

ABCD Human Subjects Study

Adolescent Brain Cognitive Development – ABCDSTUDY.org

Release Notes: Adolescent Brain Cognitive Development StudySM (ABCD) Data Release 3.0

Task-Based Functional Magnetic Resonance Imaging (task-fMRI)

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October 2020

Change Log

October 2020 – ABCD Data Release 3.0

- Initial release

List of Instruments

Instruments	Short Name
ABCD Task fMRI MID Run 1 Beta Weights Part 1	abcd_midr1bwp102
ABCD Task fMRI MID Run 1 Beta Weights Part 2	abcd_midr1bwp202
ABCD Task fMRI MID Run 1 Beta Weights Destrieux Parcellations Part 1	abcd_midr1bwdp101
ABCD Task fMRI MID Run 1 Beta Weights Destrieux Parcellations Part 2	abcd_midr1bwdp202
ABCD Task fMRI MID Run 1 Standard Error of the Mean Part 1	abcd_midsemp102
ABCD Task fMRI MID Run 1 Standard Error of the Mean Part 2	abcd_midsemp202

ABCD Task fMRI MID Run 1 SEM Destrieux Parcellations Part 1	abcd_tmidr1semdp101
ABCD Task fMRI MID Run 1 SEM Destrieux Parcellations Part 2	abcd_tmidr1semdp202
ABCD Task fMRI MID Run 2 Beta Weights Part 1	midr2bwp102
ABCD Task fMRI MID Run 2 Beta Weights Part 2	midr2bwp202
ABCD Task fMRI MID Run 2 Beta Weights Destrieux Parcellations Part 1	abcd_tr2bwdp01
ABCD Task fMRI MID Run 2 Beta Weights Destrieux Parcellations Part 2 (Release 2.0.1)	abcd_tr2bwdp202
ABCD Task fMRI MID Run 2 Standard Error of the Mean Part 1	abcd_midr2semp102
ABCD Task fMRI MID Run 2 Standard Error of the Mean Part 2	abcd_midr2semp202
ABCD Task fMRI MID Run 2 SEM Destrieux Parcellations Part 1	abcd_tr2semdp101
ABCD Task fMRI MID Run 2 SEM Destrieux Parcellations Part 2	abcd_tr2semdp201
ABCD Task fMRI MID Average Beta Weights Part 1	midaparc03
ABCD Task fMRI MID Average Beta Weights Part 2	midaparc203
ABCD Task fMRI MID Average Beta Weights Destrieux Parcellations Part 1	abcd_midabwdp01
ABCD Task fMRI MID Average Beta Weights Destrieux Parcellations Part 2	abcd_midabwdp202
ABCD Task fMRI MID Average Standard Error of the Mean Part 1	abcd_midasemp102
ABCD Task fMRI MID Average Standard Error of the Mean Part 2	abcd_midasemp202
ABCD Task fMRI MID Average SEM Destrieux Parcellations Part 1	abcd_midasemp101
ABCD Task fMRI MID Average SEM Destrieux Parcellations Part 2	abcd_midasemp202
ABCD Task fMRI SST Run 1 Beta Weights	mrissr1bw01
ABCD Task fMRI SST Run 1 Beta Weights Destrieux Parcellations Part 1	abcd_tfsr1bwdp101
ABCD Task fMRI SST Run 1 Beta Weights Destrieux Parcellations Part 2	abcd_tfsr1bwdp201
ABCD Task fMRI SST Run 1 Standard Error of the Mean	mrissr1sem01

