

ABCD Human Subject Study

Adolescent Brain Cognitive Development – ABCDSTUDY.org

Release Notes for Annual Release 1.1

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ABCD Imaging Instruments

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General Information

We are happy to announce the Adolescent Brain Cognitive Development (ABCD) Study October 2018 patch release (ABCD Release 1.1) available from <https://data-archive.nimh.nih.gov/abcd>. This release contains spreadsheet data and minimally processed imaging data for the ABCD baseline visits of participants between September 1, 2016 and September 15, 2017.

An overview of the ABCD Study is at <https://abcdstudy.org> and detailed descriptions of elements of the study are listed in <https://abcdstudy.org/scientists-publications.html>. Qualified researchers can request access to ABCD shared data. To get started, create an NIMH Data Archive (NDA) account or login to your existing one. Once approved, you will have access to query and download all data available in the repository. To get started go to <https://data-archive.nimh.nih.gov/abcd/request-access>.

This document details how to query the NDA database to obtain information, metrics, and imaging files from the magnetic resonance imaging (MRI) components of the ABCD Study. This document is the second part of the essential reading for the patch release. For essential non-imaging components, ABCD collaborators should also read the preceding document *Release Notes ABCD README FIRST*.

Nomenclature

Within the ABCD study, all measures provided are referred to as instruments. Changes of instrument names between releases are detailed in the *ABCD_release_1.1_mapping_file*. Abbreviations of anatomical locations are detailed in *NDA 1.1 Supplementary Imaging Tables*.

Individual instruments can be identified on NDA by the short name (second column) in the following table. Each data dictionary can be downloaded at this link: https://ndar.nih.gov/data_dictionary.html?source=ABCD%2BRelease%2B1.1&submission=ALL

MRI Scanner Information

Measure	NDA Short Name	Description
MRI Info	abcd_mri01	MRI Scanner Information

For each subject visit, information on the MRI scanner manufacturer, model, magnetic field strength, device software version etc. are detailed in the *Other Imaging Instruments Release Notes*.

MRI file sharing

Measure	NDA Short Name	Description
Processed MRI Data	fmriresults01	Index of minimally processed data
Image	image03	Index of Fast Track raw data

Minimally processed MRI file sharing

The ABCD Data Release 1.1 contains minimally processed neuroimaging data from 4,521 ABCD Study participants, including:

- High-resolution structural data (3D T1w and T2w scans)
- Advanced diffusion MRI (multiple b-values and directions)
- Resting State fMRI
- Task fMRI (Monetary Incentive Delay, Stop-Signal), and Emotional N-Back), along with raw E-Prime task files for each fMRI run

These series have been run through standard modality-specific pre-processing stages including conversion from raw to compressed files, distortion correction, movement correction, alignment to standard space, and initial quality control (refer to *MRI Quality Control (QC)* Release Notes). This is to enable researchers to use the ABCD neuroimaging data in their own processing pipelines more quickly and efficiently than starting with raw data. Researchers intending to use minimally processed data should take note of the appropriate acknowledgement language to include in any public disclosure of results (refer <https://data-archive.nimh.nih.gov/abcd/results>). The available minimally processed files are detailed in the *Other Imaging Instruments* Release Notes.

Fast Track DICOM file sharing

If unprocessed raw imaging data is needed, DICOM files are also made publicly available via a Fast Track mechanism. These DICOM files are released on NDA (<https://data-archive.nimh.nih.gov/abcd>) on a continual basis within approximately one month of data collection using the ABCD fast-track image sharing scripts (RRID: SCR_016021). DICOM files are arranged in BIDS-compliant directory trees and packaged in individual archive files (tgz) for each series. Metadata are included in the form of json-format text files, and for task-fMRI series, also included are the files containing stimulus and behavioral response timing information exported from the stimulus program (E-prime). A copy of the metadata is uploaded to NDA's image (version 03) database to link information to non-imaging-based assessments for the same participants. Raw DICOM Fast Track data have not undergone quality control or curation. The up-to-date index of Fast Track shared DICOM files can be downloaded in a separate image03 instrument.

