

认知心理学进阶第九讲： 功能磁共振数据预处理

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1

DPARSF

frontiers in
SYSTEMS NEUROSCIENCE

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

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METHODS ARTICLE

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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, resting-state fMRI, SPM

(Yan and Zang, 2010)

2

DPARSF

Data Processing Assistant for Resting-State fMRI (DPARSF)

Yan and Zang, 2010. Front Syst Neurosci.

<http://rfmri.org/DPARSF>

3

DPABI

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

Chao-Gan Yan
Programmer
Initiator

Xin-Di Wang
Programmer

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

4

DPABI

Resting State fMRI Data Processing

Preprocessing

→

Statistical Analysis

→

Results Viewing

FC (SCA)

ReHo

ALFF/fALFF

Degree

...

5

DPABI

Resting State fMRI Data Processing

Slice Timing

Realign

Normalize

Smooth

Detrend

ALFF/fALFF

→

Nuisance Regression

Filter

→

FC (SCA)

ReHo

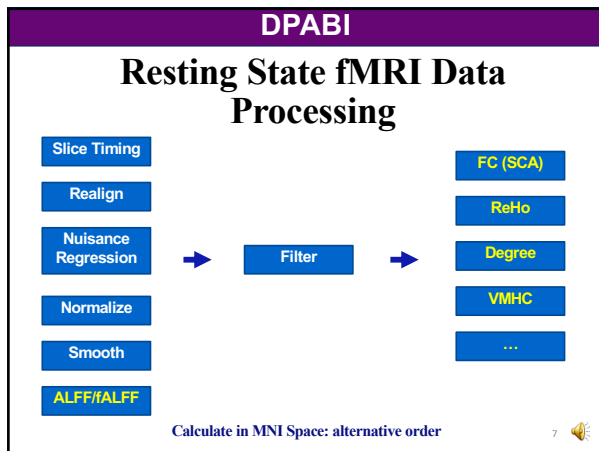
Degree

VMHC

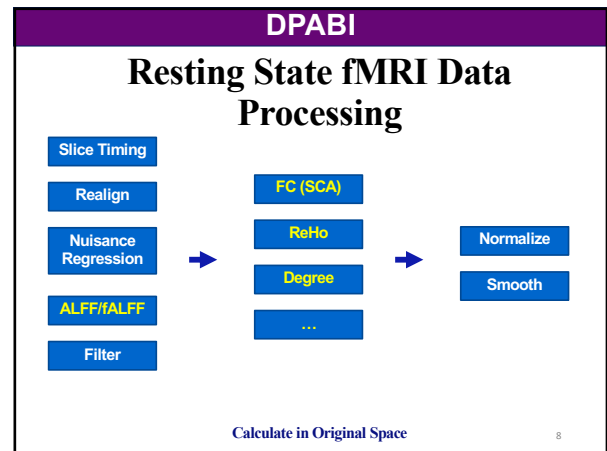
...

Calculate in MNI Space: TRADITIONAL order

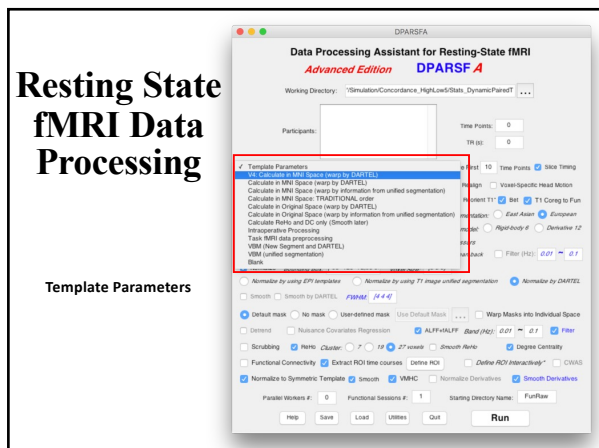
6



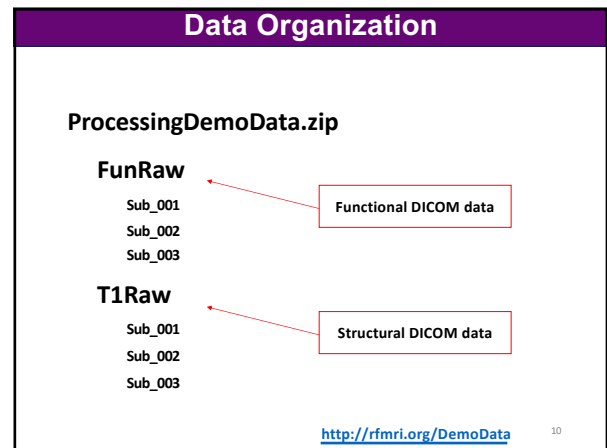
7



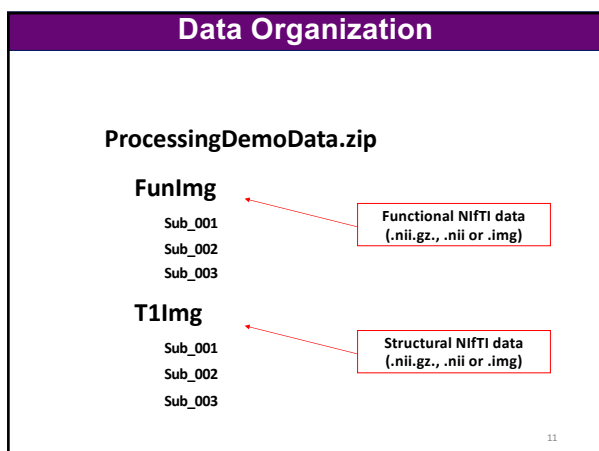
8



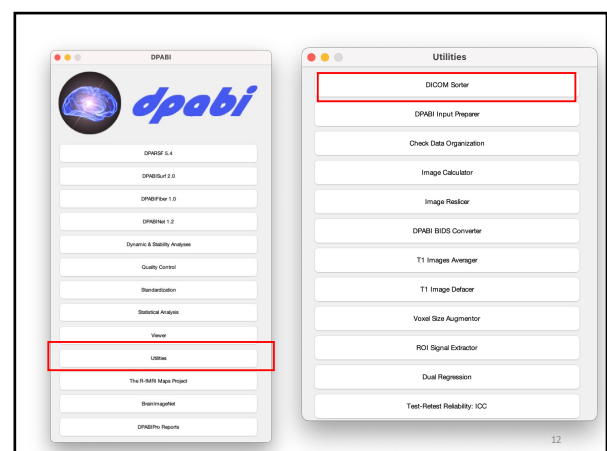
9



10



11



12

DPABI DicomSorter

DPABI DicomSorter

New features:

1. More options for MR header situation;
2. Synchronously update the output layout;
3. Add scanning date/time for repeating scan, add prefix for multi-group
4. One-click jump to DPABI_Format_Converter

13

DPABI DicomSorter

IMA dcm none

Add MR data directory
Input: raw data
directories from MR
scanner or XNAT-like
system's output
directories

14

DPABI DicomSorter

Set first output layer

15

DPABI DicomSorter

Set first output layer

16

DPABI DicomSorter

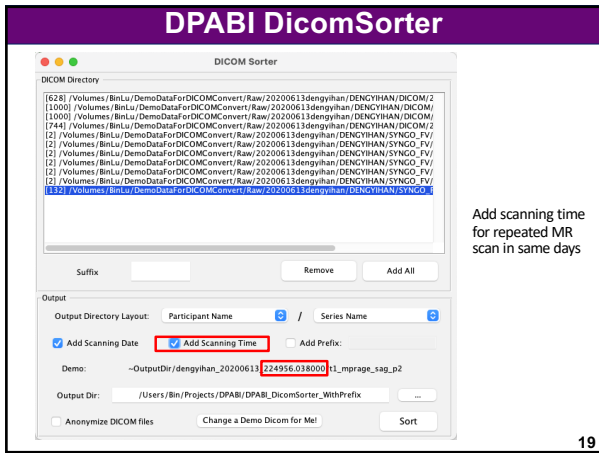
Set second output layer

17

DPABI DicomSorter

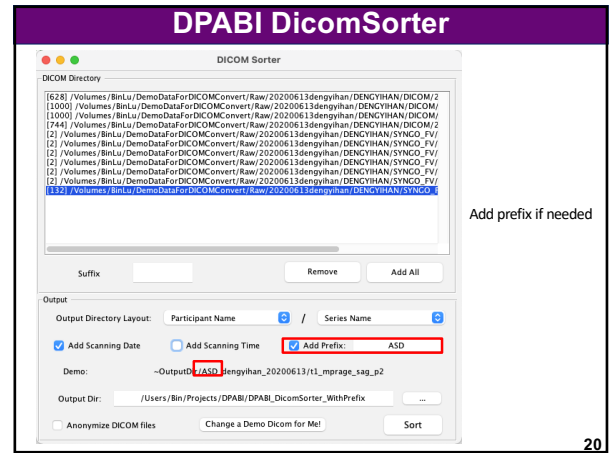
Add scanning date
for repeated MR
scan in different
days

