# The Dallas Lifespan Brain Study
# Cognitive Methods and Data Access
# Version 1.2.
# May 14, 2021

**Investigators and Sponsors**
Currently being worked on.

**"What is the "Keys to the Kingdom"**
The "Keys to the Kingdom" is a master document that includes all the components of the Dallas Lifespan Brain Study. Within this document are listed the types of data that were collected, the source documents for each, how to access the study's source documents and spreadsheets, and the coded item names and their abbreviations for each variable found in the spreadsheets.

**Describe design briefly and time frame**

The Dallas Lifespan Brain Study is an ongoing longitudinal study to examine changes in human cognition as well as changes in brain structure and function across the lifespan. This study represents the first systematic investigation of changes in neural activation across the lifespan, including middle-age. The present work is particularly noteworthy in that have integrated structural measures of the brain with functional activation patterns to predict both cognitive function and neural activation for encoding tasks. Few, if any, studies have combined both types of neural measures; the standard paradigm in the aging literature has been to use behavioral differences to predict brain function, rather than the reverse, as we have done.

The study is designed to test the same set of subjects every 4 years with the following measures: 2 days of cognitive behavioral testing, take-home questionnaires, and an MRI scan session. 464 people participated in Wave 1, which was collected between 2008-2014. Approximately 4 years later, between 2012-2017, 338 participants (73%) came back for wave 2 repeated testing. Finally, approximately 4 years later, between 2018-2020, 224 participants (48%) came back for wave 3 data collection.

**Types of Data Collected**

- Cognitive Data Constructs (present document)
    1. Speed of processing
    2. Working memory
    3. Executive Function
    4. Long term (episodic memory)
    5. Reasoning
    6. Vocabulary
    7. Verbal Fluency
- Health and Psychosocial Data (In preparation)
    - Individual differences
    - Health Data

    - Personality
- Neuroimaging Data (In preparation)
    - Structural MRI Data
    - Functional MRI
    - Diffusion Tensor Imaging
    - Amyloid PET imaging (AV-45)
    - TAU PET imaging (AV 14-51)

**Using the KTTK**

The KTTK includes all task information, data coding, and data spreadsheets for each construct used in the Dallas Lifespan Brain Study. Information on how to access DLBS cognitive data in box is also included and can be found by clicking here.

The cognitive data in the KTTK is organized by 7 constructs which includes Speed of Processing, Working Memory, Executive Function, Episodic Memory, Reasoning, Vocabulary, and Verbal Fluency.

Each of the 7 constructs has various tasks associated with it and there are a total of 30 tasks that can be found listed below. To access any of the tasks within each construct, select the task of interest. The key to the names and data structure used for data coding of each construct spreadsheet is also included in this document and can be accessed by selecting "Data Coding sheet" included under each construct listed below. Finally, the spreadsheet for each construct can be found listed below and accessed by selecting "Spreadsheet of data" listed under each construct.

## Cognitive Tasks Numbering

**3 Executive Function**

Task 10: Educational Testing Service (ETS) Cards Rotation
Task 11: NIH Toolbox Flanker Center- Arrow
Task 12: Task Switching
Task 13: NIH Toolbox Flanker Inhibitory Control and Attention Test
Task 14: NIH Toolbox Dimensional Change Card Sort Test

**4 Episodic Memory**

Task 15: Hopkins Verbal Learning, Parts 1-4 (Immediate & Delayed Recall)
Task 16: CANTAB Verbal Recognition Memory Parts 1-4
Task 17: Woodcock-Johnson Memory for Names Immediate & Delayed
Task 18: Wechsler Memory Scale Logical Memory
Task 19: NIH Toolbox Picture Sequence Memory, Parts 1-2
Data Coding sheet for Episodic Memory
Spreadsheet of Episodic Memory data

**5 Reasoning**

Task 20: Raven's Matrices
Task 21: ETS Letter Sets
Task 22: CANTAB Stockings of Cambridge
Task 23: Everyday Problem Solving
Data Coding sheet for Reasoning
Spreadsheet of Reasoning data

**6 Vocabulary**

Task 24: Educational Testing Service Advanced Vocabulary
Task 25: Shipley Vocabulary
Task 26: CANTAB Graded Naming Task
Task 27: NIH Toolbox Oral Reading Recognition Test
Task 28: NIH Toolbox Picture Vocabulary
Data Coding sheet for Vocabulary
Spreadsheet of Vocabulary data

**7 Verbal Fluency**

Task 29: Controlled Oral Word Association (FAS)
Task 30: Controlled Oral Association: Categories
Data Coding sheet for Verbal Fluency
Spreadsheet of Verbal Fluency data

# Accessing DLBS Cognitive Data

## DLBS Integrated Datasheets How-To

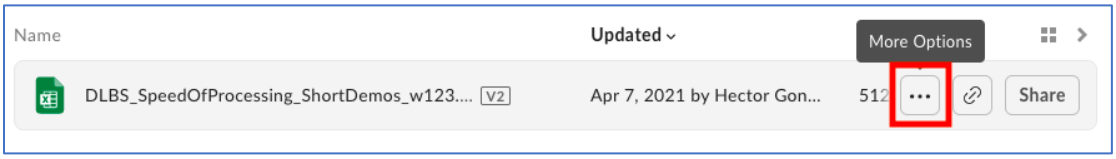
Each construct in the DLBS is separated into an individual folder in Box to allow for ease of use.

To access the construct spreadsheets in Box you must have been granted access.

1. Once you have secured access, click on the construct of interest
2. You will be able to select from 3 tabs that include:
    a. Complete task information which provides references and details about the task
    b. The source document which is a blueprint to the data sheet.
    c. Three spreadsheets with wave 1, wave 2, and wave 3 data which are fully described in the source document.
3. Indicate which wave you want to look at by clicking on the Wave 1, Wave 2, or Wave 3 tab at the bottom of the spreadsheet.
4. You may use the excel file to create your own data set. Please note that there are separate spreadsheets for wave 1, 2 and 3. You will need to integrate across these datasheets to create a longitudinal data set.
5. As an alternative, you may download the entire data set.

To download the spreadsheet onto your computer, follow these steps:

1. Click on the folder containing the construct
2. Hover your mouse over the spreadsheet and click the button with the three dots that appears toward the right of the construct
    a. If you hover over this button with your mouse it indicates “More Options”




3. Select “Download” from the drop-down list to download the file
4. Once downloaded, navigate between the waves by clicking on the W1, W2, or W3 tabs at the bottom of the spreadsheet

To download all spreadsheets at once, follow these steps:

1. On the top bar of the Box click on the button with the three dots that appears toward the right side of the screen
    a. If you hover over this button with your mouse it indicates “More Options”


2. Select “Download” from the drop-down list to download the file
    a. Double-click on which construct folder you would like to view
    b. Double-click on the spreadsheet to pull up the spreadsheet

c. Navigate between each wave by clicking on the Wave 1, Wave 2, or Wave 3 tab at the bottom of the spreadsheet

This website section will briefly describe Box folder navigation as it pertains to exportable DLBS data. The main folder is named, “DLBS Integrated Datasheets.” Within this folder, are 6 folders housing cognitive data and one folder housing individual difference data. The “Keys to the Kingdom” is a document that describes the structure of the data, and "DLBS_Metadata" is a spreadsheet compiling key statistics pertaining to participant retention as well as completeness of the cognitive data (DLBS_metadata.xlsx).

## Cognitive Data

- Six folders contain the currently organized cognitive and are named aptly: “Construct 1: Speed of Processing,” “Construct 2: Working Memory,” “Construct 4: Episodic Memory,” “Construct 5: Reasoning,” “Construct 6: Vocabulary,” and “Construct 7: Verbal Fluency.” Within each of these folders, a spreadsheet can be found containing the corresponding cognitive data as well as abbreviated individual difference variables. Each spreadsheet contains all 3 longitudinal waves sorted by tabs in Excel. More details regarding the data can be found in the KTK document.

## Psychosocial Data

- One folder currently contains the expanded individual difference data. Future folders will be added containing psychosocial data, mental health and AD screening data, and physical health data.

## Downloading the Data

- Users with experience using Box may use their usual procedure to download all necessary files. For users unfamiliar with Box, a word document titled, "DLBS Data Box Download - How To" provides detailed guidance.

# Construct 1: Speed of Processing

***Definition***

This construct measures how rapidly individuals can perceptually compare and process information (Park, 2000 in D.C. Park & N. Schwartz (Eds.)). It is highly sensitive to cognitive function and is considered a basic core component of cognition. Timothy Salthouse authored a classic paper that fully describes both theoretical importance and empirical measures of speed of processing (Salthouse,1996).

**References**

Salthouse, T.A. (1996). The processing-speed theory of adult age differences in cognition. Psychological Review, 103, 403-428.

Park, D.C. (2000). The basic mechanisms accounting for age-related decline in cognitive function. In D.C. Park & N. Schwartz (Eds.), Cognitive Aging: A primer, pp. 3 -21. Psychology Press.

***Task 1.1 Digit Comparison Task***

**Description (task duration: 2.5 minutes):** Participants have to decide whether two number strings that are either 3, 6, or 9 digits in length, have identical digits or different digits. The task is divided into 3 separate sets; a set is comprised only of 3-digits, 6-digits, or 9-digits comparisons (i.e., a set doesn't contain a mix of different string lengths). Subjects are given 45 seconds for each set to try to complete as many comparisons as they can. The number correctly completed for 3-, 6-, and 9-item strings, as well as total correct, is available. Higher scores are better.

**Primary Reference**:

Salthouse T. A., Babcock R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology,* 27, 763-776.

**Development of Cross-culturally Appropriate Measures**

Hedden, T., Park, D. C., Nisbett, R., Ji, LJ, Jing, Q., & Jiao, S. (2002). Cultural variation in verbal versus spatial neuropsychological function across the life span. *Neuropsychology*, 16, 65-73.

***Task 1.2 WAIS-III Digit Symbol***

**Description (task duration: 1.5 minutes):**

- Participants are shown nine geometric symbols that are each assigned to a digit from 1 to 9. They are then presented with randomized digits and asked to draw the corresponding symbol below each digit as quickly as possible for 90 seconds.

**Primary Reference**:

Wechsler, D., (1997). *WAIS-III: Administration and scoring manual: Wechsler Adult Intelligence Scale*. San Antonio, TX: Psychological Corporation.

***Task 1.3 NIH Toolbox Pattern Comparison Processing Speed Test***

**Description (task duration: 1.5 minutes):** Participants are shown two pictures side-by-side and are asked to discern whether the pictures are the same or different. If the pictures are the same, the participant presses the "Yes" button. If the pictures are not the same, the participant presses the "No" button. The participant is instructed to only use their index finger on their dominant hand to press either button. Participants' raw score is the number of 130 items correct in an 85-second period. The items are designed to be simple to most purely measure processing speed. Higher scores reflect faster speeds of processing.

**Caution:** Participants in DLBS Wave 2 performed the NIH Toolbox Pattern Comparison Speed Test on a desktop computer, whereas, participants in DLBS Wave 3 performed the task on an ipad. NIH toolbox provides a computed score to equate the different platforms (desktop and ipad) used. For additional details, we refer you to the the NIH Toolbox website: https://www.healthmeasures.net/explore-measurement-systems/nih-toolbox/obtain-and-administer-measures.

**Primary Reference:**

Gershon RC, Wagster MV, Hendrie HC, Fox NA, Cook KF, Nowinsky CJ. NIH Toolbox for Assessment of Neurological and Behavioral Function. Neurology. 2013; 80: S1-S92.

