



Data Processing of Resting-State fMRI: DPARSF

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DPARSF

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

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Resting-state functional magnetic resonance imaging (fMRI) has attracted more and more attention because of its effectiveness, simplicity and non-invasiveness in exploration of the intrinsic functional architecture of the human brain. However, user-friendly toolbox for "pipeline" data analysis of resting-state fMRI is still lacking. Based on some functions in Statistical Parametric Mapping (SPM) and Resting-State fMRI Data Analysis Toolkit (REST), we have developed a MATLAB toolbox called Data Processing Assistant for Resting-State fMRI (DPARSF) for "pipeline" data analysis of resting-state fMRI. After the user arranges the Digital Imaging and Communications in Medicine (DICOM) files and click a few buttons to set parameters, DPARSF will then give all the preprocessed (slice timing, realign, normalize, smooth) data and results for functional connectivity, regional homogeneity, amplitude of low-frequency fluctuation (ALFF), and fractional ALFF. DPARSF can also create a report for excluding subjects with excessive head motion and generate a set of pictures for easily checking the effect of normalization. In addition, users can also use DPARSF to extract time courses from regions of interest.

Keywords: data analysis, DPARSF, REST, resting-state fMRI, SPM

(Yan and Zang, 2010)

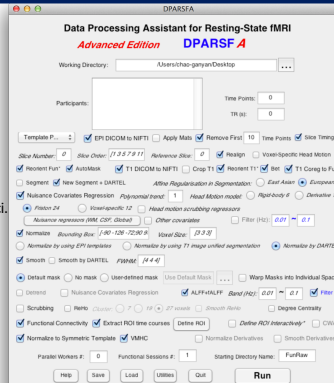
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DPARSF

Data Processing Assistant for Resting-State fMRI (DPARSF)

Yan and Zang, 2010. Front Syst Neurosci.

<http://rfmri.org/DPARSF>





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DPABI

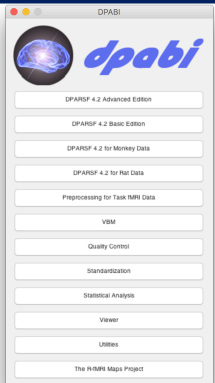
DPABI: a toolbox for Data Processing & Analysis of Brain Imaging

License: GNU GPL

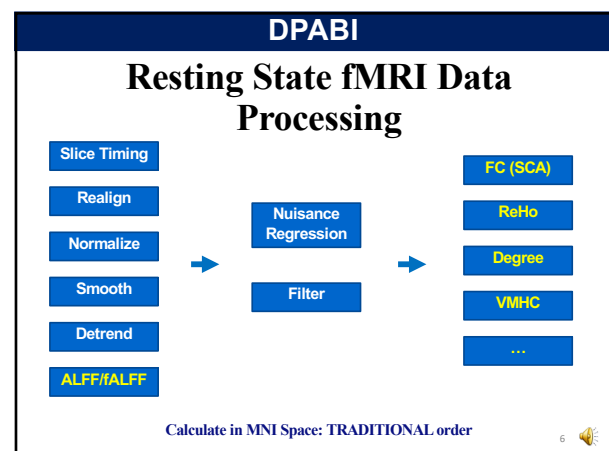
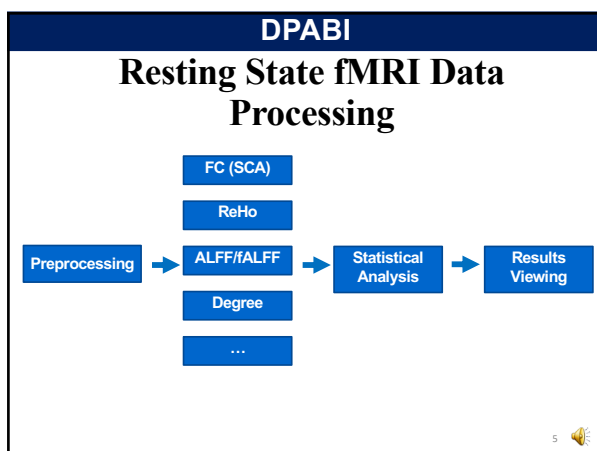

 Chao-Gan Yan
 Programmer
 Initiator

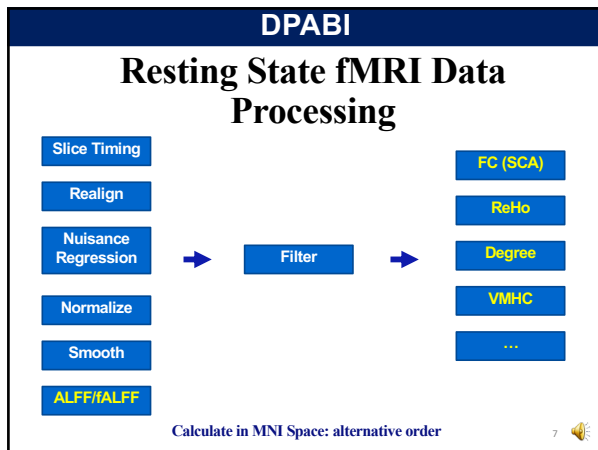

 Xin-Di Wang
 Programmer

<http://rfmri.org/dpabi>
<http://dpabi.org>

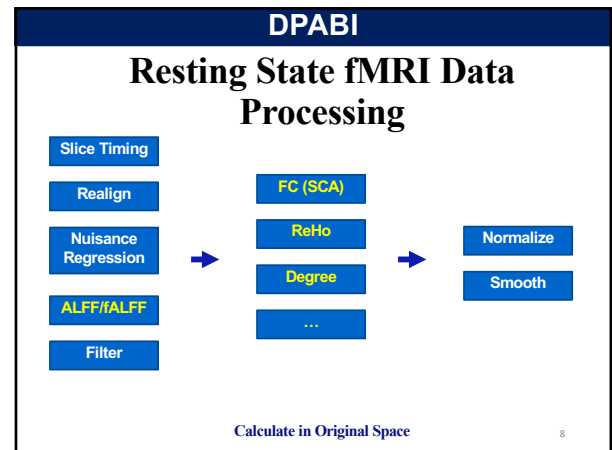


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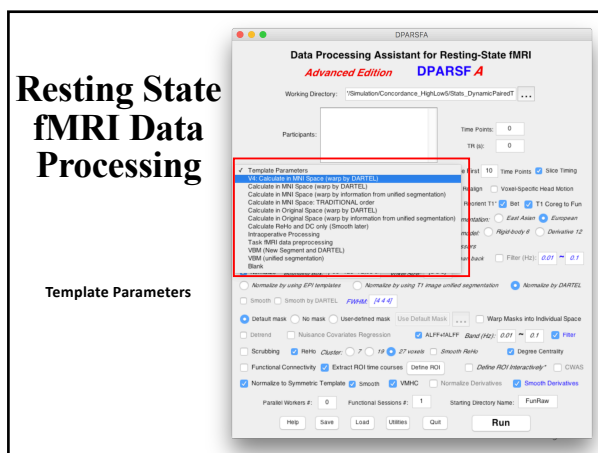




