**Supplementary File 1**. Database search strategy

Database: Ovid MEDLINE(R) ALL <1946 to December 24, 2017>

Search Strategy:

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1 AUTOMATED NEUROPSYCHOLOGICAL ASSESSMENT METRIC?.af. (125)

2 ANAM.ti,ab,kf. (170)

3 "IMMEDIATE POST-CONCUSSION ASSESSMENT AND COGNITIVE TEST???".af. (167)

4 [impact.ti,kw.] (0)

5 HOPKINS VERBAL LEARNING TEST.af. (313)

6 HVLT.ti,ab,kf. (160)

7 Trail Making Test/ (731)

8 TRAIL-MAKING TEST???.af. (3114)

9 TMT.ti,ab,kf. (2547)

10 PACED AUDITORY SERIAL ADDITION TEST???.af. (394)

11 PASAT.ti,ab,kf. (456)

12 WECHSLER ADULT INTELLIGENCE SCAL\*.af. (1840)

13 WAIS.ti,ab,kf. (2704)

14 (FUNCTIONAL INDEPENDENCE MEASURE adj10 COGNIT\*).af. (184)

15 (FIM adj10 COG\*).ti,ab,kf. (416)

16 CALIFORNIA VERBAL LEARNING TEST???.af. (892)

17 CVLT.ti,ab,kf. (573)

18 CONTROLLED ORAL WORD? ASSOCIATION TEST???.af. (282)

19 COWAT.ti,ab,kf. (103)

20 REY AUDITORY VERBAL LEARNING TEST???.af. (691)

21 RAVLT.ti,ab,kf. (342)

22 REY OSTERRIETH COMPLEX FIGURE TEST???.af. (243)

23 ROCF?.ti,ab,kf. (198)

24 MINI-MENTAL STATE EXAM\*.af. (12283)

25 MMSE.ti,ab,kf. (9394)

26 (STROOP adj3 TEST???).af. (3455)

27 Stroop Test/ (1373)

28 SCWT.ti,ab,kf. (93)

29 SYMBOL DIGIT MODALITIES TEST???.af. (555)

30 SDMT.ti,ab,kf. (366)

31 Wechsler Memory Scale/ (8)

32 wechsler memory scal\*.af. (1304)

33 WMS.ti,ab,kf. (1195)

34 or/1-33 (30405)

35 exp brain injuries/ (62041)

36 Craniocerebral Trauma/ (21290)

37 exp Brain Injuries, Traumatic/ (9549)

38 (TBI or mTBI or wrTBI).tw,kf. (22048)

39 (concuss\* or postconcuss\*).tw,kf. (8081)

40 ((brain\* or cerebr\* or intracerebr\* or crani\* or intracran\* or head\* or subdural\* or epidural\* or extradural\*) adj (haematoma\* or hematoma\* or hemorrhag\* or haemorrhag\* or bleed\*)).tw,kf. (46530)

41 ((head\* or cerebr\* or crani\* or skull\* or intracran\*) adj2 (injur\* or trauma\* or damag\* or wound\* or swell\* or oedema\* or edema\* or fracture\* or contusion\* or pressur\*)).tw,kf. (80329)

42 or/35-41 (178066)

43 34 and 42 (1385)

44 43 not ((exp infant/ or exp children/ or exp adolescent/) not (exp adult/ or exp aged/)) (1284)

45 Validation Studies.pt. (90254)

46 exp Psychometrics/ (67725)

47 (validation or validity).tw,kf. (298152)

48 exp "Reproducibility of Results"/ (360234)

49 exp Discriminant Analysis/ (9465)

50 (reliab\* or unreliab\* or valid\* or coefficient or homogeneity or homogeneous or "internal consistency").tw,kf. (1211585)

51 (agreement or precision or imprecision or "precise values" or test-retest).tw,kf. (368896)

52 (test and retest).tw,kf. (23488)

53 (reliab\* and (test or retest)).tw,kf. (78735)

54 exp "Sensitivity and Specificity"/ (528853)

55 exp Longitudinal Studies/ (116680)

56 (longitudinal\* or responsiv\*).tw,kf. (434643)

57 or/45-56 (2437359)

58 44 and 57 (517)

59 remove duplicates from 58 (517)

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| **Supplementary File 2**. Quality assessment of studies. |
| Study | Study Participation | Study Design | Study Attrition  | Prognostic Factors | Confounding Measurement | Outcome Measure | Overall |
| Key characteristics | Inclusion/exclusion | Key characteristics BS/FU | # eligible participants | Pro/retro | Sampling frame  | Recruitment | Place of recruitment | % | Description Adequacy | Attempt to collect Reasons for lost  |   | Characteristics of lost | No difference b/w participants and lost  | Definition provided | Reliable method | Same setting  | Missing data reported | Imputation | Minimum Confounders | Appropriate Analysis | Outcome definition | Duration FU | Valid/reliable measure | Same method/setting |
| Bleiberg et al. (2004) | no | yes | yes | no | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (++) |
| Chen et al. (2013) | no | partly | yes | no | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | yes | (+) |
| Christensen et al. | no | no | yes | yes | pro | unsure | no | no | no | N/A | N/A | N/A | N/A | N/A | NA | NA | NA | NA | NA | N/A | N/A | no | no | unsure | no | (+) |
| Covassin et al. (2012) | no | no | no | yes | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (++) |
| Covassin et al. (2007) | yes | partly | yes | yes | pro | unsure | no | no | no | N/A | N/A | N/A | N/A | N/A | NA | NA | NA | NA | NA | N/A | N/A | no | no | unsure | no | (+) |
| Covassin et al. (2008) | no | yes | yes | yes | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (+) |
| Dikmen et al. (2017) | no | no | yes | yes | pro | no | no | no | no | yes | yes | yes | yes | yes | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | unsure | (+) |
| Failla et al. (2015) | no | no | yes | no | pro | unsure | no | no | no | no | partly | partly | yes | unsure | no | no | no | unsure | unsure | yes | yes | no | no | unsure | no | (+) |
| Farbota et al. (2012) | no | no | no | unsure | pro | unsure | no | no | no | no | no | no | no | unsure | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (++) |
| Field et al. (2003) | no | no | yes | unsure | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (++) |
| Kersel et al. (2001) | no | no | partly | no | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (++) |
| Kontos et al. (2015) | no | no | no | yes | pro | no | no | unsure | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | unsure | (+) |
| Kwok et al. (2008) | no | no | yes | yes | pro | no | no | no | no | yes | yes | yes | partly | unsure | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (+) |
| Lee et al. (2005) | no | no | yes | yes | pro | yes | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (+) |
| Liberman et al (2002)  | no | no | partly | no | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (++) |
| Losoi et al. (2016) | no | no | partly | no | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (++) |
| Macciocchi et al. (2004) | no | no | yes | no | retro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | NA | NA | no | no | unsure | no | (+) |
| Maksymiuk et al. (2005) | no | no | yes | yes | retro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | NA | no | no | unsure | no | (+) |
| Mandleberg (1976) | no | no | no | yes | pro | unsure | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (+) |
| McCrea et al. (2005) | partly | no | yes | no | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | NA | no | no | unsure | no | (+) |
| Meier et al. (2015) | no | partly | yes | yes | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | NA | no | no | unsure | no | (+) |
| Ponsford et al. (2011) | no | no | yes | no | pro | no | no | no | no | no | no | no | yes | unsure | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (+) |
| Powell et al. (1996)  | no | no | no | unsure | pro | no | no | no | no | yes | yes | yes | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | partly | no | unsure | unsure | (+) |
| Prigatano et al. (1984) | no | yes | yes | yes | retro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/a | N/A | N/A | N/A | no | no | unsure | unsure | (+) |
| Register-Mihalik et al. (2013)  | no | yes | yes | unsure | pro | no | no | partly | yes | yes | yes | yes | yes | unsure | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | no | unsure | (+) |
| Robertson et al. (2015) | no | no | no | yes | pro | yes | no | no | no | yes | yes | yes | no | unsure | no | no | unsure | unsure | N/A | no | no | no | no | unsure | unsure | (+) |
| Sandhaug et al. (2015) | no | partly | yes | yes | pro | no | no | no | no | yes | yes | yes | yes | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (+) |
| Schmitter et al. (2015) | no | no | no | yes | pro | yes | no | no | no | yes | yes | yes | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | unsure | (+) |
| Snow et al. (1998)  | no | no | no | unsure | pro | unsure | unsure | no | no | no | no | no | yes | unsure | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | no | unsure | (+) |
| Sosnoff et al. (2008) | no | yes | yes | unsure | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | unsure | (+) |
| Sours et al. (2015) | no | no | yes | unsure | pro | unsure | no | no | no | N/A | N/A | N/A | N/A | N/A | no | unsure | no | no | N/A | yes | yes | no | no | partly | no | (++) |
| Till et al. (2008) | no | no | yes | no | pro | yes | no | no | no | N/A | N/A | N/A | no | unsure | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | unsure | (+) |
| Tofil & Clinchot. (1996) | no | partly | no | yes | pro | unsure | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (+) |
| Vanderploeg et al. (2014) | no | no | yes | yes | pro | unsure | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (+) |
| Wang et al. (2013) | no | no | yes | yes | pro | yes | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | NA | no | no | unsure | unsure | (+) |
| Whyte et al. (2013) | no | partly | no | no | pro | no | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | yes | (+) |
| Wylie et al. (2015) | no | no | no | yes | pro | unsure | no | no | no | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | no | (++) |
| Zafonte et al. (2012) | no | no | no | no | pro | unsure | no | no | no | no | no | no | yes | yes | N/A | N/A | N/A | N/A | N/A | N/A | N/A | no | no | unsure | yes | (+) |