18



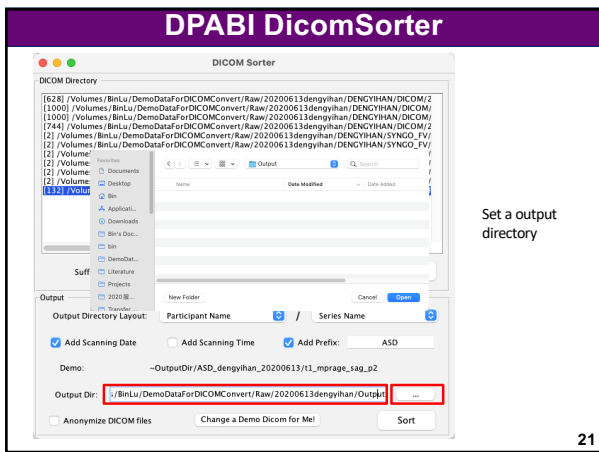
Add scanning time
for repeated MR
scan in same days

19



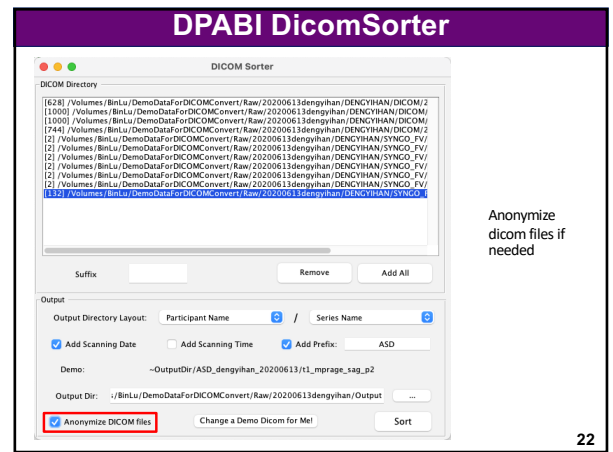
Add prefix if needed

20



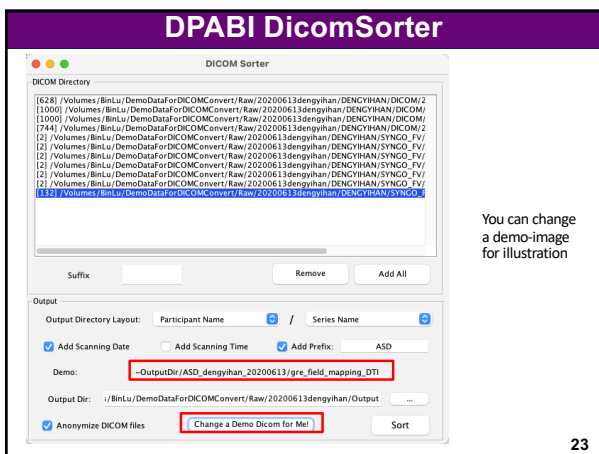
Set a output
directory

21



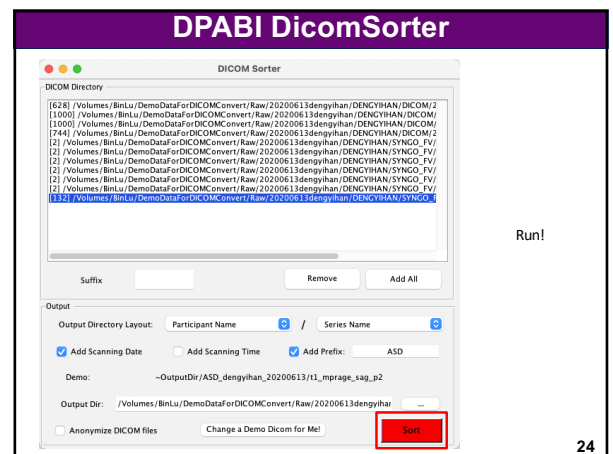
Anonymize dicom files
if needed

22



You can change
a demo-image
for illustration

23



Run!

24

DPABI DicomSorter

DICOM Sorter

DICOM Directory

```

[628] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/DICOM/2
[1000] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/DICOM/
[1000] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/DICOM/
[744] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/DICOM/2
[2] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/SYNGO_PV/
[2] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/SYNGO_PV/
[2] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/SYNGO_PV/
[2] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/SYNGO_PV/
[2] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/SYNGO_PV/
[2] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/SYNGO_PV/
[1122] /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan/DENGYHAN/SYNGO_PV/
  
```

Suffix Remove Add All

Output

Output Directory Layout: Participant Name / Series Name

☒ Add Scanning Date ☐ Add Scanning Time ☒ Add Prefix: ASD

Demo: -OutputDir\ASD_genyhan_20200613\11_mprage_sag_p2

Output Dir: /Volumes/BinLu/DemoDataForDICOMconvert/Raw/20200613denqyhan

☐ Anonymize DICOM files ☒ Convert to DPARSFA/DPABISurf Starting Directory Format!

Continue to convert data into DPARSFA/DPABISurf format

25

25

[illegible]

26

DPABI Input Preparer

```

--AD_RawDataDir_20180812a
--HW1_3-PT12080
--HW2_3-PT12080
--HW3_AE1_calibration
--HW4_DataTFLASR
--HW5_DataTFLASR
--HW6_DataTSP06CELLER
--HW7_DataDecoast
--HW8_Hog1TFLASR
--HW9_SigPT12080
--HW10_AE1_125a_cube
--HW11_AE1_125a_Wv_REST
--HW12_AE1_125a_Wv_REST
--HW13_3-PT12080
--HW14_AE1_125a_Hard
--HW15_ApertureEffFunctionCoefficient(mw)
--HW16_ExponentialApertureEffFunctionCoefficient
--HW17_PGADataDecoast
--HW18_Screensave
--AD_RawDataDir_20181219
--HW1_3-PT12080
--HW2_AE1_calibration
--HW3_DataTFLASR
--HW4_DataTFLASR
--HW5_DataTSP06CELLER
--HW6_DataDecoast
--HW7_SigPT12080
--HW8_AE1_125a_Wv_REST
--HW9_AE1_125a_cube
--HW10_AE1_125a_Hard
--HW11_ApertureEffFunctionCoefficient(mw)
--HW12_ExponentialApertureEffFunctionCoefficient
--HW13_PGADataDecoast
--HW14_Screensave
--AD_RawDataDir_20190112
--HW1_3-PT12080
--HW2_AE1_calibration
--HW3_DataTFLASR
--HW4_DataTFLASR
--HW5_DataTSP06CELLER
--HW6_DataDecoast
--HW7_SigPT12080
--HW8_AE1_125a_Wv_REST
--HW9_AE1_125a_cube
--HW10_AE1_125a_Hard
--HW11_ApertureEffFunctionCoefficient(mw)
--HW12_ExponentialApertureEffFunctionCoefficient
--HW13_PGADataDecoast
--HW14_Screensave
--AD_RawDataDir_20180817
--HW1_3-PT12080
--HW2_AE1_calibration

```

???

Data Organization

27

27

[illegible]

28

[illegible]

29

[illegible]

30

DPABI Input Preparer

Change raw subject ID into anonymous ID
- The pairing info for raw subject ID and anonymous ID would be recorded in Report.csv in output folder

31

DPABI Input Preparer

Use pseudo series to replace incomplete functional series
- e.g. Sub_013 didn't finished the task-fMRI series but finished T1-weighted series and resting-fMRI series. A pseudo series would be seemed as task-fMRI series for Sub_013, so that the structure series and resting-fMRI series would be wasted.
- The subject with pseudo series would be recorded in Report.csv in output folder.