ABCD Task fMRI SST Run 1 SEM Destrieux Parcellations Part 1	abcd_tfsstr1sem dp101
ABCD Task fMRI SST Run 1 SEM Destrieux Parcellations Part 2	abcd_tfsstr1sem dp201
ABCD Task fMRI SST Run 2 Beta Weights	mrisstr2bw01
ABCD Task fMRI SST Run 2 Beta Weights Destrieux Parcellations Part 1	abcd_tfsstr2bw dp101
ABCD Task fMRI SST Run 2 Beta Weights Destrieux Parcellations Part 2	abcd_tfsstr2bw dp201
ABCD Task fMRI SST Run 2 Standard Error of the Mean	mrisstr2bwsem01
ABCD Task fMRI SST Run 2 SEM Destrieux Parcellations Part 1	abcd_tfsstr2sem dp101
ABCD Task fMRI SST Run 2 SEM Destrieux Parcellations Part 2	abcd_tfsstr2sem dp201
ABCD Task fMRI SST Average Beta Weights	mrisst02
ABCD Task fMRI SST Average Beta Weights Destrieux Parcellations Part 1	abcd_tfsstabw dp101
ABCD Task fMRI SST Average Beta Weights Destrieux Parcellations Part 2	abcd_tfsstabw dp201
ABCD Task fMRI SST Average Standard Error of the Mean	mrisstsem01
ABCD Task fMRI SST Average SEM Destrieux Parcellations Part 1	abcd_tfsstasem dp101
ABCD Task fMRI SST Average SEM Destrieux Parcellations Part 2	abcd_tfsstasem dp201
ABCD Task fMRI nBack Run 1 Beta Weights	nbackr101
ABCD Task fMRI nBack Run 1 Beta Weights Destrieux Parcellations Part 1	abcd_tfncr1bw dp101
ABCD Task fMRI nBack Run 1 Beta Weights Destrieux Parcellations Part 2	abcd_tfncr1bw dp201
ABCD Task fMRI nBack Run 1 Standard Error of the Mean	nbackr1sem01
ABCD Task fMRI nBack Run 1 SEM Destrieux Parcellations Part 1	abcd_tfnbr1sem dp101
ABCD Task fMRI nBack Run 1 SEM Destrieux Parcellations Part 2	abcd_tfnbr1sem dp201
ABCD Task fMRI nBack Run 2 Beta Weights	nbackr201
ABCD Task fMRI nBack Run 2 Beta Weights Destrieux Parcellations Part 1	abcd_tfnbr2bw dp101

ABCD Task fMRI nBack Run 2 Beta Weights Destrieux Parcellations Part 2	abcd_tfnbr2bwdp201
ABCD Task fMRI nBack Run 2 Standard Error of the Mean	nbackr2sem01
ABCD Task fMRI nBack Run 2 SEM Destrieux Parcellations Part 1	abcd_tfnbr2dp101
ABCD Task fMRI nBack Run 2 SEM Destrieux Parcellations Part 2	abcd_tfnbr2dp201
ABCD Task fMRI nBack Average Beta Weights	nback_bwroi02
ABCD Task fMRI nBack Average Beta Weights Destrieux Parcellations Part 1	abcd_tfabwdp101
ABCD Task fMRI nBack Average Beta Weights Destrieux Parcellations Part 2	abcd_tfabwdp201
ABCD Task fMRI nBack Average Standard Error of the Mean	nbackallsem01
ABCD Task fMRI nBack Average SEM Destrieux Parcellations Part 1	abcd_tnbasemdp101
ABCD Task fMRI nBack Average SEM Destrieux Parcellations Part 2	abcd_tnbasemdp201

General Information

The following information refers to the Adolescent Brain Cognitive DevelopmentSM (ABCD) Study Data Release 3.0 available from <https://nda.nih.gov/abcd>. 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/protocols>.

This document describes the contents of various instruments available for download. To understand the context of this information, see *Release Notes ABCD README FIRST* and *Release Notes ABCD Imaging Instruments*.

Image Processing

- Image types
 - field maps: spin echo images with opposite phase encode polarity
 - multi-frame, gradient echo, echo-planar imaging
- Image processing (common to all fMRI)
 - head motion corrected by registering each frame to the first using AFNI's 3dvolreg (Cox, 1996)
 - B₀ distortions were corrected using the reversing gradient method with FSL's TOPUP (Andersson et al., 2003, Smith et al., 2004)
 - displacement field estimated from spin-echo field map scans
 - applied to gradient-echo images after adjustment for between-scan head motion
 - corrected for gradient nonlinearity distortions (Jovicich, et al., 2006)
 - between scan motion correction across all fMRI scans in imaging event
 - registration between T₂-weighted, spin-echo B₀ calibration scans and T₁-weighted structural images performed using mutual information (Wells, et al., 1996)
- task-fMRI specific pre-processing -- NOTE: not included in "minimal processing" (minproc)
 - removal of initial volumes
 - Siemens: 8 TRs
 - Philips: 8 TRs
 - GE DV25: 5 TRs
 - GE DV26: 16 TRs
 - normalization and demean
 - divide by the mean of each voxel, subtract 1, multiply by 100
- Estimation of task-related activation strength
 - general linear model (GLM) using AFNI's 3dDeconvolve (Cox, 1996)
 - nuisance regressors to model baseline, quadratic trend, and motion (Power, et al., 2014)
 - motion estimates, derivatives, and squared estimates and derivatives included
 - time points with framewise displacement (FD) > 0.9 mm censored (Siegel, et al., 2014)
 - hemodynamic response function
 - modelled as gamma functions with temporal derivatives, using AFNI's SPMG model