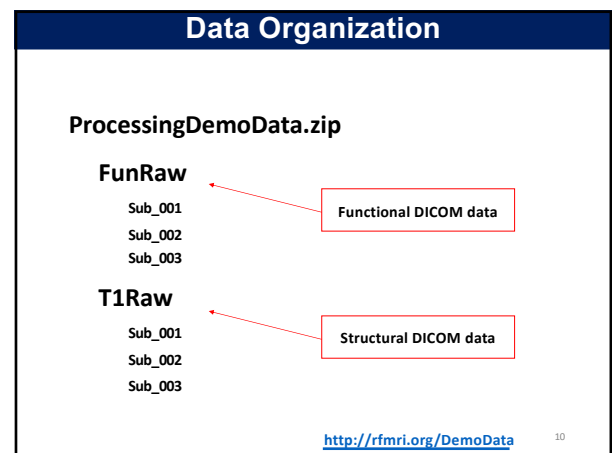
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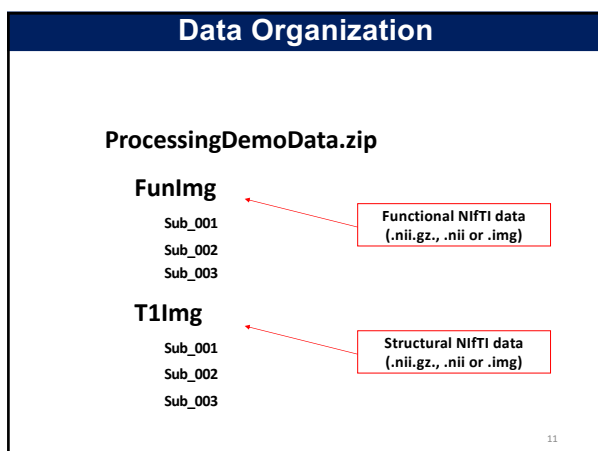
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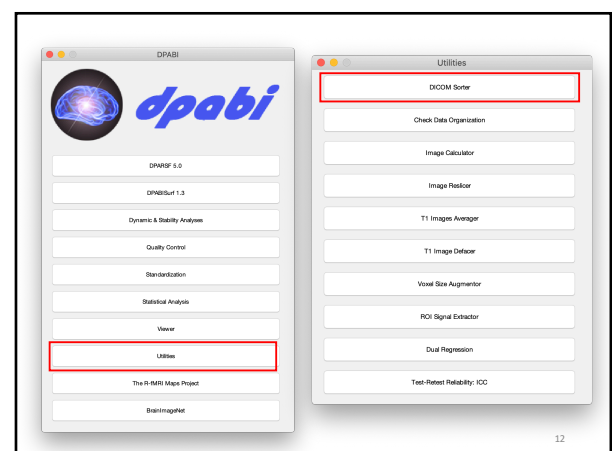
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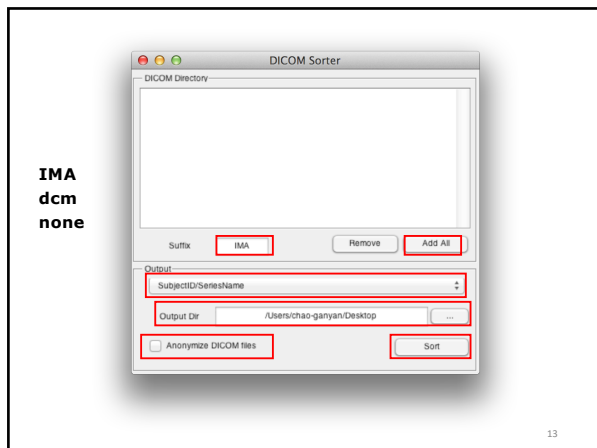
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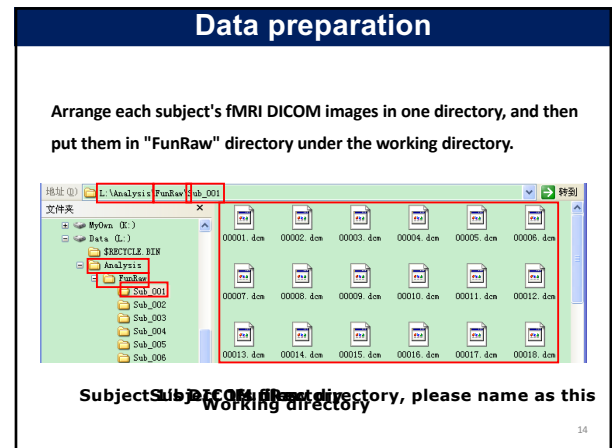
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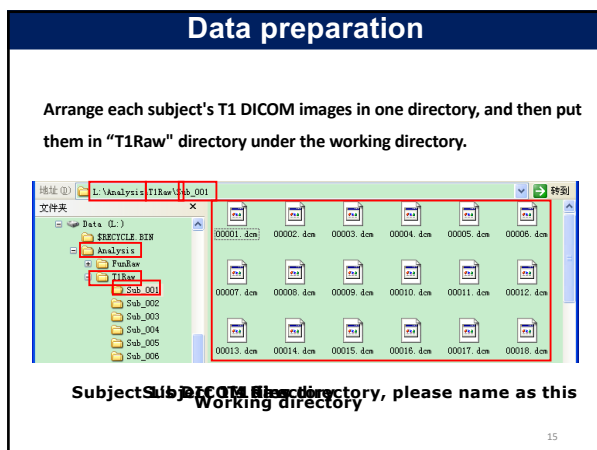
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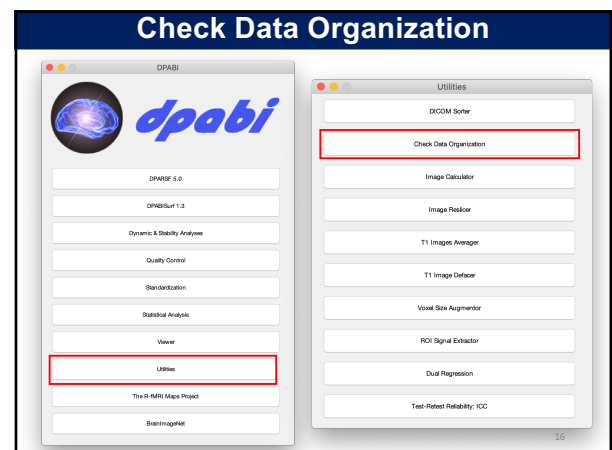
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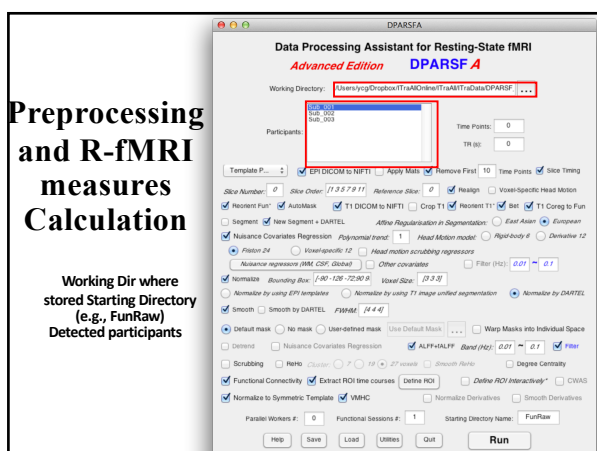
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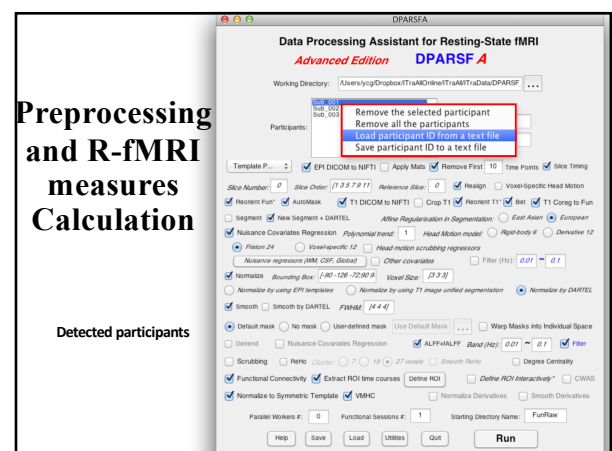
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Preprocessing and R-fMRI measures Calculation

Number of time points (if 0, detect automatically)
TR (if 0, detect from NIFTI header)

Template Parameters

DICOM to NIFTI, based on MRICron's dcm2nii
If start from BIDS data

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Preprocessing and R-fMRI measures Calculation

Apply reorientation matrices

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Preprocessing and R-fMRI measures Calculation

Apply reorientation matrices:

ReorientMats

Rename to:

DownloadedReorientMats

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Preprocessing and R-fMRI measures Calculation

Apply reorientation matrices:

ReorientMats

Rename to:

DownloadedReorientMats

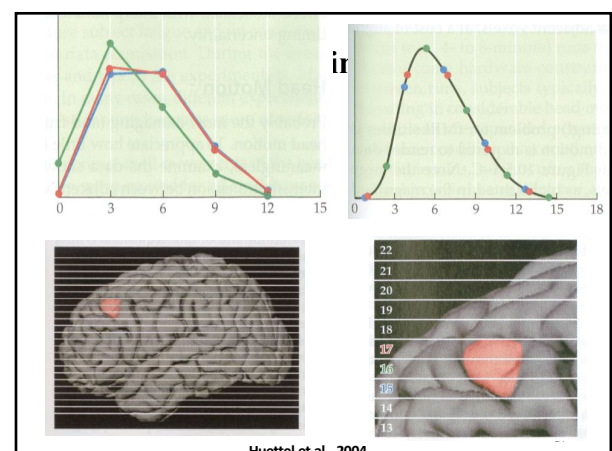
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Preprocessing and R-fMRI measures Calculation

