

ABCD Human Subjects Study

Adolescent Brain Cognitive Development – ABCDSTUDY.org

Release Notes: Adolescent Brain Cognitive Development StudySM (ABCD Study[®]) Data Release 4.0

Behavioral Performance During task-fMRI

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October 2021

Change Log

September 2021 – Data Release 4.0

- Initial release

List Instruments

Name of Instrument	Short Name
ABCD Task fMRI MID Behavior	abcd_mid02
ABCD Task fMRI SST Behavior	abcd_sst02
ABCD Task fMRI nBack Behavior	abcd_mrinback02
MRI Task fMRI REC Behavior	mrribrec02

General Information

The following information refers to the Adolescent Brain Cognitive Development StudySM (ABCD) Data Release 4.0 available from <https://nda.nih.gov/abcd>. An overview of the ABCD Study® is at <https://abcdstudy.org> and detailed descriptions of the assessment protocols can be viewed at <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.

The tasks and stimuli listed in this document are also available at <http://fablab.yale.edu/page/assays-tools>.

The behavioral performance review is part of the ABCD Study QC procedures and imaging inclusion criteria. For additional information please refer to the *MRI Quality Control (QC) and Recommended Image Inclusion Criteria* Release Notes.

fMRI Monetary Incentive Delay (MID) task

The fMRI Monetary Incentive Delay (MID) task measures domains of reward processing, including anticipation and receipt of reward and losses, and trial-by-trial motivation in speeded responses to win or avoid loss. Each trial of the MID task begins with an incentive cue of five possible trial types (Win \$20, Win \$5, Lose \$20, Lose \$5, \$0-no money at stake), a delay, a target during which the participant responds to either win money or avoid losing money and feedback.

Task performance is individualized to maintain a 60% accuracy rate. When possible, participants who were unable to complete the task in the scanner, completed the task behaviorally outside the scanner. Variables are provided to identify subjects with incomplete data for anticipation analyses, unresponsiveness suggesting inattention to the task, or suboptimal data for feedback analyses. However, these recommended thresholds are subjective, so investigators should choose inclusion/exclusion performance criteria that are appropriate for their analyses.

- **Anticipation:** If data capture is incomplete for either run 1 or run 2, this will affect the number of anticipation trials modelled. The recommended inclusion criteria (see **18. NDA 4.0 MRI Quality Control Recommended Inclusion**) for MID task fMRI require that 100 total trials were acquired: `tfmri_mid_all_beh_t_nt = 100`. In addition, the recommended inclusion criteria require that the participant make at least 20 responses (i.e., button presses) per run: `tfmri_mid_beh_performflag = 1`. Both of these variables are included in the recommended inclusion criteria for MID task fMRI: `imgincl_mid_include = 1`.
- **Feedback:** If any trial type across both runs yields less than 4 events in either the positive feedback or negative feedback, this will reduce the reliability of analyses of feedback trials. It is suggested that analyses of feedback trials be limited to participants with at least 4 events in each feedback trial type: `tfmri_mid_beh_feedbackflag = 1`. Note that this feedback flag is not included in the default, recommended inclusion criteria for MID task fMRI, but can be used in combination with `imgincl_mid_include` to further limit the sample.

In the initial version of the MID task used for ABCD, only reaction time (RT) for positive feedback trials were calculated. For the current version of the MID task, which was implemented in late 2017, RT was calculated for all valid trials (i.e., including late responses but excluding early responses). In past releases, variables for negative feedback trials and all trials combined had empty values. In the current release, scan sessions with the current task version now have values for all of these RT variables.

fMRI Stop Signal Task (SST)

The fMRI Stop Signal Task (SST) measures impulse control and impulsivity. The task requires participants to withhold or interrupt a motor response to a “Go” stimulus when it is followed unpredictably by a signal to stop. To ensure approximately 50% successful and 50% unsuccessful Stop trials, a tracking algorithm varies the interval between the onset of the Go stimulus and the onset of the Stop Signal (the Stop Signal Delay) based on individual performance. When possible, participants who were unable to complete the task in the scanner completed the task behaviorally outside the scanner.

Poor performance in the SST task (`tfmri_sst_beh_performflag` = 0) is indicated if:

Go trials

- <300 GO trials
- Correct GO trial percentage <60%
- Incorrect GO trial percentage >30%
- Late GO trial percentage (summing correct and incorrect trials) >30%
- No Response GO trial percentage >30%
- Correct GO response time < Incorrect Stop response time

STOP trials

- STOP trial accuracy (i.e., successful inhibitions) <20% or >80%

However, in many cases, the threshold for suboptimal performance is subjective so investigators should choose performance criteria that are appropriate for their analyses.