**Software Reference:**

NIH Toolbox for the iPad test ver. 2.1
https://nihtoolbox.force.com/s/article/nih-toolbox-scoring-and-interpretation-guide

**Speed of Processing Ability Construct: Key to Names and Data Structure in Data Set**

| Item Name | Abbreviation | Description | Measurement |
|---|---|---|---|
| Subject Number | S# | Subject identifier | |
| Age Interval | AgeInterval | Age at wave recoded into 3-year intervals | 20-100 |
| Sex | Sex | Participant's biological sex. | m = Male<br>f = Female |
| Race | Race | Race that the participant self-identifies with. | 1 = Asian American/ Pacific Islander<br>2 = Black/African American<br>3 = Multiracial<br>4 = Native American<br>5 = White/Caucasian<br>6 = Other<br>7 = Unknown |
| Ethnicity | Ethnicity | Ethnicity that the participant self-identifies with. | 1=Hispanic/Latin(o/a)<br>0 = Non-Hispanic |
| Handedness Score | HandednessScore | Average score of participant hand preference while completing various tasks. Higher scores indicate preference for the right hand. | Score range: 0-4<br><br>0 = Always left<br>1 = Usually left<br>2 = No preference<br>3 = Usually right<br>4 = Always right |
| Mini-Mental State Exam Total | MMSE | Total # of items answered correctly. | Score range: 0-30 |

| | | | |
|---|---|---|---|
| Cognitive Battery Wave 1-2 Interval | CogW1toW2 | Interval between cognitive testing day 1 for waves 1-2. | # of Years |
| Cognitive Battery Wave 2-3 Interval | CogW2toW3 | Interval between cognitive testing day 1 for waves 2-3. | # of Years |
| Cognitive Battery Wave 1-3 Interval | CogW1toW3 | Interval between cognitive testing day 1 for waves 1-3. | # of Years |
| Take Home Wave 1-2 Interval | TakeHomeW1toW2 | Interval between Take Home for waves 1-2. | # of Years |
| Take Home Wave 2-3 Interval | TakeHomeW2toW3 | Interval between Take Home for waves 2-3. | # of Years |
| Take Home Wave 1-3 Interval | TakeHomeW1toW3 | Interval between Take Home for waves 1-3. | # of Years |
| MRI Wave 1-2 Interval | MRIW1toW2 | Interval between MRI scan for waves 1-2. | # of Years |
| MRI Wave 2-3 Interval | MRIW2toW3 | Interval between MRI scan for waves 2-3. | # of Years |
| MRI Wave 1-3 Interval | MRIW1toW3 | Interval between MRI scan for waves 1-3. | # of Years |
| Amyloid PET Wave 1-2 Interval | PETAmyW1toW2 | Interval between amyloid PET scan for waves 1-2. | # of Years |
| Amyloid PET Wave 2-3 Interval | PETAmyW2toW3 | Interval between amyloid PET scan for waves 2-3. | # of Years |
| Amyloid PET Wave 1-3 Interval | PETAmyW1toW3 | Interval between amyloid PET scan for waves 1-3. | # of Years |
| Highest Level of Education Completed | EduComp5 | This is an ordinal measure of participants' self-reported highest level of education completed. | 1 = Less than high school graduate<br>2 = High school graduate/GED<br>3 = Some college/trade/ technical/business school<br>4 = Bachelor's degree<br>5 = Some graduate work<br>6 = Master's degree<br>7 = MD/JD/PhD/other advanced degree |
| Education Estimated Years Capped | EduYrsEstCap5 | This is a conversion of the participant's self-reported highest level of education into a capped estimated number of years it would take to reach this highest level of education.<br><br>The "capped" comes into play when someone spend a longer time than usual for a certain degree but did not complete it. In short, someone with a lot of years of education but did not complete a degree will not score higher than someone who did complete the degree. | *11 maximum* = Less than High school<br>*12* = High School<br>*15 maximum* = Some College<br>*16* = Bachelor's degree<br>*20 maximum* = Some Graduate Work<br>*18* = Master's degree<br>*21* = MD/JD/PhD/ Advanced degree |
| Construct Name | ConstructName | Speed of Processing | |
| Construct Number | ConstructNumber | Construct 1 | |
| Wave | Wave | Denotes the data collection wave. | 1 = Wave 1<br>2 = Wave 2 |

| | | | |
|---|---|---|---|
| | | See individual differences data set for more detail, including testing date intervals. | 3 = Wave 3 |
| Has Data | HasData | 1 = Yes, returned for wave<br>2 = No, did not return for wave | |
| Number of Tasks in Construct | NumTasks | How many tasks make up the speed of processing construct | 3 Tasks for Speed of Processing |
| **Task 1—Digit Comparison** | **Task1** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Digit Comparison 3 | DigComp3_1 | Total correct for 3-digit strings | Score Range:<br>0-64 |
| Digit Comparison 6 | DigComp6_1 | Dependent Variable: total correct for 6-digit strings | Score Range:<br>0-64 |
| Digit Comparison 9 | DigComp9_1 | Dependent Variable: total correct for 9-digit strings | Score Range:<br>0-64 |
| Digit Comparison Total | DigCompTotal1 | Dependent Variable: Total correct summed across T3, T6, and T9 trials | Score Range:<br>0-192 |
| **Task 2—Digit Symbol** | **Task2** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Digit Symbol Total | DigSymTotal2 | Number of items matched correctly in 90 sec | Score Range:<br>0-93 |
| **Task 3—NIH Toolbox Pattern Comparison Speed Test** | **Task3** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| NIH Toolbox Pattern Comparison Speed Test | NIHSpeedRaw3 | The participant's raw score is the number of items answered correctly in 85 seconds of response time, with a range of 0-130. This score is then converted to the NIH Toolbox normative standard scores. | Score Range:<br>0-130 |
| NIH Toolbox Pattern Comparison Speed Test | NIHSpeedComp3 | The computed score is a conversion between the desktop and iPad data present in wave 3. | Score Range:<br>0-130 |
| NIH Toolbox Pattern Comparison Speed Test | NIHSpeedUn3 | It compares the performance of the test-taker to those in the entire NIH Toolbox nationally representative normative sample, regardless of age or any other variable. | Normative Mean = 100, SD = 15 |
| NIH Toolbox Pattern Comparison Speed Test | NIHSpeedAge3 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample at the same age, where a score of 100 indicates performance that was at the national average for the test-taking participant's age. Age-corrected standard scores were derived for adults (ages 18-85). | Mean = 100, Standard Deviation = 15 |

| | | | |
|---|---|---|---|
| NIH Toolbox Pattern Comparison Speed Test | NIHSpeedPercent3 | A Percentile represents the percentage of people nationally above whom the participant's score ranks (the comparison group will be based on whichever normative score is used) | Percentile rank: 0-100 |
| NIH Toolbox Pattern Comparison Speed Test | NIHSpeedFully3 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample, while adjusting for key demographic variables (education, gender, and race/ethnicity) collected during the NIH Toolbox national norming study. | Mean = 50, Standard Deviation = 10 |

# Construct 2: Working Memory

***Definition***

The construct of working memory measures the ability of individuals to simultaneously manipulate and store information. This ability plays a key role in processes involving language comprehension, reasoning, and planning, highlighting its importance in analyzing cognition. Baddeley and Hitch present the initial transition from classically accepted short-term memory to the current definition of working memory.

**References**


Baddeley, A.D., & Hitch, G. (1974). Working Memory. *Psychology of Learning and Motivation*, *8*, 47-89. https://doi.org/10.1016/S0079-7421(08)60452-1

Salthouse, T. A., & Babcock, R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology*, *25*(5), 763-776. https://doi.org/10.1037/0033-295X.103.3.403

Park, D.C. (2000). The basic mechanisms accounting for age-related decline in cognitive function. In D.C. Park & N. Schwartz (Eds.), *Cognitive Aging: A primer*, pp. 47-89. Psychology Press.


***Task 2.4 CANTAB Spatial Working Memory***

**Description (task duration: 10 minutes):** This task assesses the participant's ability to retain spatial information while simultaneously manipulating remembered items in working memory. The objective of the task is to remember the sequence of locations where blue tokens were found (spatial memory), and simultaneously continue searching for tokens (processing component) without revisiting locations that have already yielded a token (memory component). Participants collect blue tokens that are hidden in an array of boxes (set size from 3-8 boxes). When an array of boxes is presented, participants must touch each box in turn with a touch-screen stylus until one reveals a blue token inside (a "search"). Once a blue token has been found, the participant will place it in the depository column on the right side of the screen ("home"), which indicates how many tokens remain in the sequence. The participant must search for the remaining tokens until one has been found in each box on the current screen. The boxes will remain on the screen after being touched, regardless of whether the participant locates blue tokens inside of them. The participant's task is to remember where they find the tokens because, once a token has been found in a box, that box will never contain another token for that set. After a participant has found all blue tokens for an array of boxes, the task moves onto the next trial of boxes in a different array. This task contains 15 total trials. Trials 1-3 contain 3 boxes each, trials 4-7 contain 4 boxes each, trials 8-11 contain 6 boxes each, and trials 12-15 contain 8 boxes each. Performance in the more difficult trials of this task is enhanced by the use of a heuristic search strategy, which indicates that participants did not choose boxes at random.

**Performance Errors**: Two kinds of errors can be made: *Between (memory) errors* are when a participant returns to a box in which a token has already been found during the same search trial. Lower between error scores are better.

*Within errors* are when participants search any particular box more than once in the same search sequence. Lower within error scores are better.

**Primary References**:

Robbins T.W., et al. (1994). Cambridge Neuropsychological Test Automated Battery (CANTAB): A factor-analytic study of a large sample of normal elderly volunteers. *Dementia, 5*(5):266-281. https://doi.org/10.1159/000106735.

CANTAB Eclipse (2007). https://www.cambridgecognition.com/cantab/cognitive-tests/executive-function/spatial-executive-function-swm

***Task 2.5 WAIS-III Letter-Number Sequencing***

**Description (task duration: 5 minutes): 7 blocks of 3 trials per block are presented unless task is terminated for poor performance.** Participants listen to a series of numbers and letters (e.g., 1-J-A-6) and are asked to rearrange the items in their head and recite the sequence with the numbers first, in ascending order, followed by the letters, in alphabetical order (e.g., 1-6-A-J). Researchers present the letter-number strings at a rate of one letter or number per second. Responses are recorded for accuracy and each receives a score of correct (1) or incorrect (0). There are a total of 21 trials that range from 2-8-item strings and are presented from easiest to hardest. The task is terminated when a participant responds incorrectly to all three trials within a 3-item block. Otherwise, the researcher will continue and administer the next item of increased difficulty (higher total number of letters and numbers) until all seven blocks are completed. The variables of interest are the number of trials answered correctly in each block and the total number of trials correct across all blocks. A higher score indicates better working memory performance.

**Primary Reference**:

Wechsler, D. (1997). *WAIS-III: Administration and scoring manual: Wechsler Adult Intelligence Scale*. San Antonio, TX: Psychological Corporation.

***Task 2.6 Operation Span Task***

**Description (task duration: 20 minutes):** Participants are presented with a simple arithmetic equation and they respond "yes" if the equation is accurate (e.g., (6/3) +5=7) and "no" if it is inaccurate (e.g., (3+6)/3=2). As soon as the subject responds, the equation disappears, and a concrete noun is presented. Participants read the word aloud. Participants are told to take as much time as is needed to answer the arithmetic portion but must immediately read the ensuing word after answering. Immediately after they pronounce the word, the next arithmetic-word string appears on the screen. After a block of equations and words is complete (number of items in block varies from 2-5), participants are shown a screen with three question marks and prompted to write down all the words they remembered from that block in the order that they were presented. There are 12 blocks presented that each contain 2-5 items within a block, with a total of 42 arithmetic-word strings. Blocks are randomly ordered but do not vary between participants. Variables of interest are total number of words correctly recalled for each of the four block sizes (2, 3, 4, 5) and total recalled, with a higher number of recalled words indicative of better performance. Responses to the arithmetic portion of each set are not recorded and are not used for data analysis.

**Primary Reference**:

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language*, *28*(2):127-154. https://doi.org/10.1016/0749-596X(89)90040-5

***Task 2.7 NIH Toolbox List Sorting***

**Description (task duration: 10 minutes):** Participants are presented with pictures of commonly known foods and animals that are displayed along with written text and an accompanying audio recording of the name of the item (e.g., "elephant"). Each picture is displayed on the screen, one at a time, in a "flashing" manner at a rate of 2 seconds per item. The objective is to re-order the block of pictures according to particular rules. In the one-list condition, participants sort each block of items by size and in the two-list condition, items are sorted by both size as well as by category. The variable of interest is a sum of the total correct responses across both lists, with higher scores suggesting greater global working memory capacity.

