Release Notes: Adolescent Brain Cognitive Development Study℠ (ABCD Study®) Data Release 4.0

Neurocognition

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Change Log
October 2021 – Data Release 4.0
- Initial release

List of Instruments

Instrument	Short Name
ABCD Youth NIH TB Summary Scores	abcd_tbss01
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ABCD Cash Choice Task	cct01
ABCD Little Man Task	lmtp20
ABCD Pearson Scores	absd_ps01
ABCD Youth Delay Discounting Scores	abcd_ydds01
ABCD Emotional Stroop Task	abcd_yest01
ABCD Game of Dice Task	abcd_gdss01
ABCD Social Influence Task	abcd_siss01
ABCD Stanford Mental Arithmetic Response Time Evaluation	smarte_sumscores01

| **ABCD Barkley Deficits in Executive Functioning Scale** | barkley_exec_func01 |
| **ABCD Youth Neurocognition Survey Session** | neurocog_youth_session01 |

General Information

The following information refers to the Adolescent Brain Cognitive Development Study[SM] (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*.

To access additional detailed information about the instruments administered in this domain, the constructs they are intended to measure, and relevant citations for each measure, please see: https://doi.org/10.1016/j.dcn.2018.02.006.

The ABCD Neurocognitive Workgroup suggests that users of these data first examine the participants' vision at the time of the baseline and 2-year follow-up using the *snellen_va_y* variable. It is possible that poor vision could influence task performance. See *6. NDA 4.0 Physical Health* release notes for details on the Snellen Vision Screener.

COVID-19 and Neurocognitive Testing

In response to COVID-19 restrictions beginning in March 2020, ABCD pivoted to remote testing when in-person testing was not possible or feasible and a subsequent hybrid in-person/remote testing procedure as sites allowed. In the 4.0 release, this affected the two- and three-year follow-up assessments and the 30-month assessments conducted from March 2020 on. Remote and hybrid testing required participants to complete some tasks and surveys on their own devices (i.e., phone, tablet, desktop, or laptop computer). Note that remote performance was monitored by research associates, when possible, using Zoom's screen sharing feature. The variety of devices, relative to the ABCD standard using Apple iPad devices exclusively, may affect task performances and users should consider this when analyzing data spanning the pre-COVID-19 and post-COVID-19 periods. In addition, some tasks were incompatible with remote testing and were not administered during this time. The following guidance is provided.

Determining In-person, remote, and Hybrid for Overall Visit Type
Longitudinal Tracking Instrument (abcd_lt01): This instrument includes two variables that in combination provide information about the overall visit type for the session; that is, both

neurocognitive and other questionnaires and surveys (e.g., mental health, culture and environment, etc.). The in-person, remote, and hybrid visits can be determined using:
- If *sched_delay* = 7, then visit = *In person*
- If *sched_delay* = 9 and *sched_hybrid* = 0, then visit = *Remote*
- If *sched_delay* = 9 and *sched_hybrid* = 1, then visit = *Hybrid*

Specific Visit Information for Neurocognition Tasks
The visit type (in-person, remote, or hybrid) is specified for each of the individual neurocognition tasks in the *ABCD Youth Neurocognition Survey Session* instrument (*neurocog_youth_session01*). The *neurocog_device*, *ncog_device*, and *neurocog_2_device* variables describe any issues that may have occurred in using participant devices. These codes are as follows:
1. Completed in full without disruption
2. Completed in full with temporary technical disruption
3. Completed partially due to technical disruption
4. Did not complete due to not being able to share screen
5. Did not complete due to technical issues

Changes in the Neurocognitive Assessments Due to COVID-19
Some adjustments in testing procedures were required for remote testing.

