## Outcome Domain:

Neuropsychological Impairment

### Domain Description and Relevance in TBI:

“Objective measures of neuropsychological functions such as attention, memory and executive function are very sensitive to the effects of TBI and often affect everyday activities and social role participation.” – Wilde et al. 2010

Table CDE Classification by Type of TBI Study and Relevant Population for Recommended Neuropsychological Impairment Outcome Measures.

| Outcome Measure Name | Relevant TBI Population | Acute Hospitalized | Moderate/ Severe Rehabilitation | Concussion/ Mild TBI | Epidemiology |
| --- | --- | --- | --- | --- | --- |
| Automated Neuropsychological Assessment Metrics (ANAM) | Adult TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Beery-Buktenica Developmental Test of Visual-Motor Integration, 6th edition (Beery VMI)  | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Behavior Rating Inventory of Executive Function (BRIEF) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Brief Visuospatial Memory Test – Revised (BVMT-R) | Adult TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| California Verbal Learning Test for Children (CVLT-C)  | Pediatric TBI | Basic | Basic | Basic | Supplemental |
| Color-Word Interference Test | Adult TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Conners’ Continuous Performance Test-Revised (CPT-2) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Contingency Naming Test (CNT) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Controlled Oral Word Association Test (COWAT) | Adult TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Delis-Kaplan Executive Function System (D-KEFS) Trail Making Test | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Delis-Kaplan Executive Function System (D-KEFS) Verbal Fluency | Pediatric TBI | Basic | Basic | Basic | Supplemental |
| Eriksen Flanker Test  | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Functional Assessment of Verbal Reasoning and Executive Strategies – Student Version (FAVRES-S)  | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Grooved Pegboard Test | Adult TBI and Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| NIH Toolbox Cognitive Battery | Adult TBI and Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Rey Auditory Verbal Learning Test (RAVLT) | Adult TBI and Pediatric TBI | Basic | Basic | Basic | Supplemental |
| Symbol Digit Modalities Test | Adult TBI and Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Test of Everyday Attention (Tea-Ch)  | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Test of Executive Control (TEC) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Test of Memory and Learning-Revised (TOMAL-2) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Test of Strategic Learning (TOSL) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Trail Making Test (TMT) | Adult TBI | Basic | Basic | Basic | Supplemental |
| Wechsler Abbreviated Scale of Intelligence (WASI II); 2 subtest version | Pediatric TBI | Basic | Basic | Basic | Supplemental |
| Wechsler Adult Intelligence Scale (WAIS-IV), Digit Span subtest | Adult TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Wechsler Adult Intelligence Scale (WAIS-IV), Letter-Number Sequencing subtest | Adult TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Wechsler Adult Intelligence Scale (WAIS-IV), Processing Speed Index  | Adult TBI | Basic | Basic | Basic | Supplemental |
| Wide-Range Assessment of Memory and Learning-Revised (WRAML-2) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| WISC-IV/WPPSI-III Block Design  | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| WISC-IV/WPPSI-III Processing Speed Index | Pediatric TBI | Basic | Basic | Basic | Supplemental |
| Word Reading Subtest of the Wide Range Achievement Test (WRAT-4) | Adult TBI | Supplemental | Supplemental | Supplemental | Supplemental |

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Wilde EA, Whiteneck GG, Bogner J, Bushnik T, Cifu DX, Dikmen S, French L, Giacino JT, Hart T, Malec JF, Millis SR, Novack TA, Sherer M, Tulsky DS, Vanderploeg RD, von Steinbuechel N. Recommendations for the use of common outcome measures in traumatic brain injury research. Arch Phys Med Rehabil. 2010 Nov;91(11):1650-1660.e17. [DOI: 10.1016/j.apmr.2010.06.033]

## Automated Neuropsychological Assessment Metrics (ANAM)

### DESCRIPTION:

Automated Neuropsychological Assessment Metrics (ANAM) is a computer-based neurocognitive assessment tool developed specifically for use in the military. United States service members must complete the ANAM within 12 months prior to deployment for a baseline record of the following aspects of neurocognitive function: speed and accuracy of attention, memory, and thinking ability. The TBI battery tests simple reaction time, code substitution, code substitution delayed, matching to sample, procedural reaction time, and mathematical processing and includes a sleepiness scale and a mood scale. If an injury is sustained during deployment, the test is repeated to measure changes in neurocognitive function.

### PERMISSIBLE VALUES:

Sleepiness Scale: Participant selects from 7 stages of alertness, from “Feeling very alert, wide awake, and energetic” to “Very sleepy and cannot stay awake much longer.”

Mood Scale: Participant indicates on a scale of 0 to 6 the their current state for each of Vigor, Happiness, Depression, Anger, Fatigue, Anxiety, and Restlessness with “ 0 ” as “ Not at all ” to “ 6 ” as “ Very Much. ”

Simple reaction time: Reaction time is captured for 40 trials

Code substitution: Number of correct response to code substitution out of 72 trials

Procedural reaction time: Reaction time and processing efficiency measured for 32 trials

Mathematical processing: Number of correct responses out of 20 trials

Matching to sample: Number of correct responses in 20 trials

Code substitution delayed: Number of correct response to code substitution out of 36 trials

### PROCEDURE:

It takes 15-20 minutes to complete the computer-based TBI battery of the ANAM. A baseline test must be completed before deployment and a repeat test may be completed if there is suspicion of TBI.

### COMMENTS:

The tool is appropriate for military populations. It does not screen for TBI but may be used to compare neurocognitive performance pre-deployment and post-injury.

### RATIONALE:

The ANAM is currently required for use in U.S. military populations and normative data in the military have been established.

### REFERENCES:

Automated Neuropsychological Assessment Metrics , 4 ed . Norman, OK : C-SHOP ; 2007 .

Bleiberg J, Cernich A, Cameron K, Sun W, Peck K, Ecklund J, et al; Duration of cognitive impairment after sports concussion. Neurosurgery 2004; 54; 1073-8.

