Structural Magnetic Resonance Imaging

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List of Instruments

Name of Instrument	Table Name
sMRI - Cortical Thickness (Desikan)	mri_y_smr_thk_dsk
sMRI - Cortical Thickness (Destrieux)	mri_y_smr_thk_dst
sMRI - Cortical Thickness (Fuzzy Clustering)	mri_y_smr_thk_fzy
sMRI - Sulcal Depth (Desikan)	mri_y_smr_sulc_dsk
sMRI - Sulcal Depth (Destrieux)	mri_y_smr_sulc_dst
sMRI - Sulcal Depth (Fuzzy Clustering)	mri_y_smr_sulc_fzy
sMRI - Surface Area (Desikan)	mri_y_smr_area_dsk
sMRI - Surface Area (Destrieux)	mri_y_smr_area_dst
sMRI - Surface Area (Fuzzy Clustering)	mri_y_smr_area_fzy
sMRI - T1 Intensity-Gray/White Contrast (Desikan)	mri_y_smr_t1_contr_dsk
sMRI - T1 Intensity-Gray Matter (Desikan)	mri_y_smr_t1_gray_dsk
sMRI - T1 Intensity-White Matter (Desikan)	mri_y_smr_t1_white

	_dsk
sMRI - T1 Intensity-Gray/White Contrast (Destrieux)	mri_y_smr_t1_contr_dst
sMRI - T1 Intensity-Gray Matter (Destrieux)	mri_y_smr_t1_gray_dst
sMRI - T1 Intensity-White Matter (Destrieux)	mri_y_smr_t1_white_dst
sMRI - T1 Intensity-Gray/White Contrast (Fuzzy Clustering)	mri_y_smr_t1_contr_fzy
sMRI - T1 Intensity-Gray Matter (Fuzzy Clustering)	mri_y_smr_t1_gray_fzy
sMRI - T1 Intensity-White Matter (Fuzzy Clustering)	mri_y_smr_t1_white_fzy
sMRI - T1 Intensity (Subcortical)	mri_y_smr_t1_aseg
sMRI - T2 Intensity-Gray/White Contrast (Desikan)	mri_y_smr_t2_contr_dsk
sMRI - T2 Intensity-Gray Matter (Desikan)	mri_y_smr_t2_gray_dsk
sMRI - T2 Intensity-White Matter (Desikan)	mri_y_smr_t2_white_dsk
sMRI - T2 Intensity-Gray/White Contrast (Destrieux)	mri_y_smr_t2_contr_dst
sMRI - T2 Intensity-Gray Matter (Destrieux)	mri_y_smr_t2_gray_dst
sMRI - T2 Intensity-White Matter (Destrieux)	mri_y_smr_t2_white_dst
sMRI - T2 Intensity-Gray/White Contrast (Fuzzy Clustering)	mri_y_smr_t2_contr_fzy
sMRI - T2 Intensity-Gray Matter (Fuzzy Clustering)	mri_y_smr_t2_gray_fzy
sMRI - T2 Intensity-White Matter (Fuzzy	mri_y_smr_t2_white

Clustering)	_fzy
sMRI - T2 Intensity (Subcortical)	mri_y_smr_t2_aseg
sMRI - Volume (Desikan)	mri_y_smr_vol_dsk
sMRI - Volume (Destrieux)	mri_y_smr_vol_dst
sMRI - Volume (Fuzzy Clustering)	mri_y_smr_vol_fzy
sMRI - Volume (Subcortical)	mri_y_smr_vol_aseg

General Information

An overview of the ABCD Study® can be found at abcdstudy.org and detailed descriptions of the assessment protocols are available at ABCD Protocols. This page describes the contents of various instruments available for download. To understand the context of this information, refer to the release notes *Start Page* and *Imaging Overview*.

Overview

- Image types
  - T_1-weighted (T_1w) 3D structural images
  - T_2-weighted (T_2w) 3D structural images
- Image processing
  - corrected for gradient nonlinearity distortions (Jovicich, et al., 2006)
  - T_2w images registered to T_1w images using mutual information (Wells, et al., 1996)
  - intensity non-uniformity correction based on tissue segmentation and sparse spatial smoothing
  - resampled with 1 mm isotropic voxels into rigid alignment with an atlas brain
- Cortical surface reconstruction
  - FreeSurfer v7.1.1 (https://surfer.nmr.mgh.harvard.edu)
  - skull-stripping (Segonne, et al., 2004)
  - white matter segmentation, initial mesh creation (Dale, et al., 1999)
  - correction of topological defects (Fischl, et al., 2001; Segonne, et al., 2007)

