**Data Processing of Resting-State fMRI: DPARSF**

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**DPARSF**

Data Processing Assistant for Resting-State fMRI (DPARSF)


http://rfmri.org/DPARSF

Resting State fMRI Data Processing

Preprocessing ➔ ALFF/fALFF ➔ Degree ➔ Statistical Analysis ➔ Results Viewing

**DPABI**

Resting State fMRI Data Processing

Slice Timing ➔ Realign ➔ Normalize ➔ Smooth ➔ Detrend ➔ ALFF/fALFF ➔ Nuisance Regression ➔ Filter ➔ VBM

Calculate in MNI Space: TRADITIONAL order

**DPABI**

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

License: GNU GPL

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Xin-Di Wang, Programmer

http://rfmri.org/dpabi
http://dpabi.org

Resting State fMRI Data Processing

Slice Timing ➔ Realign ➔ Normalize ➔ Smooth ➔ Detrend ➔ ALFF/fALFF ➔ Nuisance Regression ➔ Filter ➔ VBM

Calculate in MNI Space: TRADITIONAL order
Resting State fMRI Data Processing

- Slice Timing
- Realign
- Nuisance Regression
- Normalize
- Smooth
- ALFF/fALFF
- FC (SCA)
- ReHo
- Degree
- VMHC
- ALFF/fALFF
- Filter
- Calculate in MNI Space: alternative order
- Normalize
- Smooth
- ALFF/fALFF
- FC (SCA)
- ReHo
- Degree
- VMHC

Data Organization

ProcessingDemoData.zip

- FunRaw
  - Sub_001
  - Sub_002
  - Sub_003
- T1Raw
  - Sub_001
  - Sub_002
  - Sub_003

- Functional DICOM data
- Structural DICOM data

Data Organization

ProcessingDemoData.zip

- FunImg
  - Sub_001
  - Sub_002
  - Sub_003
- T1Img
  - Sub_001
  - Sub_002
  - Sub_003

- Functional NIfTI data (.nii.gz., .nii or .img)
- Structural NIfTI data (.nii.gz., .nii or .img)
Arrange each subject’s fMRI DICOM images in one directory, and then put them in “FunRaw” directory under the working directory.

Subject 1’s DICOM files in “FunRaw” directory, please name as this Subject’s directory.

Arrange each subject’s T1 DICOM images in one directory, and then put them in “T1Raw” directory under the working directory.

Subject 1’s DICOM files in “T1Raw” directory, please name as this Subject’s directory.

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
Apply reorientation matrices
Preprocessing and R-fMRI measures Calculation

Apply reorientation matrices:
- ReorientMats
- Rename to: 
  DownloadedReorientMats

Preprocessing and R-fMRI measures Calculation

Remove several first time points

Slice Timing

Total slice number (if 0, the slice order is assumed as interleaved scanning): [1:2:SliceNumber; 2:2:SliceNumber]. The reference slice is set to the slice order (ceil(SliceNumber/2)). SHOULD BE CAUTIOUS!!!

Reference slice: slice acquired in the middle time of each TR

Slice order: 1:2:33, 2:2:32 (interleaved scanning)

Preprocessing and R-fMRI measures Calculation

Why?

Realign
Check head motion:

\{\text{WorkingDir/RealignParameter/Sub}_nxxn\}_{*}.txt: realign parameters

\text{FD}_\text{Power}_{*}.txt: Frame-wise Displacement (Power et al., 2012)

\text{FD}_\text{VanDijk}_{*}.txt: Relative Displacement (Van Dijk et al., 2012)

\text{FD}_\text{Jenkinson}_{*}.txt: Relative RMS (Jenkinson et al., 2003)

\text{Check head motion:}

\text{ExcludeSubjectsAccordingToMaxHeadMotion.txt}

Excluding Criteria: 2.5 mm and 2.5 degree in max head motion

\text{Sub}_013

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

\text{Sub}_013

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

\text{Sub}_013

Excluding Criteria: 1.0 mm and 1.0 degree in max head motion

\text{Sub}_007, \text{Sub}_012, \text{Sub}_013, \text{Sub}_017, \text{Sub}_018

\text{Realign}

\text{Check head motion:}

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

\text{Threshold:}

\text{Group mean (mean FD) + 2 * Group SD (mean FD)}

\text{Yan et al., in press Neuroimage; Di Martino, in press, Mol Psychiatry}

\text{Preprocessing and R-fMRI measures Calculation}

\text{Voxel-Specific Head Motion Calculation}

\text{Voxel-Specific Head Motion Calculation}

\text{(Yan et al., Neuroimage 2013)}
Preprocessing and R-fMRI measures Calculation

This step could improve the accuracy in coregistration, segmentation and normalization, especially when images had a bad initial orientation. Also can take as a QC step.

Display the mean image after realignment. (Could take this step as a QC procedure.)

The reorientation effects on and realigned functional images and voxel-specific head motion images.

QC scores and comments are stored at {WorkDir/QC}

Automask generation

For checking EPI coverage and generating group mask

Preprocessing and R-fMRI measures Calculation

T1 DICOM files to NIfTI (based on MRIcron's dcm2ni)

Crop T1 image (.nii, .nii.gz, .img) (based on MRIcron's Dcm2ni)

Reorient T1 image Interactively
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.