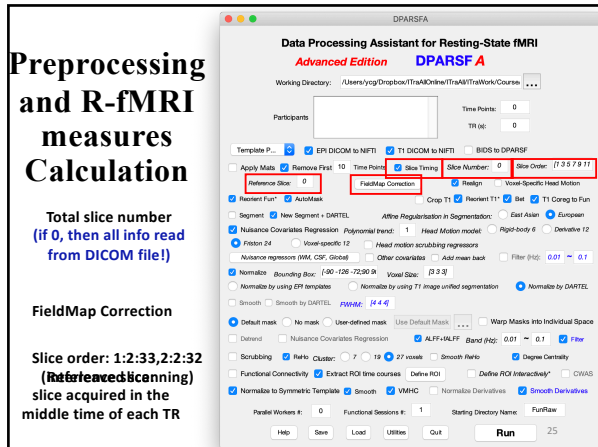
Remove several first time points

Slice Timing

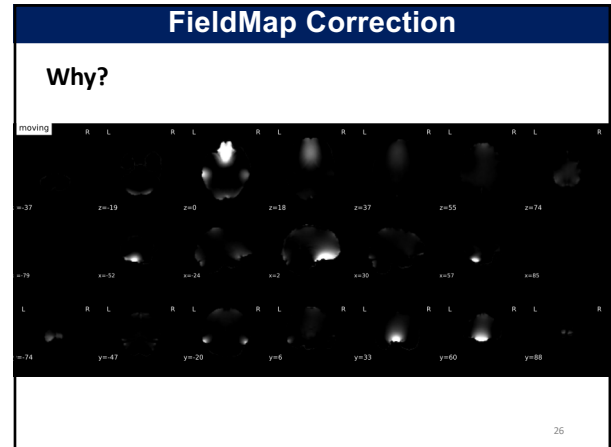
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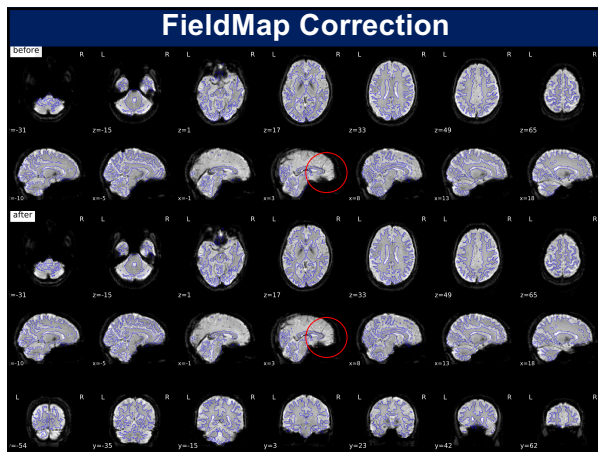
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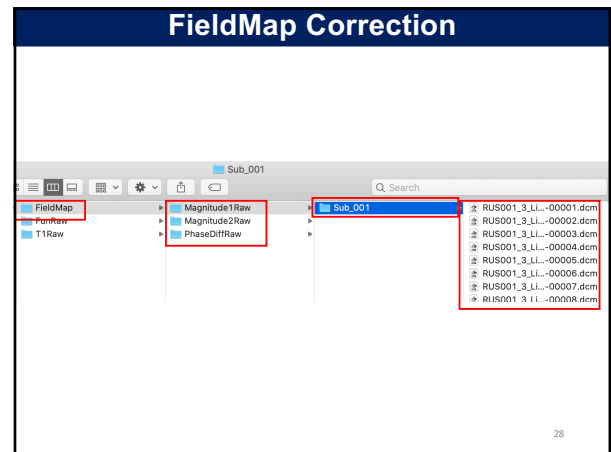
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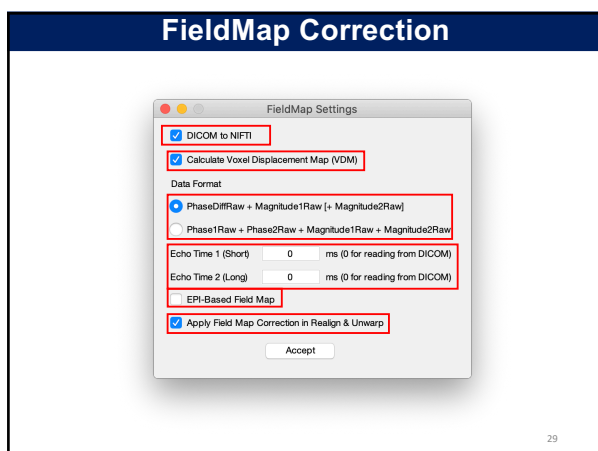
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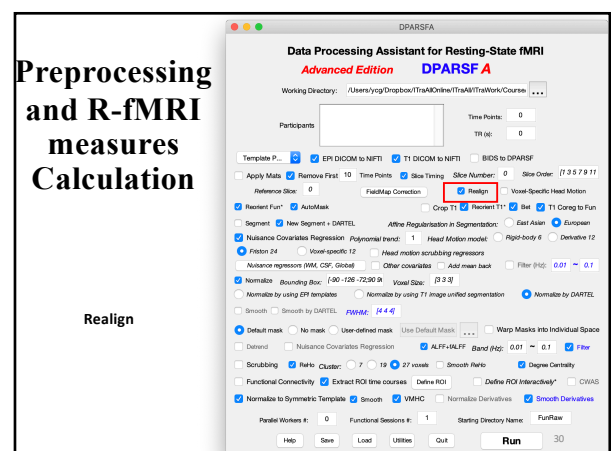
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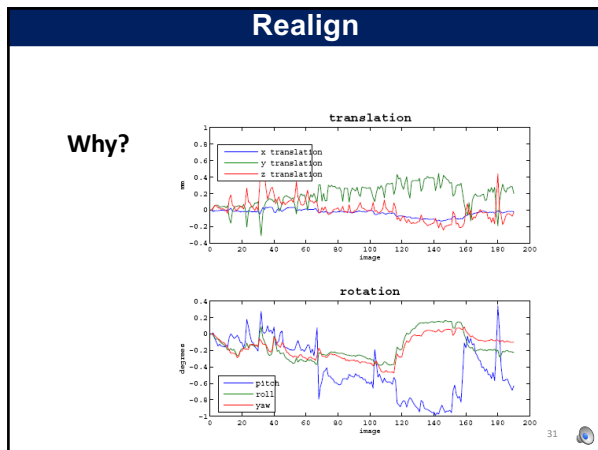
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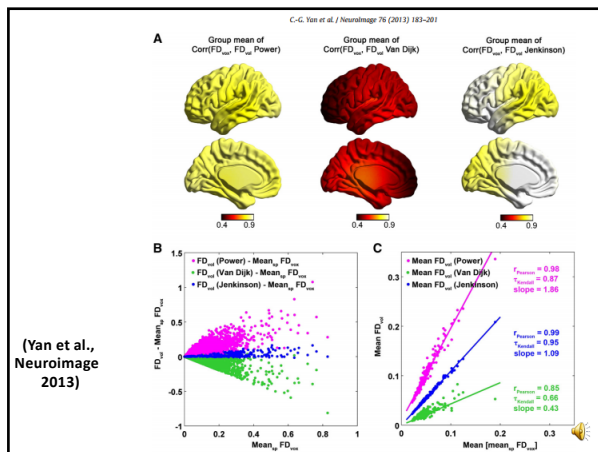
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Realign

Check head motion:
`{WorkingDir}\RealignParameter\Sub_XXX:`
rp_*.txt: realign parameters
FD_Power_*.txt: Frame-wise Displacement (Power et al., 2012)
FD_VanDijk_*.txt: Relative Displacement (Van Dijk et al., 2012)
FD_Jenkinson_*.txt: Relative RMS (Jenkinson et al., 2002)

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Realign

Excluding Criteria: 2.5mm and 2.5 degree in max head motion
None

Check head motion:
`{WorkingDir}\RealignParameter\Sub_XXX:`
rp_*.txt: realign parameters
FD_Power_*.txt: Frame-wise Displacement (Power et al., 2012)
FD_VanDijk_*.txt: Relative Displacement (Van Dijk et al., 2012)
FD_Jenkinson_*.txt: Relative RMS (Jenkinson et al., 2002)

Excluding Criteria: 2.0mm and 2.0 degree in max head motion
Sub_013

Excluding Criteria: 1.5mm and 1.5 degree in max head motion
Sub_013

Excluding Criteria: 1.0mm and 1.0 degree in max head motion
Sub_007
Sub_012
Sub_013
Sub_017
Sub_018

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Realign

Check head motion:
HeadMotion.csv: head motion characteristics for each subject
 (e.g., max or mean motion, mean FD, # or % of FD>0.2)

Threshold:
 Group mean (mean FD) + 2 * Group SD (mean FD)

Yan et al., in press Neuroimage; Di Martino, in press, Mol Psychiatry

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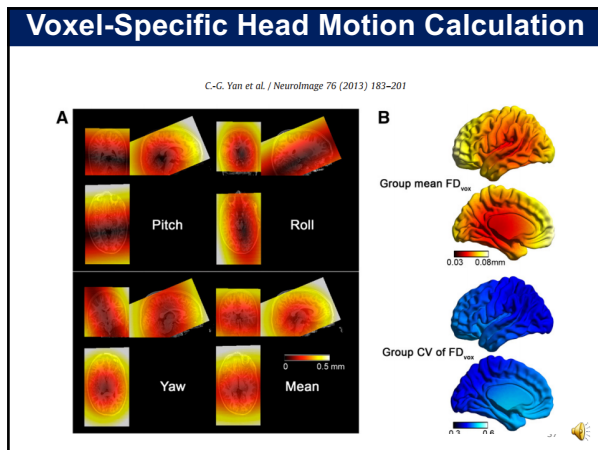
Preprocessing and R-fMRI measures Calculation

Voxel-Specific Head Motion Calculation

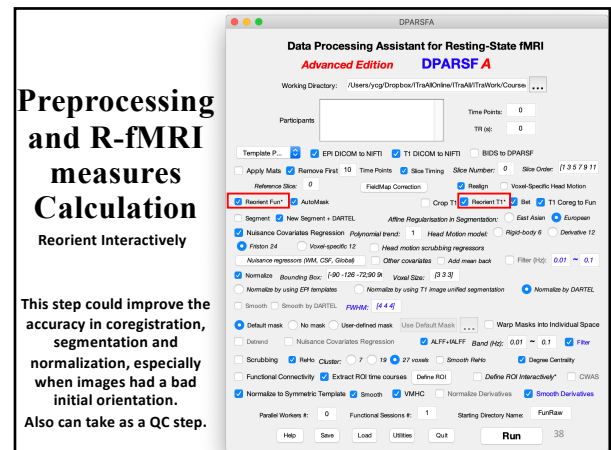
(Yan et al., Neuroimage 2013)