Friedl KE, Grate SJ, Proctor SP, Ness JW, Lukey BJ, Kane RL; Army research needs for automated neuropsychological tests; Monitoring soldier health and performance status. Arch Clin Neuropsychol 2007; 22(Suppl 1); S7-14.

National Defense Authorization Act for Fiscal Year 2008, Public Law 110-181. HR 1585, Sect. 1618, 110th Congress (2008)

Reeves DL, Winter KP, Bleiberg J, Kane RL . ANAM genogram: historical perspectives, description, and current endeavors . Arch Clin Neuropsychol 2007 ; 22 ( Suppl. 1 ): S15 – 37 .

Vincent AS, Roebuck-Spencer T, Gilliland K, Schlegel R. Automated neuropsychological assessment metrics (v4) traumatic brain injury battery: military normative data. Mil Med. 2012 Mar;177(3):256-69.

Warden DL, Bleiberg J, Cameron KL, Ecklund J, Walter J, Sparling MB, et al; Persistent prolongation of simple reaction time in sports concussion. Neurology 2001; 57; 524-6.

## Beery-Buktenica Developmental Test of Visual-Motor Integration, 6th edition (Beery VMI)

### DESCRIPTION:

The Beery™ VMI is a nonverbal assessment that tests for visual-motor deficits by having subjects copy geometric figures. This tests the subject’s gross motor, fine motor, visual, and visual-fine motor development. The test contains normative data for children as young as 2 years and adults. There is a short version and a full version of the test, with the short version often used for children ages 2 to 8 years.

### PERMISSIBLE VALUES:

Standard scores (M=100, SD=15) and scaled scores (M=10, SD=3), percentiles, and age equivalents are given.

### PROCEDURE:

The test can be administered individually or to groups and is paper and pencil format. Individual administration is recommended for the supplemental tests. The Short Format and Full Format tests each take 10–15 minutes. The supplemental Visual Perception and Motor Coordination tests take 5 minutes each.

### COMMENTS:

The test is appropriate for ages 2 and up.

**REFERENCES:**

Beery, K., Buktenica, N., and Beery, N. (2010). Beery-Buktenica Developmental Test of Visual- Motor Integration (Sixth ed.). Pearson Assessments: San Antonio, TX.

**Behavior Rating Inventory of Executive Function (BRIEF)**

### DESCRIPTION:

The BRIEF is assesses executive functions in children and adolescents. There are forms for parents and teachers and a self-report form. Scores are computed for Behavioral Regulation and Metacognition, as well as an overall Global Executive Composite score.

### PERMISSIBLE VALUES:

T scores (M=50, SD=10), percentiles, and 90% confidence intervals are given for four developmental age groups by gender.

### PROCEDURE:

The BRIEF takes 10-15 minutes to administer.

### COMMENTS:

For children aged 5-18, with a self-report form available for ages 11-22 years.

### RATIONALE:

“The three overall indexes (General Executive Composite, Metacognition Index, Behavioral Regulation Index) have been shown to be sensitive to TBI severity and outcome. The BRIEF was selected as a Supplemental measure to provide an evaluation of everyday executive function and because of its standardization on a large number of typically-developing children, thus providing age-based standard scores.” – McCauley et al. 2012

### REFERENCES:

Gioia, G., Espy, K., and Isquith, P. (2003). Behavior Rating Inventory of Executive Function-- Preschool Version. Psychological Assessment Resources, Inc: Odessa, FL.

Gioia, G., Isquith, P., Guy, S., and Kenworthy, L. (2000). BRIEF: Behavior Rating Inventory of Executive Function. Psychological Assessment Resources, Inc: Lutz, FL.

Guy, S., Isquith, P., and Gioia, G. (2004). Behavior Rating Inventory of Executive Function--Self Report Version. Psychological Assessment Resources, Inc: Odessa, FL.

Chapman, L., Wade, S., Walz, N., Taylor, H., Stancin, T., and Yeates, K. (2010). Clinically significant behavior problems during the initial 18 months following early childhood traumatic brain injury. Rehabil Psychol 55(1), 48-57

Chevignard, M., Servant, V., Mariller, A., Abada, G., Pradat-Diehl, P., and Laurent-Vanner, A.(2009). Assessment of executive functioning in children after TBI with a naturalistic open-ended task: a pilot study. Dev Neurorehabil 12(2), 76-91.

Conklin, H., Salorio, C., and Slomine, B. (2008). Working memory performance following paediatric traumatic brain injury. Brain Inj 22(11), 847-857.

Donders, J., DenBraber, D., and Vos, L. (2010). Construct and criterion validity of the Behaviour Rating Inventory of Executive Function (BRIEF) in children referred for neuropsychological assessment after paediatric traumatic brain injury. J Neuropsychol 4(Pt2), 197-209.

Gioia, G., and Isquith, P. (2004). Ecological assessment of executive function in traumatic brain injury. Dev Neuropsychol 25(1-2), 135-158.

Gioia, G., Isquith, P., Kenworthy, L., and Barton, R. (2002). Profiles of everyday executive function in acquired and developmental disorders. Child Neuropsychol 8(2), 121-137.

Gioia, G., Kenworthy, L., and Isquith, P. (2010). Executive function in the Real World: BRIEF lessons from Mark Ylvisaker. J Head Trauma Rehabil 25(6), 433-439.

Karunanayaka, P., Holland, S., Yuan, W., Altaye, M., Jones, B., Michaud, L., Walz, N., and Wade, S. (2007). Neural substrate differences in language networks and associated language-related behavioral impairments in children with TBI: A preliminary fMRI investigation. NeuroRehabilitation 22(5), 355-369.

Maillard-Wermelinger, A., Yeates, K., Gerry Taylor, H., Rusin, J., Bangert, B., Dietrich, A.,Nuss, K., and Wright, M. (2009). Mild traumatic brain injury and executive functions in school-aged children. Dev Neurorehabil 12(5), 330-341.