32

DPABI Input Preparer

Whether convert dicom files into nifty files
- One of the most common error in running DPARSFA/DPABISurf is the empty FunImg/T1img folders for sessions failed passing DCM2NII.
- If checked, the subjects with empty T1img/Funimg folders would be delete to avoid errors.

33

DPABI Input Preparer

Organize FunRaw
Add more functional sessions for S2_FunRaw, S3_FunRaw ...

34

DPABI Input Preparer

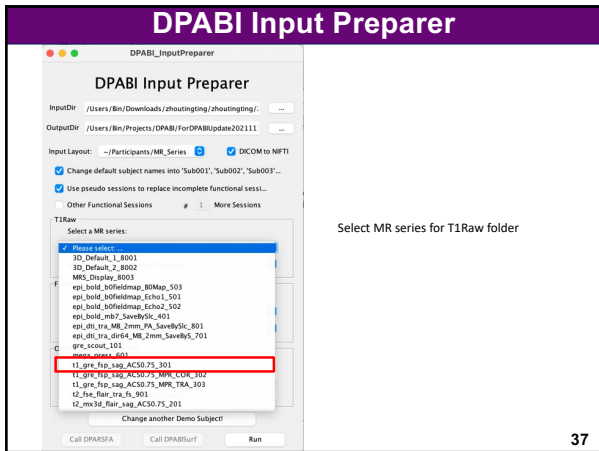
Organize DwiRaw

35

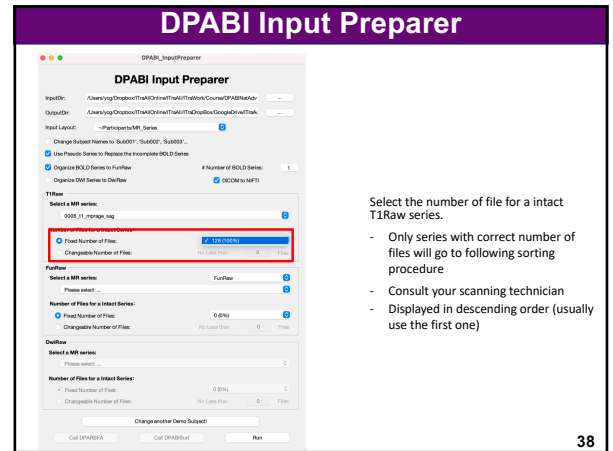
DPABI Input Preparer

Select MR series for T1raw folder

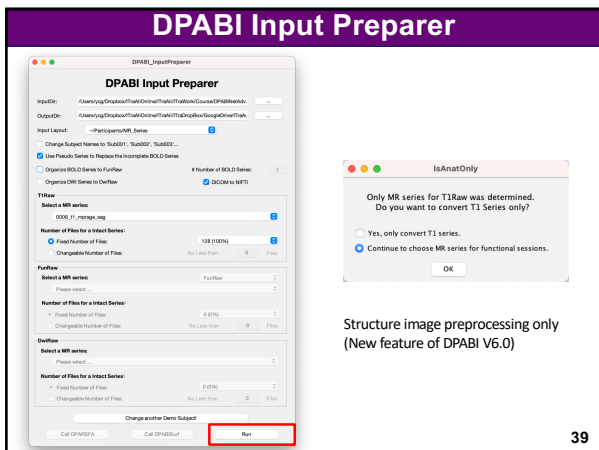
36



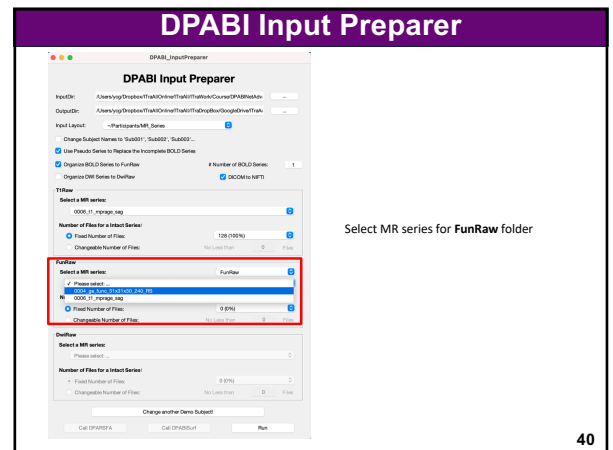
37



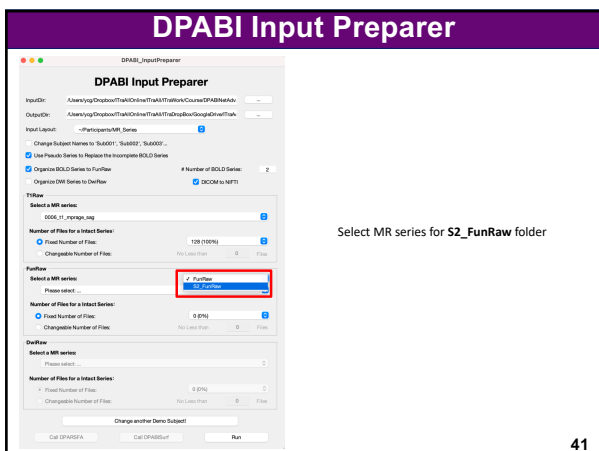
38



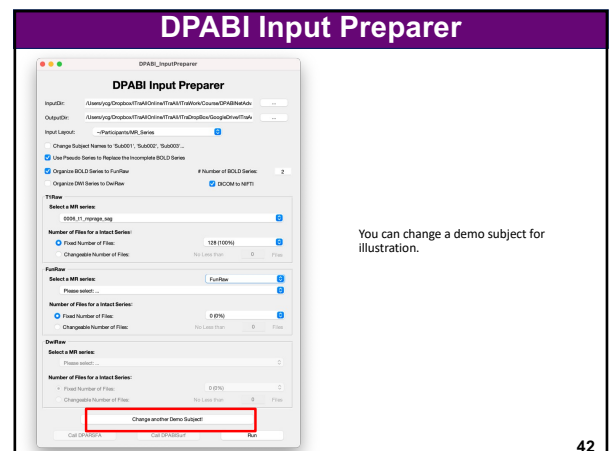
39



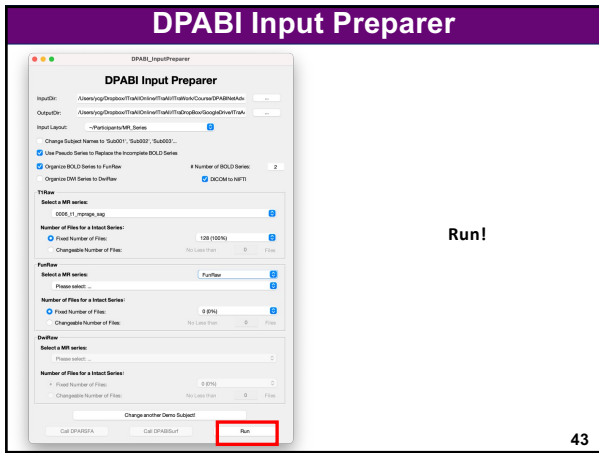
40



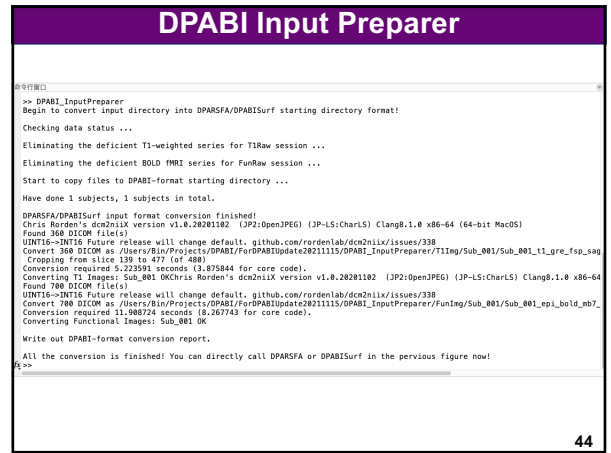
41



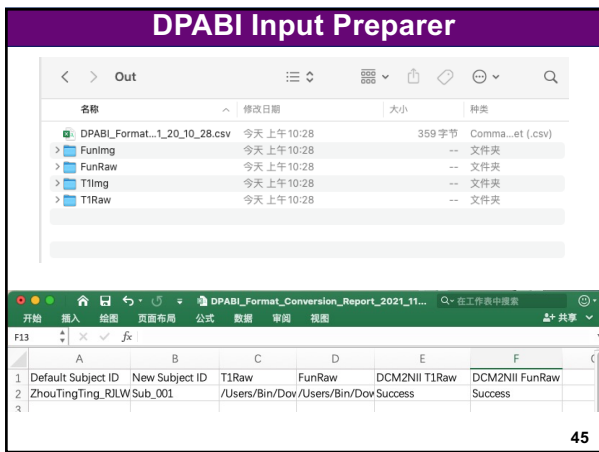
42



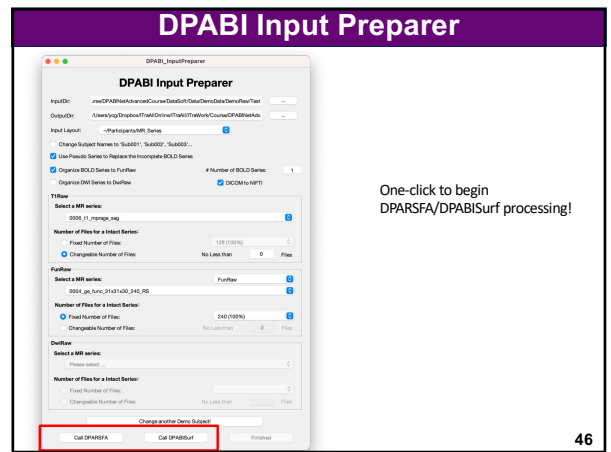
43



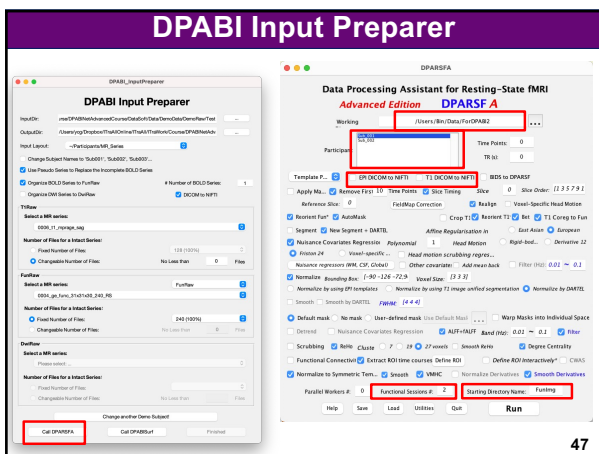
44



45



46



Data preparation

Arrange each subject's fMRI DICOM images in one directory, and then put them in "FunRaw" directory under the working directory.

Subjects' DICOM files directory, please name as this Working directory

49

Data preparation

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

Subjects' T1 DICOM files directory, please name as this Working directory

50

Check Data Organization

51

Preprocessing and R-fMRI measures Calculation

Working Dir where stored Starting Directory (e.g., FunRaw) Detected participants

52

Preprocessing and R-fMRI measures Calculation

Detected participants

53

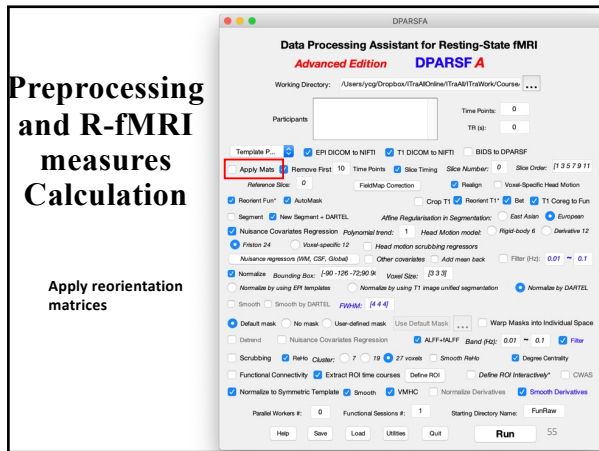
Preprocessing and R-fMRI measures Calculation