Note on high density, phased array head coils

The ABCD acquisition sites use either 32 channel head or 64 channel head/neck coils, depending on availability. Standard correction methods, such as those used by FreeSurfer, are limited when compensating for steep spatial intensity variation, leading to inaccurate brain segmentation or cortical surface reconstruction. For example, brain tissue farther from the coils, such as the temporal and frontal poles, typically have lower intensity values resulting in focal underestimation of the white matter surface or the elimination of large pieces of the cortical surface reconstruction. Furthermore, brain tissue close to coils with extremely high intensity values may be mistaken for non-brain tissue (e.g., scalp). To overcome this, the ABCD minimally processed structural MRI (sMRI) files include an improved intensity inhomogeneity correction, using a smoothly varying bias field optimized to standardize image intensities within all white matter voxels.

Tabulated ROI-based analysis

Measure	NDA Short Name	Description
ABCD sMRI Part 1	abcd_smrip101	sMRI morphometric and image intensity measures (part 1)
ABCD sMRI Part 2	abcd_smrip201	sMRI morphometric and image intensity measures (part 2)
ABCD dMRI DTI Part 1	abcd_dti_p101	Diffusion Tensor Imaging measures in subcortical (aseg) and cortical (Desikan aparc) ROIs and white matter fiber tracts (part 1)
ABCD dMRI DTI Part 2	abcd_dti_p201	Diffusion Tensor Imaging measures in subcortical (aseg) and cortical (Desikan aparc) ROIs and white matter fiber tracts (part 2)
ABCD dMRI RSI Part 1	mri_rsip102	Restriction Spectrum Imaging measures in subcortical (aseg) and cortical (Desikan aparc) ROIs and white matter fiber tracts (part 1)
ABCD dMRI RSI Part 2	mri_rsip202	Restriction Spectrum Imaging measures in subcortical (aseg) and cortical (Desikan aparc) ROIs and white matter fiber tracts (part 2)
ABCD rsfMRI Gordon Network Correlations	abcd_betnet02	Resting-state fMRI correlation within and between cortical networks
ABCD rsfMRI Network to Subcortical ROI Correlations	mrirscor02	Resting-state fMRI correlation between cortical networks and subcortical ROIs
ABCD rsfMRI Temporal Variance	abcd_mrirstv02	Resting-state fMRI temporal variance

ABCD Task fMRI MID Average Beta Weights Part 1	midaparc02	Beta weights for MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs averaged across runs (part 1)
ABCD Task fMRI MID Average Beta Weights Part 2	midaparc202	Beta weights for MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs averaged across runs (part 2)
ABCD Task fMRI MID Run 1 Beta Weights Part 1	abcd_midr1bwp101	Beta weights for run 1 MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs (part 1)
ABCD Task fMRI MID Run 1 Beta Weights Part 2	abcd_midr1bwp201	Beta weights for run 1 MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs (part 2)
ABCD Task fMRI MID Run 2 Beta Weights Part 1	midr2bwp101	Beta weights for run 2 MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs (part 1)
ABCD Task fMRI MID Run 2 Beta Weights Part 2	midr2bwp201	Beta weights for run 2 MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs (part 2)
ABCD Task fMRI MID Average Standard Error of the Mean Part 1	abcd_midasemp101	Standard error of the mean for MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs averaged across all runs (part 1)
ABCD Task fMRI MID Average Standard Error of the Mean Part 2	abcd_midasemp201	Standard error of the mean for MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs averaged across all runs (part 2)
ABCD Task fMRI MID Run 1 Standard Error of the Mean Part 1	abcd_midsemp101	Standard error of the mean for run 1 MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs (part 1)
ABCD Task fMRI MID Run 1 Standard Error of the Mean Part 2	abcd_midsemp201	Standard error of the mean for run 1 MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs (part 2)
ABCD Task fMRI MID Run 2 Standard Error of the Mean Part 1	abcd_midr2semp101	Standard error of the mean for run 2 MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs (part 1)
ABCD Task fMRI MID Run Standard Error of the Mean Part 2	abcd_midr2semp201	Standard error of the mean for run 2 MID task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs (part 2)
ABCD Task fMRI SST Average Beta Weights	mriss02	Beta weights for SST task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs averaged across all runs
ABCD Task fMRI SST Run 1 Beta Weights	mrissr1bw01	Beta weights for run 1 SST task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs
ABCD Task fMRI SST Run 2 Beta Weights	mrissr2bw01	Beta weights for run 2 SST task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs

ABCD Task fMRI SST Average Standard Error of the Mean	mrisstsem01	Standard error of the mean for SST task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs averaged across all runs
ABCD Task fMRI SST Run 1 Standard Error of the Mean	mrisstr1sem01	Standard error of the mean for run 1 SST task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs
ABCD Task fMRI SST Run 2 Standard Error of the Mean	mrisstr2bwsem01	Standard error of the mean for run 2 SST task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs
ABCD Task fMRI nBack Average Beta Weights	nback_bwroi02	Beta weights for nBack task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs averaged across all runs
ABCD Task fMRI nBack Run 1 Beta Weights	nbackr101	Beta weights for run 1 nBack task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs
ABCD Task fMRI nBack Run 2 Beta Weights	nbackr201	Beta weights for run 2 nBack task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs
ABCD Task fMRI nBack Average Standard Error of the Mean	nbackallsem01	Standard error of the mean for nBack task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs averaged across all runs
ABCD Task fMRI nBack Run 1 Standard Error of the Mean	nbackr1sem01	Standard error of the mean for run 1 nBack task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs
ABCD Task fMRI nBack Run 2 Standard Error of the Mean	nbackr2sem01	Standard error of the mean for run 2 nBack task fMRI in subcortical (aseg) and cortical (Desikan aparc) ROIs
ABCD dMRI Post Processing QC	dmriqc01	Processed dMRI data quality control measures
ABCD Task fMRI MID Behavior	abcd_mid02	Behavioral performance measures for MID task fMRI
ABCD Task fMRI SST Behavior	abcd_sst02	Behavioral performance measures for SST task fMRI
ABCD Task fMRI nBack Behavior	abcd_mrinback02	Behavioral performance measures for nBack task fMRI (working memory)
ABCD Task fMRI REC Behavior	mribrec02	Behavioral performance measures for nBack task fMRI (post-scan recall)

MR images are corrected for distortions and head motion, and cross-modality registrations are performed. Using the T1w sMRI scan, the cortical surface is reconstructed, and subcortical and white matter regions of the brain are segmented. From this, we carry out modality-specific analyses and extract imaging-derived measures using a variety of regions of interest (ROI). Finally, ROI analysis results are compiled across subjects and summarized in tabulated form.

Information on the different tabulated data is detailed in modality-specific release notes:

- Structural Magnetic Resonance Imaging (sMRI)
- Diffusion Magnetic Resonance Imaging (dMRI)

- Resting-State Functional Magnetic Resonance Imaging (rs-fMRI)
- Task-Based Functional Magnetic Resonance Imaging (task-fMRI)
- Behavioral Performance During task-fMRI

Despite the convenience of ROI-based analyses and the advantages related to reduced numbers of statistical comparisons, there are inherent limitations to this approach. Effects of interest (e.g., associations between cortical morphometry and cognitive variables, or task-related fMRI activation) could potentially straddle multiple ROIs, or occupy a small region of a large ROI, thereby reducing the sensitivity of an ROI-based analysis relative to mapping-based approaches. The standard FreeSurfer Desikan parcellation has relatively large parcels that include multiple, functionally distinct cortical areas. For this reason, users should be cautious about interpreting the results of ROI-based analyses, particularly for task fMRI.