Mangeot, S., Armstrong, K., Colvin, A., Yeates, K., and Taylor, H. (2002). Long-term executive function deficits in children with traumatic brain injuries: Assessment using the behavior rating inventory of executive function (BRIEF). Child Neuropsychol. Special Issue: Behavior Rating Inventory of Executive Function (BRIEF) 8(4), 271-284.

Merkley, T., Bigler, E., Wilde, E., McCauley, S., Hunter, J., and Levin, H. (2008). Diffuse changes in cortical thickness in pediatric moderate-to-severe traumatic brain injury. J Neurotrauma 25(11), 1343-1345.

Muscara, F., Catroppa, C., and Anderson, V. (2008). The impact of injury severity on executive function 7-10 years following pediatric traumatic brain injury. Dev Neuropsychol 33(5), 623-636.

Muscara, F., Catroppa, C., and Anderson, V. (2008). Social problem-solving skills as a mediator between executive function and long-term social outcome following paediatric traumatic brain injury. J Neuropsychol 2, 445-461.

Nadebaum, C., Anderson, V., and Catroppa, C. (2007). Executive function outcomes following traumatic brain injury in young children: a five year follow-up. Dev Neuropsychol 32(2), 703-728.

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spectroscopy following traumatic brain injury during early childhood: relationship with neurobehavioral outcomes. J Neurotrauma 25(2), 94-103.

Wozniak, J., Krach, L., Ward, E., Mueller, B., Muetzel, R., Schnoebelen, S., Kiragu, A., and Lim, K. (2007). Neurocognitive and neuroimaging correlates of pediatric traumatic brain injury: a diffusion tensor imaging (DTI) study. Arch Clin Neuropsychol 22(5), 555-568.

## Brief Visuospatial Memory Test – Revised (BVMT-R)

### DESCRIPTION

Performance measure. Six simple geometric designs repeated over 3 trials. Score based on number of designs remembered and their location.

### PERMISSIBLE VALUES

Test yields a number of scores. More reliable and useful are the total score based on 3 recall trials and delayed recall.

### PROCEDURES

Requires trained examiner to administer, but neuropsychologist or psychologist to interpret. Administration time is 15 minutes.

### COMMENTS

This is a performance based measure which requires the subject to understand what is required and participate in the testing. It requires a functional level in the severe disability or above on the GOS/GOSE.

### RATIONALE

Has good psychometric properties, and has multiple forms. It is a legacy measure for the NIH Toolbox Episodic Memory subdomain

### REFERENCES

Brief Visuospatial Memory Test - Revised. Psychological Assessment Resources, Lutz, Florida

## California Verbal Learning Test for Children (CVLT-C)

### DESCRIPTION:

The CVLT-C is a measure of verbal learning and delayed recall. The test can identify particular disorders the subject may have based on they apply learning strategies. The test has good psychometric properties and has been used in pediatric TBI, and a Spanish-language version is available. Children are given a list and asked to recall the list after an interference task.

### PERMISSIBLE VALUES:

A T score assesses overall performance (M=50, SD=10). Other variables are expressed as age-corrected z scores (M = 0, SD = 1), including short delay free recall (SDFR), short delay semantically cued recall (SDCR), long delay free recall (LDFR), long delay semantically cued recall (LDCR), and discriminability index (DISC).

### PROCEDURE:

The CVLT-C is individually administered and is 15-20 minutes long, plus a 20 minute interval in which child completes non-verbal tasks, which is included in order to assess delayed recall.

### COMMENTS:

Children aged 5-16 years

### RATIONALE:

Compared with the RAVLT, “the CVLT-C provides a more comprehensive set of indices to allow for the identification of disorder-specific profiles of deficits in learning strategies and processes and has a wider age range (down to age 4 years with supplemental normative data) with a substantial degree of validation in pediatric TBI research.” – McCauley et al. 2012.

### REFERENCES:

Delis, D., Kramar, J., Kaplan, E., and Ober, B. (1994). California Verbal Learning Test-Children's version. Pearson Assessments: San Antonio,

Goodman, A., Delis, D., and Mattson, S. (1999). Normative data for four-year old children on the California Verbal Learning Test-Children's version. Clin Neuropsychol 13(3), 274- 282.

Donders, J., and Hoffman, N. (2002). Gender differences in learning and memory after pediatric traumatic brain injury. Neuropsychology 16(4), 491-499.

Donders, J., and Minnema, M. (2004). Performance discrepancies on the California Verbal Learning Test--Children's Version (CVLT-C) in children with traumatic brain injury. J Int Neuropsychol Soc 10(482-8).

Donders, J., and Nesbit-Greene, K. (2004). Predictors of neuropsychological test performance after pediatric traumatic brain injury. Assessment 11(4), 275-284.

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## Color-Word Interference Test

### DESCRIPTION

Examinee names color patches (Condition 1); reads words that denote colors printed in black ink (Condition 2); names the ink color in which color words are printed (Condition 3); switches back and forth between naming dissonant ink colors and reading the conflicting words (Condition 4).

### PERMISSIBLE VALUES

Scoring is expressed in terms of the number of seconds required to complete each of the 4 conditions. Total uncorrected and total self-corrected errors are also recorded for each condition.

### PROCEDURES

Trained technician can administer. Neuropsychologist needs to interpret. Administration time is 7 - 10 minutes.

### COMMENTS

Can be given to persons age 8 to 89. Can be used to assess a wide range of impairment but patients should have emerged from post-traumatic amnesia.

### RATIONALE

Tests like the CWIT (i.e., "Stroop" tests) have been used frequently in a wide range of patient groups thought to have executive function deficits.

### REFERENCES

Delis, D, Kaplan, E, & Kramer, J (2001). Delis-Kaplan Executive Function System. San Antonio, TX: The Psychological Corp.

## Conners’ Continuous Performance Test-Revised (CPT-2)

### DESCRIPTION:

The CPT-2 is often used to evaluate Attention Deficit/Hyperactivity Disorder. The test is computerized and measures attention and response inhibition of the subject. During the test, the subject must press a key in response to all letters but the letter X.

### PERMISSIBLE VALUES:

T scores are given for each measure (M=50, SD=10). The confidence index given represents percent similarity to ADHD profile.