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

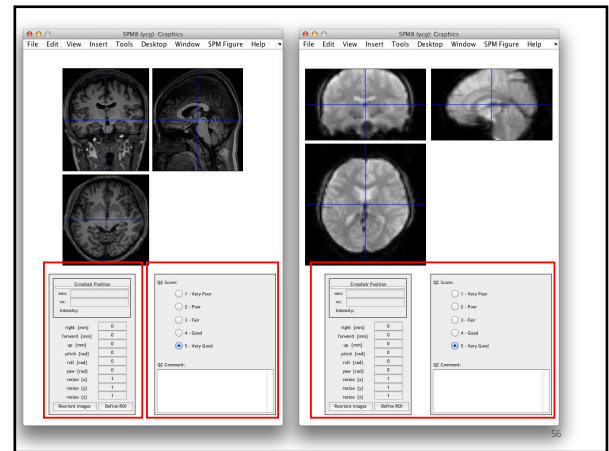
Template Parameters

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

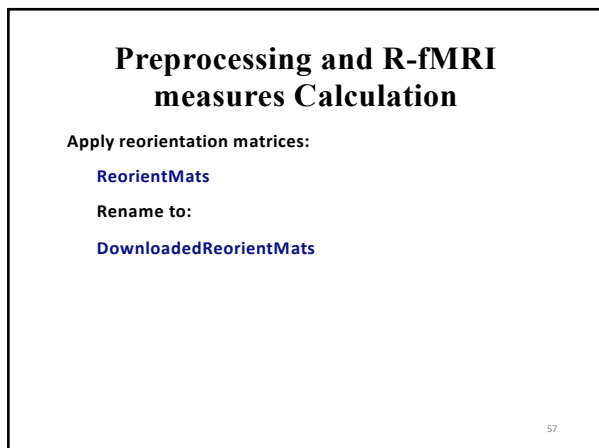
54



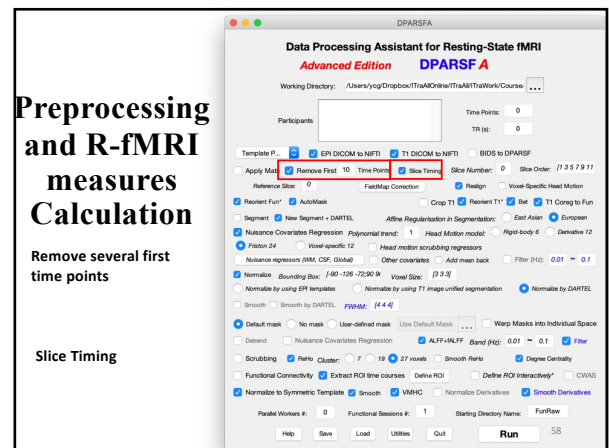
55



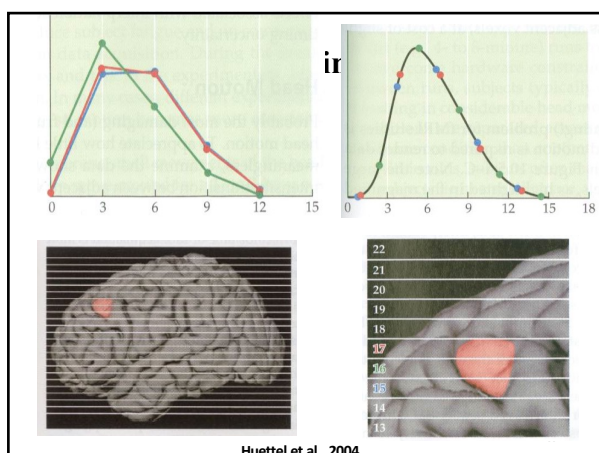
56



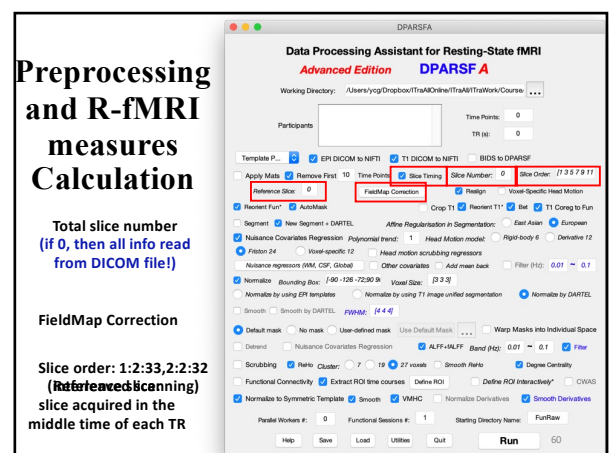
57



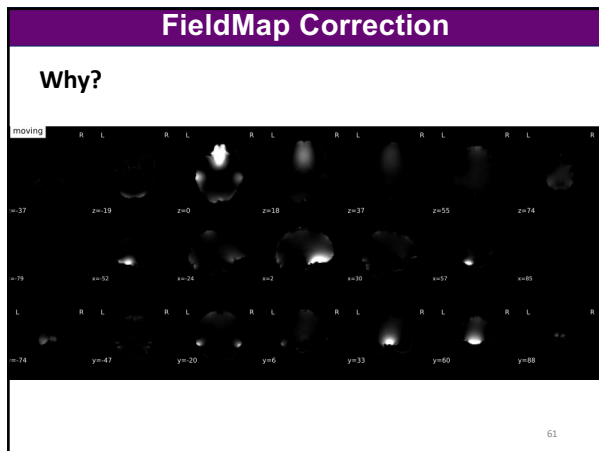
58



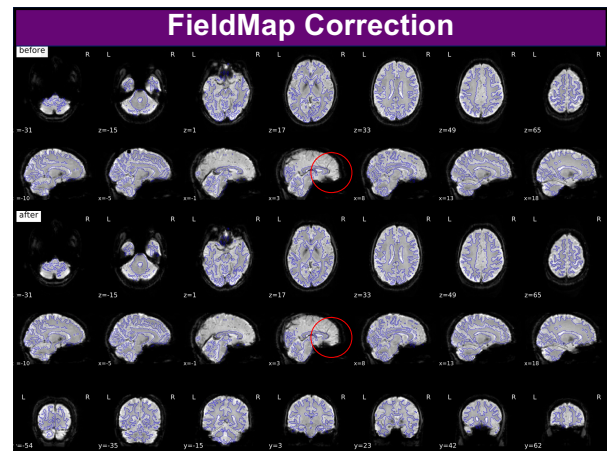
59



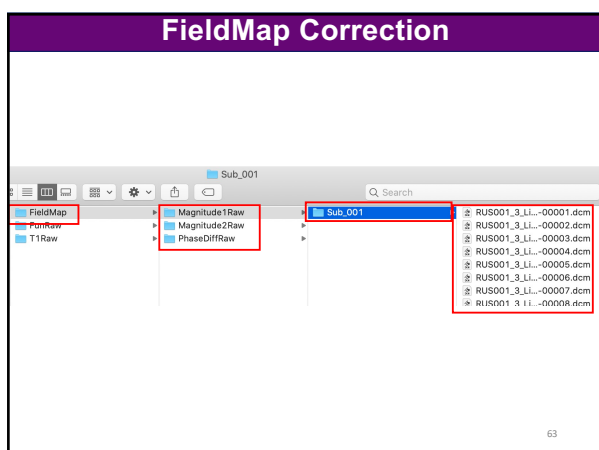
60



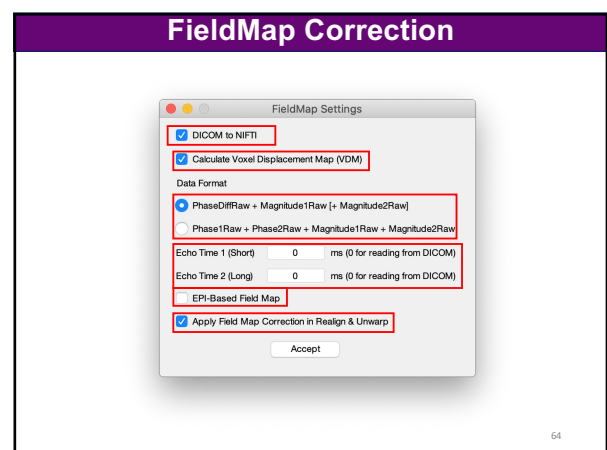
61



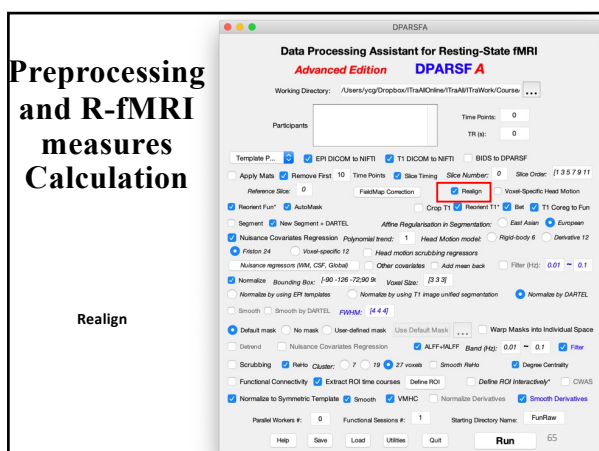
62



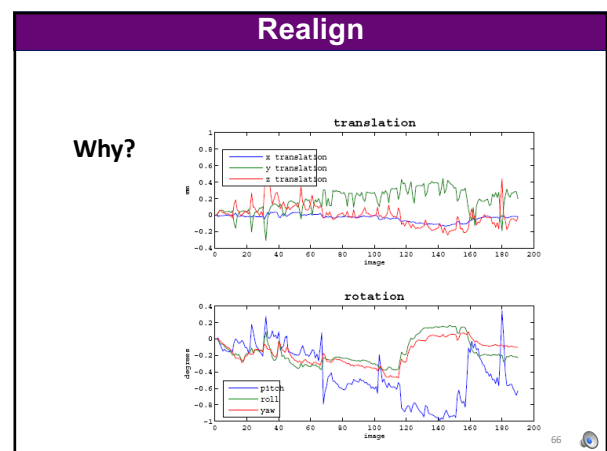
63



64



65



66

Realign

Check head motion:

{WorkingDir}\RealignParameter\Sub_000:

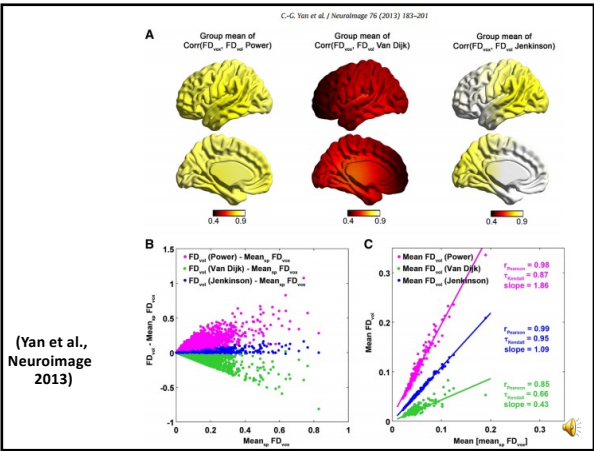
rp_*.txt: realign parameters

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)

67



Realign

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

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

69

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

70

Preprocessing
and R-fMRI
measures
Calculation

Voxel-Specific Head
Motion Calculation

(Yan et al.,
Neuroimage
2013)

DPARSFA