**One-List Condition:** Participants are presented with a sequence of 2-7 pictures (*either* food or animals) and must order the series from smallest to largest. Participants answer verbally and must name all the items in the correct order without intrusions. The task begins with a 2-item block. If answered correctly, the number of items in each block will increase up to seven total items. If answered incorrectly, participants will get a second block of similar difficulty. If they then answer correctly for the second block, they advance to the next block of higher difficulty, otherwise, the testing is terminated. This condition contains two practice blocks in which immediate feedback is provided and a maximum of 14 testing blocks.

**Two-List Condition:** Participants are presented with a series of *both* food and animals and must order the series by both size and category. Participants will sort the food items from smallest to largest, followed by the animal items from smallest to largest. This condition contains two practice blocks, in which feedback is provided, and a maximum of 12 testing blocks. The test procedure is identical to the one-list condition, only with the added complexity of sorting by both size and category.

**Primary References**:

Gershon, R.C., et al. (2013). NIH toolbox for assessment of neurological and behavioral function. *Neurology*, *80*(11 Suppl 3): S2-6. https://doi.org/10.1212/WNL.0b013e3182872e5f

Tulsky, D.S., et al. (2013). NIH Toolbox Cognitive Function Battery (NIHTB-CFB): Measuring working memory. *Monographs of the Society for Research in Child Development*, *78*(4):70–87. https://doi.org/10.1111/mono.12035

***Task 2.8 CANTAB Delayed Matching to Sample Task***

**Description (task duration: 12 minutes):** This task measures maintenance of visual memory in a four-choice delayed recognition memory paradigm. Participants are presented with a complex, abstract target pattern that consists of four quadrants differing in color and form and they must match the target to one of four choice patterns. One of the choice patterns is identical to the target, one is a novel distractor pattern, one has the shape of the sample and the colors of the distractor, and the fourth has the colors of the sample and the shape of the distractor. All four

choice patterns have at least one quadrant in common with the sample. There a four different choice conditions: (1) choices added to the screen with the target, (2) choices shown 0 seconds after the target disappears, (3) choices are shown 4 seconds after the target pattern disappears, and (4) choices are shown 12 seconds after the target pattern disappears. Participants are asked to select the choice pattern that matches the presented sample pattern by touching their response with a touch-screen stylus. Feedback is provided on-screen for incorrect responses and participants continue their search until they find the matching pattern. The variables of interest include the total number of items matched correctly across each delay period (simultaneous, 0 second delay, 4 second delay, and 12 second delay) and the total number of correctly matched items across all delayed periods. Higher scores suggest a more efficient visual memory ability.

**Primary References**:

Robbins T.W., et al. (1994). Cambridge Neuropsychological Test Automated Battery (CANTAB): A factor-analytic study of a large sample of normal elderly volunteers. *Dementia, 5*(5):266-281. https://doi.org/10.1159/000106735.

CANTAB Eclipse (2007). https://www.cambridgecognition.com/cantab/cognitive-tests/executive-function/spatial-executive-function-swm

***Task 2.9 CANTAB Spatial Recognition Memory Task***

**Description (task duration: 5 minutes):** This task measures visual-spatial recognition memory in a two-choice forced discrimination paradigm. The task has two phases: spatial encoding followed by recognition. In the encoding phase, participants are shown a white square that moves sequentially to five different locations on the screen, each for three seconds. After a five second delay, subjects are presented with two white squares for the recognition phase. One of them occupies a location where a square was presented during encoding and the other square is in a novel location (distractor stimulus). Participants are asked to select the square that is in location previously seen in the encoding phase. There are four blocks of five trials, for a total of 20 responses. The variable of interest is total number of locations correctly identified with higher scores indicating better working memory performance.

**Primary References**:

Robbins T.W., et al. (1994). Cambridge Neuropsychological Test Automated Battery (CANTAB): A factor-analytic study of a large sample of normal elderly volunteers. *Dementia, 5*(5):266-281. https://doi.org/10.1159/000106735.

CANTAB Eclipse (2007). https://www.cambridgecognition.com/cantab/cognitive-tests/executive-function/spatial-executive-function-swm

**Working Memory Data Set: Key to Names and Data Structure in Data Set**

| Item Name | Abbreviation | Description | Measurement |
|---|---|---|---|
| Subject Number | S# | Subject identifier | |
| Age Interval | AgeInterval | Age at wave recoded into 3-year intervals | 20-100 |
| Sex | Sex | Participant's biological sex. | m = Male<br>f = Female |

| | | | |
|---|---|---|---|
| Race | Race | Race that the participant self-identifies with. | 1 = Asian American/ Pacific Islander<br>2 = Black/African American<br>3 = Multiracial<br>4 = Native American<br>5 = White/Caucasian<br>6 = Other<br>7 = Unknown |
| Ethnicity | Ethnicity | Ethnicity that the participant self-identifies with. | 1=Hispanic/Latin(o/a)<br>0 = Non-Hispanic |
| Handedness Score | HandednessScore | Average score of participant hand preference while completing various tasks. Higher scores indicate preference for the right hand. | Score range: 0-4<br><br>0 = Always left<br>1 = Usually left<br>2 = No preference<br>3 = Usually right<br>4 = Always right |
| Mini-Mental State Exam Total | MMSE | Total # of items answered correctly. | Score range: 0-30 |
| Cognitive Battery Wave 1-2 Interval | CogW1toW2 | Interval between cognitive testing day 1 for waves 1-2. | # of Years |
| Cognitive Battery Wave 2-3 Interval | CogW2toW3 | Interval between cognitive testing day 1 for waves 2-3. | # of Years |
| Cognitive Battery Wave 1-3 Interval | CogW1toW3 | Interval between cognitive testing day 1 for waves 1-3. | # of Years |
| Take Home Wave 1-2 Interval | TakeHomeW1toW2 | Interval between Take Home for waves 1-2. | # of Years |
| Take Home Wave 2-3 Interval | TakeHomeW2toW3 | Interval between Take Home for waves 2-3. | # of Years |
| Take Home Wave 1-3 Interval | TakeHomeW1toW3 | Interval between Take Home for waves 1-3. | # of Years |
| MRI Wave 1-2 Interval | MRIW1toW2 | Interval between MRI scan for waves 1-2. | # of Years |
| MRI Wave 2-3 Interval | MRIW2toW3 | Interval between MRI scan for waves 2-3. | # of Years |
| MRI Wave 1-3 Interval | MRIW1toW3 | Interval between MRI scan for waves 1-3. | # of Years |
| Amyloid PET Wave 1-2 Interval | PETAmyW1toW2 | Interval between amyloid PET scan for waves 1-2. | # of Years |
| Amyloid PET Wave 2-3 Interval | PETAmyW2toW3 | Interval between amyloid PET scan for waves 2-3. | # of Years |
| Amyloid PET Wave 1-3 Interval | PETAmyW1toW3 | Interval between amyloid PET scan for waves 1-3. | # of Years |
| Highest Level of Education Completed | EduComp5 | This is an ordinal measure of participants' self-reported highest level of education completed. | 1 = Less than high school graduate<br>2 = High school graduate/GED<br>3 = Some college/trade/ technical/business school<br>4 = Bachelor's degree<br>5 = Some graduate work<br>6 = Master's degree<br>7 = MD/JD/PhD/other advanced degree |

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| Education Estimated Years Capped | EduYrsEstCap5 | This is a conversion of the participant's self-reported highest level of education into a capped estimated number of years it would take to reach this highest level of education.<br><br>The "capped" comes into play when someone spend a longer time than usual for a certain degree but did not complete it. In short, someone with a lot of years of education but did not complete a degree will not score higher than someone who did complete the degree. | *11 maximum* = Less than High school<br>*12* = High School<br>*15 maximum* = Some College<br>*16* = Bachelor's degree<br>*20 maximum* = Some Graduate Work<br>*18* = Master's degree<br>*21* = MD/JD/PhD/ Advanced degree |
| Construct Name | ConstructName | Working Memory | |
| Construct Number | ConstructNumber | Construct 2 | |
| Wave | Wave | Denotes the data collection wave. See individual differences data set for more detail, including testing date intervals. | 1=Wave 1<br>2=Wave 2<br>3=Wave 3 |
| Has Data | HasData | Yes =1<br>No=2 | |
| Number of Tasks in Construct | NumTasks | How many tasks make up the working memory construct | 6 tasks for Working Memory |
| **Task 4-CANTAB Spatial Working Memory** | **Task4** | 1 = Has data<br>2 = Task data partial<br>3 =No task data | |
| Spatial WM 4-Box Errors* | SptlWM4BoxErrs4 | Total errors for 4-box trials | No max score |
| Spatial WM 6-Box Errors* | SptlWM6BoxErrs4 | Total errors for 6-box trials | No max score |
| Spatial WM 8-Box Errors* | SptlWM8BoxErrs4 | Total errors for 8-box trials | No max score |
| Spatial WM Total Errors | SptlWMTotErrs4 | Total number of errors across all trials. | No max score |
| **Task 5 – WAIS Letter-Number Sequencing** | **Task5** | 1 = Has data<br>2 = Task data partial<br>3 =No task data | |
| Letter-Number Sequencing 2-Item Trials Total Correct | LetNumSeq2Item5 | Total number of 2-item trials recalled correctly | Score Range: 0-3 |
| Letter-Number Sequencing 3-Item Trials Total Correct | LetNumSeq3Item5 | Total number of 3-item trials recalled correctly | Score Range: 0-3 |
| Letter-Number Sequencing 4-Item Trials Total Correct | LetNumSeq4Item5 | Total number of 4-item trials recalled correctly | Score Range: 0-3 |
| Letter-Number Sequencing 5-Item | LetNumSeq5Item5 | Total number of 5-item trials recalled correctly | Score Range: 0-3 |

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| Trials Total Correct | | | |
| Letter-Number Sequencing 6-Item Trials Total Correct | LetNumSeq6Item5 | Total number of 6-item trials recalled correctly | Score Range: 0-3 |
| Letter-Number Sequencing 7-Item Trials Total Correct | LetNumSeq7Item5 | Total number of 7-item trials recalled correctly | Score Range: 0-3 |
| Letter-Number Sequencing 8-Item Trials Total Correct | LetNumSeq8Item5 | Total number of 8-item trials recalled correctly | Score Range: 0-3 |
| Letter-Number Sequencing Total | LetNumSeqTot5 | Total number of trials recalled correctly | Score Range: 0-21 |
| **Task 6 – Operation Span** | **Task6** | 1 = Has data<br>2 = Task data partial<br>3 =No task data | |
| OSpan 2-Item Block Total (Blocks 4,7,11) | OSp2BLTot6 | Total # of blocks recalled correctly for 2-item blocks | Score Range:<br>0-3 |
| OSpan 3-Item Block Total (Blocks 1,3,9) | OSp3BLTot6 | Total # of blocks recalled correctly for 3-item blocks | Score Range: 0-3 |
| OSpan 4-Item Block Total (Blocks 6,8,12) | OSp4BLTot6 | Total # of blocks recalled correctly for 4-item blocks | Score Range: 0-3 |
| OSpan 5-Item Block Total (Blocks 2,5,10) | OSp5BLTot6 | Total # of blocks recalled correctly for 5-item blocks | Score Range: 0-3 |
| OSpan Total | OSpanTot6 | Sum of total # of words recalled correctly for *perfectly recalled* blocks<br>To get a score of 42, subjects must correctly recall: Three two-item blocks (3 blocks x 2 words each = 6), three three-item blocks (3 blocks x 3 words each = 9), three four-item blocks (3 blocks x 4 words each = 12), three five-item blocks (3 blocks x 5 words each = 15); total number of words correct is thus 42. | Score Range: 0-42 |
| **Task 7 – NIH Toolbox List Sorting** | **Task7** | 1 = Has data<br>2 = Task data partial<br>3 =No task data | |
| NIH Toolbox List Sorting Raw Score | LstSrtRaw7 | Scored sum of total # of items correctly recalled and sequenced on both lists | Score Range: 0-26 |
| NIH Toolbox List Sorting Uncorrected Standard Score | LstSrtUn7 | This score compares the performance of the test-taker to those in the entire NIH Toolbox nationally representative | normative mean = 100, SD = 15 |