Two-year follow-up assessment:
- It was not possible to administer NIH Toolbox Pattern Comparison Processing Speed task remotely and we did not administer it.
- ABCD employed remote administrations on participant devices using the Inquisit system from Millisecond (https://www.millisecond.com) for the following tasks:
  - Flanker (substitute for NIH Toolbox Flanker task)
  - Little Man Task
  - Game of Dice Task
  - Social Influence Task

Three-year follow-up assessment
- Inquisit system from Millisecond was used for:
  - Emotion Stroop Task
  - Delayed Discounting Task
  - Stanford Mental Arithmetic Response Time Evaluation (SMARTE)

Instrument Descriptions

ABCD Youth NIH TB Summary Scores

Note that in the two-year follow-up assessment, five of the seven NIH Toolbox tasks were administered. The Dimensional Change Card Sort and List Sorting Working Memory were administered in the Baseline testing only. Because of this, the NIH Toolbox Fluid Composite Score could not be calculated in the two-year follow-up.

In addition, remote assessments in the two-year follow-up protocol used a Flanker task using the Inquisit system from Millisecond. This task was designed to mimic the NIH Toolbox Flanker task as closely as possible. We encourage users to consider this change in their analyses.

NIH Toolbox (NIH Tbx) Picture Vocabulary - Language vocabulary knowledge, estimated verbal IQ; from the NIH Toolbox Cognition battery; uncorrected and age corrected scores are presented; see http://www.nihtoolbox.org

NIH Tbx Flanker Inhibitory Control & Attention - Attention, cognitive control, executive function, inhibition of automatic response, from the NIH Toolbox Cognition battery; uncorrected and age corrected scores are presented; see http://www.nihtoolbox.org. Note, remote assessments used a replicated Flanker task administered using the Inquisit platform, because the NIH Toolbox version could not be administered remotely.

NIH Tbx Picture Sequence Memory - Episodic memory; sequencing; from the NIH Toolbox Cognition battery; uncorrected and age corrected scores are presented; see http://www.nihtoolbox.org

NIH Tbx Dimensional Change Card Sort - Executive function: set shifting, flexible thinking, concept formation; from the NIH Toolbox Cognition battery; uncorrected and age corrected scores are presented; see http://www.nihtoolbox.org. Administered in Baseline assessment only.

NIH Tbx Pattern Comparison Processing Speed - Information processing, processing speed; from the NIH Toolbox Cognition battery; uncorrected and age corrected scores are presented; see http://www.nihtoolbox.org

NIH Tbx Oral Reading Recognition - Language, oral reading (decoding) skills, academic achievement; from the NIH Toolbox Cognition battery; uncorrected and age corrected scores are presented; see http://www.nihtoolbox.org

<u>NIH Tbx List Sorting Working Memory</u> - Working memory, information processing; from the NIH Toolbox Cognition battery; uncorrected and age corrected scores are presented; see http://www.nihtoolbox.org. Administered in Baseline assessment only.

ABCD TBX Demo - Demographics (Age only)

ABCD Youth NIH TB Summary Scores included in the NDA data share
<u>Uncorrected Scores</u>: Uncorrected scores compare the score of the test taker to those in the nationally representative NIH Toolbox normative sample (ages 3 to 85 years) regardless of age or any other variable. These are presented as Standard Scores (mean=100, SD=15).

<u>Age Corrected Scores</u>: Age-corrected scores compare the score of the test-taker to others of the same age. Age-corrected scores were derived separately for children (ages 3-17) and adults (ages 18-85). For children, normative scores are provided separately for each year of age to take into account expected developmental changes. These are presented as Standard Scores (mean=100, SD=15).

<u>Fully Corrected T-Score</u>: Fully Corrected T-Scores (mean = 50, SD = 10) compare the score of the test-taker to those in the NIH Toolbox nationally representative normative sample, while adjusting for key demographic variables. These variables include age, gender, race/ethnicity (white/Asian, black, Hispanic, multiracial), and educational attainment (for ages 3-17, parent's education is used; education is often used as a proxy for socioeconomic status). Thus a "fully corrected" score allows for comparison within a narrower grouping.