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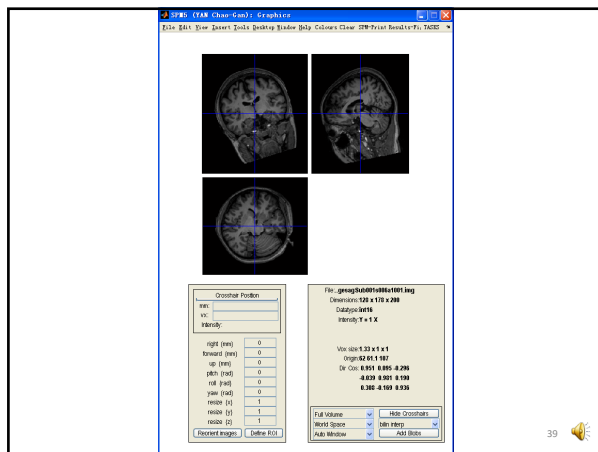
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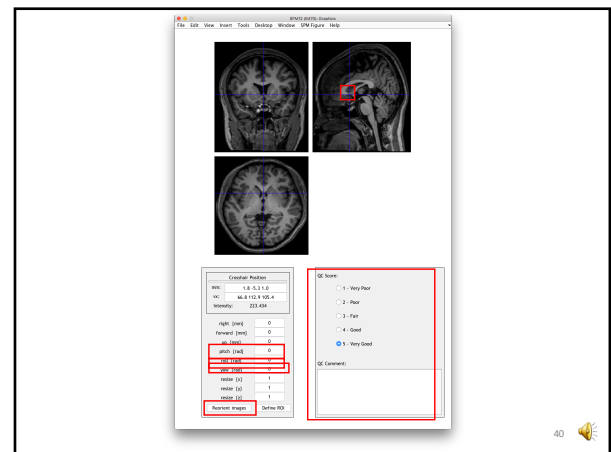
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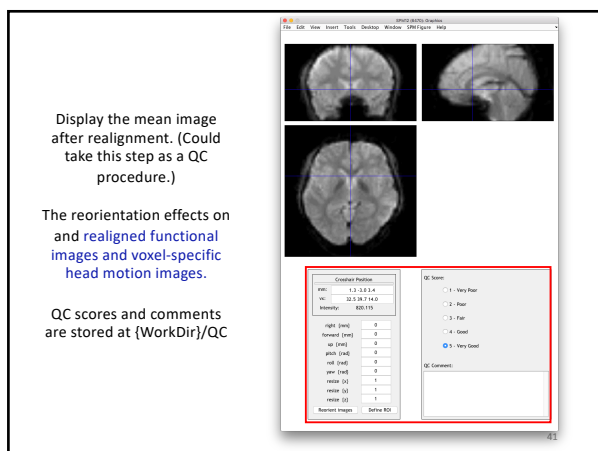
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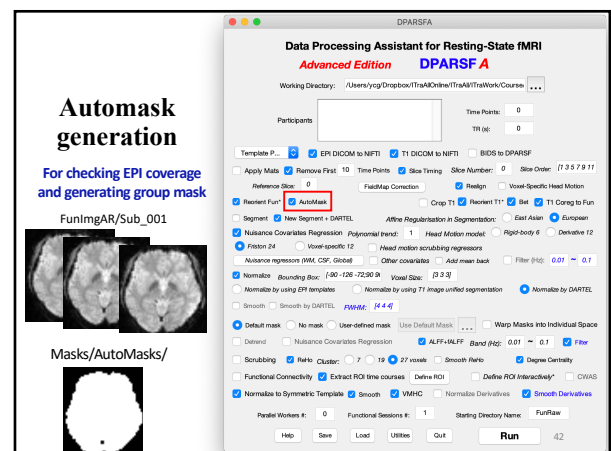
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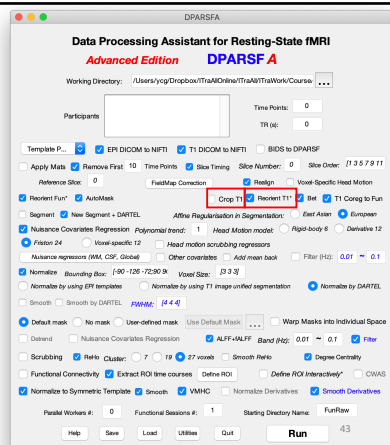
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Preprocessing and R-fMRI measures Calculation

Crop T1 image (.nii, .nii.gz, .img)
(based on MRICron's Dcm2nii)
Reorient T1 image Interactively



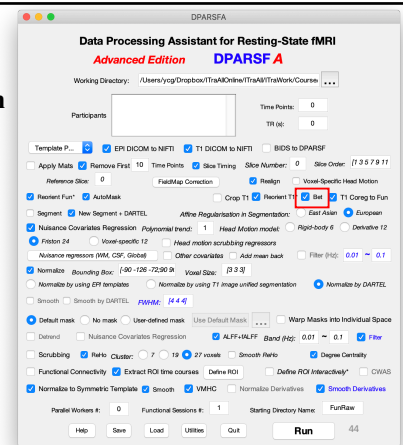
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Brain extraction (Skullstrip)

For better coregistration

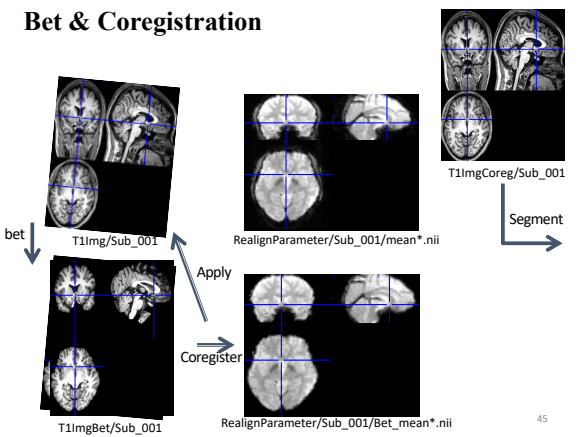
For Linux and Mac:
Need to install FSL or dpabi docker.

For Windows:
Thanks to Chris Rorden's compiled version of bet in MRICron, our modified version can work on Nifti images directly.



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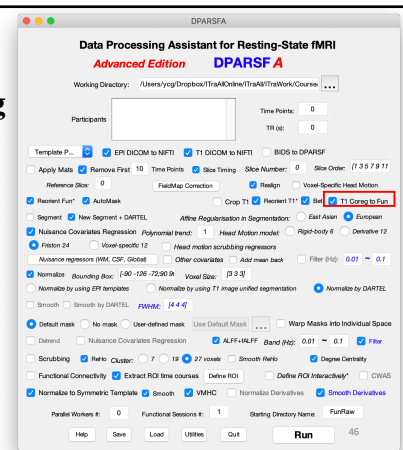
Bet & Coregistration



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Preprocessing and R-fMRI measures Calculation

Coregister T1 image to functional space



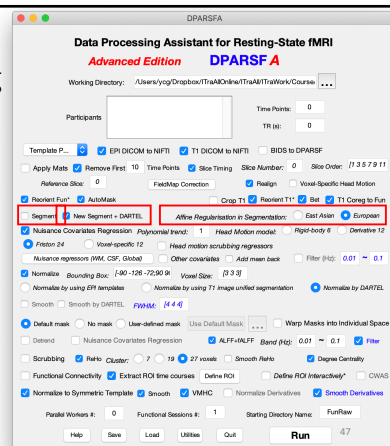
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Preprocessing and R-fMRI measures Calculation

Unified Segmentation.
Information will be used in spatial normalization.
(in New Segment and DARTEL).

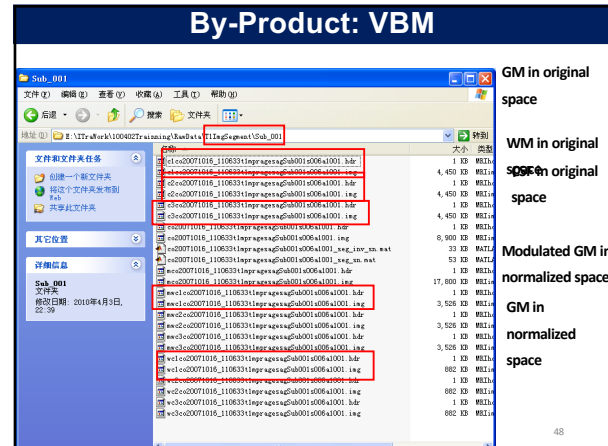
Information will be used in spatial normalization.