### PROCEDURE:

No specific qualifications are required for supervising the CPT-2 test, which is administered to the subject via computer software. The test takes 14 minutes to administer.

### COMMENTS:

The test can be administered to persons ages 6 to over 55 years.

### REFERENCES:

Conners, C. (2004). Continuous Performance Test. Technical guide and software manual (Second ed.). MultiHealth Systems: North Tonawanda, NY.

## Contingency Naming Test (CNT)

### DESCRIPTION:

The CNT tests response switching with four different tasks. Each task has a different rule by which the subject must identify colored shapes (i.e. according to its color or to its shape).

### PERMISSIBLE VALUES:

A cognitive flexibility index, numbers of errors and self-corrections, and response latency are scored

### PROCEDURE:

The test takes around 5 minutes to administer

### COMMENTS:

For children aged 6-16, although can be used in older adolescents.

### RATIONALE:

“The CNT was selected as a Supplemental measure based on its good psychometric features, its sensitivity to TBI in children, and its availability in the public domain. The CNT has been used to study short and long term outcomes of moderate to severe TBI in children and it has been shown to predict social problem-solving skills.” – McCauley et al. 2012

### REFERENCES:

Taylor, H., Schatsneider, C., and Rich, D. (1992). Sequelae of Haemophilus Influenzae meningitis: Implications for the study of brain disease and development. In M. Tramontana & S. Hooper (Eds.), Advances in clinical neuropsychology (Vol. I, pp. 50- 108). New York: Springer-Verlag.

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Muscara, F., Catroppa, C., and Anderson, V. (2008a). The impact of injury severity on executive function 7-10 years following pediatric traumatic brain injury. Dev Neuropsychol 33(5), 623-636.

## Controlled Oral Word Association Test (COWAT)

### DESCRIPTION

Patient is instructed by examiner to say as many words that begin with a specific letter of the alphabet as quickly as possible during a 60-second period. Three 60-second trials are given using the letters F-A-S.

### PERMISSIBLE VALUES

The total correct is the sum of all admissible words

### PROCEDURES

Trained technician can administer, but neuropsychologist needs to interpret. Administration time is 5 minutes.

### COMMENTS

Can be given to persons age 7 to 85. Can be used to assess a wide range of impairment but patients should have emerged from post-traumatic amnesia.

### RATIONALE

COWAT is sensitive to severity of TBI. A meta-analysis of patients with TBI found that patients with focal frontal (but not temporal) lobe injuries were impaired on tests of phonemic fluency like COWAT.

### REFERENCES

Spreen, O, & Benton, A (1977). Neurosensory Center Comprehensive Examination for Aphasia. Victoria, BC: Neuropsychology Laboratory, University of Victoria

**Delis-Kaplan Executive Function System (D-KEFS) Trail Making Test**

### DESCRIPTION:

The D-KEFS TM is based on the original Trail Making Test, and includes several timed tasks where the test-taker employs visuomotor skills to connect a circle.

### PERMISSIBLE VALUES:

Completion times are reported as raw scores and scaled scores (M=10, SD=3). Error analyses are reported as raw scores and cumulative % rank.

### PROCEDURE:

The test takes around 5-10 minutes to administer. Individuals qualified to use the instrument would have a doctorate in psychology, education, or a related field.

### COMMENTS:

The test can be used in individuals 8-89 years.

### RATIONALE:

“Trail Making tests have been shown to be sensitive to TBI in children. The D-KEFS TM was selected as a supplementary test because it has been standardized on 1,750 typically developing children 8-19 years old, allowing comparison with D-KEFS Verbal Fluency and providing age-based percentile scores.” – McCauley et al. 2012

### REFERENCES:

Delis, D., Kaplan, E., and Kramar, J. (2001). Delis-Kaplan Executive Function System. Pearson Assessment: San Antonio, TX.

Reitan, R., and Wolfson, D. (1992). Neuropsychological evaluation of older children.Neuropsychology Press.

## Delis-Kaplan Executive Function System (D-KEFS) Verbal Fluency

### DESCRIPTION:

The D-KEFS VF is an executive function test with three conditions: phonemic fluency (child must name words beginning with a certain letter), semantic fluency (child must name words that fall into certain categories), and semantic switching. There are alternate forms for verbal fluency.

### PERMISSIBLE VALUES:

Raw scores are converted to scaled scores (M=10, SD=3).

### PROCEDURE:

The D-KEFS is individually administered in a game-like format. The Verbal Fluency Test is one of nine subtests which in their entirety take 90 minutes to complete. Test is to be used only by individuals with a doctorate in psychology, education, or related field. Administrator must be comfortable scoring and timing simultaneously.

### COMMENTS:

The D-KEFS VF can be given to children ages 8-19 years.

### RATIONALE:

“The D-KEFS VF was selected … because verbal fluency has been shown to be sensitive to TBI severity and to focal left frontal lesions and because all of the D-KEFS tests were standardized on normative data for 1,750 typically developing children. … The integration of verbal fluency with semantic fluency and the switching condition also potentially enhances the usefulness of the D-KEFS VF as a measure of executive function.” – McCauley et al. 2012

### REFERENCES:

Delis, D., Kaplan, E., and Kramar, J. (2001). Delis-Kaplan Executive Function System. Pearson Assessment: San Antonio, TX.

Levin, H., Song, J., Ewing-Cobbs, L., Chapman, J., and Mendelsohn, D. (2001). Word fluency in relation to severity of closed head injury, associated frontal brain lesions, and age injury in children. Neuropsychologia 39(2), 122-131.

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Ziviani, J., Ottenbacher, K., Shephard, K., Foreman, S., Astbury, W., and Ireland, P. (2001). Concurrent validity of the Functional Independence Measure for Children (WeeFIM) and the Pediatric Evaluationof Disabilities Inventory in children with developmental disabilities and acquired brain injuries. Phys Occup Ther Pediatr 21(2-3), 91-101.