Yes – yes, sources of potential bias are presented

No – no potential bias

Unsure – not enough details were reported to make a decision

N/A - not applicable according to the study design or type of analyses used

**Supplementary File 3.** Characteristics of 15 selected instruments (ANAM, COWAT, CVLT, FIM-Cog, MMSE, HVLT, ImPACT, PASAT, RAVLT, ROCF, SDMT, Stroop Task, TMT, WAIS, and WMS)

**THE AUTOMATED NEUROPSYCHOLOGICAL ASSESSMENT METRICS (ANAM)**

|  |  |  |
| --- | --- | --- |
| Descriptive | Method of Development | Developed as a clinical subset of OMPAT’s TWB cognitive processing library of tests; initially for use in healthy subjects w/ environmental challenges but adapted as brief assessment of cognition w/i clinical populations1 |
| Purpose | To briefly assess patients w/ cognitive impairment1 over repeated testing1-2 |
| Content | Assesses sustained attention, working memory, visual search, spatial processing, computation, immediate and delayed reaction time, performance efficiency3, decision-making, executive function, concentration4Modules: 2-CRT, CDS (Learning/Immediate/CDD), EM, G/NG, GR, LR (Symbolic), Manikin, MG, MTS, MTH, STN, PRO, PT, RMCPT, SRT, SPA (Sequential/Simultaneous), Standard CPT, Stroop, Switching, Tapping, TWP5 |
| Response – options | Responses to each module made using a computer and keyboard/mouse6 |
| Recall period | Not applicable  |
| Endorsements | Available to individuals w/ appropriate qualification4 |
| Practical | To obtain | Available from Vista: http://www.vistalifesciences.com/order-anam6 |
| Method of administration | Patient must complete each module; individual descriptions of administration available for certain frequently used modules2 |
| Scoring and interpretation | APR software generates full report for subtests and compares to norms; ADEPT software extracts and organizes data3-4; common scores include % correct/AC; mean RT for accurate responses, and TP (accuracy to speed ratio)7  |
| Respondent burden | Few minutes (individual modules); up to 90+ minutes (entire battery)7 |
| Admin burden | Administrator must have knowledge of APA distribution and administration, guidelines4; must purchase software and obtain computer access6 |
| Translations | English6 |
| Critical Appraisal Value | Strengths, Cautions, Clinical and Research Applicability | Allows for generation of infinite alternative forms, randomization of stimuli, cognitive profile creation8, and subtle detection of RT changes w/ short administration time and automated analysis7,8Not an ideal concussion screening tool beyond the first 72 hours post-injury9Little established normative data;8 not extensively studied in TBI samples |

AC, accuracy; ADEPT, ANAM Data Extraction and Presentation Tool; ANAM, Automated Neuropsychological Assessment Metrics; APA, American Psychological Association; APR, ANAM Performance Report; CDD, Code Substitution Delayed Recall; CDS, Code Substitution; EM, Effort Measure; G/NG, Go/No-Go; GR, Grammatical Reasoning; LR, Logical Reasoning; MG, Matching Grids; MTH, Mathematical Processing; MTS, Matching to Sample; OMPAT, Office of Military Performance Assessment Technology; PRO, Procedural Reaction Time; RMCPT, Running Memory Continuous Performance Task; PT, Pursuit Tracking; RT, reaction/response time; SPA, Spatial Processing; SRT, Simple Reaction Time; STN, Sternberg Memory Search; TBI, traumatic brain injury; TP, throughput; TWB, Tester’s Workbench; TWP, Tower Puzzle; TBI-only population