Affine regularisation in segmentation



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By-Product: VBM

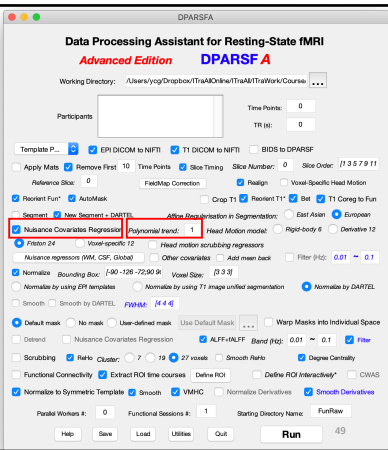


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Preprocessing and R-fMRI measures Calculation

Nuisance Covariates regressions as regressors:

- 1: constant (no trends)
- 2: constant + linear trend + quadratic trend
- 3: constant + linear trend + quadratic trend + cubic trend



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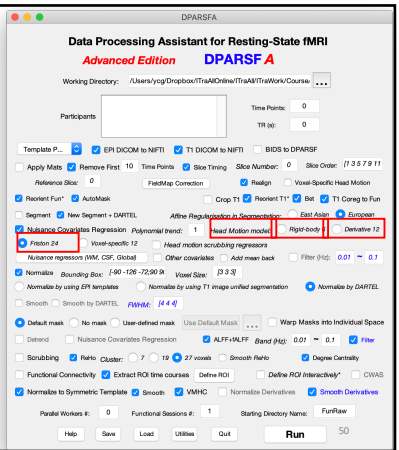
Preprocessing and R-fMRI measures Calculation

Head Motion regression model

6 head motion parameters

12: 6 head motion parameters, 6 first derivatives

motion parameters one time point before, and the 12 corresponding squared items (Friston et al., 1996).

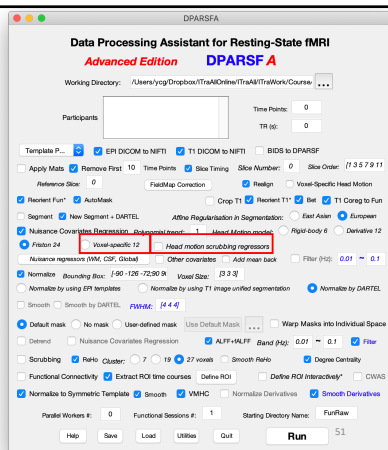


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Preprocessing and R-fMRI measures Calculation


Voxel-specific 12-parameter model: the 3 voxel-specific translation parameters in x, y, z, the same 3 parameters for one time point before, and the 6 corresponding squared items

Head Motion Scrubbing Regressors



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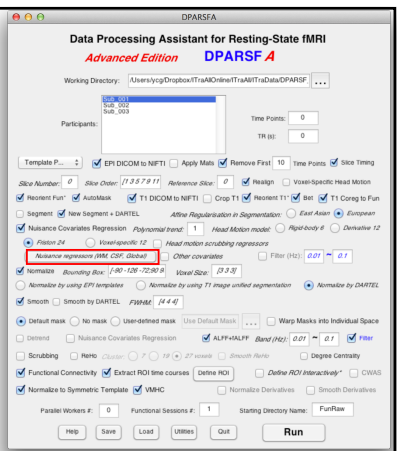
Each "bad" time point defined by FD will be used as a separate regressor.



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Preprocessing and R-fMRI measures Calculation

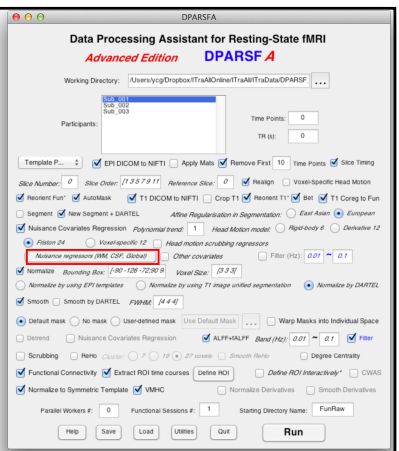
Nuisance Regressors (WM, CSF, Global)



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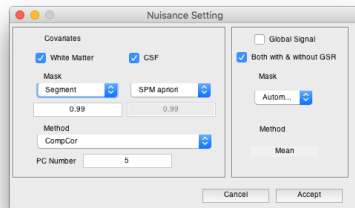
Preprocessing and R-fMRI measures Calculation

Nuisance Regressors (WM, CSF, Global)



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Nuisance Regression

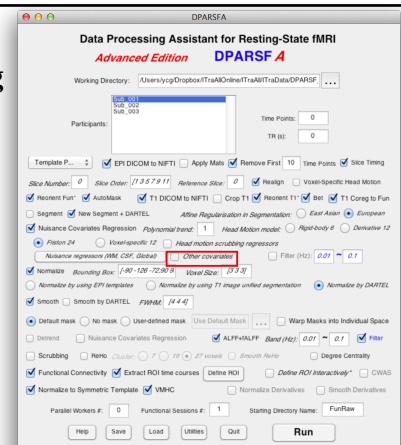


- Mask based on segmentation or SPM apriori
- CompCor or mean [note: for CompCor, detrend (demean) and variance normalization will be applied before PCA, according to Behzadi et al., 2007]
- Global Signal based on Automask

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Preprocessing and R-fMRI measures Calculation

Define other covariates

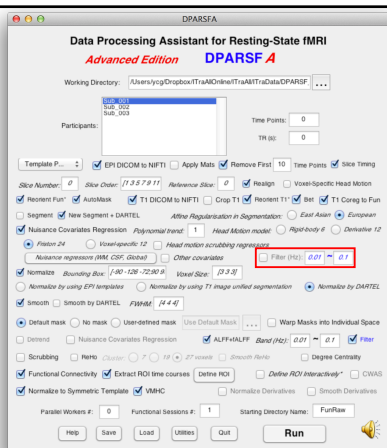


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Preprocessing and R-fMRI measures Calculation

Filtering

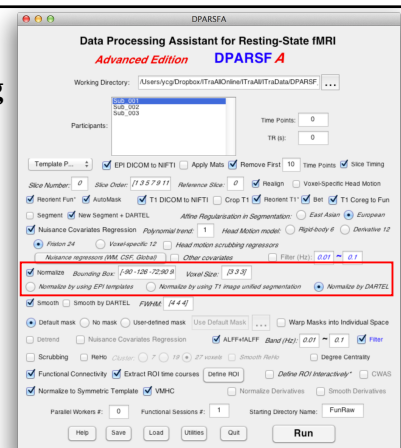
The filtering parameters will be used later (Blue checkbox).



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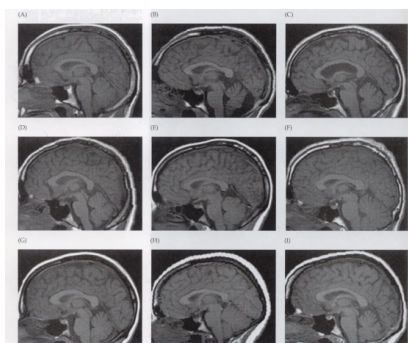
Preprocessing and R-fMRI measures Calculation

Spatial Normalization



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Normalize



Huettel et al., 2004

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Normalize

Methods:

- I. Normalize by using EPI templates
- II. Normalize by using T1 image unified segmentation
- ➔ III. Normalize by using DARTEL
- IV. Normalize by using T1 templates (hidden)

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Normalize

III. Normalize by using DARTEL

- Structural image was coregistered to the mean functional image after motion correction
- The transformed structural image was then segmented into gray matter, white matter, cerebrospinal fluid by using a unified segmentation algorithm (New Segment)
- DARTEL: create template
- DARTEL: Normalize to MNI space. The motion corrected functional volumes were spatially normalized to the MNI space using the normalization parameters estimated in DARTEL.

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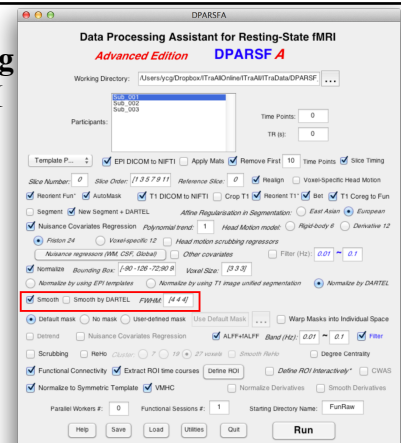
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Preprocessing and R-fMRI measures Calculation

Smooth

For ReHo, Degree Centrality: don't smooth before calculation

FWHM kernel settings can be applied to later steps



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Smooth

Why?

- Reduce the effects of bad normalization
- Increase SNR
- ...

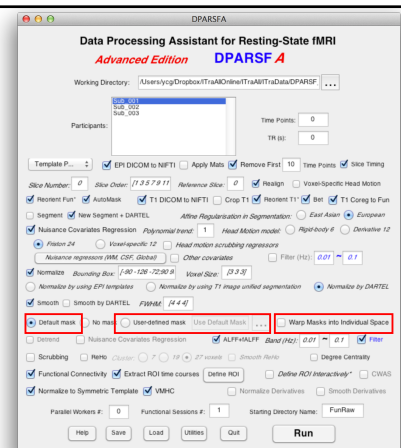
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Mask

Default mask: SPMS apriori mask (brainmask.nii) thresholded at 50%.
User-defined mask

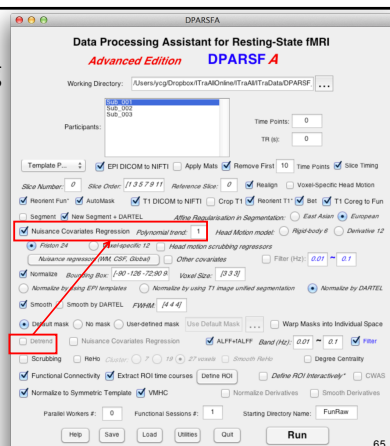
Warp the masks into individual space by the information of DARTEL or unified segmentation.