Quality Control and Recommended Inclusion Criteria

Measure	NDA Short Name	Description
MR Findings	abcd_mrfindings01	Neuroradiology reports - scores, hydrocephalus and herniation
ABCD MRI QC Raw Part 1	mriqc02	Quality control measures (part 1)
ABCD MRI QC Raw Part 2	mriqcp202	Quality control measures (part 2)
FreeSurfer QC	freesqc01	Freesurfer reconstruction quality control measures
ABCD dMRI Post Processing QC	dmriqc01	Processed dMRI data quality control measures

Incidental findings

T1w and T2w images, if available, were screened for incidental findings by a Board Certified Neuroradiologist. Any findings requiring clinical investigation were relayed to appropriate site personnel via the ABCD Coordinating Center (CC). Detailed information on the scoring of this instrument are in the *Other Imaging Instruments* Release Notes.

Protocol Compliance and Quality Control

All ABCD MRI exams have been systematically checked for MRI protocol compliance and completeness, and images have been manually rated for quality by trained MR analysts before and after processing. All MRI data is provided to ABCD collaborators, but we highly recommend that researchers filter subjects by QC results based on the project aims and tolerance for MR artifacts/motion. Please note that severe artifact in all T1w image in a given visit (MRI Quality Control (QC):iqc_t1_ok_ser = 0) may result in the inability to produce subsequent MR-metrics for other modalities. FreeSurfer cortical surface reconstructions were visually inspected, and reviewers assigned a QC score of 0 or 1, indicating whether it is recommended that a subject be

excluded (0) or included (1) in group analyses involving cortical surface ROIs. Please refer to the *MRI Quality Control (QC)* Release Notes for further details.

Behavioral performance in task fMRI

Behavioral measures calculated from participant button presses during task fMRI acquisition are also included (see *Behavioral Performance During task-fMRI* Release Notes). Based on those measures, behavioral performance flags were provided, indicating whether a subject's performance for each task was within acceptable standards. It is suggested that users exclude subjects from group analysis based on sub-optimal performance and possibly additional criteria such as the number of degrees of freedom (reduced by motion censoring) in the individual subject task-fMRI analysis or based on outlier detection on the ROI-averages themselves. Users should choose inclusion/exclusion performance criteria that are appropriate for their analyses.

Recommended Inclusion Criteria

Fast Track DICOM data, minimally processed data and tabulated ROI-based data (MR-metric tables) provides the researcher with all the possible ABCD data permitted to be shared.

For projects that require MR artifacts and/or motion, all data can be used. Refer to the *ABCD MRI QC Raw Part 1/2* instruments for details of motion severity and categories of artifacts. For projects that require no MR artifacts and minimal motion, we recommend the following inclusion criteria.

Preliminary option

- If needed, review *MR Findings* (abcd_mrfindings01) to exclude clinical referrals (mrif_score = 3 OR mrif_score = 4) or incidental findings (e.g. hydrocephalus, herniation).

T1w analysis

To use quality T1w files

- ABCD MRI QC Raw Part 1: iqc_t1_ok_ser > 0

For T1w FreeSurfer tabulated ROI-based data (ABCD sMRI Part 1/2)

- FreeSurfer QC: fsqc_qc = 1

T2w analysis

To use quality T2w files

- ABCD MRI QC Raw Part 1: iqc_t2_ok_ser > 0

For T2w FreeSurfer tabulated ROI-based data (ABCD sMRI Part 2)

- FreeSurfer QC: fsqc_qc = 1
- ABCD MRI QC Raw Part 1: iqc_t2_ok_ser > 0

dMRI analysis (DTI/RSI)

To use quality dMRI files

- ABCD MRI QC Raw Part 1: `iqc_dmri_ok_ser > 0`
- ABCD MRI QC Raw Part 1: `iqc_t1_ok_ser > 0` (for registration to T1w image)

For dMRI FreeSurfer tabulated ROI-based data (ABCD sMRI Part 2)

- FreeSurfer QC: `fsqc_qc = 1`
- ABCD dMRI Post Processing QC: `dmri_dti_postqc_qc = 1`