**Eriksen Flanker Test**

### DESCRIPTION:

The Eriksen Flanker Test is a computer-based test. Arrow stimuli appear on the screen and either appear alone or are flanked by arrows that either point in the same direction or the opposite direction to the target arrow. Response inhibition is compared between the two test conditions.

### PERMISSIBLE VALUES:

The variable of interest is the subject's reaction time.

### PROCEDURE:

There are no restrictions on use/interpretation of this test.

### COMMENTS:

The Eriksen Flanker task has not been normed to any specific ages.

### REFERENCES:

Eriksen, B., and Eriksen, C. (1974). Effects of noise letters upon identification of a target letter in a nonsearch task. Percept Psychophys 16, 143-149.

Levin, H., Hanten, G., Zhang, L., Swank, P., and Hunter, J. (2004). Selective impairment of inhibition after TBI in children. J Clin Exp Neuropsychol 26(5), 589-597.

## Functional Assessment of Verbal Reasoning and Executive Strategies – Student Version –(S- FAVRES)

### DESCRIPTION:

The S- FAVRES measures a child’s reasoning skills by presenting him/her with everyday scenarios that the child must respond to orally or in writing. Standard scores and the following subscale scores are computed: 1) getting the facts; 2) eliminating irrelevant material; 3) weighing facts; 4) flexibility; 5) predicting consequences; and 6) a total reasoning score.

### PERMISSIBLE VALUES:

Time to complete, accuracy of solution (0-5), and quality of rationale (0-5) provided are measured on each the S-FAVRES tasks. Total test scores for time, accuracy, and reasons are calculated as the sum of each of the four subtests. Normative data for the adult version are available for comparison with the subject's score.

### PROCEDURE:

The test is individually administered and subjects note their responses in response booklets. Takes approximately 60 minutes to complete.

### COMMENTS:

The test is specifically for populations with acquired brain injury.

### RATIONALE:

“The FAVRES is sensitive to impairments in high-functioning individuals. The adult version of the FAVRES has been shown to discriminate well those with TBI from typically-developing individuals and also has been validated in relation to return to work.” – McCauley et al. 2012

### REFERENCES:

MacDonald S. Functional Assessment of Verbal Reasoning and Executive Strategies. Guelph, Canada: Clinical Publishing; 1998

## Grooved Pegboard Test

### DESCRIPTION

Timed placement of 25 pegs with the dominant hand followed by the non-dominant hand

### PERMISSIBLE VALUES

Raw score: Seconds required for each hand, T Score: 1-99.

### PROCEDURES

Requires hand use and visual acuity. Minimal training required. Administration time is 10 minutes maximum.

### COMMENTS

Adults 20-85

### RATIONALE

The GPT is a widely used test of fine motor skill that has proven sensitive to the effects of TBI

### REFERENCES

Heaton, R.K., Miller, S.W., Taylor, M.J., Grant, I. (2004) Revised Comprehensive Norms for an Expanded Halstead-Reitan Battery: Demographically Adjusted Neuropsychological Norms for African American and Caucasian Adults Profession Manual. Lutx, FL: Psychological Assessment Resources

## NIH Toolbox Cognitive Battery

### DESCRIPTION

Validation version contains 8 new tests designed to measure unique domains of cognitive functioning (Episodic Memory, Reading, Vocabulary, Processing Speed, Working Memory, Executive Function, and Attention).

### PERMISSIBLE VALUES

Under development - Likely will have T scores for all scales.

### PROCEDURES

The battery is administered on a touchscreen computer with the assistance of a technician. Technician will read instructions and administer items. Touch screen computer will record responses and computer scored. Administration time for the cognitive domain = < 30 minutes).

### COMMENTS

The battery is designed to be used with ages 3 to 85. Should be able to examine broad range of function but functional level of at least severe disability on the GOS/GOSE would be needed. Has not been validated in TBI yet.

### RATIONALE

Designed as part of the NIH Blueprint initiative for use in NIH research involving large epidemiological studies and clinical trials. The battery will examine various cognitive constructs, will be at nominal cost and will take no more than 30 minutes to complete. Will be both in English and Spanish. Large standardization is being planned.

### REFERENCES

[The NIH Toolbox Instrument Page](http://www.nihtoolbox.org/) Principal Investigator: Richard Gershon PhD e-mail: gershon@northwestern.edu

## Rey Auditory Verbal Learning Test (RAVLT)

### DESCRIPTION

Performance measure. 15 unrelated words repeated 5 times with recall after each presentation. Task includes immediate recall and delayed recall and recognition

### PERMISSIBLE VALUES

Test yields a number of scores. More reliable and useful are the total score based on 5 recall trials and delayed recall.

### PROCEDURES

Requires trained examiner to administer but neuropsychologist or psychologist to interpret. Administration time is 15 minutes.

### COMMENTS

This is a performance based measure which requires the subject to understand what is required and participate in the testing. It requires a functional level in the severe disability or above on the GOS/GOSE.

### RATIONALE

This measure has good psychometric properties, is widely used, translated into multiple languages, has multiple forms, and is in the public domain. It is a legacy measure for the NIH Toolbox Episodic Memory subdomain.

### REFERENCES

Strauss E, Sherman E, Spreen O (2006). Rey Auditory Verbal Learning Test. In Compendium of Neuropsychological Tests (3rd Edition) Oxford University Press.776-807.

## Symbol Digit Modalities Test

### DESCRIPTION

The Symbol Digit Modalities Testis a measure of divided attention, visual scanning and motor speed. This measure involves a coding key consisting of 9 abstract symbols, each paired with a number ranging from 1 to 9. The subject is required to scan the key and write down the number corresponding to each symbol as fast as possible. The number of correct substitution within 90 seconds is recorded. In the written version of the test the subject fills in the numbers that correspond to the symbols. In the oral version the examiner records the numbers spoken by the subject.

### PERMISSIBLE VALUES

Scores range from 0 to a maximum of 110 correct raw scores.

### PROCEDURE

Trained examiners. A written or oral version of the test may be administered. Test can be completed in under 5 minutes.