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Preprocessing and R-fMRI measures Calculation

Linear detrend (NO need since included in nuisance covariate regression)



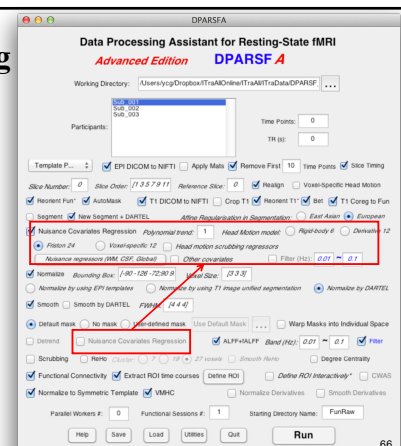
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Preprocessing and R-fMRI measures Calculation

Nuisance Covariates Regression

If needed, then use the parameters set in the upper section.

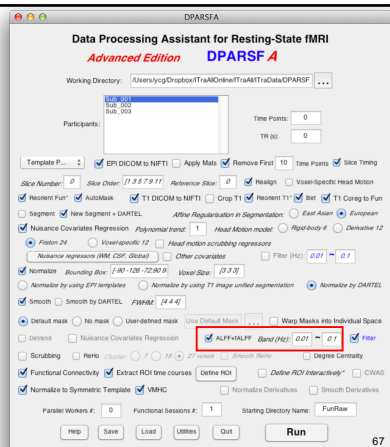


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Preprocessing and R-fMRI measures Calculation

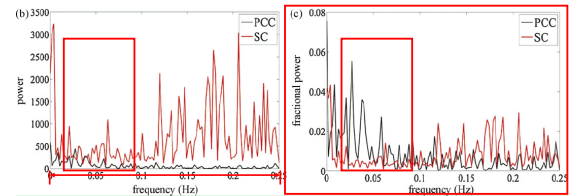
ALFF and fALFF calculation
(Zang et al., 2007; Zou et al., 2008)



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ALFF/fALFF

Amplitude of low frequency fluctuation / Fractional ALFF



PCC: posterior cingulate cortex
SC: suprasellar cistern

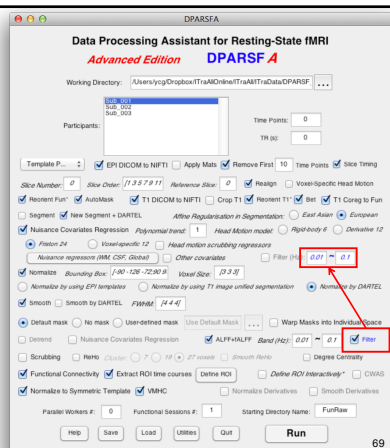
Zang et al., 2007; Zou et al., 2008

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Preprocessing and R-fMRI measures Calculation

Filtering

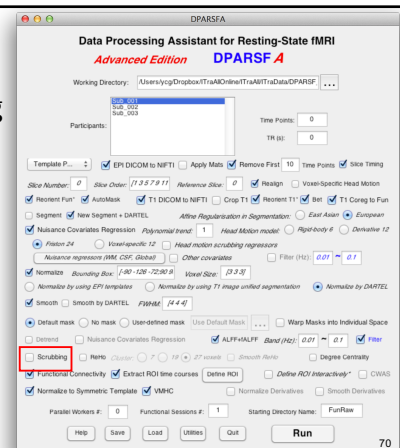
Use the parameters set in the blue edit boxes.



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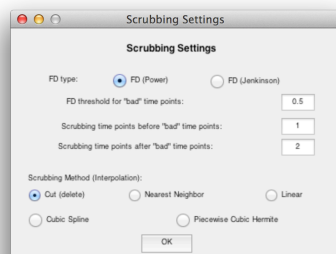
Preprocessing and R-fMRI measures Calculation

Scrubbing



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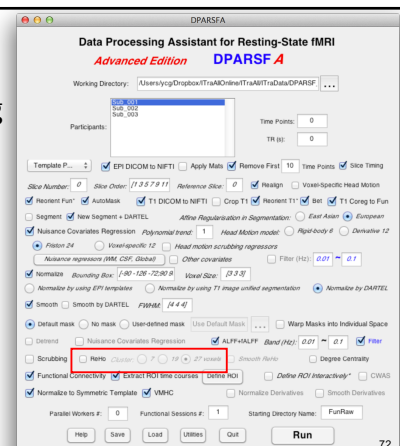
The "bad" time points defined by FD_Power (Power et al., 2012) will be interpolated or deleted as the specified method.



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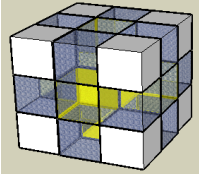
Preprocessing and R-fMRI measures Calculation

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



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ReHo (Regional Homogeneity)



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

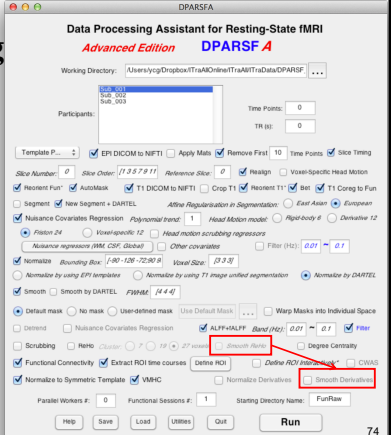
Zang et al., 2004

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

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Preprocessing and R-fMRI measures Calculation

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

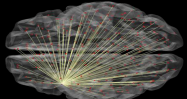
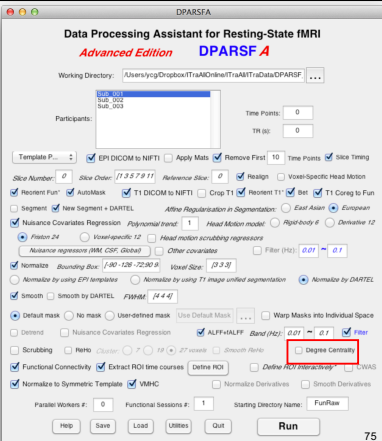


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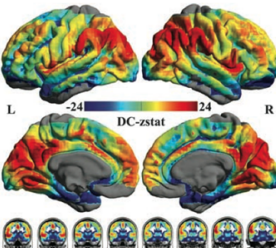
Preprocessing and R-fMRI measures Calculation

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

> r Threshold (default 0.25)

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Zuo et al., 2012

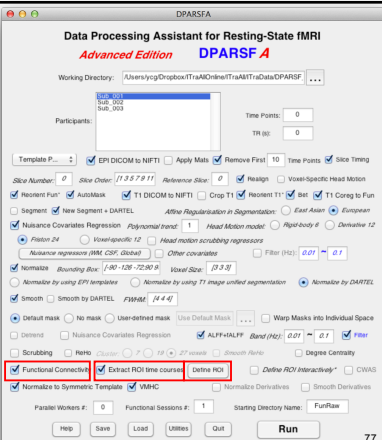
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Preprocessing and R-fMRI measures Calculation

Functional Connectivity (voxel-wise seed based correlation analysis)

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

Define ROI



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Define ROI

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

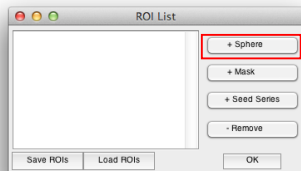
☒ Multiple Labels in mask file

AAL atlas	Harvard-Oxford atlas
Dosenbach et al., 2010	Andrews-Hanna et al., 2010
Dosenbach's 160 functional ROIs	Andrews-Hanna's DMN ROIs
Craddock et al., 2011	Define Other ROIs
Craddock's 200 clustering ROIs	

Define other ROIs

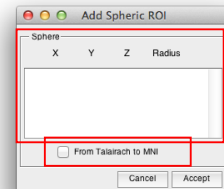
78

Define ROI



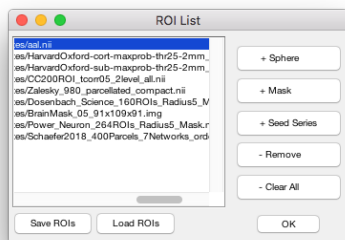
79

Define ROI



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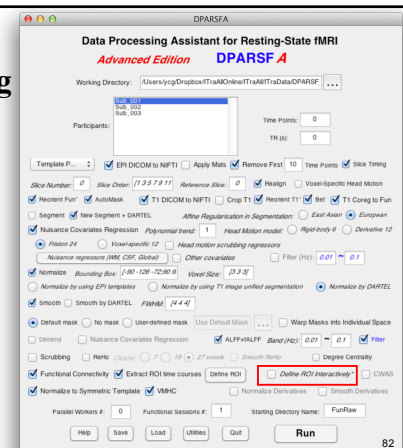
Define ROI



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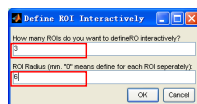
Preprocessing and R-fMRI measures Calculation

Define ROI Interactively



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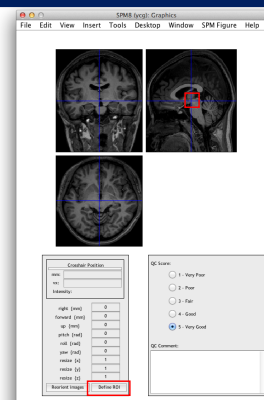
Define ROI



0 means define ROI Radius for each ROI separately

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Define ROI



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Functional Connectivity

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

zROI1FCMap_Sub_001.img

zROI2FCMap_Sub_001.img

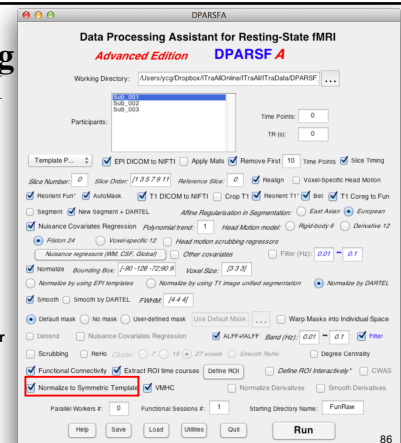
For ROI-wise results, please see {working directory}\Results\FunImgARCV*_ROISignals.