Concerns regarding ABCD STOP task

A number of concerns regarding the ABCD STOP task have been raised (<https://www.biorxiv.org/content/10.1101/2020.05.08.084707v1>). One is a coding error wherein a fast response (<50msec) made when the Stop Signal Delay (SSD) was 50 msec results in all subsequent Stop trials recording this same fast response. This error disrupts the functioning of the SSD tracking algorithm. Although useful data (before the occurrence of the coding error) may be retrievable for many of these participants, we identify for possible exclusion all participants with this coding error (variable `tfmri_sst_beh_glitchflag`). A second concern relates to the Go stimuli not being presented on trials in which the SSD was 0 msec. On these trials, participants saw only the Stop signal (up arrow) which may have created confusion for participants. Across the full sample of participants, the impact of these occasional trials appears

to be minimal for both the Stop Signal Reaction Time calculation and brain activation. However, we now provide a count of 0ms SSD trials per participant (variable `tfmri_sst_beh_0SSDcount`) which investigators can use to set a threshold for excluding participants, if desired. Finally, in accordance with race model assumptions and best practices (Verbruggen et al., eLife 2019) the Stop Signal Reaction Time should not be estimated for participants whose Stop Fail RT > Go RT. These participants are identified by the variable `tfmri_sst_beh_violatorflag`. However, there is no compelling reason to exclude these participants from brain activation analyses unless researchers believe that doing so is warranted given the neuroimaging measurements they are investigating or given their specific research question. More details on these matters are provided in the *Trial Level Behavioral Data Release Notes*. The ABCD team has conducted analyses addressing these matters

(<https://www.biorxiv.org/content/10.1101/2020.07.27.223057v1>) and concludes that while the concerns have legitimacy, there is little evidence that they have an actual impact on the task reaction time and fMRI data. While we await further empirical data addressing these matters we believe researchers can use these data with confidence. However, we do encourage researchers to carefully evaluate any impact that these concerns may have on their specific analyses.

Variable names for the indicator flags:

- `tfmri_sst_beh_violatorflag`: Race model violators where Stop Fail RT > Go RT
- `tfmri_sst_beh_glitchflag`: Task coding error
- `tfmri_sst_beh_0SSDcount`: Number of Stop trials with 0ms SSD

Estimates of Stop Signal Reaction Time

We provide two estimates of the Stop Signal Reaction Time (Logan et al., Psychological Review, 1984), a derived measure of the response inhibition process. The mean method (`tfmri_sst_all_beh_total_mssrt`) subtracts each participant's mean SSD from their mean Go RT. (In previous data releases this variable was labelled `tfmri_sst_all_beh_total_meanrt`). The second estimate uses the integration method (`tfmri_sst_all_beh_total_issrt`) in which the mean SSD is subtracted from the nth Go RT with n being the participant's overall successful inhibition rate. For the integration method calculation, any Go RT omissions were replaced with the longest go RT for that participant. In addition, premature responses on Stop trials (i.e., choice responses made before the Stop signal was presented) were included when calculating the participant's probability of successful stopping and the SSD's on these trials were included in calculating the average SSD.

Variable names for SSRT

- `tfmri_sst_all_beh_total_mssrt`: Stop Signal Reaction Time, mean estimation
- `tfmri_sst_all_beh_total_issrt`: Stop Signal Reaction Time, integration estimation

Mislabeled trials

A small number of trial outcomes are mislabeled in the Stop task's E-Prime output (these are listed as Issue 6 in <https://www.biorxiv.org/content/10.1101/2020.05.08.084707v1>). Users

should be aware that all of these errors were identified and corrected prior to behavioral or functional data analysis in all data releases including this one. The label corrections are detailed in the script “abcd_extract_eprime_sst” available on the ABCD github site (<https://github.com/ABCD-STUDY/>).

fMRI Emotional nBack Working Memory Task

The fMRI Emotional nBack task assesses memory, emotion and face and place perceptual processes. The task is a block design working memory task using four categories of stimuli (places, positive faces, negative faces and neutral faces) and two memory load conditions (0 and 2 back). The task includes 80 trials for each of the two memory load conditions, 20 trials for each stimulus type in each of the two memory load conditions and 40 trials of each stimulus type.

Accuracy and reaction time (RT) are provided for all conditions. When possible, participants who were unable to complete the task in the scanner, completed the task behaviorally outside the scanner.

Poor performance in the nBack task is indicated if the overall response accuracy for the 0-back or 2-back blocks is less than 60% (tfmri_nback_beh_performflag = 0).