ABCD Cash Choice Task
Impulsivity, delayed gratification; this single-item task asked the child "Let's pretend a kind person wanted to give you some money. Would you rather have $75 in three days or $115 in 3 months?". The child indicates one of these two options or a third "can't decide" option. See Wulfert, E., Block, J.A., Santa Ana, E., Rodriguez, M.L., & Colsman, M., 2002; Anokhin, A.P., Golosheykin, S., Grant, J.D. & Heath, A.C., 2011. Administered in Baseline assessment only.

ABCD Little Man Task
Visuospatial processing flexibility, attention; participants view pictures of a figure (little man) presented in different orientations and holding a suitcase and must use mental rotation skills to assess which hand (left or right) is holding the suitcase. Accuracy and latency scores are provided for each trial. Note that the Little Man Task used in the baseline assessment was administered using a customized program designed by ABCD, whereas the two-year follow-up assessment used a task presented in the Inquisit system from Millisecond. We recommend users consider this difference in analyses. For details, see Acker, W., & Acker, W., 1982; Nixon, S. J., Prather, R. A., & Lewis, B., 2014.

ABCD Pearson Scores

<u>Rey Auditory Verbal Learning Test</u> – Verbal learning and memory; the task is administered according to standard instructions using a 15-item word list; there are five learning trials (Trials I-V), a distractor trial (List B), measures of immediate recall (Trial VI) and 30-minute delayed recall (Trial VII); for all trials, the total correct is recorded together with the number of perseverations and intrusions. Details can be found in Strauss, E., Sherman, E.M.S., & Spreen, O., 2006; Lezak, M.D., Howieson, D.B., Bigler, E.D., & Tranel, D., 2012. An alternate form of the RAVLT word list was used at the Year 2 assessment.

<u>Matrix Reasoning Task</u> – Measures fluid intelligence, visuospatial reasoning; the task is from the Wechsler Intelligence Scale for Children-V and administered using Pearson Clinical Assessment-s Q-interactive platform. Total raw scores, scaled scores (ranging from 0-19; mean = 10, SD = 3) and scores for each item are available. See Wechsler, D., 2014; Daniel, M.H., Wahlstrom, D. & Zhang, O., 2014. Administered in Baseline assessment only.

Delay-discounting task

The participant makes several choices between a small-immediate hypothetical reward right now, or a standard hypothetical $100 reward at different time points (6h, 1 day, 1 week, 1 month, 3-month, 1 year, and 5 years) in the future. Each block of choices features the same delay to the larger reward, and the immediate reward is titrated after each choice, until both the smaller-sooner reward and the delayed-$100 reward have equal subjective value to the participant. The summary results file calculates the "indifference point" (the small-immediate amount deemed to have the same subjective value as the $100 delayed reward) at each of the seven delay intervals. When plotted, the area under the (hyperbolic) curve formed by these indifference points is frequently used to quantify severity of discounting of delayed rewards. The summary file also has a two-part validity check called "JB Pass" 1 and 2, the criteria for which can be found in (Johnson, M.W., and Bickel, W.K. (2008) Experimental and Clinical Psychopharmacology 16(3): 264–274). Failure on these criteria suggests inconsistent responding, such as a lack of an orderly decay in subjective value of a reward with progressively lengthening delays to its presentation. Users should consider restricting data analysis to participants for whom "values. Consistent per_JBcriterion1" and "values.Consistent per_JBcriterion2" are both "yes."

Emotional Stroop Task

The emotional Stroop task (Stroop, 1935) measures cognitive control under conditions of emotional salience (see Başgöze et al., 2015; Banich et al., 2019). The task-relevant dimension is an emotional word, which participants categorize as either a "good" feeling (happy, joyful) or a "bad" feeling (angry, upset). The task-irrelevant dimension is an image, which is of a teenager's face with either a happy or an angry facial expression. Trials are of two types. On congruent trials, the word and facial emotion are of the same valence (e.g. a happy face paired with word "joyful"). The location of the word varies from trial-to-trial, presented either on the top of the image or at the bottom. On incongruent trials, the word and facial expression are of different valence (e.g., a happy face paired with word "angry"). Participants work through 2 test blocks:

one block consists of 50% congruent and 50% incongruent trials; the other consists of 25% incongruent trials and 75% congruent trials. The composition of the former type of block helps individuals keep the task set in mind more so than the latter (Kane & Engle, 2003). The 25% incongruent/75% congruent block is always administered first, followed by the 50% incongruent/50% congruent block. Accuracy and response times for congruent versus incongruent trials for the total task and within each emotion subtype (happy/joyful; angry/upset) are calculated. Relative difficulties with cognitive control are indexed by lower accuracy rates and longer reaction times for incongruent relative to congruent trials.

ABCD Game of Dice Task
The Game of Dice Task (GDT; Brand et al., 2005) assesses decision-making under conditions of specified risk and has been successfully used with adolescent samples (Drechsler, Rizzo, & Steinhausen, 2008; Duperrouzel et al., 2019; Ross, Graziano, Pacheco-Colón, Coxe, & Gonzalez, 2016). Risk taking is assessed by having participants attempt to predict the outcome of a dice roll by choosing among different options that vary on their outcome probability and pay-off across 18 trials. Specific rules and probabilities for monetary gains and losses are evident throughout the task (Brand et al., 2005). On each trial, participants predict the outcome of a die roll by choosing from four different options (e.g., one number vs. multiple numbers). Options with more numbers (i.e. higher probability of winning) are associated with a lesser reward compared to those with one or two possible numbers (i.e. lower probability of winning). The two options with the lowest probability of winning are considered 'risky choices.' The total number of risky choices is often used to quantify performance. Summary scores are provided.

ABCD Social Influence Task
The Social Influence Task (SIT) assesses risk perception and propensity for risk taking, as well as susceptibility to perceived peer influence. Over the course of 40 trials, participants are presented with a variety of risky scenarios. Participants are asked to rate an activity's risk by moving a slider bar between "very LOW risk" (left) and "very HIGH risk" (right). After submitting an initial rating, participants are shown a risk rating of the same activity that is seemingly provided by a group of peers. This peer rating condition is either 4 points lower ('-4' condition), 2 points lower ('-2' condition), 2 points higher ('+2' condition) or 4 points higher ('+4' condition) than the participant's initial rating. Participants are asked to rate the riskiness of the scenario again. For both the initial and final rating trials, participants have a time limit of 4500 ms to provide their rating.

The task is designed to try to ensure ~25% of trials (~10 trials) are in each of the peer rating conditions. To do this, the task script restricts random sampling to only those conditions that can be run given the participant's initial ratings (e.g., if a participant selected a rating of 1.8, condition -4 and condition -2 cannot be run as both of those conditions would result in a peer rating < 0). If none of the unselected peer conditions can be run due to rating constraints, yet 10 trials have already been in run in all the realistic peer conditions, the script uses the 'switch sign' method; it (randomly) selects from the unselected peer conditions and then switches the sign

(e.g., selected peer condition -4 will be run as peer condition +4 and vice versa). The script tracks how many such switches had to be made. Summary scores are provided.

ABCD Stanford Mental Arithmetic Response Time Evaluation
The Stanford Mental Arithmetic Response Time Evaluation (SMARTE) is a youth measure that assess math fluency and single- and double-digit arithmetic operations via an iPad or smart phone app. Multiple accuracy and reaction time summary scores are calculated. See Starkey & McCandliss BD (2014). Summary scores are provided

ABCD Barkley Deficits in Executive Functioning Scale
The short form of the Barkley Deficits in Executive Functioning Scale for Children and Adolescents on which a parent reports several different dimensions of their child or adolescent's day-to-day executive functioning, such as organization, acting without thinking, clarity of expression, and procrastination that are predictive of future impairments in psychosocial functioning. See Barkley (2012).

ABCD Youth Neurocognition Survey Session
Information regarding your neurocognition in-person, remote, and hybrid visit type and device status information.

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