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Preprocessing and R-fMRI measures Calculation

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

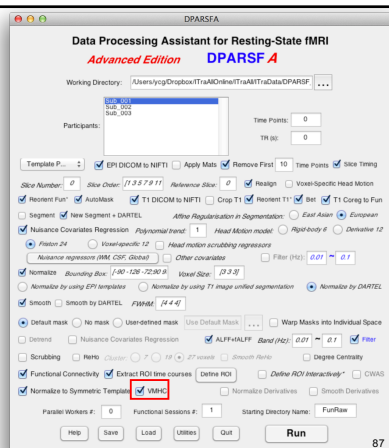
Prepare for VMHC: Further register to a symmetric template



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Preprocessing and R-fMRI measures Calculation

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

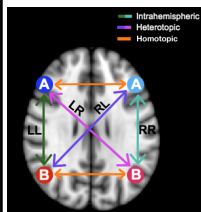


87

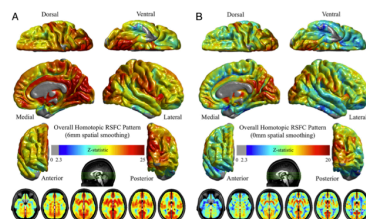
VMHC

- 1) Get the T1 images in MNI space (e.g., wco*.img or wco*.nii under T1ImgNewSegment or T1ImgSegment) for each subject, and then create a **mean T1 image template** (averaged across all the subjects).
- 2) Create a **symmetric T1 template** by averaging the mean T1 template (created in Step 1) with its flipped version (flipped over x axis).
- 3) **Normalize the T1 image in MNI space** (e.g., wco*.img or wco*.nii under T1ImgNewSegment or T1ImgSegment) for each subject to the **symmetric T1 template** (created in Step 2), and **apply the transformations** to the functional data (which have been normalized to MNI space beforehand). Please see a reference from Zuo et al., 2010.

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Gee et al., 2011



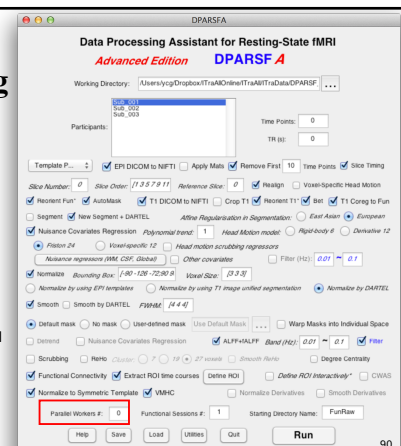
Zuo et al., 2010

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Preprocessing and R-fMRI measures Calculation

Parallel Workers (if parallel computing toolbox is installed)

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

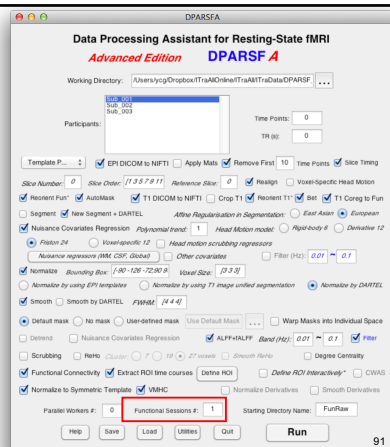


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Preprocessing and R-fMRI measures Calculation

Multiple functional sessions

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

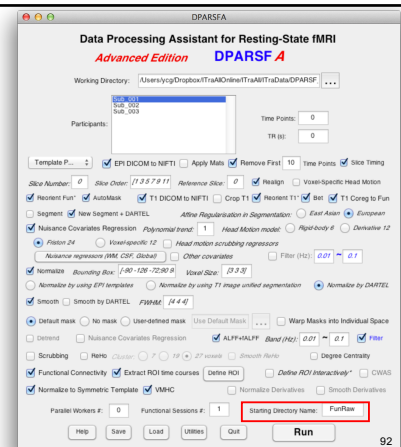


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Starting Directory Name

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

E.g. "FunimgARW" means you start with images which have been slice timed, realigned and normalized.
A - Slice timing
R - Realigned
W - Normalized
S - Smooth
D - Detrend
F - Filter
C - Covariates Removed
B - Scrubbing

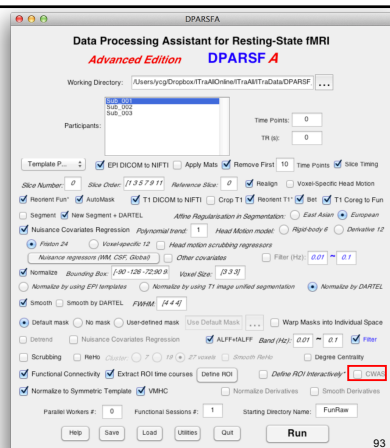


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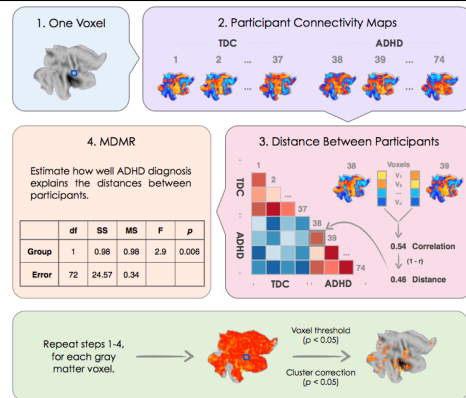
Preprocessing and R-fMRI measures Calculation

Connectome-wide association studies based on multivariate distance matrix regression (Shehzad et al., 2014)

Resource consuming as compared to other measures



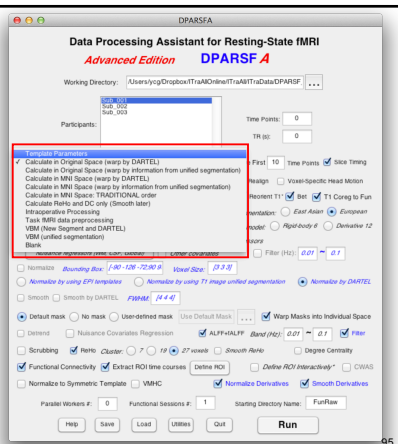
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Resting State fMRI Data Processing

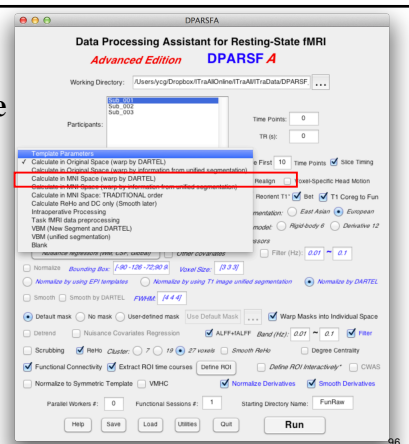
Template Parameters



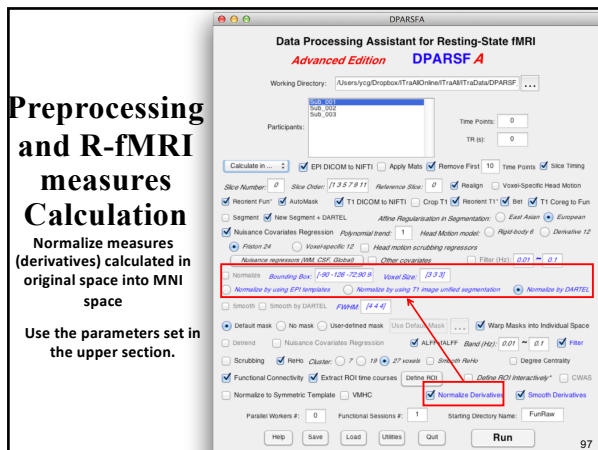
95

Resting State fMRI Data Processing

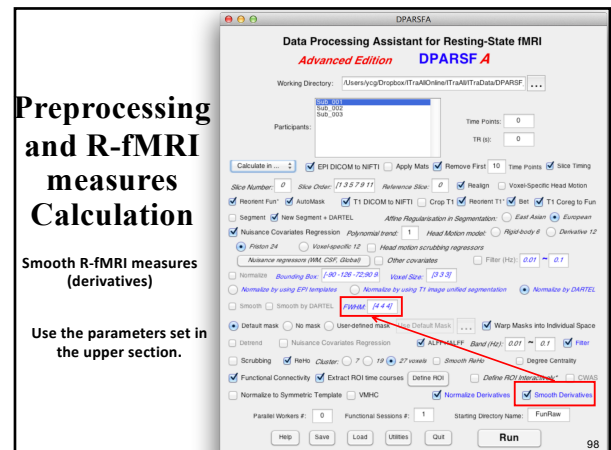
Calculate in MNI space
Calculate in Original space