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| | | normative sample, regardless of age or any other variable. | |
| NIH Toolbox List Sorting Age-Corrected Standard Score | LstSrtAge7 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample at the same age, where a score of 100 indicates performance that was at the national average for the test-taking participant's age. Age-corrected standard scores were derived for adults (ages 18-85). | mean=100, standard deviation=15 |
| NIH Toolbox List Sorting National Percentile | LstSrtPercent7 | A Percentile represents the percentage of people nationally above whom the participant's score ranks (the comparison group will be based on whichever normative score is used). | Percentile Rank: 0-100 |
| NIH Toolbox List Sorting Fully-Corrected T-score | LstSrtFully7 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample, while adjusting for key demographic variables (education, gender, and race/ethnicity) collected during the NIH Toolbox national norming study. | mean=50, standard deviation=10 |
| **Task 8 – CANTAB Delayed Matching to Sample** | **Task8** | 1 = Has data<br>2 = Task data partial<br>3 =No task data | |
| Delayed Matching to Sample Simultaneous Total* | DMSSimTot8 | Total # of items matched correctly with simultaneous presentation | Score Range: 0-10 |
| Delayed Matching to Sample Immediate (0 second delay) Total* | DMSImmTot8 | Total # of items matched correctly with immediate (0 second delay) presentation | Score Range: 0-10 |
| Delayed Matching to Sample 4 Second Delay Total* | DMS4SecTot8 | Total # of items matched correctly with 4 second delay presentation | Score Range: 0-10 |
| Delayed Matching to Sample 12 Second Delay Total* | DMS12SecTot8 | Total # of items matched correctly with 12 second delay presentation | Score Range: 0-10 |
| Delayed Matching to Sample Total | DMSTot8 | Total # of items matched correctly | Score Range: 0-40 |
| **Task 9 – CANTAB Spatial Recognition Memory** | **Task9** | 1 = Has data<br>2 = Task data partial<br>3 =No task data | |

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|---|---|---|---|
| Spatial Recognition Memory Total | SRMTot9 | Total # of locations correctly identified | |

# Construct 4: Episodic Memory

***Definition***

This construct measures how well individuals can store, maintain, and retrieve detailed information in long-term memory. It is highly sensitive to normal aging processes and shows robust deficits in mild cognitive impairment and Alzheimer's disease (Koen & Yonelinas, 2014). Two classic papers by Endel Tulving (1972, 2002) provide both a theoretical conceptualization of episodic memory and relevant empirical measures.

**References**


Koen, J. D., & Yonelinas, A. P. (2014). The effects of healthy aging, amnestic mild cognitive impairment, and Alzheimer's disease on recollection and familiarity: A meta-analytic review. *Neuropsychology Review*, 24(3), 332-354. https://doi.org/10.1007/s11065-014-9266-5

Tulving, E. (1972). Episodic and semantic memory. *Organization of memory, 1*, 381-403.

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology, 53*, 1–25. https://doi.org/10.1146/annurev.psych.53.100901.135114


**Note**: For all included memory tasks, the same item lists were used at each wave of data collection as there was an approximately 4-year interval between testing sessions.

***Task 4.15 Hopkins Verbal Learning, Parts 1-4***

**Description (task duration: 6 minutes):**

- **Encoding:** Participants memorize a semantically categorized list of 12 concrete nouns that are read aloud by the experimenter at a rate of one word every 1.5 seconds. The three semantic categories are sports, professions, and vegetables, with 4 words in each category.
- **Immediate Recall:** Immediately following the presentation, participants are asked to recall aloud as many words from the list as they can in any order. The experimenter records the words recalled on a scoring sheet. The dependent measure is the number of items correctly recalled out of 12.
- **Delayed Recall:** After approximately 20 minutes, participants are again asked to recall aloud as many words as possible from the previous list in any order. The experimenter records the words recalled on a scoring sheet. The dependent measure is the number of items correctly recalled out of 12.
- **Delayed Recognition:** Following delayed recall, participants are given a recognition test in which the experimenter reads another list of 24 words, including 12 target words (from recall list) and 12 new words (lures). Of the 12 lures, 6 are semantically related to the target items (2 for each semantic category) and 6 are not semantically related to the target items. Participants make "yes"/"no" judgments to indicate if the word was on the original study list. The dependent measure is the total number of correct judgments (including hits + correction rejections) out of 24. In addition, false alarm rates are available for related and unrelated items, as are hits to old items.

**Primary Reference:**

Brandt, J. (1991). The Hopkins Verbal Learning Test: Development of a new memory test with six equivalent forms. *The Clinical Neuropsychologist*, *5*(2), 125-142. https://doi.org/10.1080/13854049108403297

***Task 4.16 CANTAB Verbal Recognition Memory, Parts 1-4***

**Description (task duration: 7 minutes):**

- **Encoding**: Twelve nouns are presented on the computer screen one at a time. Participants are asked to read each word aloud and remember as many as they can.
- **Immediate Recall:** Immediately following the presentation of the word list, participants are asked to recall aloud as many of the words as possible in any order. Data for the number of items recalled, out of 12, are available.
- **Immediate Recognition:** Immediately following recall, participants complete a recognition test in which the computer displays the 12 target items and 12 distractor items, one at a time. Participants answer whether they remember seeing the item earlier in the task on the computer ("yes" or "no"). Performance was near ceiling for this test, and data are not currently processed/checked.
- **Delayed Recognition:** The recognition phase is repeated after a delay of approximately 40 minutes. Data for the number of items recognized (and correct rejections), out of 24, are available. Performance was near ceiling for this task and we advise against using it but include it to provide a complete accounting of the methodology.

**Primary Reference:**

Robbins, T.W., James, M., Owen, A.M., Sahakian, B.J., McInnes, L., Rabbitt, P. (1994). Cambridge Neuropsychological Test Automated Battery (CANTAB): A factor analytic study of a large sample of normal elderly volunteers. *Dementia, 5*, 266-281. https://doi.org/10.1159/000106735

**Software Reference:**

CANTAB Eclipse. *Cambridge Cognition* (2007). https://www.cambridgecognition.com/cantab/cognitive-tests/memory/verbal-recognition-memory-vrm/

**Note**: It is recommended that the delayed recognition score (CantabVrmDelayRcg16) should NOT be used as it has strong ceiling effects, resulting in severe skewness and kurtosis. Standard data transformations were unable to correct this issue.

***Task 4.17 Woodcock-Johnson Memory for Names, Parts 1-3***

**Description (task duration: 15 minutes):**

- **Task Overview:** In this paired-associate recognition task, participants are given 12 trials that each include both an encoding and recognition component. This task is administered using color illustrations in a printed flip-book. On each trial, the participant first learns the name of a single cartoon space creature. Then, they must identify that creature in an array of nine aliens. Finally, they are asked to identify previously learned creatures in that array. The difficulty increases across trials as participants are required to remember the

names of an increasingly larger set of creatures (up to 12 unique creatures). A separate delayed recognition test is administered 20 minutes later.

- **Encoding:** For the encoding component of each trial, participants are shown a color illustration of the space creature by itself on a page. Participants are told the name of the creature and are asked to point to it on the page (e.g., "This is Meegoy. Point to Meegoy."; see figure below).
- **Immediate Recognition:** Next, for the recognition component of that trial, participants are shown a page of nine space creatures and are asked to point to the newly-introduced creature among the distractors ("Now point to Meegoy"; see figure below). Then, they are asked to point to previously learned creatures ("Now point to Kiptron"). For each trial, the previously learned creatures are tested in a novel order, and whenever the participant responds incorrectly, they are corrected (e.g., "No, this is Meegoy. Point to Meegoy."). For each trial, they are tested on all previously learned creatures up to a total of 9 creatures; for trials 10-12, the earliest creatures are dropped to keep that total at 9. Specifically, the total number of creatures to be recognized on each trial progresses across the 12 trials as follows: 1, 2, 3, 4, 5, 6, 7, 8, 9, 9, 9, 9 (total = 72 items). The dependent measure is the number of creatures recognized out of 72.
- **Delayed Recognition:** After a 20-minute delay, participants are given a surprise recognition test in which they are asked to point to each space creature when prompted by the experimenter. This delayed test has 3 parts, with 12 trials per part. In each trial, the participant is shown an array of nine space creatures, as before, and is asked to point to a previously learned creature ("Now point to Meegoy"). Next, they are shown a new array and asked to point to a different creature ("Now point to Kiptron"). In this test, incorrect responses are no longer corrected by the experimenter, and creatures are not presented in the order originally learned. This process repeats for part 1 until they have been asked to recognize all 12 unique space creatures in one of the 12 different arrays. For parts 2 and 3, they repeat this processing going through the 12 arrays in the same order, but with the items tested being put in a new order—for example, in trial 1 they may now be asked to identify "Delton" instead of "Meegoy". Thus, all 12 space creatures are tested 3 times each, and the dependent measure is the number of creatures recognized out of 36.

**Primary Reference**:

Woodcock, R. W., & Johnson, M. B. (1989). *Woodcock-Johnson Tests of Achievement*. Allen, TX: DLM Teaching Resources.

***Task 4.18 Wechsler Memory Scale (WMS-III) Logical Memory, Parts 1-3***

**Description (task duration: 7 minutes):**

- **Encoding:** The experimenter reads two highly detailed stories to the participant. One story describes a fictional character reporting a robbery and another describes a character listening to a weather bulletin.
- **Immediate Recall:** Immediately after each story, the participant is asked to recall as much of the story as they can, verbatim. The participant's response is recorded via tape recorder. Reviewing the tape, the experimenter scores the participant's response by awarding one point per highly specific detail recalled by the participant (called Story Units, e.g., the main character's name is Anna, the story took place in Boston, the

weather forecast predicted rain and hail, etc.). Story Unit scores for Story A and Story B (each out of 25) are calculated by summing all correct details (total out of 50).

- **Delayed Recall:** After a delay of approximately 30 minutes, the participant is asked to repeat as much each of the two stories as they can remember with answers recorded. Story Unit scores for Story A and B (each out of 25) are again calculated, with a combined score out of 50.

**Task Example:**
Story A: This story involves a fictional character, Anna Thompson, reporting at a police station that she was robbed, including additional details about her profession and family. (length: 351 characters)

Story B: This story involves a fictional character, Joe Garcia, hearing a detailed weather bulletin about inclement weather and then Joe deciding to stay home for the day. (length: 470 characters)

**Primary Reference**:

Wechsler, D. (1997). *Wechsler memory scale (WMS-III)*. San Antonio, TX: Psychological Corporation.

**Note:** The Logical Memory task can also be scored based on the participants' recall of seven or eight thematic details from the stories (e.g., broadly, indication of character's gender, indication of major events in the story – storm, robbery, etc.). The thematic score is not checked or verified and is not used.

***Task 4.19 NIH Toolbox Picture Sequence Memory, Parts 1-2***
**Description (task duration: 7 minutes):**

- **Encoding:** This test involves recalling increasingly lengthy series of illustrated objects and activities that are presented in a particular order on the computer screen. These picture sequences revolve around two scenarios: playing in a park and going camping. During encoding, each picture is presented individually in the center of the screen for approximately 5 s with pre-recorded instructions describing the image (e.g., "roasting a marshmallow") and the item then being placed below in a sequence mirroring presentation order (from left-to-right) (see below example).
- **Retrieval:** After all items are placed, these pictures are then returned to the center of the screen in a jumbled pattern, and the participant's task is to move them below again in the correct sequence. There are 15 items in the first trial, and 18 items in the second trial.
- **Scoring:** Participants are given credit for each adjacent pair of pictures that are put in the correct sequence, regardless of location. For example, if pictures in locations 7 and 8 are placed in that order and adjacent to each other anywhere–such as slots 1 and 2–one point is awarded. The maximum score for each trial is one less than the trial length, which equates to 14 points for trial 1 and 17 points for trial 2 (Total Score Range: 0-31). Multiple dependent variables are provided via NIH Toolbox: (1) a *raw score* is their combined score across the two trials (Score Range: 0-31), (2) a *computed score* uses item response theory to put everyone on a scale of 200-750, (3) an *unadjusted scale score* compares this computed score with the full NIH Toolbox nationally representative normative sample (normative $M = 100$, $SD = 15$) (4) an *age-adjusted scale score*

compares the computed score of the test-taker to those in the NIH normative sample at the same age ($M$ = 100, $SD$ = 15), (5) an *age-adjusted national percentile* represents the percentage of people nationally above whom the participant's score ranks (using NIH normative sample), and (6) a *fully-adjusted scale score* further adjusts for key demographic variables from the NIH normative sample, including age, gender, race/ethnicity (white/Asian, black, Hispanic, multiracial), and educational attainment ($M$ = 50, $SD$ = 10; NIH Toolbox: Scoring and Interpretation Guide, 2016).