Data Processing Assistant for Resting-State fMRI
Advanced Edition DPARSFA

Working Directory: /Users/yog/Dropbox/ITraOnline/ITraAll/ITraWork/Courses/...

Participants: [] Time Points: 0 TR (s): 0

Template P... [] EPI DICOM to NIFTI [] T1 DICOM to NIFTI [] BIDS to DPARSFA

Apply Maps [] Remove First 10 Time Points [] Slice Timing [] Slice Number: 0 Slice Order: [1 3 5 7 9 11]

Reference Size: 0 FastMap Correction [] Reslice [] Voxel-Specific Head Motion [] Crop T1 [] Realign [] T1 Corrig to Fun

Reorient Fun* [] AutoMask [] Crop T1 [] Realign [] T1 Corrig to Fun

Segment [] New Segment + DARTEL [] Affine Regularization in Segmentation: [] East Asian [] European

Nuisance Covariates Regression Polynomial trend: 1 Head motion scrubbing regressors [] Rigid body [] Derivative 12

Fitnon 24 [] Voxel-specific 12 [] Head motion scrubbing regressors [] Rigid body [] Derivative 12

Nuisance regression (MM, CSF, Global) [] Other covariates [] Add mean back [] Filter (Hz): 0.01 ~ 0.1

Normalize Bounding Box: [90 -126 -72 90] Voxel Size: [3 3 3] [] Normalize by using T1 image unflattened segmentation [] Normalize by DARTEL

Smooth [] Smooth by DARTEL [] FWHM: [4 4 4]