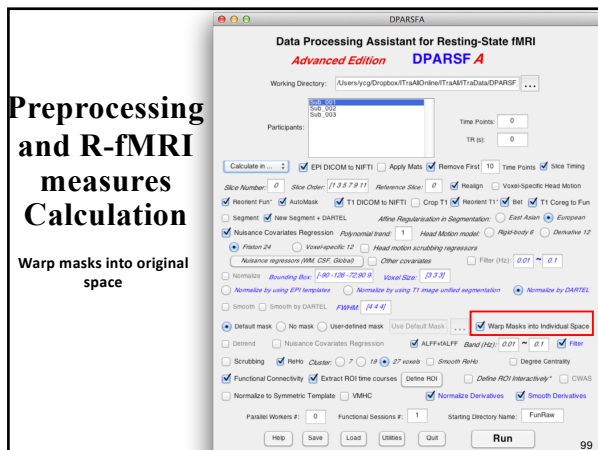
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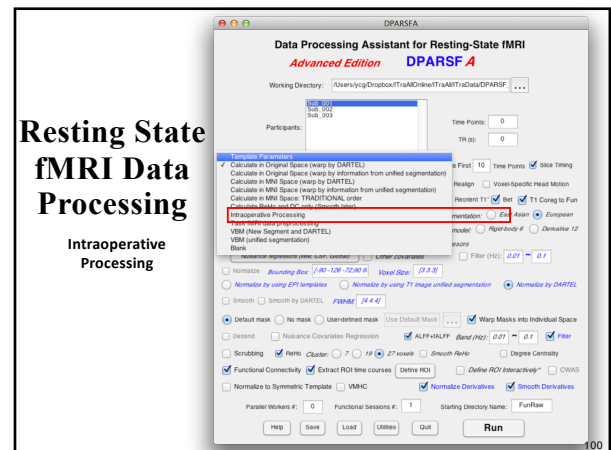
97



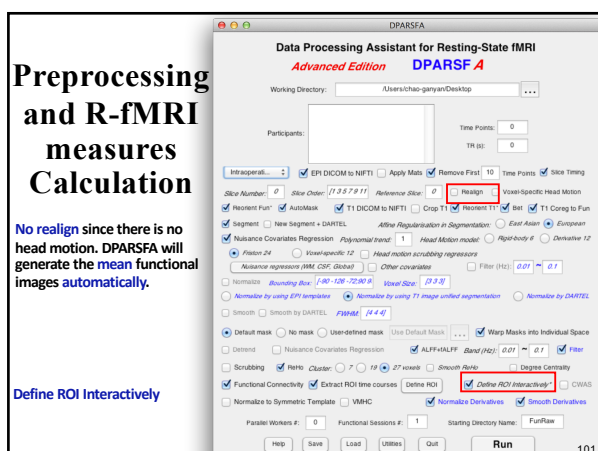
98



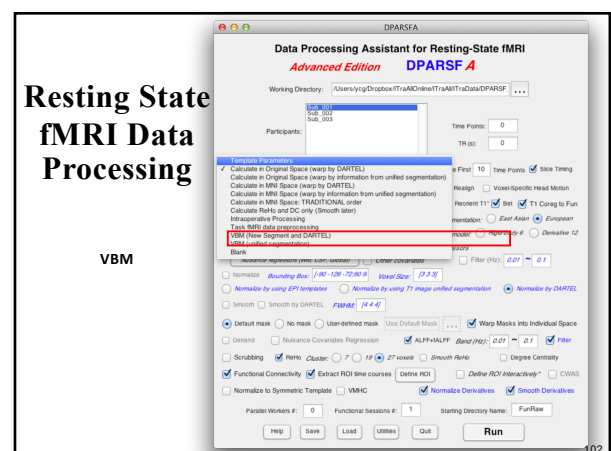
99



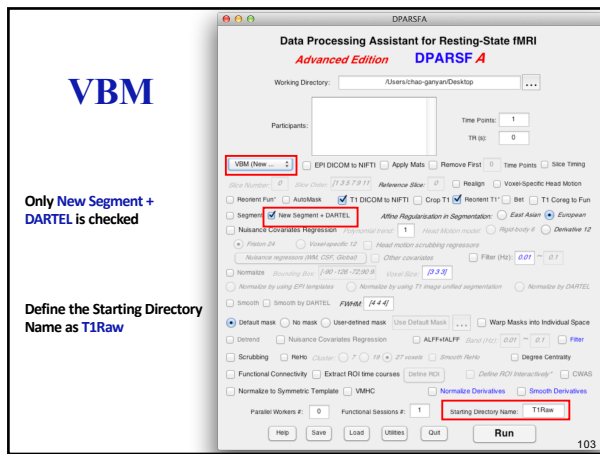
100



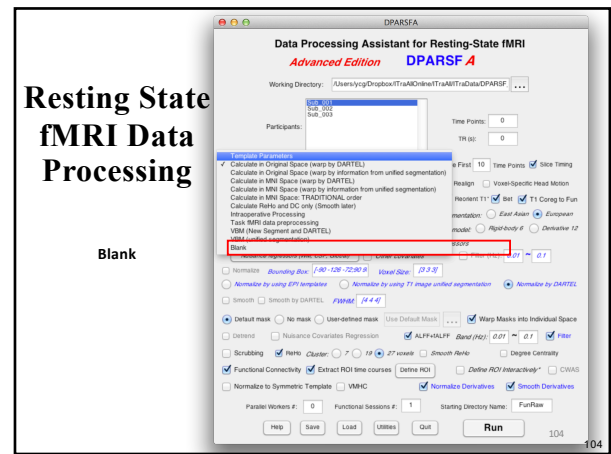
101



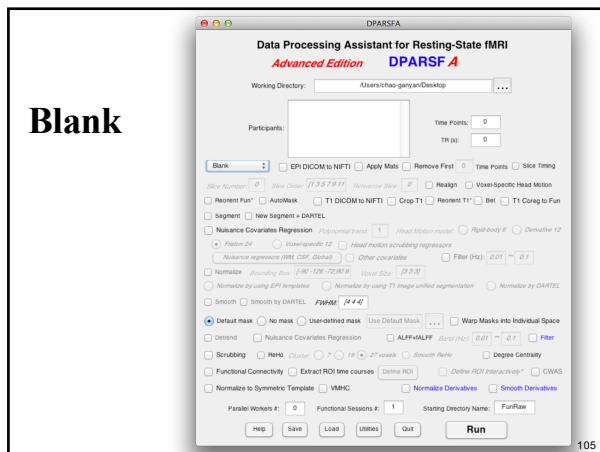
102



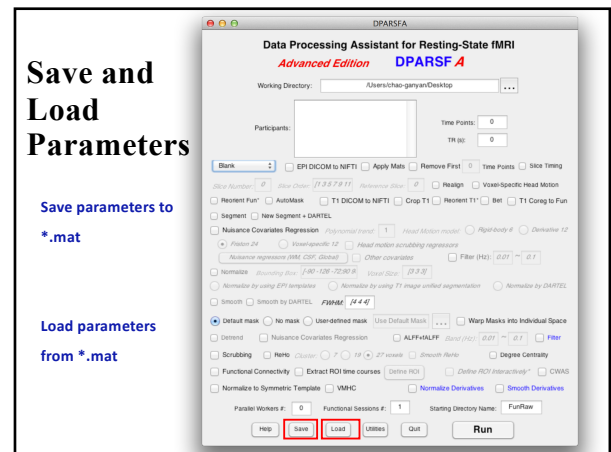
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Further Help

The R-fMRI Course V2.1

严超群
Chao-Gan Yan, Ph.D.

<http://rfmri.org/Course>

<http://wiki.rfmri.org>

The R-fMRI Journal Club

Official Account: RFMRILab

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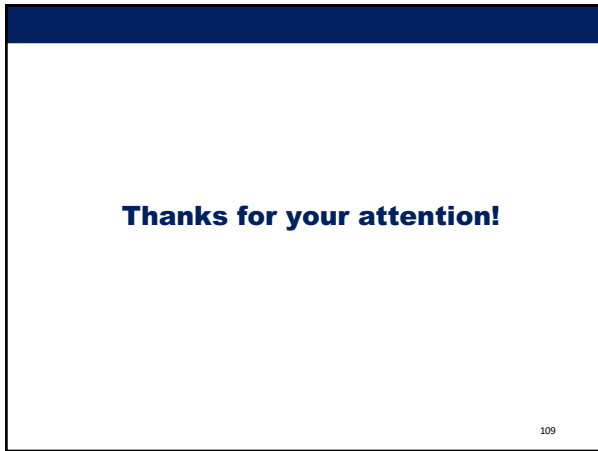
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Child Mind Institute Michael P. Milham

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