### COMMENTS

This measure can be used in ages 8 to 91. It can be used in broad spectrum of TBI severity and type of injuries as long as the subject is sufficiently functional to be testable.

### RATIONALE

This measure takes less than 5 minutes to administer (using both the verbal and written versions), has been extensively studied, has very good psychometric properties, and is sensitive to various neurological conditions of the brain

### REFERENCES

Smith A. (1991). Symbol Digit Modalities Test. Los Angeles,CA: Western Psychological services.

Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). A compendium of neuropsychological tests: Administration, norms, and commentary. Oxford; New York: Oxford University Press.

## Test of Everyday Attention (Tea-Ch)

### DESCRIPTION:

Nine tasks using everyday materials measure attention in the TEA-Ch. Scores for focused (selective) attention, sustained attention, and attention switching can be computed.

### PERMISSIBLE VALUES:

Standardized scores (M = 10; SD = 3) and percentile ranks are given for each subtest.

### PROCEDURE:

The test is individually administered and takes 55-60 minutes.

### COMMENTS:

The test is appropriate for children aged 6-16.

### RATIONALE:

“This measure has been shown to be sensitive to children with severe TBI.” – McCauley et al. 2012

### REFERENCES:

Manly, T., Robertson, I., Anderson, V., and Nimmo-Smith, I. (1999). TEA-Ch: The Test of Everyday Attention for Children. Thames Valley Test Company: Bury St. Edmunds, England.

## Test of Executive Control (TEC)

### DESCRIPTION:

The TEC includes an n-back paradigm testing working memory load and a go/no-go task to test executive control. The measure is computer-administered.

### PERMISSIBLE VALUES:

T-scores (M=50, SD=10) and percentiles are given.

### PROCEDURE:

The test is individually administered by computer and is 20-30 minutes in length.

### COMMENTS:

The test is appropriate for children and adolescents aged 5 to 18 years.

### RATIONALE:

“The TEC was standardized on a large and representative sample and has demonstrated reliability and concurrent validity with clinical populations including those with mild TBI.” – McCauley et al. 2012

### REFERENCES:

Isquith, P., Roth, R., and Gioia, G. (2010). Tasks of Executive Control (TEC). Psychological Assessment Resources, Inc: Odessa, FL.

## Test of Memory and Learning-Revised (TOMAL-2)

### DESCRIPTION:

The TOMAL-2 tests learning abilities related to verbal memory, nonverbal memory, composite memory. Additional indices may be computed for 1) verbal delayed recall, 2) learning, 3) attention and concentration, 4) sequential memory, 5) free recall, and 6) associate recall. The test has extensive validation and normative data.

### PERMISSIBLE VALUES:

Scaled scores for subtests have M = 10, SD = 3. Composite scores and indexes are M = 100, SD = 15.

### PROCEDURE:

The three core indices can be completed in about 30 minutes; with the supplemental battery, testing time increases to 1 hour. Examiners should have formal training in administering standardized assessments.

### COMMENTS:

The test is for children and adults aged 5-59 years.

### RATIONALE:

“The TOMAL-2 and its predecessor have been found to be useful in studies of pediatric TBI.” – McCauley et al. 2012

### REFERENCES:

Reynolds, C., and Voress, J. (2007). Test of Memory and Learning--Revised (Second ed.). Pearson Assessments: San Antonio, TX.

Alexander, A., and Mayfield, J. (2005). Latent factor structure of the Test of Memory and Learning in a pediatric traumatic brain injured sample: support for a general memory construct. Arch Clin Neuropsychol 20(5), 587-598.

Lowther, J., and Mayfield, J. (2004). Memory functioning in children with traumatic brain injuries: a TOMAL validity study. Arch Clin Neuropsychol 19(1), 105-118.

Ramsay, M., and Reynolds, C. (1995). Separate digits tests: A brief history, a literature review, and a reexamination of the factor structure of the Test of Memory and Learning (TOMAL). Neuropsychol Rev 5(3), 151-171.

Reynolds, C., and Bigler, E. (1996). Factor structure, factor indexes, and other useful statistics for interpretation of the Test of Memory and Learning (TOMAL). Arch Clin Neuropsychol 11(1), 29-43.

## Test of Strategic Learning (TOSL)

### DESCRIPTION:

In the TOSL, subjects use higher-order verbal reasoning, including processing complex information extracting abstract ideas from text. Two scores are given: one for gist-reasoning ability and a second for fact-learning

### PERMISSIBLE VALUES:

Two core scores indicate the subject's ability to abstract meaning from complex information. Range score for gist-reasoning ability is 0-28 and for fact-learning is 0-24.

### PROCEDURE:

The test is individually administered. The examiner reads the text to the child and the child may follow along on paper. The child must provide a verbal summary of the text.

### COMMENTS:

TOSL has been used extensively in the 7 to 20 year age range

### RATIONALE:

“The TOSL was selected … because, although not yet published, it provides a functional measure of the strategies a student uses to understand and encode meaning from information that is much like what is encountered in the classroom and everyday life. The TOSL provides a measure of cognition that is not available in typical standardized tests that rely on multiple choice answers. The validity of the TOSL as a measure of higher order cognitive function has been established in prior studies conducted across 15 years of research in cognitive neuroscience. Moreover, gist reasoning ability as measured by the TOSL has been associated with frontally mediated measures of executive function such as working memory, concept abstraction, cognitive switching, and fluid reasoning.” – McCauley et al. 2012

### REFERENCES:

Chapman, S. B., Gamino, J. F., and Anand, R. (in press). Higher-order strategic gist reasoning in adolescence.

Gamino, J. F., Chapman, S. B., Hull, E. L., and Lyon, G. R. (2010). Effects of higher-order cognitive strategy training on gist reasoning and fact-learning in adolescents. Front Psychol 1, 1-16.

## Trail Making Test (TMT)

### DESCRIPTION

It requires the examinee to connect, by making pencil lines, 25 encircled numbers randomly arranged on a page in proper sequence (Part A) and 25 encircled numbers and letters in alternating order (Part B).