**Primary Reference:**

Dikmen, S. S., Bauer, P. J., Weintraub, S., Mungas, D., Slotkin, J., Beaumont, J. L., ... & Heaton, R. K. (2014). Measuring episodic memory across the lifespan: NIH Toolbox Picture Sequence Memory Test. *Journal of the International Neuropsychological Society*, *20*(6), 611-619. https://doi.org/10.1017/S1355617714000460

**Software Reference:**

NIH Toolbox for the iPad test ver. 2.1
https://nihtoolbox.force.com/s/article/nih-toolbox-scoring-and-interpretation-guide

**Note:** Participants in DLBS Wave 2 performed the NIH Toolbox Picture Sequence Memory on a desktop computer, whereas, participants in DLBS Wave 3 performed the task on an ipad. For additional details, we refer you to the the NIH Toolbox website: https://www.healthmeasures.net/explore-measurement-systems/nih-toolbox/obtain-and-administer-measures

**Episodic Memory Data Set: Key to Names and Data Structure in Data Set**

| Item Name | Abbreviation | Description | Measurement |
|---|---|---|---|
| Subject Number | S# | Subject identifier | |
| Age Interval | AgeInterval | Age at wave recoded into 3-year intervals | 20-100 |
| Sex | Sex | Participant's biological sex. | m = Male<br>f = Female |
| Race | Race | Race that the participant self-identifies with. | 1 = Asian American/ Pacific Islander<br>2 = Black/African American<br>3 = Multiracial<br>4 = Native American<br>5 = White/Caucasian<br>6 = Other<br>7 = Unknown |
| Ethnicity | Ethnicity | Ethnicity that the participant self-identifies with. | 1=Hispanic/Latin(o/a)<br>0 = Non-Hispanic |
| Handedness Score | HandednessScore | Average score of participant hand preference while completing various tasks. Higher scores indicate preference for the right hand. | Score range: 0-4<br><br>0 = Always left<br>1 = Usually left<br>2 = No preference<br>3 = Usually right<br>4 = Always right |
| Mini-Mental State Exam Total | MMSE | Total # of items answered correctly. | Score range: 0-30 |

| | | | |
|---|---|---|---|
| Cognitive Battery Wave 1-2 Interval | CogW1toW2 | Interval between cognitive testing day 1 for waves 1-2. | # of Years |
| Cognitive Battery Wave 2-3 Interval | CogW2toW3 | Interval between cognitive testing day 1 for waves 2-3. | # of Years |
| Cognitive Battery Wave 1-3 Interval | CogW1toW3 | Interval between cognitive testing day 1 for waves 1-3. | # of Years |
| Take Home Wave 1-2 Interval | TakeHomeW1toW2 | Interval between Take Home for waves 1-2. | # of Years |
| Take Home Wave 2-3 Interval | TakeHomeW2toW3 | Interval between Take Home for waves 2-3. | # of Years |
| Take Home Wave 1-3 Interval | TakeHomeW1toW3 | Interval between Take Home for waves 1-3. | # of Years |
| MRI Wave 1-2 Interval | MRIW1toW2 | Interval between MRI scan for waves 1-2. | # of Years |
| MRI Wave 2-3 Interval | MRIW2toW3 | Interval between MRI scan for waves 2-3. | # of Years |
| MRI Wave 1-3 Interval | MRIW1toW3 | Interval between MRI scan for waves 1-3. | # of Years |
| Amyloid PET Wave 1-2 Interval | PETAmyW1toW2 | Interval between amyloid PET scan for waves 1-2. | # of Years |
| Amyloid PET Wave 2-3 Interval | PETAmyW2toW3 | Interval between amyloid PET scan for waves 2-3. | # of Years |
| Amyloid PET Wave 1-3 Interval | PETAmyW1toW3 | Interval between amyloid PET scan for waves 1-3. | # of Years |
| Highest Level of Education Completed | EduComp5 | This is an ordinal measure of participants' self-reported highest level of education completed. | 1 = Less than high school graduate<br>2 = High school graduate/GED<br>3 = Some college/trade/ technical/business school<br>4 = Bachelor's degree<br>5 = Some graduate work<br>6 = Master's degree<br>7 = MD/JD/PhD/other advanced degree |
| Education Estimated Years Capped | EduYrsEstCap5 | This is a conversion of the participant's self-reported highest level of education into a capped estimated number of years it would take to reach this highest level of education.<br><br>The "capped" comes into play when someone spend a longer time than usual for a certain degree but did not complete it. In short, someone with a lot of years of education but did not complete a degree will not score higher than someone who did complete the degree. | *11 maximum* = Less than High school<br>*12* = High School<br>*15 maximum* = Some College<br>*16* = Bachelor's degree<br>*20 maximum* = Some Graduate Work<br>*18* = Master's degree<br>*21* = MD/JD/PhD/ Advanced degree |
| Construct Name | ConstructName | Episodic Memory | |

| Construct Number | ConstructNumber | Construct 4 | |
|---|---|---|---|
| Wave | Wave | Denotes the data collection wave. See individual differences data set for more detail, including testing date intervals. | 1 = Wave 1<br>2 = Wave 2<br>3 = Wave 3 |
| Has Data | HasData | 1 = Yes, returned for wave; 2 = No, did not return for wave | |
| Number of Tasks in Construct | NumTasks | How many tasks make up the episodic memory construct | 5 tasks for Episodic Memory |
| **Task 15—Hopkins Verbal Learning** | **Task15** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Hopkins immediate recall | HopImmRcll15 | Total correctly recalled | Score Range: 0-12 |
| Hopkins delayed recall | HopDelayRcll15 | Total correctly recalled | Score Range: 0-12 |
| Hopkins delayed recognition | HopRcgCrrct15 | Total correct (hits + correct rejections) | Score Range: 0-24 |
| Hopkins delayed recognition | HopRcgHit15 | Total hits (calling old item old) | Score Range: 0-12 |
| Hopkins delayed recognition | HopRcgFaRelat15 | Total false alarms to distractors semantically related to target (calling new item old) | Score Range: 0-6 |
| Hopkins delayed recognition | HopRcgFaUnrelat15 | Total false alarms to distractors semantically unrelated to target (calling new item old) | Score Range: 0-6 |
| Hopkins delayed recognition | HopRcgFaTotal15 | Total false alarms to distractors (calling new item old) | Score Range: 0-12 |
| Hopkins delayed recognition | HopRcgHitminusfa15 | Total hits – false alarms | Score Range: -12-12 |
| **Task 16—CANTAB Verbal Recognition Memory** | **Task16** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| CANTAB Verbal Recognition immediate recall | CantabVrmImmRcll16 | Total correctly recalled | Score Range: 0-12 |
| CANTAB Verbal Recognition delayed | CantabVrmDelayRcg16 | Total correctly recognized (hits + correct rejections) | Score Range: 0-24 |
| **Task 17—Woodcock-Johnson Memory for Names** | **Task17** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Woodcock-Johnson immediate recognition | WjImm17 | Total correctly recognized | Score Range: 0-72 |
| Woodcock-Johnson delayed recognition | WjDelay17 | Total correctly recognized | Score Range: 0-36 |
| **Task 18—Wechsler Memory Scale Logical Memory** | **Task18** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |

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|---|---|---|---|
| Logical memory immediate recall | LmStoryAImm18 | Total immediate Story A recall score | Score Range: 0-25 |
| Logical memory immediate recall | LmStoryBImm18 | Total immediate Story B recall score | Score Range: 0-25 |
| Logical memory immediate recall | LmStoryImm18 | Total immediate Story A+B recall score | Score Range: 0-50 |
| Logical memory delayed recall | LmStoryADelay18 | Total delayed Story A recall score | Score Range: 0-25 |
| Logical memory delayed recall | LmStoryBDelay18 | Total delayed Story B recall score | Score Range: 0-25 |
| Logical memory delayed recall | LmStoryDelay18 | Total delayed Story A+B recall score | Score Range: 0-50 |
| **Task19--NIH Toolbox Picture Sequence Memory** | **Task19** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| NIH Toolbox Picture Sequence Memory | NIHPicSeqRaw19 | Total number of pictures placed in the correct sequence across both trials | Score Range: 0-31 |
| NIH Toolbox Picture Sequence Memory | NIHPicSeqComp19 | This computed score uses item response theory to put everyone on a scale of 200-750 | Score Range: 200-750 |
| NIH Toolbox Picture Sequence Memory | NIHPicSeqUn19 | It compares the performance of the test-taker to those in the entire NIH Toolbox nationally representative normative sample, regardless of age or any other variable. | Normative Mean = 100, SD = 15 |
| NIH Toolbox Picture Sequence Memory | NIHPicSeqAge19 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample at the same age, where a score of 100 indicates performance that was at the national average for the test-taking participant's age. Age-corrected standard scores were derived for adults (ages 18-85). | Mean = 100, Standard Deviation = 15 |
| NIH Toolbox Picture Sequence Memory | NIHPicSeqPercent19 | A Percentile represents the percentage of people nationally above whom the participant's score ranks (the comparison group will be based on whichever normative score is used) | Percentile Rank: 0-100 |
| NIH Toolbox Picture Sequence Memory | NIHPicSeqFully19 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample, while adjusting for key demographic variables | Mean = 50, Standard Deviation = 10 |

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|---|---|---|---|
| | | (education, gender, and race/ethnicity) collected during the NIH Toolbox national norming study. | |

# Construct 5: Reasoning

***Definition***

The construct of reasoning measures an individual's ability to recognize novel patterns and the conceptual relationship among objects and effectively apply these patterns to solve similar problems.

**References**

Schaie, K. W., & Willis, S. L. (1986). Can decline in adult intellectual functioning be reversed? *Developmental Psychology*, *22*(2), 223–232. https://doi.org/10.1037/0012-1649.22.2.223

Boron, Julie Blaskewicz, Turiano, Nicholas A., Willis, Sherry L., Schaie, K. Warner (2007). Effects of Cognitive Training on Change in Accuracy in Inductive Reasoning Ability *Journal of Gerontology: Psychological Sciences*, 62B (3), 179-186.

***Task 5.20 Raven's Matrices***

**Description (task duration: 15 minutes):**

- Participants are presented with a set of geometric patterns that have a sequential structure with one piece missing. At the same time, they are also presented with an array of 6 or 8 geometric shape options. Participants must determine which pattern out of these 6 or 8 options is required to complete the visual pattern set.
- The problems are divided into 4 blocks. In the first two blocks, subjects chose the correct pattern out of 6 options; in the last two blocks, subjects choose the correct pattern out of 8 options. Within a block, problems are arranged by increasing difficulty, with problems 1 and 2 being the easiest, problems 3 and 4 being moderately difficult, and problems 5 and 6 the most difficult.
- Participants are given 15 minutes to complete 24 problems. We note that this is a modification of the original Raven's Matrices, which has a larger pattern set.

**Primary Reference:**

Raven, J., Raven, J. C., & Court, J. H. (1998a). Manual for Raven's Progressive Matrices and Vocabulary Scales. Section 1: General Overview. San Antonio, TX: Harcourt Assessment.

***Task 5.21 ETS Letter Sets***

**Description (task duration: 14 minutes):**

- Subjects are presented with 5 sets of letters; each set is made up of 4 letters. 3 of the sets of letters are alike in some way, while the fourth set of letters does not follow the same rule. Subjects are asked to determine which set of letters does not follow the same rule as the other 3 sets of letters. Subjects are instructed to mark a line through the set of letters that does not follow the same rule as the other 3 sets of letters.
- Participants have a total of 14 minutes to complete 30 problems. The task is presented in 2 parts each part lasting 7 minutes with 15 problems to complete.
- Higher scores indicate better reasoning ability.