Definition of terms

- all_beh_0.back = all of the 0_back trials in the session
- run1_beh_0.back = all 0_back trials in run 1
- run2_beh_0.back = all 0_back trials in run 2
- all_beh_2.back = all of the 2_back trials in the session
- run1_beh_2.back = all 2_back trials in run 1
- run2_beh_2.back = all 2_back trials in run 2
- pos.face = all trials with happy stimuli
- neg.face = all trials with fear stimuli
- neut.face = all trials with neutral stimuli
- place = all trials with place stimuli
- run1_beh_0.back.pos.face= all 0_back trials with happy stimuli in run 1
- run2_beh_2.back.neg.face= all 2_back trials with fear stimuli in run 2
- run1_beh_0.back.place_rate = accuracy for all 0_back trials with place stimuli in run 1

nBack Recognition Memory (RECMEM) Task

The Emotional nBack Recognition Memory task engages short-term memory for items presented during the fMRI Emotional nBack task. This task was performed outside the scanner after the completion of the fMRI nBack task. Both HitRate (HR) and False Alarms (FA) are provided for each condition along with key dependent variables of response bias, corrected accuracy, and d-prime.

Definition of terms

- NEW = any stimuli that were NOT present in the nBack task
- OLD = any stimuli that were present in the nBack task
- neut.face = neutral face stimuli
- pos.face = happy face stimuli
- neg.face = fearful face stimuli
- place = place stimuli
- 0.back denotes if the stimuli were presented during 0-back
- 2.back denotes if the stimuli were presented from 2-back

Key dependent variables

- hr = hit rate
- fa = false alarms
- br is for response bias [$(\text{mean}(\text{FA}) / (1 - \text{mean}(\text{HR}) - \text{mean}(\text{FA}))) - 0.5$]
- pr is for corrected recognition [$\text{mean}(\text{HR}) - \text{mean}(\text{FA})$]
- dprime is for discriminability index [$z(\text{HR}) - z(\text{FA})$]

Behavioral tasks performed outside of the scanner

Some participants were unable to complete one or more of the fMRI behavioral tasks in the scanner (MID, SST, or nBack), instead performed the missing task or tasks outside the scanner on a laptop computer. Whether a participant performed the MID, SST, or nBack task in the scanner or on a laptop is indicated respectively, by the following variables:

ra_scan_cl_mid_scan_lap, *ra_scan_cl_nbac_scan_lap*, *ra_scan_cl_sst_scan_lap*. For more details, see the *ABCD RA Scanning Checklist and Notes*.

Methods

Image processing and analysis methods corresponding to ABCD Release 2.0.1 are described in Hagler et al., 2019, *Image processing and analysis methods for the Adolescent Brain Cognitive Development Study*. Neuroimage, 202:116091. Changes to image processing and analysis methods in Release 3.0 and Release 4.0 are documented below.

Changes for ABCD 3.0

Stop Signal Task behavioral measures

The SST behavioral variable *tfmri_sst_all_beh_total_meanrt* was removed, and two new variables were added:

tfmri_sst_all_beh_total_mssrt: Stop Signal Reaction Time, mean estimation

tfmri_sst_all_beh_total_issrt: Stop Signal Reaction Time, integration estimation

Changes for ABCD 4.0

Task fMRI E-prime file behavioral responses

E-prime files for a small number of pGUID-events have string response (e.g., "LEFTARROW" vs "RIGHTARROW") instead of numeric (i.e., 1 vs 2). Minor changes were made to handle these cases (for SST and nBack tasks), resulting in the recovery of task fMRI and behavioral results for such cases.

MID task behavioral measures

In the initial version of the MID task used for ABCD, only reaction time (RT) for positive feedback trials were able to be calculated. For the current version of the MID task, which was implemented in late 2017, RT can be calculated for all valid trials (i.e., including late responses but excluding early responses). In past releases, variables for negative feedback trials and all trials combined had empty values. In the current release, scan sessions with the current task version now have values for all of these RT variables. For participant-events using the original MID task, those variables remain empty. The method for setting the performance flag variable *tfmri_mid_performflag* (in data structure *abcd_mid02*) was changed to require at least 20 responses per run to be considered acceptable performance for inclusion in analyses. The old method for setting the performance flag was to require at least 4 of each trial type across runs. This method is now used to set the new variable *tfmri_mid_feedbackflag*, which is provided as an additional, optional filter not included in the recommended inclusion criteria used to set the inclusion flags in *abcd_imgincl01* (see **18. NDA 4.0 MRI Quality Control Recommended Inclusion**).

Miscellaneous changes to E-prime file handling and variable extraction

- Truncated DICOM-derived SeriesTime instead of rounding, affecting calculated time delays.
- E-prime file with special (problematic) characters in the file name was renamed, avoiding errors that prevented task fMRI analysis for that participant-event.
- Set E-prime derived variables to NaN instead of 0 in case of missing or invalid E-prime file.
- Created variables indicating whether experiment name matches labeling of E-prime file (e.g., *iqc_mid_ep_exper_ok*) and has readable behavioral data (e.g., *iqc_mid_ep_behav_readable*).

Changes to data dictionaries

- modified data structure *abcd_mid02*
 - added element *tfmri_mid_beh_feedbackflag*
 - changed description for element *tfmri_mid_beh_performflag*

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