    - surface optimization (Dale, et al., 1999; Dale and Sereno, 1993; Fischl and Dale, 2000)
    - nonlinear registration to a spherical surface-based atlas (Fischl, et al., 1999b)
- Morphometry
    - subcortical regional volume
    - cortical volume
    - cortical thickness (Fischl and Dale, 2000)
    - cortical area (Chen, et al., 2012; Joyner, et al., 2009)
    - sulcal depth (Fischl, et al., 1999a)
- Image intensity measures
    - T_1w and T_2w intensity measures in white matter (-0.2 mm from gray/white boundary)
    - T_1w and T_2w intensity measures in gray matter (+0.2 mm from gray/white boundary)
    - Normalized T_1w and T_2w cortical gray/white intensity contrast (Westlye, et al., 2009)
- Regions of interest (ROIs)
    - subcortical structures labeled with atlas-based segmentation (Fischl, et al., 2002)
    - cortical regions labeled with the Desikan atlas-based classification (Desikan, et al., 2006)
    - cortical regions labeled with the Destrieux atlas-based classification (Destrieux, et al., 2010)
    - fuzzy-cluster parcels, based on genetic correlation of surface area (Chen, et al., 2012)

Methods

Image processing and analysis methods corresponding to ABCD Release 2.0.1 are described Hagler et al., 2019, NeuroImage. Image processing and analysis methods for the Adolescent Brain Cognitive Development Study (doi: 10.1016/j.neuroimage.2019.116091). Changes to image processing and analysis methods in Release 3.0 and Release 4.0 are documented below. No significant changes were made to the processing pipeline for Release 5.0.

Changes for ABCD 4.0

sMRI processing: registration to atlas

The sMRI processing pipeline has included registration to a pre-existing, custom in-house T_1w atlas and rigid body resampling. In rare cases this registration step may fail (e.g., in some participants with enlarged ventricles), resulting in non-standard head orientations in the processed data for those participant-events. In the current processing pipeline, we use a new ABCD-specific atlas that reduces the frequency of failed registration to atlas.

sMRI processing: bias correction

The correction of sMRI T_1w and sMRI T_2w images for intensity inhomogeneity uses a smoothly varying bias field constrained to have uniform intensities in voxels segmented as white matter. In addition, outlier voxels, defined as voxels in the white matter mask with low T_1w intensities or high T_2w intensities, are removed from the white matter mask. This was done to prevent slight inaccuracies in the initial white matter mask from causing poor bias field estimation in those regions with outlier intensities in voxels labeled as white matter. In the current pipeline, the smoothing algorithm for generating the bias field was changed slightly to use a robust, sparse smoothing algorithm with parameters optimized for a slightly more flexible (less smooth) bias field to better handle locally steep intensity gradients. The removal of outlier voxels from the white matter mask was done iteratively and was limited to the outer band (~1 cm) of white matter. For T_2w images, a bug in the previous implementation of the outlier removal resulted in a sparse, slightly shrunken white matter mask. Correcting this issue resulted in a less sparse white matter mask and more spatially uniform bias correction for the T_2w images than before.

T_2w registration to T_1w

The procedure for registration of sMRI T_2w to T_1-weighted images involves a pre-registration of the T_1w image to a T_1w atlas, pre-registration of the T_2w image to a T_2w atlas (co-registered to the T_1w atlas), and then fine registration between the T_2w and T_1w images using mutual information. In rare cases, the pre-registration of the T_1w image to the T_1w atlas essentially failed, subsequently resulting in a poor registration between the T_2w and T_1w images. To reduce the likelihood of registration failure, the T_1w atlas was edited by applying a brain mask, preventing non-brain regions of the atlas from influencing the registration.

FreeSurfer version

The FreeSurfer version was updated from 5.3.0 to 7.1.1. Changes to

FreeSurfer processing across versions are documented here. Differences in the resulting surfaces and subcortical ROIs were generally quite small and free of systematic bias, but it should be noted that the sulcal depth measure differs in scale by a factor of 10 (i.e., now in units of mm instead of cm), resulting in large differences in the “sulc” ROI-averages included in the tabulated imaging data (in data NDA data structure `abcd_smrip102`).

Changes to data dictionaries

- new versions of NDA data structures `abcd_smrip102`, `abcd_smrip202`, and `abcd_smrip302` based on `abcd_smrip101` and `abcd_smrip201`
- split data structures to separate FreeSurfer-derived morphometry, T_1w intensities, and T_2w intensities
- removed unused aliases
- new versions of NDA data structures `abcd_mrisdp102`, `abcd_mrisdp202`, and `abcd_mrisdp302` based on `abcd_mrisdp101` and `abcd_mrisdp201`
- split data structures to separate FreeSurfer-derived morphometry, T_1w intensities, and T_2w intensities
- removed unused aliases

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