Default mask [] No mask [] User-defined mask [] Use Default Mask [] Warp Masks into Individual Space

Denoise [] Nuisance Covariates Regression [] ALFF/ALFF Band (Hz): 0.01 ~ 0.1 [] Filter

Scrubbing [] Phase Cluster: 7 ~ 12 ~ 27 voxels [] Smooth Rho [] Degree Centrality

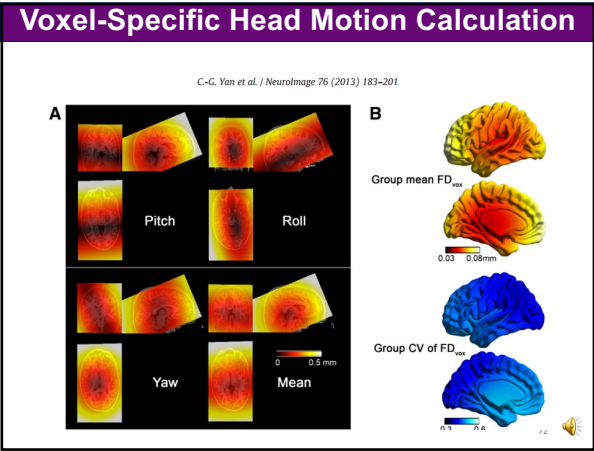
Functional Connectivity [] Extract ROI time courses [] Define ROI Interactively [] CWAS

Normalize to Symmetric Template [] Smooth [] VMHC [] Normalize Derivatives [] Smooth Derivatives

Parallel Workers #: 0 Functional Sessions #: 1 Starting Directory Name: FunRaw

Help Save Load Utilities Quit Run

71



Preprocessing and R-fMRI measures Calculation

Reorient Interactively

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.

73

74

75

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

76

Automask generation

For checking EPI coverage and generating group mask

FunImAR/Sub_001

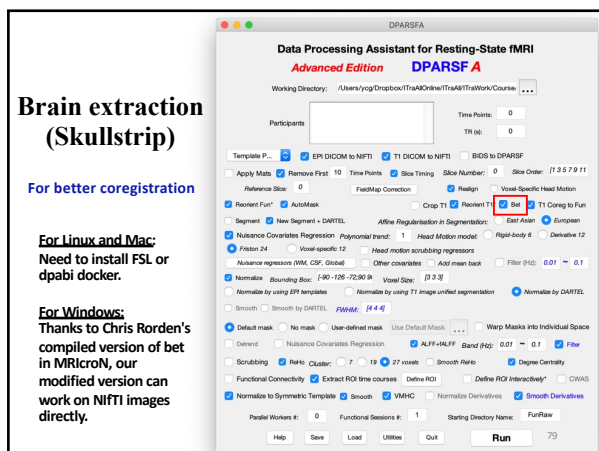
Masks/AutoMasks/

77

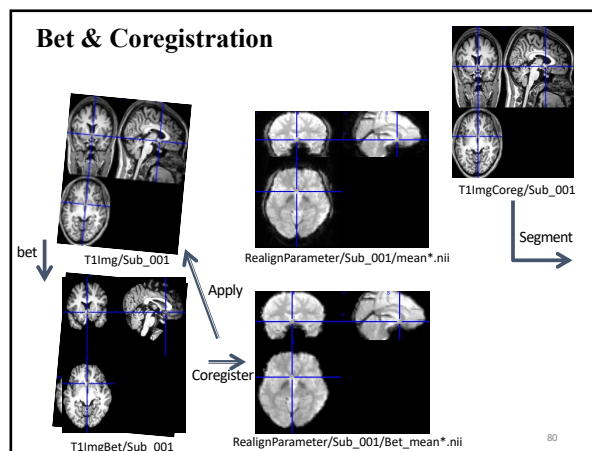
Preprocessing and R-fMRI measures Calculation

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

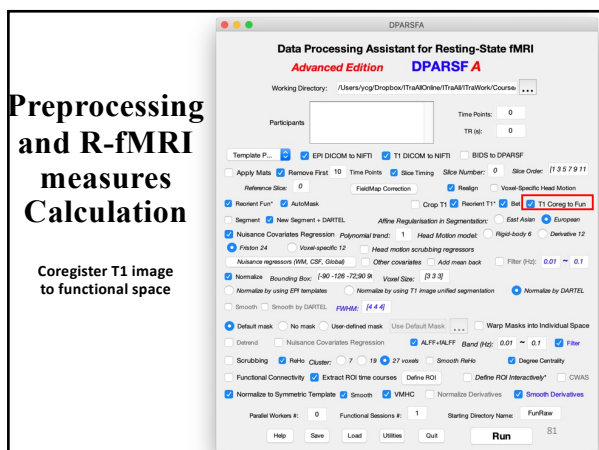
78



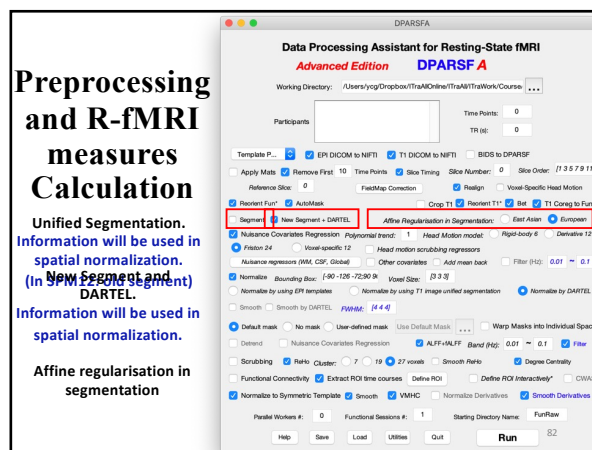
79



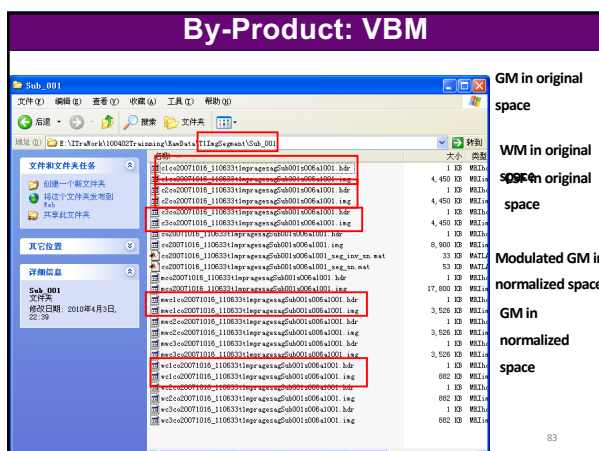
80



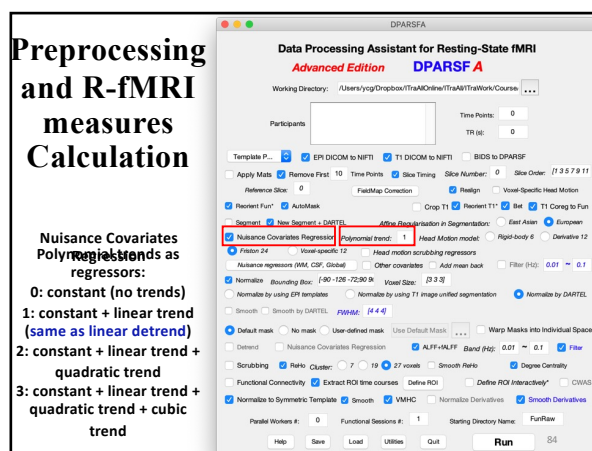
81



82



83



84

Preprocessing and R-fMRI measures Calculation

Head Motion regression model
6 head motion parameters
Derivative 12: 6 head motion parameters
Friston 24-parameter model
6 head motion parameters
12 corresponding squared items (Friston et al., 1996).