**Primary Reference:**

Ekstrom, R. B., French, J. W., Harman, H., & Derman, D. (1976). Kit of factor-referenced cognitive tests (rev. ed.). Princeton, NJ: Educational Testing Service.

***Task 5.22*** CANTAB ***Stockings of Cambridge***

**Description (task duration: approximately 15 minutes):**

- Stockings of Cambridge is a computerized version of Tower of London (Shallice 1982) in which participants are shown a split screen with two displays each containing three colored balls.
- ***Task Phase:*** The balls are arranged in such a way that they look like they are stacked in stockings hanging from a beam. Participants must move the balls in the bottom arrangement one at a time in order to match the top arrangement in as few moves as possible.
- ***Motor Phase:*** The balls are arranged in the same way as in the task phase, but now the top arrangement and the bottom arrangement begin identical. The computer will automatically move a ball in the top arrangement. The participant should copy the same movement on the bottom arrangement, moving the same-colored ball to the same position the computer moved the ball in the top arrangement.
- ***Practice Phase:*** Subjects are given 8 1 or 2-move practice problems, which are not included in the overall score.
- Stockings of Cambridge is completed in 4 blocks. It starts with the task phase, which is followed by the motor phase. This sequence is then repeated with a slight increase in difficulty. In the first task phase subjects see 2, 3 and 4-move problems twice each. In the second task phase subjects see 4-move problems twice, and 5-move problems four times. There is a total of 12 scored items.

**Primary Reference:**

Robbins, T.W., James, M., Owen, A.M., Sahakian, B.J., McInnes, L., Rabbitt, P. (1994). Cambridge Neuropsychological Test Automated Battery (CANTAB): A factor analytic study of a large sample of normal elderly volunteers. *Dementia, 5*, 266-281. https://doi.org/10.1159/000106735

**Software Reference:**

CANTAB Eclipse (2007) http://www.cambridgecognition.com/academic/cantabsuite/tests

***Task 5.23 Everyday Problem Solving***

**Description (task duration: approximately 30 minutes):**

- Participants are asked to read things taken from things people think are important, such as labels, credit applications and bus schedules, and answer questions based on them.
- This test has 42 questions and is not timed.

**Primary Reference:**

Willis, S. L., & Marsiske, M. (1993). Manual for the everyday problems test. University Park: Pennsylvania State University.

## Reasoning Construct: Key to Names and Data Structure in Data Set

| Item Name | Abbreviation | Description | Measurement |
|---|---|---|---|
| Subject Number | S# | Subject identifier | |
| Age Interval | AgeInterval | Age at wave recoded into 3-year intervals | 20-100 |
| Sex | Sex | Participant's biological sex. | m = Male<br>f = Female |
| Race | Race | Race that the participant self-identifies with. | 1 = Asian American/ Pacific Islander<br>2 = Black/African American<br>3 = Multiracial<br>4 = Native American<br>5 = White/Caucasian<br>6 = Other<br>7 = Unknown |
| Ethnicity | Ethnicity | Ethnicity that the participant self-identifies with. | 1=Hispanic/Latin(o/a)<br>0 = Non-Hispanic |
| Handedness Score | HandednessScore | Average score of participant hand preference while completing various tasks. Higher scores indicate preference for the right hand. | Score range: 0-4<br><br>0 = Always left<br>1 = Usually left<br>2 = No preference<br>3 = Usually right<br>4 = Always right |
| Mini-Mental State Exam Total | MMSE | Total # of items answered correctly. | Score range: 0-30 |
| Cognitive Battery Wave 1-2 Interval | CogW1toW2 | Interval between cognitive testing day 1 for waves 1-2. | # of Years |
| Cognitive Battery Wave 2-3 Interval | CogW2toW3 | Interval between cognitive testing day 1 for waves 2-3. | # of Years |
| Cognitive Battery Wave 1-3 Interval | CogW1toW3 | Interval between cognitive testing day 1 for waves 1-3. | # of Years |
| Take Home Wave 1-2 Interval | TakeHomeW1toW2 | Interval between Take Home for waves 1-2. | # of Years |
| Take Home Wave 2-3 Interval | TakeHomeW2toW3 | Interval between Take Home for waves 2-3. | # of Years |
| Take Home Wave 1-3 Interval | TakeHomeW1toW3 | Interval between Take Home for waves 1-3. | # of Years |
| MRI Wave 1-2 Interval | MRIW1toW2 | Interval between MRI scan for waves 1-2. | # of Years |
| MRI Wave 2-3 Interval | MRIW2toW3 | Interval between MRI scan for waves 2-3. | # of Years |
| MRI Wave 1-3 Interval | MRIW1toW3 | Interval between MRI scan for waves 1-3. | # of Years |

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|---|---|---|---|
| Amyloid PET Wave 1-2 Interval | PETAmyW1toW2 | Interval between amyloid PET scan for waves 1-2. | # of Years |
| Amyloid PET Wave 2-3 Interval | PETAmyW2toW3 | Interval between amyloid PET scan for waves 2-3. | # of Years |
| Amyloid PET Wave 1-3 Interval | PETAmyW1toW3 | Interval between amyloid PET scan for waves 1-3. | # of Years |
| Highest Level of Education Completed | EduComp5 | This is an ordinal measure of participants' self-reported highest level of education completed. | 1 = Less than high school graduate<br>2 = High school graduate/GED<br>3 = Some college/trade/ technical/business school<br>4 = Bachelor's degree<br>5 = Some graduate work<br>6 = Master's degree<br>7 = MD/JD/PhD/other advanced degree |
| Education Estimated Years Capped | EduYrsEstCap5 | This is a conversion of the participant's self-reported highest level of education into a capped estimated number of years it would take to reach this highest level of education.<br><br>The "capped" comes into play when someone spend a longer time than usual for a certain degree but did not complete it. In short, someone with a lot of years of education but did not complete a degree will not score higher than someone who did complete the degree. | *11 maximum* = Less than High school<br>*12* = High School<br>*15 maximum* = Some College<br>*16* = Bachelor's degree<br>*20 maximum* = Some Graduate Work<br>*18* = Master's degree<br>*21* = MD/JD/PhD/ Advanced degree |
| Construct Name | ConstructName | Reasoning | |
| Construct Number | ConstructNumber | Construct 5 | |
| Wave | Wave | Denotes the data collection wave. See individual differences data set for more detail, including testing date intervals. | 1 = Wave 1<br>2 = Wave 2<br>3 = Wave 3 |

| | | | |
|---|---|---|---|
| Has Data | HasData | 1 = Yes, returned for wave; 2 = No, did not return for wave | |
| Number of Tasks in Construct | NumTasks | How many tasks make up the reasoning construct | 4 Tasks for Reasoning |
| **Task 20—Ravens Matrices** | **Task20** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Ravens Accuracy Easy | RavenAccE20 | Total number of correct items for first 18 Easy problems divided by 18 | Score Range:<br>0-1 |
| Ravens Accuracy Medium | RavenAccM20 | Total number of correct items for first 18 Medium problems divided by 18 | Score Range:<br>0-1 |
| Ravens Accuracy Hard | RavenAccH20 | Total number of correct items for first 18 Hard problems divided by 18 | Score Range:<br>0-1 |
| Ravens Accuracy All | RavenAccAll20 | Total number of correct items for all 24 problems divided by 24 | Score Range:<br>0-1 |
| Ravens Number Correct | RavenNumCor20 | Number of correct responses for all 24 problems | Score Range:<br>0-24 |
| Ravens Time | RavenTime20 | Time subjects needed to complete the task | 0-15 minutes |
| Ravens Number Answered | RavenNumAnswer20 | Number of problems answered in 15 minutes | Score Range:<br>0-24 |
| **Task 21—ETS Letter Sets** | **Task21** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| ETS Letter Sets Part 1 | EtsLsP1_21 | Total number of correct items for the first 15 Sets | Score Range:<br>0-15 |
| ETS Letter Sets Part 2 | EtsLsP2_21 | Total number of correct items for the last 15 Sets | Score Range:<br>0-15 |
| ETS Letter Sets Total | EtsLsTOTAL21 | Total number of correct items for the whole task. | Score Range:<br>0-30 |
| **Task 22—Cantab Stockings of Cambridge** | **Task22** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Cantab Stocking of Cambridge – Number of Problems solved in Minimum Moves | CantabSOCMinMov22 | The number of times upon which the subject has successfully completed a test problem in the minimum possible number of moves. | Score Range:<br>0-12 |

| | | | |
|---|---|---|---|
| Cantab Stocking of Cambridge – Mean 2-move problems | CantabSOCMeanMove2_22 | The average number of moves the subject made for 2-move problems | |
| Cantab Stocking of Cambridge - Mean 3-move problems | CantabSOCMeanMove3_22 | The average number of moves the subject made for 3-move problems | |
| Cantab Stocking of Cambridge – Mean 4-move problems | CantabSOCMeanMove4_22 | The average number of moves the subject made for 4-move problems | |
| Cantab Stocking of Cambridge – Mean 5-move problems | CantabSOCMeanMove5_22 | The average number of moves the subject made for 5-move problems | |
| Cantab Stocking of Cambridge | CantabSOCIntialTime2_22 | Average initial thinking time is the difference in time taken to select the first ball for the same 2-move problems in the task phase vs. the motor phase. | |
| Cantab Stocking of Cambridge | CantabSOCIntialTime3_22 | Average initial thinking time is the difference in time taken to select the first ball for the same 3-move problems in the task phase vs. the motor phase. | |
| Cantab Stocking of Cambridge | CantabSOCIntialTime4_22 | Average initial thinking time is the difference in time taken to select the first ball for the same 4-move problems in the task phase vs. the motor phase. | |
| Cantab Stocking of Cambridge | CantabSOCIntialTime5_22 | Average initial thinking time is the difference in time taken to select the first ball for the same 5-move problems in the task phase vs. the motor phase. | |
| Cantab Stocking of Cambridge | CantabSOCSubsequentTime2_22 | The average difference in time between selecting the first ball and completing the 2-move problem for the task vs. motor phase, and then dividing this | |

| | | | |
|---|---|---|---|
| | | result by the number of moves made. | |
| Cantab Stocking of Cambridge | CantabSOCSubsequentTime3_22 | The average difference in time between selecting the first ball and completing the 3-move problem for the task vs. motor phase, and then dividing this result by the number of moves made. | |
| Cantab Stocking of Cambridge | CantabSOCSubsequentTime4_22 | The average difference in time between selecting the first ball and completing the 4-move problem for the task vs. motor phase, and then dividing this result by the number of moves made. | |
| Cantab Stocking of Cambridge | CantabSOCSubsequentTime5_22 | The average difference in time between selecting the first ball and completing the 5-move problem for the task vs. motor phase, and then dividing this result by the number of moves made. | |
| **Task 23—Everyday Problem Solving** | **Task23** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Everyday Problem Solving | Eps23 | Total number correct | Score Range:<br>0-42 |

# Construct 6: Vocabulary

***Definition***

This construct measures the breadth of vocabulary known by an individual and is a core measure of crystallized intelligence (Diehl, Willis, and Schaie, 1995). Unlike most cognitive measures, verbal ability has been shown to be greater in older adults relative to the young (Park et al., 2002). A classic paper Horn and Cattell (1967) provides a theoretical conceptualization of verbal ability—in relation to crystallized intelligence—and relevant measures.

**References**


Diehl, M., Willis, S.L., Schaie, K.W. (1995). Everyday problem solving in older adults: Observational assessment and cognitive correlates. *Psychology and Aging, 10*, 478-491. https://doi.org/10.1037/0882-7974.10.3.478

Horn, J., & Cattell, R.B. (1967). Age differences in fluid and crystallized intelligence. *Acta Psychologica, 26*, 107-129. https://doi.org/10.1016/0001-6918(67)90011-X

Park, D.C., Lautenschlager, G., Hedden, T., Davidson, N.S., Smith, A.D., Smith, P.K. (2002). Models of visuospatial and verbal memory across the adult life span. *Psychology and Aging, 17*, 299–320. https://doi.org/10.1037/0882-7974.17.2.299


***Task 6.24 Educational Testing Service Advanced Vocabulary***

- **Description (task duration: self-paced, approximately 10-20 minutes):** This a paper and pencil task. Participants compare a target word with five other words and select the one word that means the same or most nearly the same as the target word. The task is divided into 2 sections. Participants are given 4 minutes per section to select 18 synonyms (or 36 trials total).
- **Scoring:** Participants' scores are penalized for wrong answers; total score equals total number of items correct - .25*(number of items incorrect). Higher scores indicate better vocabulary.