**References**

1. Kane, R., Roebuckspencer, T., Short, P., Kabat, M., & Wilken, J. (2007). Identifying and monitoring cognitive deficits in clinical populations using Automated Neuropsychological Assessment Metrics (ANAM) tests. *Archives Of Clinical Neuropsychology*, *22*(Supplement 1), 115-126. http://dx.doi.org/10.1016/j.acn.2006.10.006
2. Kabat, M., Kane, R., Jefferson, A., & DiPino, R. (2001). Construct Validity of Selected Automated Neuropsychological Assessment Metrics (ANAM) Battery Measures. *The Clinical Neuropsychologist (Neuropsychology, Development And Cognition: Section D)*, *15*(4), 498-507. http://dx.doi.org/10.1076/clin.15.4.498.1882
3. Register-Mihalik, J., Guskiewicz, K., Mihalik, J., Schmidt, J., Kerr, Z., & McCrea, M. (2013). Reliable Change, Sensitivity, and Specificity of a Multidimensional Concussion Assessment Battery. *Journal Of Head Trauma Rehabilitation*, *28*(4), 274-283. http://dx.doi.org/10.1097/htr.0b013e3182585d37
4. *ANAM Software Suite*. *Vistalifesciences.com*. Retrieved 10 August 2017, from http://www.vistalifesciences.com/anam-software-suite
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7. Ibarra, S. (2011). Automated Neuropsychological Assessment Metrics. In: *Encyclopedia of Clinical Neuropsychology*. Springer International Publishing, pp. 325-327.
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9. Coldren, R., Russell, M., Parish, R., Dretsch, M., & Kelly, M. (2012). The ANAM Lacks Utility as a Diagnostic or Screening Tool for Concussion More Than 10 Days Following Injury. *Military Medicine*, *177*(2), 179-183. http://dx.doi.org/10.7205/milmed-d-11-00278
10. Bleiberg, J., Cernich, A.N., Cameron, K., Sun, W., Peck, K., Ecklund, P.J., Reeves, D., Uhorchak, J., Sparling, M.B., Warden, D.L. (2004). Duration of cognitive impairment after sports concussion. Neurosurgery, 54(5), 1073-78; discussion 1078-80.

**THE CONTROLLED ORAL WORD ASSOCIATION TEST (COWAT)**

|  |  |  |
| --- | --- | --- |
| Descriptive | Method of Development | Developed to provide a short test that is also feasible for patients w/ lower education or limited use of writing hand1 |
| Purpose | To evaluate verbal fluency, specifically phonemic fluency1 |
| Content | Assesses ability to retrieve information – selective attention, mental set shifting, response generation, and self-monitoring1 |
| Response – options | Patient must name words that begin with a given letter1 |
| Recall period | Not applicable  |
| Endorsements | Available to individuals w/ appropriate qualification2 |
| Practical | To obtain | Available as part of the MAE battery from PAR: http://www4.parinc.com/Products/Product.aspx?ProductID=MAE2 |
| Method of administration | Patient is given 1 minute to name as many words as possible beginning with a certain letter; repeated for two other letters1; commonly used English letter sets are are CFL, PRW, and FAS3 |
| Scoring and interpretation | Overall: # words for all three letters w/o repetitions and proper nounsOther possible measures include: error analysis (error patterns suggestive of executive dysfunction), Troyer clustering (extent of production of items within a given group/mean cluster size), Troyer switching (ability to switch to another group of words/# of switches)1, Abwender cluster switches (from one cluster to a related cluster), and Abwender hard switches (from a cluster to non-cluster words, or b/w non-cluster words4 |
| Respondent burden | 3 minutes to complete3 |
| Admin burden | Requires Level C qualification; must purchase test kit2 |
| Translations | English, Spanish2 |
| Critical Appraisal Value | Strengths, Cautions, Clinical and Research Applicability | Measurement properties not extensively studied in TBI populationsSignificant predictors of score include education [F(2, 336) = 16.21; p < 0.0001]3and size of the corpus callosum (R2 = 0.14; p < 0.05) 5Total score moderately correlated w/ education (r = 0.367; p < 0.01) but NS w/ age (r = -0.03; p > 0.05) 6 |

COWAT, Controlled Oral Word Association Test; MAE, Multilingual Aphasia Examination; PAR, Psychological Assessment Resources; TBI, traumatic brain injury

**References**

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2. *MAE (Multilingual Aphasia Examination, 3rd Ed.)*. (2012). *www4.parinc.com*. Retrieved 1 August 2017, from http://www4.parinc.com/Products/Product.aspx?ProductID=MAE#Items
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**THE CALIFORNIA VERBAL LEARNING TEST (CVLT)**

|  |  |  |
| --- | --- | --- |
| Descriptive | Method of Development | Developed by Delis et al. in 1987 to assess learning and memory in terms of what is remembered, how items are remembered and what errors are made1 |
| Purpose | To evaluate learning with respect to a verbally-presented list of words1 |
| Content | Assesses verbal learning and memory2 CVLT: contains 3 lists of shopping items from various semantic categories2-3; + List A (tools, fruits, clothing, and spices and herbs); List B (interference list consisting of fruits, spices and herbs – shared w/ List A – fish, and kitchen utensils – distinct); 44-item recognition list containing target words from List A and distractor words3CVLT-II: 4 categories are semantically unrelated; optional 16-item forced choice discrimination task to measure effort; new alternate test form and new short form (9-item lists) for patients with severe cognitive dysfunction4 |
| Response – options | Recall: FR (patient must recall as many words as possible in any order); CR (examiner prompts patient w/ category name); can be SDFR/SDCR or 20-minute LDFR/LDCRRecognition: patient must classify 44 words as targets or distractors3 |
| Recall period | Not applicable  |
| Endorsements | Available to individuals w/ appropriate qualification5 |
| Practical | To obtain | CVLT-II available from Pearson Education: http://www.pearsonclinical.com/psychology/products/100000166/california-verbal-learning-test--second-edition-cvlt-ii.html5 |
| Method of administration | CVLT: examiner reads each list out loud with 1s intervals b/w words; 5 List A trials and 1 List B trial w/ immediate FR after each trial; List A SDFR/SDCR assessed immediately after the 6 trials; List A LDFR/LDCR assessed 20 minutes later; recognition list read and assessed at the end2-3CVLT-II: forced choice discrimination task follows recognition task4 |
| Scoring and interpretation | Can be scored manually but accompanying computer software is encouraged3 CVLT: various scores possible, including # words correctly recalled per List A/B trial, # correctly recalled in SDFR/SDCR/LDFR/LDCR, and # RHs/FPs2 CVLT-II: primary measures are total trials 1-5, SDFR, SDCR, LDFR, LDCR, and total recognition discrim., w/ additional process measures6  |
| Respondent burden | CVLT-II: 30 minutes of testing + 30 minute delay period (standard from); 15 minutes of testing + 15 minute delay period (short from)5 |
| Admin burden | Requires Level C qualification; must purchase test kit and software3  |
| Translations | English, Italian, German3, Korean7 |
| Critical Appraisal Value | Strengths, Cautions, Clinical and Research Applicability | Demonstrated predictive validity in TBI populationsModerate to high convergent validity and test-retest reliability but not widely studied in TBI populations |

CR, cued recall; CVLT/CVLT-II, California Verbal Learning Test/California Verbal Learning Test-Second Edition; FP, false positives; LDCR, long delay cued recall; LDFR, long delay free recall; LDR, long delay recall; NS, non-significant/non-significantly; RAVLT, Rey Auditory Verbal Learning Test; RH, recognition hits; SDCR, short delay cued recall; SDFR, short delay free recall; TBI; traumatic brain injury