85

Preprocessing and R-fMRI measures Calculation

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

Head Motion Scrubbing Regressors

86

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

87

Yan et al., 2013, Neuroimage

Table 3 Summary recommendations.	
Summary recommendation	
• Individual-level correction with the Friston-24 model is recommended.	
• Additionally, group-level correction for mean FD is recommended, and removes the need for scrubbing.	
• If group-level correction for mean FD is contraindicated or not practical, then individual-level correction with scrubbing is recommended for PCC-FC, VMHC and ReHo (not ALFF*, fALFF, DC**).	
Additional considerations	
• Inclusion of global signal regression at the individual-level produces robust reductions in the relationships between motion and R-fMRI measures across participants – particularly for measures without Z-standardization. The benefits of GSR 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 this case, we recommend consideration of lower-order (i.e., 6 or 12-parameter) models to minimize the potential for over-fitting, as noted in Satterthwaite et al. (2013).	
• fALFF appeared to be relatively insensitive to motion correction strategies in the present work. Prior work (Satterthwaite et al., 2012) has suggested greater sensitivity in higher motion populations; as such we recommend continued application of correction procedures at the present time.	
* Recommendations against scrubbing for ALFF and fALFF apply to commonly employed FFT-based implementations (see Limitations and future directions section for alternatives).	
** Recommendations against scrubbing for DC were based on concerns regarding its ability to compromise graph construction (see The ability of motion correction strategies to decrease residual relationships between motion and R-fMRI metrics at group-level section for demonstration).	

88

Preprocessing and R-fMRI measures Calculation

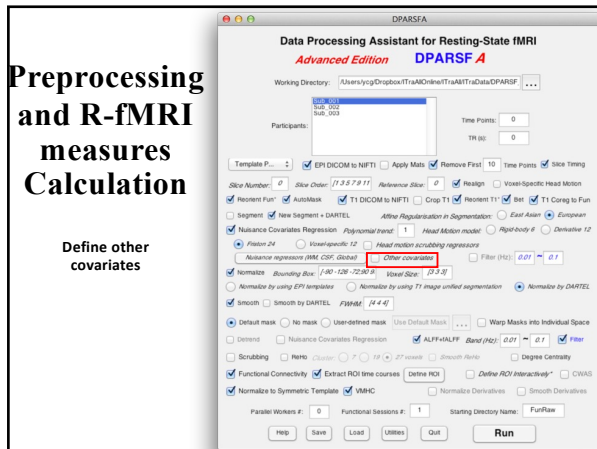
Nuisance Regressors (WM, CSF, Global)

89

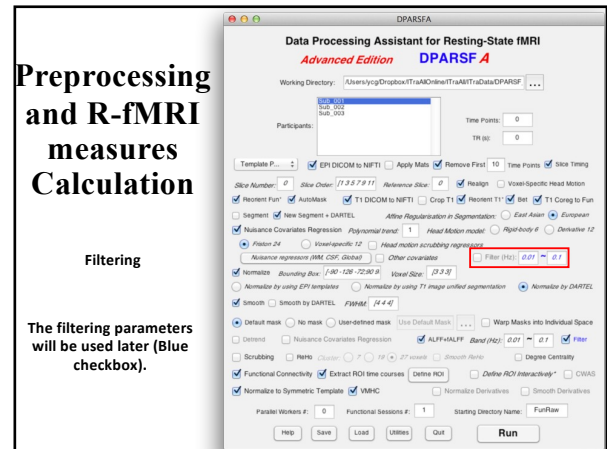
Nuisance Regression

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 Autotask

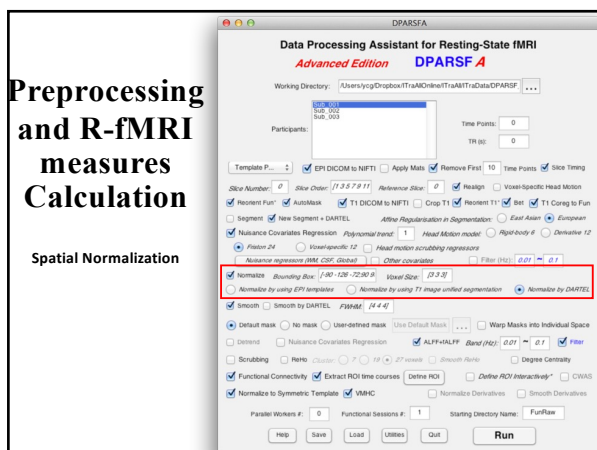
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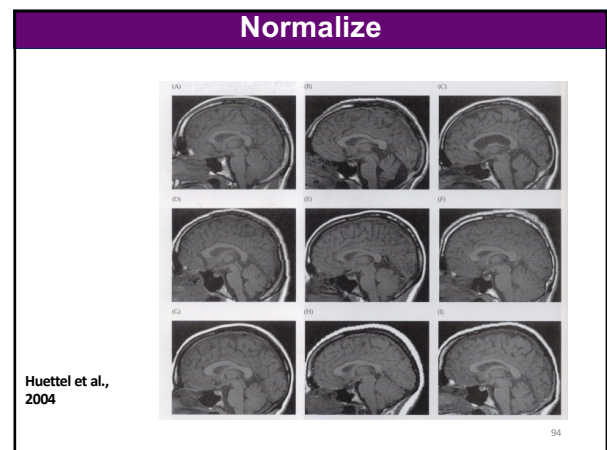
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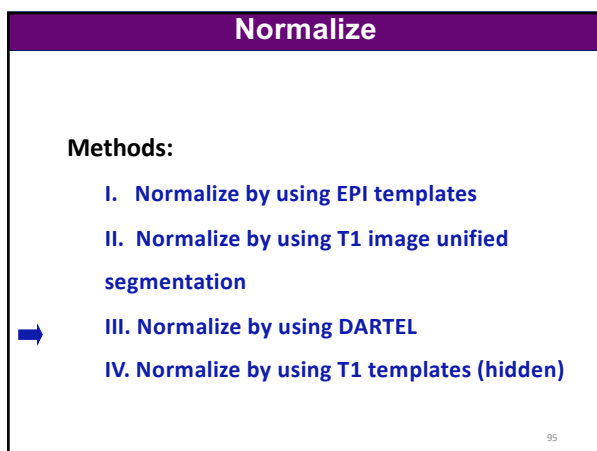
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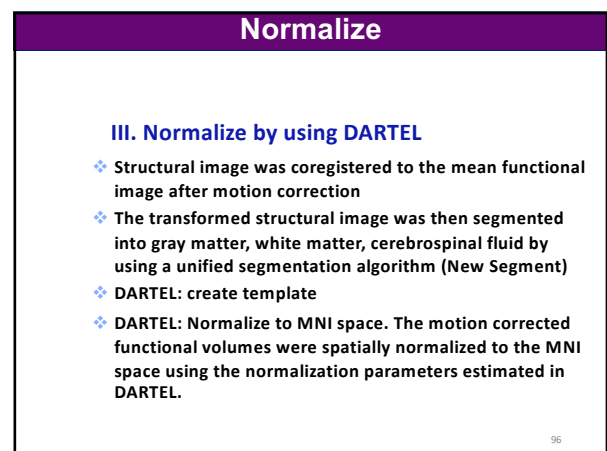
93



94



95



96

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

97

Smooth

Why?

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

98

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.

99

Preprocessing and R-fMRI measures Calculation

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

100

Preprocessing and R-fMRI measures Calculation

Nuisance Covariates Regression

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

101

R-fMRI measures Calculation

102

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)

103

Preprocessing and R-fMRI measures Calculation

Multiple functional sessions

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

104

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 A - Slice timing, R - Realigned and normalized. W - Normalize S - Smooth D - Detrend F - Filter C - Covariates Removed B - Scrubbing

105

Resting State fMRI Data Processing

Template Parameters

106

Resting State fMRI Data Processing

Calculate in MNI space
Calculate in Original space

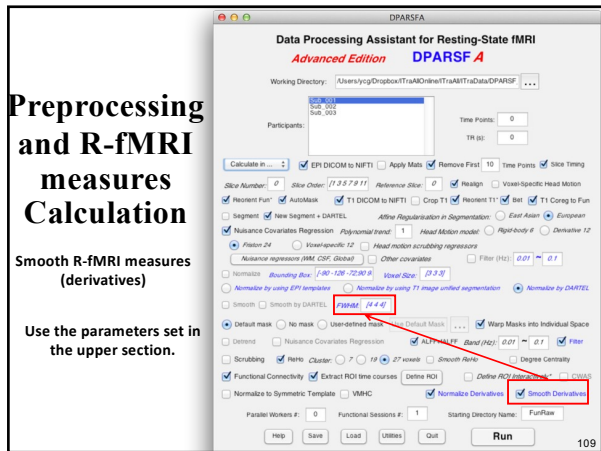
107

Preprocessing and R-fMRI measures Calculation

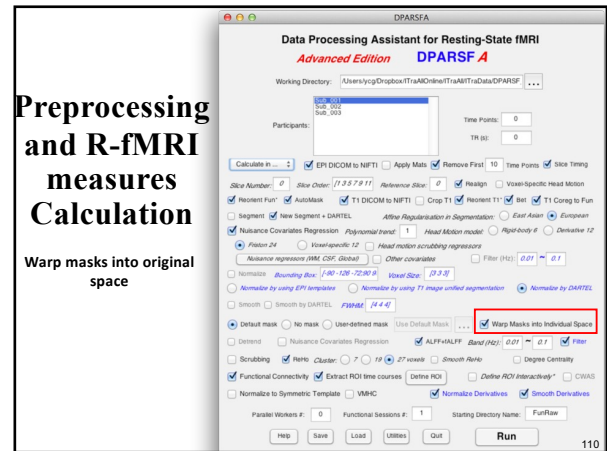
Normalize measures (derivatives) calculated in original space into MNI space

Use the parameters set in the upper section.

