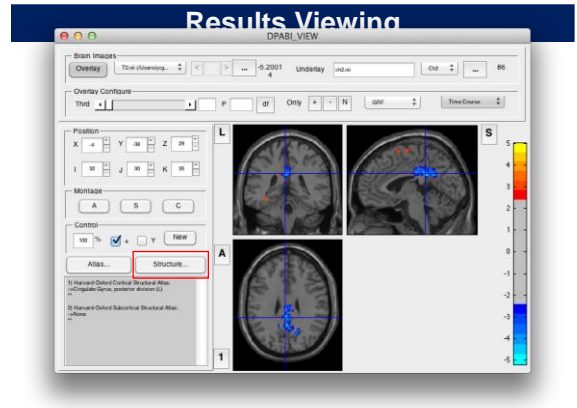
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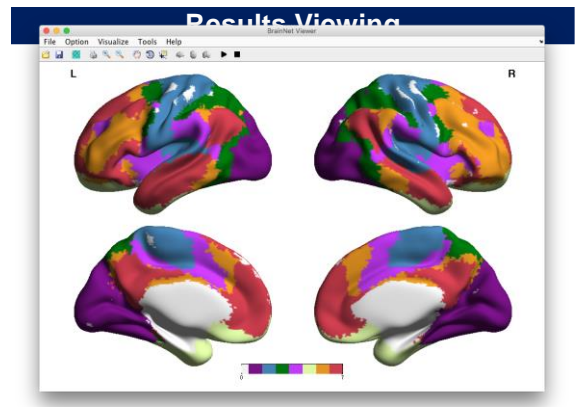
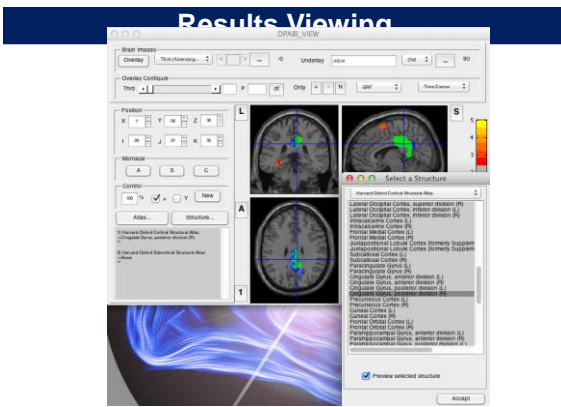
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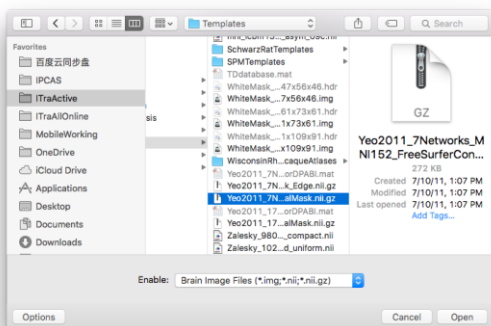
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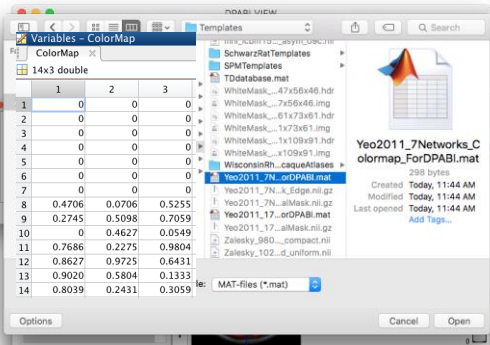
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## Results Viewing

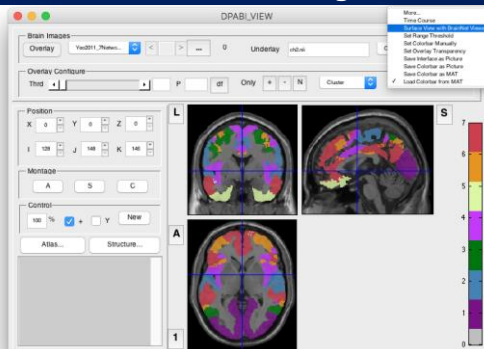


## Results Viewing

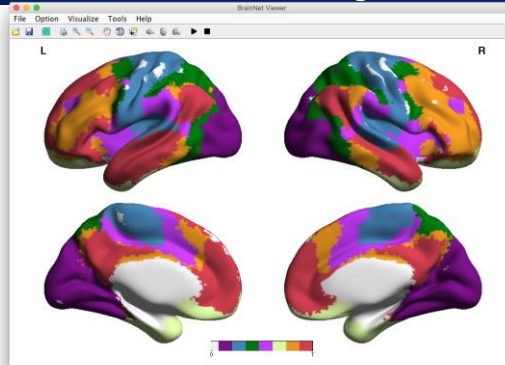


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## Results Viewing



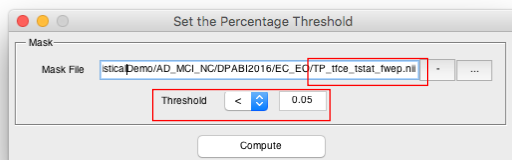
## Results Viewing



## Results Viewing



## Permutation Test





## DPABI计算工作站

DPABI计算工作站	台式服务器
2. (Linux/Windows) DPABI Computational Core	20核X86服务器(四路E114 2.2G +2.0 GCT/2x 2UPL1488 Turbo HT85W) 4*16GB RDIMM 64CPR9 2866MT/s 4*1TB 7.2K RPM SASL 1575转速 7.5年电 源 RAID卡 H330L DVD-RW 双电 三年服务

<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

## Acknowledgments



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

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

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**Thanks for your attention!**

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