- for MID and SST models, events modeled as instantaneous
 - for n-back, duration of cues (~3 s) and trial blocks (~24 s) modeled as square waves convolved with SPMG
- GLM coefficients and t-statistics sampled onto cortical surface
 - projected 1mm into cortical gray matter along surface normal vector
- Monetary Incentive Delay (MID)
 - predictors for anticipation of large, small, and no rewards and feedback for large, small, and no rewards for wins and losses
 - linear contrasts computed for anticipation of large and small reward vs. no reward, anticipation of large and small loss vs. no reward, feedback of win vs. no reward, and feedback of loss vs. no reward
- Stop Signal Task (SST)
 - predictors for successful go trial, failed go trial, successful stop trial, and failed stop trial
 - contrasts computed for successful vs. failed stop trials and successful vs. failed go trials
- Emotional n-back (EN-back)
 - predictors for each type of stimulus (i.e. place and emotional face) in each of the n-back conditions (i.e., 0-back and 2-back) plus fixation
 - linear contrasts computed for 2-back vs. 0-back across stimulus types, emotional faces vs. places across memory loads, 2-back vs. 0-back for each stimulus type, and each memory load and each stimulus type vs. fixation
- 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)
 - ROI average coefficients and t-statistics for each run were averaged across two runs, weighted by degrees of freedom

Mismatched E-prime output files and imaging data

The task fMRI behavioral and stimulus timing files, which are exported from the E-prime stimulus presentation program, have a date and time stamp recording when the stimulus program was started for a particular task run. E-prime timing is compared to date and time derived from imaging DICOM metadata to identify events with potentially mismatched E-prime file and imaging data. In some cases, these mismatches are due to clock offsets on stimulus computers relative to the MRI console computer; e.g., on days of transition to and from Daylight Saving Time (DST), or small, fixed differences in clock time. In other cases, imaging sites uploaded E-prime files for one participant but assigned them to a different pGUID, which can result in very large timing differences. Participant-events with timing mismatches less than 12.5 minutes are identified by these variables:

MID E-prime timing match: *mriqcrp302:iqc_mid_ep_t_series_match*

EN-Back E-prime timing match: *mriqcrp302:iqc_nback_ep_t_series_match*

SST E-prime timing match: *mriqcrp302:iqc_sst_ep_t_series_match*

Participant-events for which timing mismatches can be ignored, e.g., DST transitions or persistent clock offsets, are identified by these variables:

MID ignore E-prime mismatch: *mriqcrp302:eprime_mismatch_ok_mid*

EN-nack ignore E-prime mismatch: *mriqcrp302:eprime_mismatch_ok_nback*

SST ignore E-prime mismatch: *mriqcrp302:eprime_mismatch_ok_sst*

These variables have been included in the recommended imaging inclusion criteria and the imaging inclusion flags. Refer to *ABCD Imaging Instruments* Release Notes for more details.

Task fMRI results have not been generated for participants with timing mismatches (e.g., *iqc_mid_ep_t_series_match* = 0) unless they can be ignored (i.e., *eprime_mismatch_ok_mid* = 1). The ABCD DAIRC continues to work with ABCD imaging sites to recover missing or mismatched E-prime files to enable the inclusion of these participants' results in future releases.

Irregular acquisitions

In a small percentage of participant-events (< 2%), the number of scans acquired and the number of task runs documented in E-prime output files differed, leading to potential ambiguity in the assignment of stimulus runs to imaging scan. To prevent matching a stimulus run to the wrong scan and using an incorrect stimulus event time series in the GLM analysis of the imaging data, the task fMRI GLM analysis is currently skipped for participant-events with an irregular acquisition, resulting in missing derived values in the task fMRI tabulated data and missing minimally processed data. Examples of irregular acquisitions creating potential ambiguity include the collection of 3 scans but only 2 stimulus runs, or 1 scan but 2 stimulus runs. This sometimes occurs because of a scan was aborted at the participant's request. The correct mapping between scan and run can sometimes be ascertained with information about all of scans collected and which of those were aborted. However, variation and special cases can make it difficult to fashion general rules that work correctly for all. Future efforts will be devoted

to testing a more permissive approach allowing analysis in potentially ambiguous cases when appropriate.

In a very small number of participant-events (< 0.1%), the RA or scan operator used the wrong scan protocol for the first of two runs; e.g., using the MID scan protocol while using the SST stimulus. Because the length of the scans differs for the different tasks, mismatched scans and tasks are not analyzed. The second scan of the mismatched pair can be correctly analyzed if assigned to the second stimulus run. These situations were identified as having only one scan of a given task that was immediately preceded by a scan of a different task instead of a field map scan.