**Primary Reference**:


Ekstrom, R. B., French, J. W., Harman, H., & Derman, D. (1976). *Kit of factor-referenced cognitive tests* (rev. ed.). Princeton, NJ: Educational Testing Service.


***Task 6.25 Shipley Vocabulary***

- **Description (task duration: self-paced, approximately 10-20 minutes):** This a paper and pencil task. Participants compare a target word with four other words and select the one that means the same or most nearly the same as the target word. This task is not timed and there are 40 trials.
- **Scoring:** Final score is the total number of items correct. Higher scores indicate better vocabulary.

**Primary Reference**:


Zachary, A. & Shipley, W. C. (1986). *Shipley Institute of Living Scale. RevisedManual.* Los Angeles, CA: Western Psychological Services.

***Task 6.26 CANTAB Graded Naming Task***

- **Description (task duration: approximately 10-15 minutes):** Thirty-line drawings are present on a computer screen, one at a time, with increasing difficulty. Participants must orally identify the exact name of each drawing (e.g., kangaroo, bellows). This task is not timed.
- **Scoring:** Final score is the total number of items correct. Higher scores indicate better vocabulary.

**Primary Reference**:

Robbins, T.W., James, M., Owen, A.M., Sahakian, B.J., McInnes, L., Rabbitt, P. (1994). Cambridge Neuropsychological Test Automated Battery (CANTAB): A factor analytic study of a large sample of normal elderly volunteers. *Dementia, 5*, 266-281. https://doi.org/10.1159/000106735

**Software Reference:**

CantabEclipse. *Cambridge Cognition* (2007).
https://www.cambridgecognition.com/cantab/cognitive-tests/graded-naming-test-gnt/

***Task 6.27 NIH ToolBox Oral Reading Recognition Test***

- **Description (task duration: 3 minutes):** Participants see a series of letters and words presented one at a time on the computer screen and are to give the correct pronunciation for that series of letters or word. Items are presented in order of difficulty; the iPad adjusts the difficulty level of items depending on the participant's performance. The number of items presented will depend on age and performance; for most participants, the measure will last approximately 3 minutes and will contain about 25 items. The iPad will administer each item one by one, in an untimed fashion, until the test is completed. The examiner is responsible for recording whether each response is correct.
- **Scoring:** Participants are given credit for each series of letters or word pronounced correctly. Multiple dependent variables are provided via NIH Toolbox: (1) the *NIH Oral Reading Recognition Task Theta score* represents the overall ability or performance of the participant, (2) the *NIH Oral Reading Recognition Task Standard Error* represents the standard error, (3) the *NIH Oral Reading Recognition Task Uncorrected Standard Score* uses a standard score metric (normative mean=100, SD=15) and compares the participant's score to the entire NIH Toolbox nationally representative normative sample, (4) the *NIH Oral Reading Recognition Task Age-Corrected Standard Score* compares the participant's score to scores of participants of the same age in the NIH Toolbox nationally representative normative sample, (5) the *NIH Oral Reading Recognition Task National Percentile (age adjusted)* represents the percentage of participants the test-taker scored higher than when being compared to participants of the same age, (6) the *NIH Oral Reading Recognition Task Fully-Corrected T-score* represents the performance of the participant in comparison to the NIH Toolbox nationally representative normative sample, while adjusting for key demographic values.

**Primary Reference:**

Gershon, Richard C et al. "NIH toolbox for assessment of neurological and behavioral function."

*Neurology* vol. 80,11 Suppl 3 (2013): S2-6. doi:10.1212/WNL.0b013e3182872e5f

**Software Reference:**
NIH Toolbox for the iPad test ver. 2.1
https://nihtoolbox.force.com/s/article/nih-toolbox-scoring-and-interpretation-guide

**Note:** Please note the differences in administration for this task across the three waves of data collection. Participants in DLBS Wave 2 performed NIH Toolbox Oral Reading Recognition Task on a desktop computer, whereas participants in DLBS Wave 3 performed the task on an iPad. This change was mandated by developers and standardized scores will differ between the two forms of administration. For additional details, we refer you to the NIH Toolbox website: https://www.healthmeasures.net/explore-measurement-systems/nih-toolbox/obtain-and-administer-measures

***Task 6.28 NIH ToolBox Picture Vocabulary***

- **Description (task duration: 5 minutes):** Participants are presented with four pictures on the iPad screen and an audio recording saying a word. The participant is instructed to touch the picture that most closely shows the meaning of the word. After the participant makes a choice, another set of pictures automatically appears with the next item and associated audio file. The number of items presented depends on age and performance; for most participants, the measure will last approximately five minutes and will contain about 25 items. The iPad administers each item one by one, in an untimed fashion, until the test is completed.
- **Scoring:** Participants are given credit for each correct pairing of audio recording and picture. Multiple dependent variables are provided via NIH Toolbox: (1) the *NIH Picture Vocabulary Task Theta score* represents the overall ability or performance of the participant, (2) the *NIH Picture Vocabulary Task Standard Error* represents the standard error, (3) the *NIH Picture Vocabulary Task Uncorrected Standard Score* uses a standard score metric (normative mean=100, SD=15) and compares the participant's score to the entire NIH Toolbox nationally representative normative sample, (4) the *NIH Picture Vocabulary Task Age-Corrected Standard Score* compares the participant's score to participants of the same age in the NIH Toolbox nationally representative normative sample, (5) the *NIH Picture Vocabulary Task National Percentile (age adjusted)* represents the percentage of participants the test-taker scored higher than when being compared to participants of the same age, (6) the *NIH Picture Vocabulary Task Fully-Corrected T-score* represents the performance of the participant in comparison to the NIH Toolbox nationally representative normative sample, while adjusting for key demographic values.

**Primary Reference:**
Gershon, Richard C et al. "NIH toolbox for assessment of neurological and behavioral function." *Neurology* vol. 80,11 Suppl 3 (2013): S2-6. https://doi.org/10.1212/WNL.0b013e3182872e5f

**Software Reference:**
NIH Toolbox for the iPad test ver. 2.1
https://nihtoolbox.force.com/s/article/nih-toolbox-scoring-and-interpretation-guide
**Note:** Please note the differences in administration for this task across the three waves of data collection. Participants in DLBS Wave 2 performed NIH Toolbox Picture Vocabulary Task on a desktop computer, whereas participants in DLBS Wave 3 performed the task on an iPad. This change was mandated by developers and standardized scores will differ between the two forms of administration. For additional details, we refer you to the NIH Toolbox website: https://www.healthmeasures.net/explore-measurement-systems/nih-toolbox/obtain-and-administer-measures

## Vocabulary Construct Data Set: Key to Names and Data Structure in Data Set

| Item Name | Abbreviation | Description | Measurement |
|---|---|---|---|
| Subject Number | S# | Subject identifier | |
| Age Interval | AgeInterval | Age at wave recoded into 3-year intervals | 20-100 |
| Sex | Sex | Participant's biological sex. | m = Male<br>f = Female |
| Race | Race | Race that the participant self-identifies with. | 1 = Asian American/ Pacific Islander<br>2 = Black/African American<br>3 = Multiracial<br>4 = Native American<br>5 = White/Caucasian<br>6 = Other<br>7 = Unknown |
| Ethnicity | Ethnicity | Ethnicity that the participant self-identifies with. | 1=Hispanic/Latin(o/a)<br>0 = Non-Hispanic |
| Handedness Score | HandednessScore | Average score of participant hand preference while completing various tasks. Higher scores indicate preference for the right hand. | Score range: 0-4<br><br>0 = Always left<br>1 = Usually left<br>2 = No preference<br>3 = Usually right<br>4 = Always right |
| Mini-Mental State Exam Total | MMSE | Total # of items answered correctly. | Score range: 0-30 |
| Cognitive Battery Wave 1-2 Interval | CogW1toW2 | Interval between cognitive testing day 1 for waves 1-2. | # of Years |
| Cognitive Battery Wave 2-3 Interval | CogW2toW3 | Interval between cognitive testing day 1 for waves 2-3. | # of Years |
| Cognitive Battery Wave 1-3 Interval | CogW1toW3 | Interval between cognitive testing day 1 for waves 1-3. | # of Years |
| Take Home Wave 1-2 Interval | TakeHomeW1toW2 | Interval between Take Home for waves 1-2. | # of Years |
| Take Home Wave 2-3 Interval | TakeHomeW2toW3 | Interval between Take Home for waves 2-3. | # of Years |

| | | | |
|---|---|---|---|
| Take Home Wave 1-3 Interval | TakeHomeW1toW3 | Interval between Take Home for waves 1-3. | # of Years |
| MRI Wave 1-2 Interval | MRIW1toW2 | Interval between MRI scan for waves 1-2. | # of Years |
| MRI Wave 2-3 Interval | MRIW2toW3 | Interval between MRI scan for waves 2-3. | # of Years |
| MRI Wave 1-3 Interval | MRIW1toW3 | Interval between MRI scan for waves 1-3. | # of Years |
| Amyloid PET Wave 1-2 Interval | PETAmyW1toW2 | Interval between amyloid PET scan for waves 1-2. | # of Years |
| Amyloid PET Wave 2-3 Interval | PETAmyW2toW3 | Interval between amyloid PET scan for waves 2-3. | # of Years |
| Amyloid PET Wave 1-3 Interval | PETAmyW1toW3 | Interval between amyloid PET scan for waves 1-3. | # of Years |
| Highest Level of Education Completed | EduComp5 | This is an ordinal measure of participants' self-reported highest level of education completed. | 1 = Less than high school graduate<br>2 = High school graduate/GED<br>3 = Some college/trade/ technical/business school<br>4 = Bachelor's degree<br>5 = Some graduate work<br>6 = Master's degree<br>7 = MD/JD/PhD/other advanced degree |
| Education Estimated Years Capped | EduYrsEstCap5 | This is a conversion of the participant's self-reported highest level of education into a capped estimated number of years it would take to reach this highest level of education.<br><br>The "capped" comes into play when someone spend a longer time than usual for a certain degree but did not complete it. In short, someone with a lot of years of education but did not complete a degree will not score higher than someone who did complete the degree. | *11 maximum* = Less than High school<br>*12* = High School<br>*15 maximum* = Some College<br>*16* = Bachelor's degree<br>*20 maximum* = Some Graduate Work<br>*18* = Master's degree<br>*21* = MD/JD/PhD/ Advanced degree |
| Construct Name | ConstructName | Vocabulary | |
| Construct Number | ConstructNumber | Construct 6 | |
| Wave | Wave | Denotes the data collection wave. See individual differences data set for more detail, including testing date intervals. | 1 = Wave 1<br>2 = Wave 2<br>3 = Wave 3 |
| Has Data | HasData | Yes = 1<br>No = 2 | |