**References**

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**THE FUNCTIONAL INDEPENDENCE MEASURE (FIM), COGNITIVE SUBSCALE (FIM-Cog)**

|  |  |  |
| --- | --- | --- |
| Descriptive  | Method of Development | Developed by ACRM/AAPMR task force to improve rehabilitation services through a software system w/ uniform measurement of outcomes, and established reliability/validity; created through literature review of other measures1 |
| Purpose | 18-item measure to assess motor and cognitive dimensions in rehabilitation1 |
| Content | 6 areas of function (self-care, sphincter control, transfers, locomotion, communication, and social cognition)1 – motor (13 items) and cognitive (5 items – comprehension, expression, social interaction, problem solving and memory)2,3 |
| Response – Options | Actions as observed by the examiner or short answer responses by the patient1,4  |
| Recall Period | Not applicable  |
| Endorsements  | Not available online; requires UDSMR subscription5  |
| Practical | To obtain | Subscription information: https://www.udsmr.org/WebModules/FIM/Fim\_About.aspx5 User manual: https://www.va.gov/vdl/documents/Clinical/Func\_Indep\_Meas/fim\_user\_manual.pdf6 |
| Method of Administration | Examiner observes and scores patient functioning; trained interviewers can conduct telephone interviews post-discharge1 |
| Scoring and Interpretation | * Individual items: scores range from 1 (total assistance) to 7 (complete independence); patients with scores < 6 require some level of assistance1,3
* Total: sum of individual, ranging from 18-1261
 |
| Respondent Burden | 30-45 minutes to complete4  |
| Admin Burden | Must purchase subscription5 and receive certification2 |
| Translations | Afrikaans, English, Finnish, French, German, Italian, Portuguese, Spanish, Swedish, Turkish2 |
| Critical appraisal value  | Strengths, cautions, clinical and research applicability  | Worse score associated w/ increased age and presence of comorbid conditions6 |

FIM, Functional Independence Measure (former acronym, now simply FIM Instrument); Uniform Data System for Medical Rehabilitation

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**THE MINI-MENTAL STATE EXAMINATION (MMSE)**

|  |  |  |
| --- | --- | --- |
| Descriptive  | Method of Development | Initially developed to assess cognitive deficits within dementia, affective disorder, schizophrenia, personality disorder w/ drug abuse, and neuroses; developed w/ a focus on cognitive aspects of mental functions rather than mood, abnormal mental experiences or thought1 |
| Purpose | To assess mental status and track cognitive impairment/recovery1-2 |
| Content  | 11 questions covering 5 domains of cognition: orientation to time and place, registration (object memory), attention and calculation, recall (short-term), language (object naming, word repetition, comprehension, reading, writing, and drawing)1-2 |
| Response - Options | Orientation, registration, attention and calculation, and recall require verbal responses; language requires verbal and written responses2 |
| Recall Period | Within 51-2-153 minutes (total test time): recall domain requires short-term recall of 3 words learned in registration domain2 |
| Endorsements  | Questions publicly viewable,2 forms and scoring kits available to individuals w/ appropriate qualification3 |
| Practical | To obtain | Questions can be viewed at: https://www.mountsinai.on.ca/care/psych/on-call-resources/on-call-resources/mmse.pdf2Forms/manual can be purchased from PAR: https://www.parinc.com/Products/Pkey/2373 |
| Method of Administration | Orientation: patient is asked year/season/date/day/month, and state/country/town/hospital/floor2Registration: examiner names 3 objects and patient is asked to repeat, multiple trials used until all 3 words are learned2Attention and calculation: patient is asked to carry out 5 serial additions of 7, or spell a word backwards2Recall: patient is asked to name the 3 objects from the registration domain2Language: patient is asked to name 2 objects, repeat a series of words, follow a 3-stage command, read and obey an instructive phrase, write a sentence, and copy a design2 |
| Scoring and Interpretation | Maximum score is out of 30: orientation (10), registration (3), attention and calculation (5), recall (3), and language (9)1-2 Recommended score categories: normal cognitive functioning (27–30), mild cognitive impairment (21–26), moderate cognitive impairment (11–20), severe cognitive impairment (0–10) reflecting severe cognitive impairment;1 score of ≤23 typically interpreted as cognitive impairment2 |
| Respondent Burden | 51-2-153 minutes to complete |
| Admin Burden | 51-2-153 minutes to administer + 5 minutes to score; Level S qualification required for purchase of materials3 |
| Translations | Available in >70 languages3 |
| Critical appraisal value  | Strengths, cautions, clinical and research applicability  | Quickly administered and suitable for routine use2Can measure change in mental status w/ repeated use2Sex not significantly associated with score 4Less practical for patients w/ physical impairments that impede participation intubated or those w/ low English literacy2Less sensitive than MoCA at detecting TBI, 5 post-stroke cognitive impairment6 and dementia7 Fewer years of education related to decreased specificity and increased sensitivity; 8 educational background observed to have a strong effect on writing, reading and obeying, and copy design 9Higher age related to decreased specificity 9 |

MoCA, Montreal Cognitive Assessment; TBI, traumatic brain injury

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**THE HOPKINS VERBAL LEARNING TEST (HVLT)**

|  |  |  |
| --- | --- | --- |
| Descriptive | Method of Development | Developed to provide brief method of longitudinal assessment; semantic categories chosen from previously determined set (4 most common words in each, w/ 2 most common designated distractors)1-3 |
| Purpose | To evaluate memory and verbal learning1 |
| Content | Assesses immediate and delayed recall, and delayed recognition2Consists of a 12-word list (4 words each from 3 semantic categories) w/ 6 alternate forms, a 24-word recognition list (12 target words, 6 semantically-related and 6 semantically-unrelated distractor words)1,3 |
| Response – options | Patient must learn a list of words and demonstrate recall/recognition1  |
| Recall period | Not applicable  |
| Endorsements | Available to individuals w/ appropriate qualification2 |
| Practical | To obtain | HVLT-R available from PAR: http://www4.parinc.com/Products/Product.aspx?ProductID=HVLT-R2 |
| Method of administration | HVLT: patient is verbally presented w/ 12 words (2 words/s) and immediate free recall is assessed; repeated 2x (total 3 trials) and followed by recognition3 HVLT-R: DR and recognition assessed ~25 minutes later4 |
| Scoring and interpretation | HVLT: Trials 1/2/3 # recalled, Learning (higher of Trials 2/3 – Trial 1), TR (3-trial total), Recognition TPs/FPs, Recognition Discrim. (TP – FP), and RB HVLT-R: Trial 4 (DR) # recalled, % retained (higher of Trials 2/3 divided by Trial 4)4 |
| Respondent burden | HVLT-R: 5-10 minutes testing time + 25 minutes delay2  |
| Admin burden | Requires Level C qualification; must purchase; 2 minutes to score2  |
| Translations | English2, French5, Chinese6 |
| Critical Appraisal Value | Strengths, Cautions, Clinical and Research Applicability | Use of 6 alternate forms is practical in patient populations that require follow-up evaluation and assessment of treatment gains1 |
| HVLT: weakly correlated w/ level of education (r = 0.27; p = 0.04) 7HVLT-R: age seen to be significant predictor (β = -0.28; p = 0.002) 8 |
| HVLT: better sensitivity than MMSE in detecting dementia patients 7HVLT-R: better sensitivity/specificity than MMSE and CogState in detecting MCI patients 8 |