For approximately 2.0-2.4% of participant-events, only a single imaging scan was available for analysis for one or more task, either because only one scan was acquired for that task, one of two scans was aborted during acquisition, or one of two scans failed raw QC. For the SST, if only the second scan was analyzed, these fMRI data are currently assigned to run1 variables in the tabulated data releases. For the MID and EN-back, if there were errors with run1 scans, neither scan1 or scan2 task fMRI data were analyzed. If there were no issues with the first scan, these data were analyzed. For future releases, modifications to the task fMRI analysis pipeline will enable the analysis of valid run2 data for all three tasks and correct assignment to run2 variables in the tabulated data.

References

- Andersson, J. L., Skare, S., & Ashburner, J. (2003). How to correct susceptibility distortions in spin-echo echo-planar images: application to diffusion tensor imaging. *NeuroImage*, 20(2), 870–888. [https://doi.org/10.1016/S1053-8119\(03\)00336-7](https://doi.org/10.1016/S1053-8119(03)00336-7).
- Chang, H., Fitzpatrick, J.M. (1992) A technique for accurate magnetic resonance imaging in the presence of field inhomogeneities. *IEEE Trans Med Imaging*, 11:319-29.
- Cox, R.W. (1996) AFNI: software for analysis and visualization of functional magnetic resonance neuroimages. *Comput Biomed Res*, 29:162-73.
- Desikan, R.S., Segonne, F., Fischl, B., Quinn, B.T., Dickerson, B.C., Blacker, D., Buckner, R.L., Dale, A.M., Maguire, R.P., Hyman, B.T., Albert, M.S., Killiany, R.J. (2006) An automated labeling system for subdividing the human cerebral cortex on MRI scans into gyral based regions of interest. *Neuroimage*, 31:968-80.
- Destrieux C, Fischl B, Dale A, Halgren E. (2010) Automatic parcellation of human cortical gyri and sulci using standard anatomical nomenclature. *Neuroimage*. 2010 Oct 15;53(1):1-15.
- Fischl, B., Salat, D.H., Busa, E., Albert, M., Dieterich, M., Haselgrove, C., van der Kouwe, A., Killiany, R., Kennedy, D., Klaveness, S., Montillo, A., Makris, N., Rosen, B., Dale, A.M. (2002) Whole brain segmentation: automated labeling of neuroanatomical structures in the human brain. *Neuron*, 33:341-55.
- Holland, D., Kuperman, J.M., Dale, A.M. (2010) Efficient correction of inhomogeneous static magnetic field-induced distortion in Echo Planar Imaging. *Neuroimage*, 50:175-83.
- Jovicich, J., Czanner, S., Greve, D., Haley, E., van der Kouwe, A., Gollub, R., Kennedy, D., Schmitt, F., Brown, G., Macfall, J., Fischl, B., Dale, A. (2006) Reliability in multi-site structural

MRI studies: effects of gradient non-linearity correction on phantom and human data. *Neuroimage*, 30:436-43.

Morgan, P.S., Bowtell, R.W., McIntyre, D.J., Worthington, B.S. (2004) Correction of spatial distortion in EPI due to inhomogeneous static magnetic fields using the reversed gradient method. *J Magn Reson Imaging*, 19:499-507.

Power, J.D., Mitra, A., Laumann, T.O., Snyder, A.Z., Schlaggar, B.L., Petersen, S.E. (2014) Methods to detect, characterize, and remove motion artifact in resting state fMRI. *Neuroimage*, 84:320-41.

Siegel, J.S., Power, J.D., Dubis, J.W., Vogel, A.C., Church, J.A., Schlaggar, B.L., Petersen, S.E. (2014) Statistical improvements in functional magnetic resonance imaging analyses produced by censoring high-motion data points. *Hum Brain Mapp*, 35:1981-96.

Smith, S. M., Jenkinson, M., Woolrich, M. W., Beckmann, C. F., Behrens, T. E., Johansen-Berg, H., Bannister, P. R., De Luca, M., Drobnjak, I., Flitney, D. E., Niazy, R. K., Saunders, J., Vickers, J., Zhang, Y., De Stefano, N., Brady, J. M., & Matthews, P. M. (2004). Advances in functional and structural MR image analysis and implementation as FSL. *NeuroImage*, 23 Suppl 1, S208–S219. <https://doi.org/10.1016/j.neuroimage.2004.07.051>.

Wells, W.M., 3rd, Viola, P., Atsumi, H., Nakajima, S., Kikinis, R. (1996) Multi-modal volume registration by maximization of mutual information. *Med Image Anal*, 1:35-51.

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