### PERMISSIBLE VALUES

Scoring is expressed in terms of the time in seconds required for completion of both parts of the test.

**PROCEDURES**

Trained technician can administer TMT. Neuropsychologist needs to interpret. Administration time is 5-10 minutes.

### COMMENTS

Can be given to persons age 7 to 85. Can be used to assess a wide range of impairment, but patients should have emerged from post-traumatic amnesia.

### RATIONALE

TMT is one of the most widely used and researched neuropsychological measures. It has been shown to be sensitive to a wide range of neurocognitive deficits.

### REFERENCES

Reitan, R, & Wolfson, D (1985). The Halstead-Reitan Neuropsychological Test Battery. Tucson, AZ: Neuropsychology Press.

## Wechsler Abbreviated Scale of Intelligence (WASI II); 2 subtest version

### DESCRIPTION

The WASI-II is an update of the WASI, and provides a brief estimate of general intelligence and cognitive ability for persons aged 6 to 89 years. The 2 subtest version includes the Vocabulary and Matrix Reasoning Subtests. A full scale IQ score can be computed.

### PERMISSIBLE VALUES

WASI subtest scores have mean=50 and standard deviation=10.

### PROCEDURE

The two subtest version takes about 15 minutes to administer.

### COMMENTS

The WASI is appropriate for persons aged 6-89 years.

### RATIONALE

“Although the WASI does not have specific sensitivity to mild injury severity, it has been shown to be sensitive to a range of neurologic conditions including moderate-to-severe TBI.” – McCauley et al. 2012

### REFERENCES

Wechsler, D. (1999). Weschler Abbreviated Scale of Intelligence. The Psychological Corporation: New York.

Gamino, J., Chapman, S., and Cook, L. (2009). Strategic learning in youth with traumatic brain injury: evidence for stall in higher-order cognition. Top Lang Disord 29(3), 224-235.

Catroppa, C., and Anderson, V. (2004). Recovery and predictors of language skills two years following pediatric traumatic brain injury. Brain Lang 88(1), 68-78.

Prigatano, G., and Gray, J. (2008a). Predictors of performance on three developmentally sensitive neuropsychological tests in children with and without traumatic brain injury.Brain Inj 22(6), 491-500.

## Wechsler Adult Intelligence Scale (WAIS-IV), Digit Span subtest

### DESCRIPTION

Two sections: Digits Forward and Digits Backward

### PERMISSIBLE VALUES

Raw score: 0-30 Scaled Score: 1-19.

### PROCEDURES

Administered verbally. Requires minimal training. Administration time is 10 minutes.

### COMMENTS

Adults 16-89

### RATIONALE

The Digit Span subtest is a widely used measure of auditory attention that is well-normed and sensitive to the effects of TBI

### REFERENCES

Wechsler, D. (1997) WAIS-III Administration and Scoring Manual. San Antonio, TX: The Psychological Corporation

## Wechsler Adult Intelligence Scale (WAIS-IV), Letter-Number Sequencing subtest

### DESCRIPTION

This is a complex span task involving simultaneous processing. The subject is presented with a mixed list of numbers and letters and their task is to repeat the list by saying the numbers first in ascending order and then the letters in alphabetical order.

### PERMISSIBLE VALUES

Performance on this measure is converted to scaled scores with a mean of 10 and standard deviation of 3. The scaled score is adjusted for age.

### PROCEDURES

Requires trained examiner to administer. Administration time is 5 minutes.

### COMMENTS

This is a performance based measure which requires the subject to understand what is required and participate in the testing. It requires a functional level in the severe disability or above on the GOS/GOSE.

### RATIONALE

Highest factor analytic loading on Working Memory factor. Good psychometric properties and sensitivity to severity of TBI. Legacy measure for the NIH Toolbox Working Memory Subdomain.

### REFERENCES

Wechsler Adult Intelligence Scale III. Letter-Number Sequencing Subtest. Pearson Education Inc, San Antonio, Texas.

## Wechsler Adult Intelligence Scale (WAIS-IV), Processing Speed Index

### DESCRIPTION

This index is based on 2 subtests of the Wechsler Adult Intelligence Scale. For Digit Symbol, examinee must accurately fill in symbols, according to matched number-symbol pairs in a key in 120 seconds. For Symbol Search, examinee determines whether either of two target symbols match any of the symbols in a search group; examinee must respond to as many items as able in 120 seconds.

### PERMISSIBLE VALUES

The 2 subtests yield scaled scores adjusted for age with a mean of 10 and standard deviation of 3. The WAIS PS Index is based on the 2 subtests with a mean of 100 and standard deviation of 15 adjusted for age.

### PROCEDURES

Requires trained examiner to administer and neuropsychologist or psychologist to interpret. Administration time is 10 minutes.

**COMMENTS**

This is a performance based measure which requires the subject to understand what is required and participate in the testing. It requires a functional level in the severe disability or above on the GOS/GOSE.

### RATIONALE

Good psychometric properties. Sensitive to TBI and its severity. Legacy measure for NIH Toolbox Processing Speed Subdomain.

### REFERENCES

Wechsler Adult Intelligence Scale III/IV. Processing Speed Index. Pearson Education Inc, San Antonio, Texas.

## Wide-Range Assessment of Memory and Learning-Revised (WRAML-2)

### DESCRIPTION:

The WRAML-2 measures verbal and visual learning abilities, including verbal memory; visual memory; attention and concentration; and working memory. It assess both immediate and delayed memory.

### PERMISSIBLE VALUES:

Standard scores for the entire index (M=100, SD=15) and subtests (M=10, SD=3) and percentile ranks by age.

### PROCEDURE:

The core battery takes under 1 hour and the Memory Screening Form takes 10-15 minutes.

### COMMENTS:

The WRAML2 is appropriate for ages 5-90.

### RATIONALE:

“The WRAML-2 and its predecessor have excellent psychometric properties and have been found to be useful in studies of pediatric TBI.” – McCauley et al. 2012

### REFERENCES:

Sheslow, D., and Adams, W. (2003). Wide Range Assessment of Memory and Learning--Revised (WRAML-2). Administration and Technical Manual. Wide Range, Inc: Wilmington, DE.