DR, delayed recall; FP, false positive; HVLT/HVLT-R, Hopkins Verbal Learning Test/Hopkins Verbal Learning Test-Revised; MCI; mild cognitive impairment; MMSE, Mini–Mental State Examination; RB, response bias; SD, standard deviation; TP, true positive; TR, total recall

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**THE IMMEDIATE POST-CONCUSSION ASSESSMENT AND COGNITIVE TESTING (IMPACT)**

|  |  |  |
| --- | --- | --- |
| Descriptive | Method of Development | Developed to have an inexpensive and easily-administered instrument; alternative to time-consuming and expensive paper and pencil methods w/ poor norms, sensitivity, specificity and vulnerability to practice effects1,2 |
| Purpose | To evaluate baseline and post-concussion cognitive performance1  |
| Content | WM: assesses immediate/learning and delayed/retention verbal recognition memoryDM (version 2.0): assesses immediate/learning and delayed/retention spatial recognition memoryX’s and O’s: assesses visual working memory and cognitive speedSM: assesses visual-motor speed and memoryCM: assesses visual-motor speed and impulse inhibitionTLM: assesses verbal working memory and cognitive speed2 |
| Response – options | Responses to each module made using a computer and mouse1  |
| Recall period | Not applicable  |
| Endorsements | Available to individuals w/ appropriate qualification1  |
| Practical | To obtain | Available from ImPACT Applications: https://www.impacttest.com/purchase/form3 |
| Method of administration | Patient must complete each online module, demographic information and PCSS1; details about specific modules not reported |
| Scoring and interpretation | VEM: composite of learning and delayed WM, SM, and TLM scoresVIM: learning and delayed DM, X’s and O’s % correctVMPS: X’s and O’s avg. correct distractors, SM avg. correct responses, Three Letters Memory # correct responsesRT: X’s and O’s avg. correct RT, SM avg. weighted corrected RT, CM avg. correct RTIC: X’s and O’s #incorrect distractors, CM # errors2 |
| Respondent burden | 25 minutes to complete1  |
| Admin burden | Requires appropriate certification, computer access1, and test package and training fees3; scoring and data storage automatically completed by software1  |
| Translations | English  |
| Critical Appraisal Value | Strengths, Cautions, Clinical and Research Applicability | Can be administered with little supervision4  |
| BMI was a predictor of VIM score (∆R2 = 0.02; p = 0.03)5 |

avg. average; BMI, Body Mass Index; CM; Colour Match; CPT, Continuous Performance Test; DM, Design Memory; IC, Impulse Control; ImPACT, Immediate Post Concussion Assessment and Cognitive Testing; RT, Reaction Time; SM, Symbol Match; TLM, Three Letter Memory; VEM, Verbal Memory; VF, Verbal Fluency; VIM, Visual Memory; VMPS, Visual-Motor Processing Speed; WM, Word Memory

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**THE PACED AUDITORY SERIAL ADDITION TEST (PASAT)**

|  |  |  |
| --- | --- | --- |
| Descriptive | Method of Development | Initially developed to assess immediate memory and attention using visual stimuli, and later adapted for use in a TBI population1 |
| Purpose | To evaluate rate of information processing in TBI and MS patients1 |
| Content | Sustained/divided attention, concentration, information processing speed2 |
| Response – options | Patient is presented with a series of single digits; must add last presented digit to previous one and state sum1,3 |
| Recall period | Not applicable |
| Endorsements | Available to individuals w/ appropriate qualification4 |
| Practical | To obtain | Available from: http://pasat.us/4Manual: http://www.nationalmssociety.org/NationalMSSociety/media/MSNationalFiles/Brochures/10-2-3-31-MSFC\_Manual\_and\_Forms.pdf5 |
| Method of administration | A series of 61digits is played in 4 trials (same series presented at 4 ISIs – 2.4, 2.0, 1.6, and 1.2 s1,3– w/ a 60 s break b/w trials)3; each is digit presented for 0.4 s1,3; 1.6 and 1.2 s trials are administered if score is ≥20 on 2.0s trial or ≥40s on 2.4 trial3; multiple versions where ISI or length of trial vary3 |
| Scoring and interpretation | Total score: total # correct in each trial (max = 60)1,3Composite score: total # correct summed over all trials1,3Avg. time/correct response: ratio of # correct to trial duration (ISI x 60)1,3Other: # times stimulus added to previous answer, longest string correct, RT3 |
| Respondent burden | 6-8 to 15-20 minutes to complete, depending on version used3 |
| Admin burden | Requires training3; must purchase forms, recordings, and CD player 4 |
| Translations | Available in 27 languages4; computerized versions available3 |
| Critical Appraisal Value | Strengths, Cautions, Clinical and Research Applicability | High internal consistency and test-retest reliability in non-TBI populations, but need to be documented in TBI patients2, 6-7,8-11 |
| Low divergent validity – performance appears to be related to cognitive abilities other than attention and processing speed2Low score cannot be used to determine presence of cognitive dysfunction1Documented practice effects, particularly at shorter ISI values1 |
| Worse score associated w/ increased age, decreased IQ, and lower math ability1 |

avg, average; ISI, interstimulus interval; IQ, intelligence quotient; MS, multiple sclerosis; TBI, traumatic brain injury;

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**THE REY AUDITORY VERBAL LEARNING TEST (RAVLT)**

|  |  |  |
| --- | --- | --- |
| Descriptive | Method of Development | Developed in French in 1941 and adapted to English in 1959; designed to provide different measures that correspond to different memory processes1 |
| Purpose | To evaluate nature/ severity of memory dysfunction and changes in memory1 |
| Content | Assesses inhibition, retention, encoding, retrieval, and organization2Contains 2 15-item lists of nouns (List A and interference List B) + 50-item recognition list w/ 30 A/B words and 20 distractor words1 |
| Response – options | Free recall (FR): patient must recall as many A/B words as possible; can be short-delay/immediate (SDFR) or long-delay/after 20 minutes (LDFR)Recognition: patient must classify recognition words as targets or distractors1  |
| Recall period | Not applicable  |
| Endorsements | Available to individuals w/ appropriate qualification2 |
| Practical | To obtain | Available from PAR: http://www4.parinc.com/Products/Product.aspx?ProductID=RAVLT2 |
| Method of administration | Each list is verbally presented; 5 List A trials and 1 List B trial w/ immediate FR after each; List A SDFR assessed immediately after List B presentation; List A LDFR assessed 20 minutes later; recognition list assessed at the end1 |
| Scoring and interpretation | List A Trials 1/2/3/4/5/1-5/SDFR/LDFR and List B: # correctly recalled1,3Recognition: hits and false positives4PI: List B/Trial 1RI: SDFR/Trial 53 |
| Respondent burden | 10-15 minutes to complete2 |
| Admin burden | Requires Level C qualification; must purchase test kit2 |
| Translations | English2, French, Spanish, Greek, Brazilian Portuguese, Hebrew1 |
| Critical Appraisal Value | Strengths, Cautions, Clinical and Research Applicability | Several alternate forms in English version to diminish practice effects1 |
| Low to moderate effect of age (r = –0.22 to –0.55) and education (r = –0.14 to –0.54)5 |