| | | | |
|---|---|---|---|
| Number of Tasks in Construct | NumTasks | How many tasks make up the Vocabulary construct | 5 tasks for Vocabulary |
| **Task 24—ETS Vocabulary** | **Task24** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| ETS Advanced Vocabulary Total | ETSVocab24 | Dependent Variable: Total # of items correct - .25*(# of items incorrect) | Score range:<br>0-36 |
| **Task 25—Shipley Vocabulary** | **Task25** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Shipley Vocabulary Total | ShipVocab25 | Dependent Variable: Total # of items correct | Score range: 0-40 |
| **Task 26—Cantab Graded Naming Task** | **Task26** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| CANTAB Graded Naming Task Total | CantabGnt26 | Dependent Variable: Total # of items named correctly | Score range: 0-30 |
| **Task 27—Oral Reading Recognition Task** | **Task27** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| NIH Oral Reading Recognition Task Theta | NIHOralReadTheta27 | Item Response Theory (IRT) is used to score ORRT. A score known as a theta score is calculated for each participant; it represents the relative overall ability or performance of the participant. | Mean = 0, Standard Deviation = 1 |
| NIH Oral Reading Recognition Task Standard Error | NIHOralReadSE27 | Standard Error | |
| NIH Oral Reading Recognition Task Uncorrected Standard Score | NIHOralReadUn27 | It compares the performance of the test-taker to those in the entire NIH Toolbox nationally representative normative sample, regardless of age or any other variable. | Normative Mean = 100, Standard Deviation = 15 |
| NIH Oral Reading Recognition Task Age-Corrected Standard Score | NIHOralReadAge27 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample at the same age, where a score of 100 indicates performance that was at the national average for the test-taking participant's age. Age-corrected standard scores were derived for adults (ages 18-85). | Mean = 100, Standard Deviation = 15 |
| NIH Oral Reading Recognition Task | NIHOralReadPercent27 | A Percentile represents the percentage of people nationally above whom the | Percentile rank: 0-100 |

| | | | |
|---|---|---|---|
| National Percentile (age adjusted) | | participant's score ranks (the comparison group will be based on whichever normative score is used) | |
| NIH Oral Reading Recognition Task Fully-Corrected T-score | NIHOralReadFully27 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample, while adjusting for key demographic variables (education, gender, and race/ethnicity) collected during the NIH Toolbox national norming study. | Mean = 50, Standard Deviation = 10 |
| **Task 28—Picture Vocabulary** | **Task28** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| NIH Picture Vocabulary Task Theta | NIHPicVocabTheta28 | Item Response Theory (IRT) is used to score the TPVT. A score known as a theta score is calculated for each participant; it represents the relative overall ability or performance of the participant. | Mean = 0, Standard Deviation = 1 |
| NIH Picture Vocabulary Task Standard Error | NIHPicVocabSE28 | Standard Error | |
| NIH Picture Vocabulary Task Uncorrected Standard Score | NIHPicVocabUn28 | It compares the performance of the test-taker to those in the entire NIH Toolbox nationally representative normative sample, regardless of age or any other variable. | Normative Mean = 100, Standard Deviation = 15 |
| NIH Picture Vocabulary Task Age-Corrected Standard Score | NIHPicVocabAge28 | This score compares the score of the test-taker to those in the NIH Toolbox nationally representative normative sample at the same age, where a score of 100 indicates performance that was at the national average for the test-taking participant's age. Age-corrected standard scores were derived for adults (ages 18-85). | Mean = 100, Standard Deviation = 15 |
| NIH Picture Vocabulary Task National Percentile (age adjusted) | NIHPicVocabPercent28 | A Percentile represents the percentage of people nationally above whom the participant's score ranks (the comparison group will be based on whichever normative score is used) | Percentile rank: 0-100 |
| NIH Picture Vocabulary Task | NIHPicVocabFully28 | This score compares the score of the test-taker to those in the NIH Toolbox nationally | Mean = 50, Standard Deviation = 10 |

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| Fully-Corrected T-score | | representative normative sample, while adjusting for key demographic variables (education, gender, and race/ethnicity) collected during the NIH Toolbox national norming study. | |

# Construct 7: Verbal Fluency

***Definition***

The construct of verbal fluency measures verbal knowledge, but also addresses speed of retrieval from semantic memory and thus, has a speed/working memory component. For this reason, verbal fluency is treated as a separate construct from vocabulary. The task requires participants to generate as many words as possible in 60 seconds relating to a letter or a category.

**Caution: Please note that there are differences in the administration of the phonemic letter task across waves. Also note that the semantic category task was not presented in wave 1.**

**References**


Spreen, O., & Benton, A. L. (1977). *Neurosensory Center Comprehensive Examination for Aphasia: Manual of instructions (NCCEA)* (rev. ed.). Victoria, BC: University of Victoria.

Salthouse, T. A. (2019). Trajectories of normal cognitive aging. *Psychology and Aging, 34*(1), 17–24.

Hedden, T., Lautenschlager, G., & Park, D. C. (2005). Contributions of Processing Ability and Knowledge to Verbal Memory Tasks across the Adult Life-Span. *The Quarterly Journal of Experimental Psychology Section A*, *58*(1), 169-190.


***Task 7.29 Controlled Word Oral Association (FAS)***

**Description (task duration: 3 minutes):** This task assesses the spontaneous production of words under a phonemic search condition. Participants are presented with three blocks of letters (F, A, and S) and are asked to **write down (wave 1) or say out loud (wave 2 and wave 3)** as many words beginning with that specific letter as possible in 60 seconds. Responses are recorded for accuracy and each unique word response receives a score of correct (1) or incorrect (0). Proper nouns and repeated words with a different suffix (e.g., friend, friends, friendly) are counted as incorrect. The variables of interest for this task are the number of correct words produced for the F, A, and S blocks as well as a total score.

***Caution:*** In Wave 1, participants were instructed to write down their responses for 60 seconds. In Wave 2 and Wave 3, participants were instructed to orally respond, and responses would be recorded for later scoring and validation.

**Primary Reference:**


Bechtoldt, H.P., Benton, A.L. & Fogel, M.L. (1962). An application of factor analysis in neuropsychology. *The Psychological Record*, *12*, 147–156.


***Task 7.30 Controlled Oral Association: Categories***

**Description (task duration: 2 minutes)**: This task is similar to the letter task but assesses the spontaneous production of words under a semantic search condition. Participants are present with two blocks of categories (animals and vegetables) and asked to verbally respond with all the items they can think of that fit into that specific category in 60 seconds. Responses are recorded for accuracy and each unique word response receives a score of correct (1) or incorrect (0). The

variables of interest for this task are the total number of correct words produced for the animal and vegetable blocks as well as a total score. It is important to note that this task was *not administered in wave 1*.

**Primary Reference:**

Bechtoldt, H.P., Benton, A.L. & Fogel, M.L. (1962). An application of factor analysis in neuropsychology. *The Psychological Record*, *12*, 147–156.

**Verbal Fluency Data Set: Key to Names and Data Structure in Data Set**

| Item Name | Abbreviation | Description | Measurement |
|---|---|---|---|
| Subject Number | S# | Subject identifier | |
| Age Interval | AgeInterval | Age at wave recoded into 3-year intervals | 20-100 |
| Sex | Sex | Participant's biological sex. | m = Male<br>f = Female |
| Race | Race | Race that the participant self-identifies with. | 1 = Asian American/ Pacific Islander<br>2 = Black/African American<br>3 = Multiracial<br>4 = Native American<br>5 = White/Caucasian<br>6 = Other<br>7 = Unknown |
| Ethnicity | Ethnicity | Ethnicity that the participant self-identifies with. | 1=Hispanic/Latin(o/a)<br>0 = Non-Hispanic |
| Handedness Score | HandednessScore | Average score of participant hand preference while completing various tasks. Higher scores indicate preference for the right hand. | Score range: 0-4<br><br>0 = Always left<br>1 = Usually left<br>2 = No preference<br>3 = Usually right<br>4 = Always right |
| Mini-Mental State Exam Total | MMSE | Total # of items answered correctly. | Score range: 0-30 |
| Cognitive Battery Wave 1-2 Interval | CogW1toW2 | Interval between cognitive testing day 1 for waves 1-2. | # of Years |
| Cognitive Battery Wave 2-3 Interval | CogW2toW3 | Interval between cognitive testing day 1 for waves 2-3. | # of Years |
| Cognitive Battery Wave 1-3 Interval | CogW1toW3 | Interval between cognitive testing day 1 for waves 1-3. | # of Years |
| Take Home Wave 1-2 Interval | TakeHomeW1toW2 | Interval between Take Home for waves 1-2. | # of Years |
| Take Home Wave 2-3 Interval | TakeHomeW2toW3 | Interval between Take Home for waves 2-3. | # of Years |

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| Take Home Wave 1-3 Interval | TakeHomeW1toW3 | Interval between Take Home for waves 1-3. | # of Years |
| MRI Wave 1-2 Interval | MRIW1toW2 | Interval between MRI scan for waves 1-2. | # of Years |
| MRI Wave 2-3 Interval | MRIW2toW3 | Interval between MRI scan for waves 2-3. | # of Years |
| MRI Wave 1-3 Interval | MRIW1toW3 | Interval between MRI scan for waves 1-3. | # of Years |
| Amyloid PET Wave 1-2 Interval | PETAmyW1toW2 | Interval between amyloid PET scan for waves 1-2. | # of Years |
| Amyloid PET Wave 2-3 Interval | PETAmyW2toW3 | Interval between amyloid PET scan for waves 2-3. | # of Years |
| Amyloid PET Wave 1-3 Interval | PETAmyW1toW3 | Interval between amyloid PET scan for waves 1-3. | # of Years |
| Highest Level of Education Completed | EduComp5 | This is an ordinal measure of participants' self-reported highest level of education completed. | 1 = Less than high school graduate<br>2 = High school graduate/GED<br>3 = Some college/trade/ technical/business school<br>4 = Bachelor's degree<br>5 = Some graduate work<br>6 = Master's degree<br>7 = MD/JD/PhD/other advanced degree |
| Education Estimated Years Capped | EduYrsEstCap5 | This is a conversion of the participant's self-reported highest level of education into a capped estimated number of years it would take to reach this highest level of education.<br><br>The "capped" comes into play when someone spend a longer time than usual for a certain degree but did not complete it. In short, someone with a lot of years of education but did not complete a degree will not score higher than someone who did complete the degree. | *11 maximum* = Less than High school<br>*12* = High School<br>*15 maximum* = Some College<br>*16* = Bachelor's degree<br>*20 maximum* = Some Graduate Work<br>*18* = Master's degree<br>*21* = MD/JD/PhD/ Advanced degree |
| Construct Name | ConstructName | Verbal Fluency | |
| Construct Number | ConstructNumber | Construct 7 | |
| Wave | Wave | Denotes the data collection wave. See individual differences data set for more detail, | 1 = Wave 1<br>2 = Wave 2<br>3 = Wave 3 |

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| | | including testing date intervals. | |
| Has Data | HasData | 1 = Yes, returned for wave; 2 = No, did not return for wave | |
| Number of Tasks in Construct | NumTasks | How many tasks make up the Verbal Fluency construct | 2 Tasks for Verbal Fluency |
| **Task 29—Controlled Oral Association Letters** | **Task 29** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Written Controlled Oral Association Letters *[Wave 1 Only]* | WContOralAssocF29 | Total # correct for words beginning with letter F | DLBS Score Range:<br>0-25 |
| Written Controlled Oral Association Letters *[Wave 1 Only]* | WContOralAssocA29 | Total # correct for words beginning with letter A | DLBS Score Range:<br>0-25 |
| Written Controlled Oral Association Letters *[Wave 1 Only]* | WContOralAssocS29 | Total # correct for words beginning with letter S | DLBS Score Range:<br>0-25 |
| Written Controlled Oral Association Letter *[Wave 1 Only]* | WContOralAssocLetterTot29 | Total # of words correct summed across F, A, and S blocks | DLBS Score Range:<br>0-75 |
| Controlled Oral Association Letters | ContOralAssocF29 | Total # correct for words beginning with letter F | Score Range:<br>0-30 |
| Controlled Oral Association Letters | ContOralAssocA29 | Total # correct for words beginning with letter A | Score Range:<br>0-30 |
| Controlled Oral Association Letters | ContOralAssocS29 | Total # correct for words beginning with letter S | Score Range:<br>0-30 |
| Controlled Oral Association Letters | ContOralAssocTot29 | Total # of words correct summed across F, A, and S blocks | Score Range:<br>0-90 |
| **Task 30—Controlled Oral Association Categories** | **Task30** | 1 = Has data<br>2 = Task data partial<br>3 = No task data | |
| Controlled Oral Association Categories | ContOralAssocCatAni30 | Total # correct for animals produced | Score Range:<br>0-36 |

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| Controlled Oral Association Categories | ContOralAssocCatVeg30 | Total # correct for vegetables produced | Score Range:<br>0-30 |
| Controlled Oral Association | ContOralAssocCatTot30 | Total # of words correct summed across animal and vegetable blocks | Score Range:<br>0-66 |