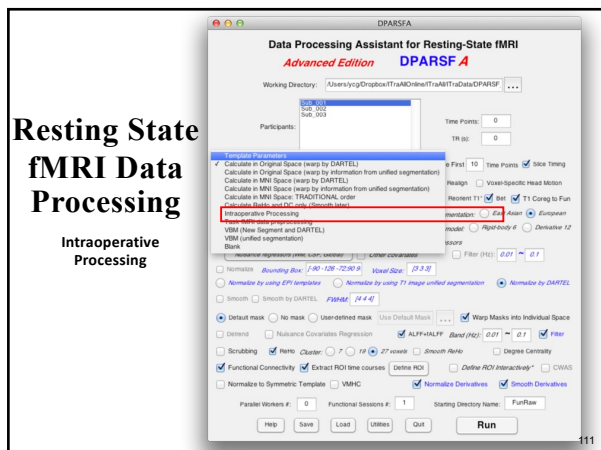
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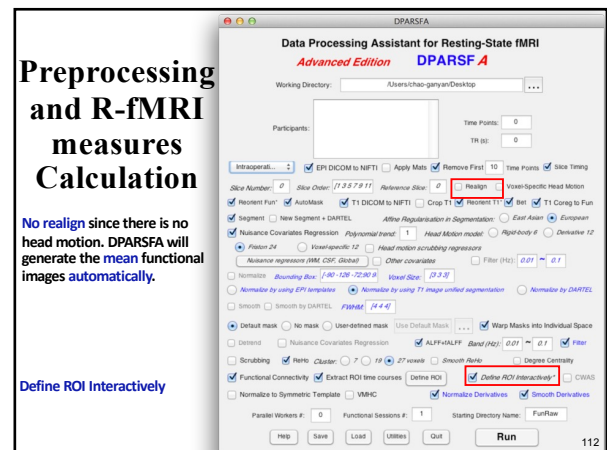
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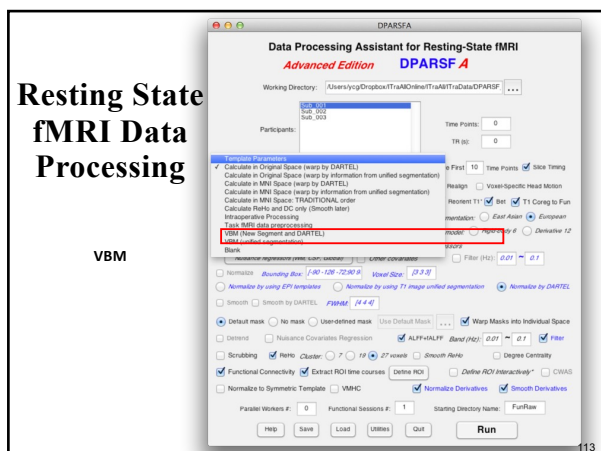
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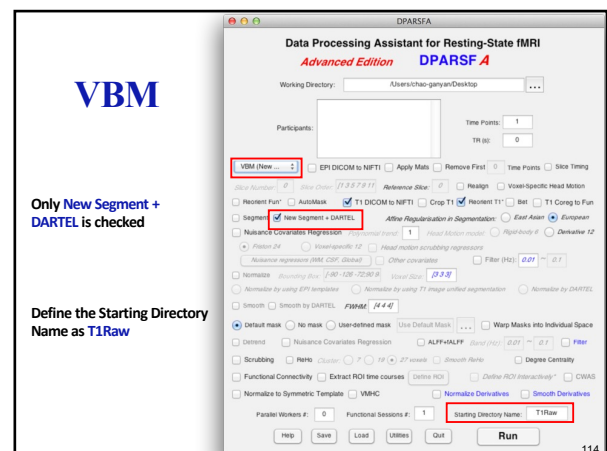
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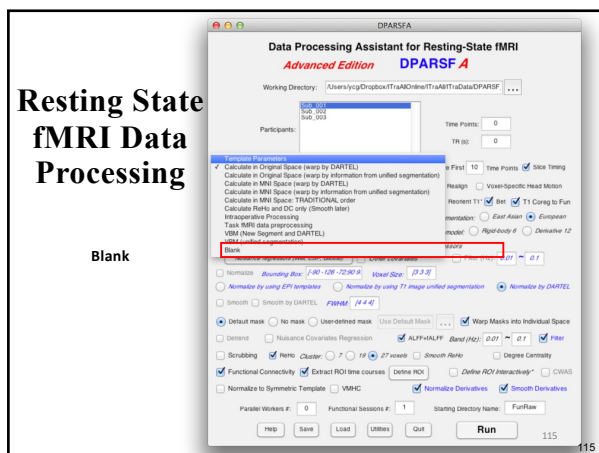
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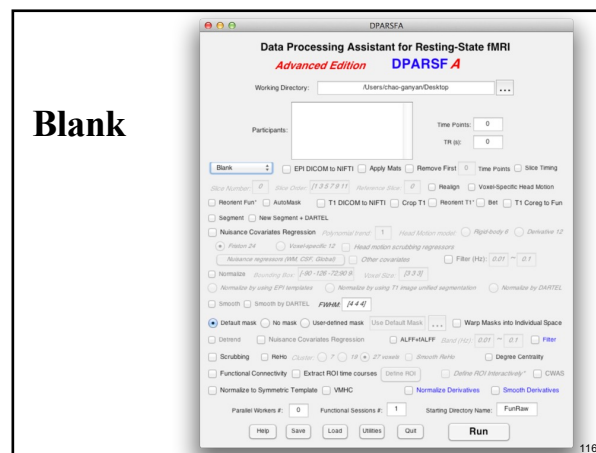
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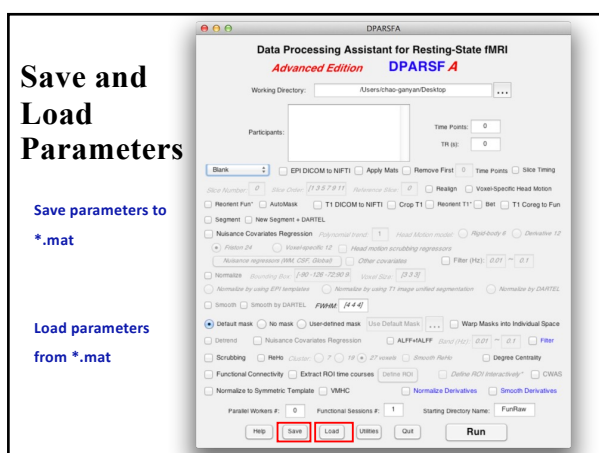
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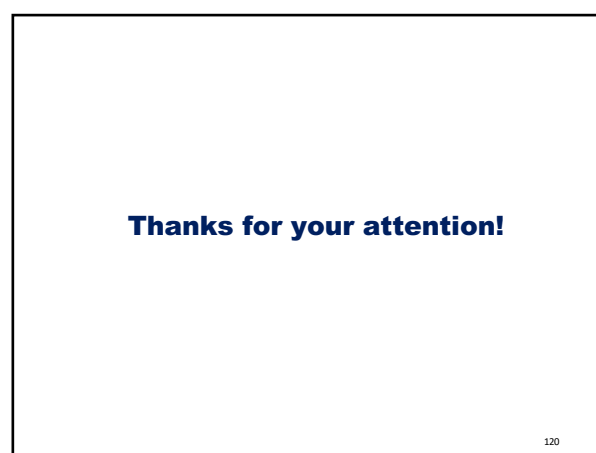
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118



119



120