FR, free recall; LDFR, long delay free recall; MCI; mild cognitive impairment; NS, non-significant/non-significantly; PAR, Psychological Assessment Resources; RAVLT, Rey Auditory Verbal Learning Test; SDFR, short delay free recall

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**THE REY OSTERRIETH COMPLEX FIGURE TEST (ROCF)**

|  |  |  |
| --- | --- | --- |
| Descriptive  | Method of Development | Developed by Rey in 1941; 36-point scoring system developed and normed by Osterrieth in 1944, and by Meyers and Meyers in 1995 (most commonly used)1 |
| Purpose | To assess memory and organization in patients (6-89 years) w/ brain damage1,2 |
| Content | Assesses visuospatial perception, visual memory, long-term memory encoding/storage/retrieval, strategic planning and organization, attention, concentration, fine-motor coordination3 |
| Response – Options | Patient is presented w/ a figure and must either copy, draw or recognize aspects of it from memory1  |
| Recall Period | Not applicable  |
| Endorsements  | Available to individuals w/ appropriate qualification2 |
| Practical | To obtain | Meyers and Meyers version (RCFT) available from PAR: http://www4.parinc.com/Products/Product.aspx?ProductID=RCFT2 |
| Method of Administration | Patient must copy a complex geometric figure (Copy Trial), followed by immediate and/or delayed reproduction from memory (IR/DR Trials); delay timing of the DR Trial can vary3; patient must complete recall trials w/i 10 minute time limit; RCFT ends w/ a Recognition Trial where patients are given 12 original design features + 12 foils and must circle original details; sequence of strokes can be tracked by pen-switching (providing a different coloured pen when specific points on the figure are reached) or following w/ a flow chart1 |
| Scoring and Interpretation | * Figure divided into 18 units w/ a score of 0 (inaccurately drawn/ unrecognizable/omitted + incorrectly placed), 0.5, 1, or 2 (accurately drawn + correctly placed); unit scores are summed to give a total ranging from 0 to 36; low Copy score corresponds to reduced visual-perceptual and visuomotor skills; low Recall scores correspond to reduced visuospatial recall ability; differences in IR and DR indicate disruptions in encoding, storage and retrieval processes3
 |
| Respondent Burden | Overall 40-60 minutes to complete (10 minutes each for Copy, IR and DR + 20-30 minute delay)3  |
| Admin Burden | Requires Level C qualification; must purchase test kit; 15 minutes to score2 |
| Translations | English2 |
| Critical appraisal value  | Strengths, cautions, clinical and research applicability  | COWAT, TMT B and WCST # perseverative responses were significant predictors of Copy, IR, DR and recognition (R2 = 0.11-0.16; p < 0.05)4Age had a significant effect on Copy, IR and DR scores (F = 5.44-8.32; p < 0.001) w/ older individuals scoring significantly lower (p < 0.05)5Sex had a significant effect on Copy, IR and DR scores (F = 4.76-23.51; p < 0.05) w/ males producing more accurate copies and recalling more information5IQ had a significant effect on Copy, IR and DR scores (F = 4.35-7.50; p < 0.05) where individuals w/ IQ scored higher than those with lower IQ19dNS differences in Copy, IR and DR scores b/w pen-switching and flow chart methods (t = 0.14, –0.31 - –0.19; p ≥ 0.05) using the 36-point scoring system6 |

COWAT, Controlled Oral Word Association Test; DR, Delayed Recall; GPT, Grooved Pegboard Test; IQ, Intelligence Quotient; IR, Immediate Recall; RCFT, Rey Complex Figure Test and Recognition Trial; ROCF, Rey–Osterrieth Complex Figure Test; TMT, Trail Making Test; US, United states; VPA, Verbal Paired Associates; Vocab, Vocabulary; VR, Visual Reproduction; WCST, Wisconsin Card Sorting Test

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**THE SYMBOL DIGIT MODALITIES TEST (SDMT)**

|  |  |  |
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| Descriptive  | Method of Development | Developed by Smith in 1982; similar to WAIS DST (where presented numbers are substituted w/ corresponding symbols), but advantageous in that patients are more familiar w/ writing out numbers and are able to respond orally1,6 |
| Purpose | Brief test to screen for organic cerebral dysfunction in individuals aged 8 and up1 |
| Content | Assesses attention, visual scanning, motor speed2, graphomotor skills, visuospatial ability, incidental memory3 |
| Response – Options | Patient must indicate a specific number (written or oral) in response to various presented geometric figures1  |
| Recall Period | Not applicable  |
| Endorsements  | Available to individuals w/ appropriate qualification1 |
| Practical | To obtain | Available from WPS: https://www.wpspublish.com/store/p/2955/sdmt-symbol-digit-modalities-test1 |
| Method of Administration | Patient is presented w/ a key and a series of 9 geometric figures in random order, and must pair each one w/ its corresponding number (1-9) w/i a 90s time limit2; can conduct written version, followed by oral; can be individual or group1 |
| Scoring and Interpretation | Possible variables include total correct4 and number of figures attempted5 |
| Respondent Burden | < 5 minutes to complete1  |
| Admin Burden | Requires Level C qualification; must purchase test kit and stopwatch1 |
| Translations | English, Dutch, Spanish1 |
| Critical appraisal value  | Strengths, cautions, clinical and research applicability  | Oral/written versions can accommodate patients with motor/speech disabilities1 Can be used w/ patients who do not speak English1,6Used to assess MS patients as part of the MSFC4 |
| Low to moderate correlations w/ age, sex and education (r = 0.20-0.24, –0.42; p < 0.01) 7Brain lesion burden and atrophy observed to be significant predictors of score, especially third ventricle width (R2 = 0.57; p < 0.001) 8Oral/written show NS differences in age, sex and income effects2Low correlation w/ gender and education (r = 0.17-0.22; p < 0.05); weak, NS correlation w/ age (r = 0.03; p ≥ 0.05) 9 |

DST, Digit Symbol Test; NS, non-significant/non-significantly; SDMT, Symbol Digit Modalities Test; WAIS, Wechsler Adult Intelligence Scale