Donders, J., and Hoffman, N. (2002). Gender differences in learning and memory after pediatric traumatic brain injury. Neuropsychology 16(4), 491-499.

Farmer, J., Haut, J., Williams, J., Kapila, C., Johnstone, B., and Kirk, K. (1999). Comprehensive assessment of memory functioning following traumatic brain injury in children. Dev Neuropsychol 15(2), 269-289.

Williams, J., and Haut, J. (1995). Differential performances on the WRAML in children and adolescents diagnosed with epilepsy, head injury and substance abuse. Dev Neuropsychol 11(2), 201-213.

Woodward, H., and Donders, J. (1998). The performance of children with traumatic head injury on the Wide Range Assessment of Memory and Learning--Screening. Appl Neuropsychol 5(3), 113-119.

## WISC-4/WPPSI-3 Block Design

### DESCRIPTION:

The Wechsler Block Design subtest measures a subject’s ability to synthesize abstract visual information.

### PERMISSIBLE VALUES:

The Block Design subtest is part of the assessment for performance IQ, which yields an IQ between 40 and 160 (M=100, SD=15).

### PROCEDURE:

The tests are individually administered and completed by paper-and-pencil. Individuals qualified to use the instrument would have a doctorate in psychology, education, or a related field.

### COMMENTS:

Children 2:6 to 7:3 can complete the WPPSI-III and children 6-16 can complete the WISC-IV.

### REFERENCES:

Wechsler, D. (2002). Wechsler Preschool and Primary Scale of Inteligence, 3rd edition administration manual. Pearson Assessments: San Antonio, TX.

Wechsler, D. (2003a). WISC-IV administration manual. Pearson Assessments: San Antonio, TX.

Wechsler, D. (2003b). WISC-IV technical and interpretive manual. Pearson Assessments: San Antonio, TX.

Prigatano, G., and Gray, J. (2008a). Predictors of performance on three developmentally sensitive neuropsychological tests in children with and without traumatic brain injury.Brain Inj 22(6), 491-500.

Prigatano, G., Gray, J., and Gale, S. (2008b). Individual case analysis of processing speed difficulties in children with and without traumatic brain injury. Clin Neuropsychol 22(4), 603-619.

## WISC-IV/WPPSI-III Processing Speed Index

### DESCRIPTION:

The Wechsler Processing Speed Index is calculated from the Coding and Symbol Search subtests.

### PERMISSIBLE VALUES:

Test results in a score for processing speed (M=100, SD=15, range=40-160).

### PROCEDURE:

Test results in a score for processing speed (M=100, SD=15, range=40-160).

### COMMENTS:

The WISC-IV is appropriate for children 6-16 years, and the WPPSI-III is appropriate for children 4:0-7:3 years.

### RATIONALE:

“The tests have extensive normative data and excellent psychometric properties. As a measure of information processing rate, these indices from the WISC-III and WISC-IV are highly sensitive to the effects of TBI and its severity. It has been used in different languages, cultures, and ethnic groups. The WISC-IV Spanish version was designed to assess Spanish-speaking children in the United States and is available from the publisher. “– McCauley et al. 2012

### REFERENCES:

Wechsler, D. (2003a). WISC-IV administration manual. Pearson Assessments: San Antonio, TX.

Flanagan, D., and Kaufman, A. (2004). Essentials of WISC-IV assessment. John Wiley & Sons:

Hoboken, NJ.Prifitera, A., Saklofske, D., and Weiss, L. (Eds.). (2005). WISC-IV clinical use and interpretation: Scientist-practitioner perspectives. New York: Elsevier Academic Press.

Sattler, J., and Dumont, R. (2004). Assessment of children: WISC-IV and WPPSI supplement. Jerome M. Sattler Publisher, Inc: San Diego,CA

Wechsler, D. (2003b). WISC-IV technical and interpretive manual. Pearson Assessments: San Antonio, TX.

Wechsler, D. (2002). Wechsler Preschool and Primary Scale of Inteligence, 3rd edition administration manual. Pearson Assessments: San Antonio, TX.

Allen, D., Thaler, N., Donohue, B., and Mayfield, J. (2010). WISC-IV profiles in children with traumatic brain injury: Similarities to and differences from the WISC-III. Psychol Assess 22(1), 57-64.

Donders, J. (1997). Sensitivity of the WISC-III to injury severity in children with traumatic head injury. Assessment 4, 107-109.

Donders, J., and Janke, K. (2008). Criterion validity of the Wechsler Intelligence Scale for Children--Fourth Edition after pediatric traumatic brain injury. J Int Neuropsychol Soc 14(4), 651-655.

Yeates, K., and Donders, J. (2005). The WISC-IV and neuropsychological assessment. In A. Prifitera, D. Saklofske & L. Weiss (Eds.), WISC-IV clinical use and interpretation: Scientist-practitioner perspectives. New York: Elsevier Academic Press.

Tremont, G., Mittenberg, W., and Miller, L. (1999). Acute intellectual effects of pediatric head trauma. Child Neuropsychol 5, 104-114.

Wechsler, D. (2004). WISC-IV Spanish technical and interpretive manual. Pearson Assessments: San Antonio, TX.

## Word Reading Subtest of the Wide Range Achievement Test (WRAT-4)

### DESCRIPTION

Two sections: Letter Reading (15 items) and Word Reading (55 items).

### PERMISSIBLE VALUES

Raw score: 0-70 Standard Score: 55-145

### PROCEDURES

Material is read by subject. Requires minimal training. Administration time is 10 minutes.

### COMMENTS

Ages 5-95

### RATIONALE

Reading recognition has been identified as a brief, but effective, measurement of academic skills and intelligence that is not impacted by TBI in most cases

### REFERENCES

Wilkinson, G.S., Robertson, G.J. (2006) Wide Range Achievement Test-4 Professional Manual. Lutz, FL: Psychological Assessment Resources