For dMRI AtlasTrack tabulated ROI-based data (ABCD dMRI DTI Part 1/2; ABCD dMRI RSI Part 1/2)

- ABCD dMRI Post Processing QC: `dmri_dti_postqc_qc = 1`

resting-state fMRI analysis

To use 5 minutes of quality resting-state fMRI files (i.e., 5 mins x 60 secs x 0.8 TR = 375)

- ABCD MRI QC Raw Part 1: `iqc_rsfmri_ok_ser > 0`
- ABCD MRI QC Raw Part 1: `iqc_t1_ok_ser > 0` (for registration to T1w image)
- ABCD rsfMRI Gordon Network Correlations: `rsfmri_c_ngd_ntpoints > 375`

For resting-state fMRI tabulated ROI-based data (ABCD rsfMRI Gordon Network Correlations; ABCD rsfMRI Network to Subcortical ROI Correlations; ABCD rsfMRI Temporal Variance)

- FreeSurfer QC: `fsqc_qc = 1`
- ABCD rsfMRI Gordon Network Correlations: `rsfmri_c_ngd_ntpoints > 375`

task fMRI analysis

To use quality task fMRI files

- ABCD MRI QC Raw Part 1: `iqc_t1_ok_ser > 0` (for registration to T1w image)

MID

- ABCD MRI QC Raw Part 1: `iqc_mid_ok_ser > 0`
- ABCD Task fMRI MID Behavior: `tfmri_mid_beh_performflag = 1`
- ABCD Task fMRI MID Average Beta Weights Part 1: `tfmri_mid_all_b_dof > 200`
- ABCD Task fMRI MID Average Standard Error of the Mean Part 1: `tfmri_mid_all_sem_dof > 200`

SST

- ABCD MRI QC Raw Part 2: `iqc_sst_ok_ser > 0`
- ABCD Task fMRI SST Behavior: `tfmri_sst_beh_performflag = 1`
- ABCD Task fMRI SST Average Beta Weights Part 1: `tfmri_sst_all_b_dof > 200`
- ABCD Task fMRI SST Average Standard Error of the Mean Part 1: `tfmri_sst_all_sem_dof > 200`

nBACK

- ABCD MRI QC Raw Part2: `iqc_nback_ok_ser > 0`
- ABCD Task fMRI nBack Behavior: `tfmri_nback_beh_performflag = 1`
- ABCD Task fMRI nBack Average Beta Weights Part 1: `tfmri_nback_all_b_dof > 200`
- ABCD Task fMRI nBack Average Standard Error of the Mean Part 1: `tfmri_nback_all_sem_dof > 200`

For task-based fMRI tabulated ROI-based data (ABCD Task fMRI instruments)

- FreeSurfer QC: fsqc_qc = 1 (for registration to T1w image)

MID

- ABCD MRI QC Raw Part 1: iqc_mid_ok_ser > 0
- ABCD Task fMRI MID Behavior: tfmri_mid_beh_performflag = 1
- ABCD Task fMRI MID Average Beta Weights Part 1: tfmri_mid_all_b_dof > 200
- ABCD Task fMRI MID Average Standard Error of the Mean Part 1:
tfmri_mid_all_sem_dof > 200

SST

- ABCD MRI QC Raw Part 2: iqc_sst_ok_ser > 0
- ABCD Task fMRI SST Behavior: tfmri_sst_beh_performflag = 1
- ABCD Task fMRI SST Average Beta Weights Part 1: tfmri_sst_all_b_dof > 200
- ABCD Task fMRI SST Average Standard Error of the Mean Part 1:
tfmri_sst_all_sem_dof > 200

nBACK

- ABCD MRI QC Raw Part2: iqc_nback_ok_ser > 0
- ABCD Task fMRI nBack Behavior: tfmri_nback_beh_performflag = 1
- ABCD Task fMRI nBack Average Beta Weights Part 1: tfmri_nback_all_b_dof > 200
- ABCD Task fMRI nBack Average Standard Error of the Mean Part 1:
tfmri_nback_all_sem_dof > 200