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**THE STROOP TASK**

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| --- | --- | --- |
| Descriptive  | Method of Development | Developed in 1929 by Jaensch; English version introduced in 1935 by Stroop; multiple versions w/ 100 items presented in either 10x10 or 5x20 girds1; current standardized version uses a 5x20 grid and was introduced by Golden in 1978 and updated in 20022 |
| Purpose | 3 subtask measure developed to study interference in serial verbal reactions3; used to distinguish normal, brain-damaged, and non-brain-damaged psychiatric patients of ages 15 to 904 |
| Content  | Assesses cognitive flexibility, resistance to interference, cognitive stress coping, and ability to process complex input4Measures interference of colour stimuli on reading words and of word stimuli on naming colour1 Standardized version consists of 3 cards:W – 100 colour names (red, green, and blue) printed in black, and placed randomly on a white backgroundC – 100 coloured bars (XXXX) printed in red, green or blue, and placed randomly on a white backgroundIncongruent CW – 100 colour names printed in red, green or blue such that no word matches the colour it names5-6 |
| Response -Options | W – RCNb C – NC CW – RCNd or NCWd3 |
| Recall Period | Not applicable  |
| Endorsements  | Available to individuals w/ appropriate qualifications4 |
| Practical | To obtain | Complete test kit available from PAR: http://www4.parinc.com/Products/ Product.aspx?ProductID=STROOP#Items2 |
| Method of Administration | Can be administered individually or as part of a group; 3 8.5” x 11” cards presented in W, C, CW order; must go down the columns while reading words or naming colours; given 45 seconds for each task, and must circle last completed item; if < 45 seconds, patient must begin list again4 |
| Scoring and Interpretation | Basic scores: W, C, and CW # correct responses, and Interference Score3 (difference b/w W/C and CW3,5: RCNb – RCNd interference of colour on reading; NC – NCWd interference of words on naming colours)3Derived scores: error scores and patterns of responses (serial scores)7Normative scores for current version based on normal sample of 300 individuals, aged 15-90, w/ 2-20 year education range; ideal scores predicted based on age and education; difference b/w obtained and predicted scores is converted to a T score5 |
| Respondent Burden | 5 minutes to complete4 |
| Admin Burden | Requires Level C qualification; must purchase test pages and stopwatch2 |
| Translations | English, Danish, Dutch, French, German, Greek, Spanish8 |
| Critical appraisal value  | Strengths, cautions, clinical and research applicability  | Validated in TBI populationsShort administration time, relatively inexpensive4 |
| Reliability not consistently determined in neurologic populations; high practice effects |
| W, C and CW can distinguish b/w frontal and non-frontal patients – W (d = –0.45 - –0.33; p < 0.05); CW can distinguish b/w left and right frontal patients (d = -0.39; p < 0.05)9Observed sex differences – females consistently seen to be better at colour naming than males |

CW, Colour Word; NC, name colours; NCWd, name colour of word; NS, non-significant/non-significantly; RCNb, read colour names in black; RCNd, read colour name printed in a different color; RT, reaction/response time; TBI, traumatic brain injury; W, Word

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**THE TRAIL MAKING TEST (TMT)**

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| --- | --- | --- |
|  | Method of Development | Developed by US Army as part of the AITB1; later used as an indicator of organic brain damage1 and incorporated into the HRNB2 |
| Descriptive  | Purpose | 2-part test used to detect neurological impairment3 |
| Content  | Assesses attention, processing speed, mental flexibility4, memory, executive functioning5, and visuospatial tracking6TMT A: 25 circles, numbered from 1 to 25, randomly distributed over the entire page7; measures visual search and motor speed skills3TMT B: 25 circles, numbered 1 to 13 or lettered from A to L7; additionally measures mental flexibility3CTMT: 5 parts, w/ 1-3 similar to TMT A and 4-5 similar to TMT B6 |
| Response -Options | Patient must connect circles in ascending order (alternating b/w numbers and letters for TMT B)7  |
| Recall Period | Not applicable  |
| Endorsements  | Available to public |
| Practical | To obtain | Available from Reitan Neuropsychology Labs: http://www.mcssl.com/store/reitan-neuropsychologylaboratory/tests/trail-making-test-for-adults-item-18 |
| Method of Administration | Following 7-circle sample, patient must complete 25-circle task as fast as possible4,7 w/i 5-minute time limit w/o lifting pencil or making mistakes4 (though any mistakes can be quickly crossed out)7Originally called for examiner to stop test after 3 errors, but now allows the examiner to point out errors so patient can correct them8  |
| Scoring and Interpretation | Most common system does not incorporate number of errors7; score for each part determined by # seconds required for completion9,10Secondary: TMT B – A or B:A ratio (interference by mental flexibility) Scores determined by comparing w/ normative for healthy populations3  |
| Respondent Burden | 5-10 minutes to complete3  |
| Admin Burden | No training required; must purchase forms, pencil/pen, and stopwatch3 |
| Translations | English, Arabic, Chinese, Hebrew |
| Critical appraisal value  | Strengths, cautions, clinical and research applicability  | Can be administered by itself or as part of a larger battery3Easy to administer, quick and inexpensive3Alternate forms for children aged 9-14 and adults >154 |
| Significant difference in mean score b/w patients with ABI and healthy controls (p<0.001)1TMT A can distinguish b/w frontal and non-frontal patients (d = -0.23; p < 0.05) but not b/w left and right frontal patients (d = -0.05; p ≥ 0.05)11; TMT B scores not observed to distinguish b/w frontal and non-frontal patients (t = 0.05-1.79; p = 0.10-1.00 or d = -0.16, p ≥ 0.05)11,12TMT A weakly correlated w/ age (r = 0.225; p < 0.01) and NS correlated w/ education (r = 0.047; p > 0.01); TMT B weakly correlated w/ age and education (r = 0.278, -0.166; p < 0.01)13 |

ABI, acquired brain injury; AITB, Army Individual Test Battery; CTMT, Comprehensive Trail Making Test; TMT, Trail Making Test; US, United States

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**THE WECHSLER ADULT INTELLIGENCE SCALE (WAIS)**

|  |  |  |
| --- | --- | --- |
| Descriptive  | Method of Development | Developed from Wechsler–Bellevue Intelligence Scale (1939), which introduced splitting of FSIQ into VIQ and PIQ; developed as an intelligence test solely for adults (1955), and followed by WAIS-R (1981), WAIS-III (1997), and WAIS-IV (2008)1,3; WAIS-IV updated to improve clinical utility, developmental appropriateness, user friendliness, psychometric properties, and structural foundations2-3 |
| Purpose | 15-item (10 core and 5 supplementary subtests)1 measure of cognitive ability in adults (ages 16 to 90)2 |
| Content  | Assesses crystallized (VIQ) and fluid (PIQ) intelligence, as well as full mental ability (FSIQ)3Four subscales including:VCI – Info, Sim, and Vocab; Comp (supplemental)PRI – BDT, MR, and VP (WAIS-IV); FW(WAIS-IV, ages 16-69 only) and PC (supplemental)WMI – DG and Arith; LNS (supplemental, ages 16-69 only)PSI – SS and DST; Cancel (WAIS-IV, supplemental, ages 16-69 only)1,3Some subtests not included in WAIS-IV: OA, PA, DST Recall (DST-Incidental Learning), and DST Copy (DST-Copy)1 |
| Response -Options | Individual subtests are completed w/ paper and pencil or computer2 |
| Recall Period | Not applicable  |
| Endorsements  | Available to individuals w/ appropriate qualification2 |
| Practical | To obtain | WAIS-IV test kit available from Pearson Education: http://www.pearsonclinical.com/psychology/products/100000392/wechsler-adult-intelligence-scalefourth-edition-wais-iv.html2 |
| Method of Administration | Pencil and paper or web-based software 2 |
| Scoring and Interpretation | Scoring can be web-based or manual2Composite scores:FSIQ – from 10 core subtests1; mean = 100, SD = 15, range = 40 to 603VIQ and PIQ – WAIS-III and prior only3Index Scores – VCI, PRI, WMI, PSI, GAI (VCI + PRI, optional)1; mean = 10, SD = 33 |
| Respondent Burden | 60-90 minutes2 (Avg. 3-15 minutes for individual WAIS-III subtests)4 |
| Admin Burden | Requires training and Level C qualification, must purchase test kit and software2 |
| Translations | English, Chinese, Danish, Dutch, Finnish, French, German, Greek, Hebrew, Hungarian, Icelandic, Italian, Japanese, Korean, Lithuanian, Norwegian, Polish, Portuguese, Spanish, Swedish5  |
| Critical appraisal value  | Strengths, cautions, clinical and research applicability  | WAIS:DST performance significantly slower for older age groups (t = 6.74; p < 0.01)6WAIS-R:BDT % Broken Configuration Errors weakly correlated w/ GCS (r = –0.26; p < 0.05); weak, NS correlations w/ age, education, and time post-injury (r = 0.05-0.10, –0.18; p > 0.05)7Lower BDT performance associated with increasing age; higher education associated w/ less decline in performance 8WAIS-III:Education and presence of intracranial lesion were significant predictors of LNS (R2 = 0.04-0.12; p < 0.05) 9Education was significant predictor of MR (R2 = 0.06; p < 0.05) 9Education and presence of coma were significant predictors of SS(R2 = 0.04-0.21; p < 0.05) 9Scores on tests involving information processing speed and perceptual organization seen to decrease with increasing age while verbal scores show minimal change 10 |