Preprocessing and R-fMRI measures Calculation

Coregister T1 image to functional space

Preprocessing and R-fMRI measures Calculation

Unified Segmentation. Information will be used in spatial normalization. (In SPM12: old segment)

Affine registration in segmentation

By-Product: VBM

GM in original space
WM in original space
CSF in original space
Modulated GM in normalized space
Modulated WM in normalized space
Modulated CSF in normalized space

Preprocessing and R-fMRI measures Calculation

Nuisance Covariates Regression as regressors:
0: constant (no trends)
1: constant + linear trend (same as linear detrend)
2: constant + linear trend + quadratic trend
3: constant + linear trend + quadratic trend + cubic trend...
Head Motion regression model
6 head motion parameters, 6 first derivatives of head motion parameters, 6 head motion parameters one time point before, and the 12 corresponding squared items (Friston et al., 1996).

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

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

Nuisance Regressors
(WM, CSF, Global)

Preprocessing and R-fMRI measures Calculation

Yan et al., 2013, Neuroimage

Nuisance Regression

Mask based on segmentation or SPM a priori
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

Table 3
Summary recommendations:
- Individual-level correction with the Friston-24 model is recommended.
- Additionally, group-level correction for mean FD is recommended, and smoothing should be applied if group-level correction is not practical.
- Nuisance regression with scrubbing is recommended for fMRI and PET.

Additional considerations:
- Inclusion of global signal regressors at the individual level produces robust inferences in the relationships between motion and fMRI measures across participants, particularly for measures without contamination. The benefits of GLR need to be balanced against potential risks for introduction of artifact in the specific analyses employed.
- For studies limited to low-motion datasets, the utility of higher-order Friston-24 model decreases.
- In the case of no-regressors model, it is recommended to use the present work (Yan et al., 2013) has suggested greater efficiency.
- The recommended method is based on the recommended methods.

Note: Recommendations for scrubbing may apply to commonly employed PET-based implementations (see limitations and future directions section).

Note: Recommendations for CompCor or mean based on concerns regarding its ability to improve graph construction and the ability of various correction strategies to decrease residual relationships between motion and fMRI metrics at group-level significance levels (see limitations and future directions section).
Preprocessing and R-fMRI measures Calculation

Define other covariates

Spatial Normalization

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)

Filtering

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

Normalize

Huettel et al., 2004

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.
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

**Why?**

- Reduce the effects of bad normalization
- Increase SNR

**Mask**

Default mask: SPM5 apriori mask (brainmask.nii) thresholded at 50%.

User-defined mask

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

**Preprocessing and R-fMRI measures Calculation**

Nuisance Covariates Regression

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

**ALFF and fALFF calculation**

(Zang et al., 2007; Zou et al., 2008)
**Preprocessing and R-fMRI measures Calculation**

**ALFF/fALFF**

Amplitude of low frequency fluctuation / Fractional ALFF

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

**PCC:** posterior cingulate cortex  
**SC:** suprasellar cistern

**Filtering**

Use the parameters set in the blue edit boxes.

**Preprocessing and R-fMRI measures Calculation**

**Scrubbing**

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

**ReHo (Regional Homogeneity)**

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

\[ W = \frac{\sum (R_i - R) \sum (R_i - R)^2}{\sum (R_i - R)^2} \]

Zang et al., 2004

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

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

Functional Connectivity (voxel-wise seed based correlation analysis)

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

Define ROI

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

Dosenbach et al., 2010
Andreas-Hanna et al., 2010
Craddock et al., 2011
Define other ROIs
Define ROI Interactively

**Preprocessing and R-fMRI measures Calculation**

0 means define ROI Radius for each ROI separately

Define ROI Interactively

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

-zROI1FCMap_Sub_001.img
-zROI2FCMap_Sub_001.img

For ROI-wise results, please see \(\text{(working directory)/Results/UnimARCW*_ROISignals.} \)
Preprocessing and R-fMRI measures Calculation

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

Prepare for VMHC: Further register to a symmetric template

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.

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)

Preprocessing and R-fMRI measures Calculation

Multiple functional sessions

1st session: FunRaw
2nd session: S2_FunRaw
3rd session: S3_FunRaw…
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 timing, realigned and normalized.

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

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

Resting State fMRI Data Processing

Calculate in MNI space
Calculate in Original space

Normalize measures (derivatives) calculated in original space into MNI space
Use the parameters set in the upper section.
Preprocessing and R-fMRI measures Calculation

Smooth R-fMRI measures (derivatives)

Use the parameters set in the upper section.

Warp masks into original space

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

Define ROI Interactively

VBM

Only New Segment + DARTEL is checked

Define the Starting Directory Name as T1Raw
Resting State fMRI Data Processing

Save and Load Parameters

Save parameters to *.mat

Load parameters from *.mat

Further Help

http://rfmri.org/wiki

The R-fMRI Journal Club

http://rfmri.org/Course

Official Account: RFMRILab

DPABI特训营与DPABISurf加强营

第六届DPABI/DPARSF特训营
暨DPABISurf加强营通知

中国·北京 2019.10.26～10.28

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http://deepbrain.com
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DPABISurf并行计算：
每天完成20个被试的皮层计算!!!

The R-fMRI Lab

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