Arith, Arithmetic; BDT, Block Design Test; CAT, Category Test; CDN, Canadian; Comp, Comprehension; COWAT, Controlled Oral Word Association Test; DG, Digit Span; DST, Digit Symbol Test/Digit Symbol Coding/Coding; ESAT, Everyday Spatial Activities Test; FR, Free Recall; FSIQ, Full Scale Intelligence Quotient; FP, Family Pictures; FW, Figure Weights; GAI, General Ability Index; IQ, Intelligence Quotient; LM, Logical Memory; LNS, Letter Number Sequencing; MR, Matrix Reasoning; MRI, magnetic resonance imaging; NS, non-significant/non-significantly; OA, Object Assembly; PA, Picture Arrangement; PASAT, Paced Auditory Serial Addition Test; PC, Picture Completion; PIQ, Performance Intelligence Quotient; PPVT, Peabody Picture Vocabulary Test; PRI, Perceptual Reasoning Index; PSI, Processing Speed Index; RCFT, Rey Complex Figure Test and Recognition Trial; RMT, Road Map Test; SD, standard deviation; Sim, Similarities; SRA, Science Research Associates; SS, Symbol Search; STM, short-term memory; TBI, traumatic brain injury; TMT, Trail Making Test; VCI, Verbal Comprehension Index; VFD, Benton Visual Form Discrimination Test; VIQ, Verbal Intelligence Quotient; Vocab, Vocabulary; VP, Visual Puzzles; VPA, Verbal Paired Associates; VR, Visual Reproduction; WAIS (-R/III/IV), Wechsler Adult Intelligence Scale (-Revised/Third Edition/Fourth Edition); WBIS, Wechsler–Bellevue Intelligence Scale; WIAT-III, Wechsler Individual Achievement Test-Third Edition; WM, Working Memory; WMI, Working Memory Index, WMS-III, Wechsler Memory Scale-Third Edition; WRAT, Wide Range Achievement Test

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**THE WECHSLER MEMORY SCALE (WMS)**

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| --- | --- | --- |
| Descriptive  | Method of Development | WMS developed in 1945 by adapting existing memory tests and combining with normative data; revisions include WMS-R (1987), WMS-III (1997), and WMS-IV (2009); WMS-IV updated to improve clinical utility, administration time, test items, and scoring rules; WMS-IV scores derived for Older Adult Battery (65-90) and Adult Battery (16-69)1 |
| Purpose | To assess various domains of memory, including STM, LTM and WM1, in persons aged 16 to 902 |
| Content  | Standard WMS-IV subtests – LM I and II, VPA I and II, Designs I and II, VR I and II, SA, SSStandard WMS-IV indexes – IM, DM, AM, VM, VWMSubtests not included in standard WMS-IV battery – Logos I and II, Names I and IIIndexes not included in standard WMS-IV battery – VIM, VDM, AVM, AVIM, AVDM3Subtests removed from WMS-IV (previous versions only) – I&O, SpS, MC, Faces, DG, FP, LN, WL2 |
| Response -Options | Individual subtests are completed w/ paper and pencil or computer2 |
| Recall Period | Not applicable  |
| Endorsements  | Available to individuals w/ appropriate qualification2 |
| Practical | To obtain | WMS-IV test kit available from Pearson Education: https://www.pearsonclinical.com/psychology/products/100000281/wechsler-memory-scale--fourth-edition-wms-iv.html2 |
| Method of Administration | Pencil and paper or web-based software2 |
| Scoring and Interpretation | Scoring can be web-based or manual1Five composite scores: AM, VM, VWM, IM, DMContrast scores (WMS-IV) – scores on one subtest scaled based on performance on a related subtest1-2 |
| Respondent Burden | WMS-III – 30 to 35 min (primary subtests) + 15-20 min (supplemental subtests)1 |
| Admin Burden | Requires training and Level C qualification, must purchase test kit and software2 |
| Translations | English, Chinese, Czech, Danish, Dutch, Finnish, French, German, Italian, Japanese, Korean, Norwegian, Spanish, Swedish4 |
| Critical appraisal value  | Strengths, cautions, clinical and research applicability  | WAIS-R:VIQ and PIQ were significant predictors of VeM score5VIQ, PIQ, gender, # drugs, education, and seizure type were significant predictors of VM score5VIQ, PIQ, and gender were significant predictors of GM score5 |

AL, Associate Learning; AM, Auditory Memory; AVDM, Auditory-Visual Delayed Memory; AVIM, Auditory-Visual Immediate Memory; AVM, Auditory-Visual Memory; DG, Digit Span; DM, Delayed Memory; DR, Delayed Recall; FP, Family Pictures; GM, General Memory; IM, Immediate Memory; IMIS, Inpatient Memory Impairment Scale; I&O, Information & Orientation; LM, Logical Memory; LN, Letter Number; LTM, long-term memory; MC, Mental Control; MQ, Memory Quotient; PIQ, Performance Intelligence Quotient; PTA, post-traumatic amnesia; SA, Spatial Addition; SpS, Spatial Span; SS, Symbol Span; STM, short-term memory; TMT, Trail Making Test; VDM, Visual Delayed Memory; VeM, Verbal Memory; VIM, Visual Immediate Memory; ViPA, Visual Paired Associates; VIQ, Verbal Intelligence Quotient; VM, Visual Memory; VPA, Verbal Paired Associates; VR, Visual Reproduction; VWM, Visual Working Memory; WL, Word List; WM, working memory; WAIS-I/R/III/IV; Wechsler Adult Intelligence Scale-First/Revised/Third/Fourth Edition; WMS-I/R/III/IV; Wechsler Memory Scale-First/Revised/Third/Fourth Edition

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