Cognitive Assessments and Neuropsychology

CHAPTER 2

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Neuropsychology as a discipline, examines how an individual's cognition, emotion and behaviour, relate to brain function, both in health and disease. A neuropsychological assessment involves a range of psychometrically-validated tasks designed to probe different domains of cognition, providing a profile of intact functions and areas of weakness (or deficit) with the aim of characterising specific cognitive-behavioural syndromes, help clarify diagnoses and provide recommendations for a tailored care plan. The Diagnostic and Statistical Manual of Mental Disorders (DSM-V) defines 6 cognitive domains[1] (see Table 1), although this is only one of a range of classifications of cognitive domains[2]. Each of the 6 cognitive domains have well defined biological substrates, and are anatomically and functionally linked, for example executive functioning plays a role controlling the utilisation of other lower cognitive functions such as attention and memory.

The cognitive domains are comprised of subdomains that represent different cognitive processes (see Figure 1), and assessments are generally targeted at subdomains from each of the major cognitive domains. A careful combination of tasks can identify specific patterns that are related to neuropsychiatric disorders. The subdomains are explained in greater detail later in this chapter.

Social cognition

- Recognition of emotions
- Theory of mind
- Insight

Complex attention

- Sustained attention
- Divided attention
- Selective attention
- Processing speed

Learning and memory

- Free recall
- Cued recall
- Recognition memory
- Semantic and autobiographical long-term memory
- Implicit learning

Perceptual-motor function

- Visual perception
- Visuoconstructional reasoning
- Perceptual-motor coordination

Language

- Object naming
- Word finding
- Fluency
- Grammar and syntax
- Receptive language

Executive function

- Planning
- Decision-making
- Working memory
- Responding to feedback
- Inhibition
- Flexibility

Figure 1: Neurocognitive domains and their subdomains as defined by the Diagnostic and Statistical Manual of Mental Disorders 5th edition. (DSM-5). Figure adapted from Sachdev PS, Blacker D, Blazer DG, et al. Classifying neurocognitive disorders: the DSM-5 approach. *Nat Rev Neurol.* 2014;10(11):634-642. doi:10.1038/nrneurol.2014.181.

Table 1 – SAMPLE for cognitive domains

S - Social cognition

A - Attention (Complex Attention)

M - Memory and Learning

P - Perceptual-Motor

L - Language

E - Executive function

Requesting the Neuropsychological Assessment

The utility of a neuropsychological assessment depends partly upon the quality of the initial clinical assessment and referral, and this onus lies upon the primary neuropsychiatrist (or another referrer). When making a referral, the clinician should set out a clearly formulated question and understand how the answer to the question will alter clinical decision making. The referral should include key information about the patient including reason for the request and referral questions, detailed history and a description of the current clinical state.

Referral questions may be focussed on cognition as it relates to diagnosis (e.g. Is the patients profile of cognitive deficits consistent with a dementia subtype?), behaviours (e.g. Is there a cognitive deficit secondary to the patient's stroke that is likely to impair medication compliance?), prognosis (e.g. Given the current cognitive state of the patient how are they likely to progress?), functioning (e.g. What supports or modifications is the patient likely to need with their profile of cognitive deficits?) and capacity (e.g. Does the patient have the cognitive ability to make decisions independently or with support?)[3].

Full neuropsychological assessments generally take several hours and for a valid assessment requires an engaged and cooperative patient, who is giving their best performance. A true picture of patient cognitive capacity cannot be gained with patients who are not interested, who are badly fatigued, severely drug affected, psychotic/manic, highly depressed/anxious, physically unwell, or seeking secondary gain. The neuropsychological assessment tries to capture the full potential or best performance of the patient to not incorrectly diagnose them as more poorly functioning than they are.

Prior to requesting a neuropsychological assessment, it is generally recommended that the treating clinician perform a cognitive screening test (e.g. MMSE, MOCA, RUDAS etc.) and include the results as part of the referral. This gives a sense of the patient's cognitive capacity and ability to engage with cognitive testing. If they are unable to complete a cognitive screening test they will not be able to complete a valid full neuropsychological assessment.

Understanding the Results of Neuropsychological Assessments

Neuropsychological tests are generally designed such that the performance within the population approximates a normal (bell shaped curve) distribution (Figure 2). Cognitive tests have a degree of inherent measurement error, and a level of variability is also expected among a person's cognitive performances. Therefore, any single test result should not be taken as a definitive characterisation of ability. It is for these reasons neuropsychologists often will not report raw scores but rather describe findings in terms of categories of ability (e.g. average, high average, above average, exceptionally high). Furthermore, understanding what are "normal" or "abnormal" scores on cognitive tests depends on the age, sex and education levels of the individual (i.e. a normal performance for a 20-year-old will be very different from a 50- or 85-year-old person), as such the computation of scaled scores, t-scores and percentiles are based on matched population norms[4,5]. Most tests have data available from normative samples adjusting or stratifying by age and education, and some will additionally adjust for sex. Normative samples ideally should also reflect other sociodemographics such as ethnicity, language and cultural background. Most available normative data are based on Caucasian, native English speakers and comparing a person of non-English speaking backgrounds with such normative samples may bias the test interpretation. The types of scoring systems used in neuropsychology are described in the Table 2 and Figure 2.

Table 2 – Scoring systems used in neuropsychological assessments

Score Type	Description
Raw Scores	The direct score from the test (e.g. number correct, time to finish). This does not account for age, sex or education but can provide useful context in interpreting performance.
Z-scores	Indicates how many standard deviations a test score is from the mean, with the mean and standard deviation taken from a normative population sample.
Standard Scores/IQ	Standardised scores, based on a normative population sample, with a mean score of 100 and a standard deviation of 15, that is widely used for IQ and overall cognitive indices.
T-scores	Standardized scores, based on a normative population sample, with a mean score of 50 and standard deviation of 10, often used in neuropsychology and personality testing.
Scaled Scores	Standardized scores, based on a normative population sample, commonly used for cognitive subtests (e.g. WISC, WAIS), with a mean score of 10 and standard deviation of 3.
Percentile	The percentage of the normative sample scoring below the individual. This is advantageous because it is easily understood by patients and families but is limited in that percentiles are not equal interval differences (e.g. the difference between the 1st and 5th centile is much larger than the difference between the 51st and 55th centile.)
Verbal Description	Qualitative labels attached to score ranges (e.g. Exceptionally high ~ > 98th centile, Average ~ 25 – 75th centiles, exceptionally low < 2nd centile)

Table 3 – Equivalent scores from the different scoring systems with consensus descriptors from Guilmette et al (2020)[6] and Strauss, Sherman & Spreen (2006), *A Compendium of Neuropsychological Tests: Administration, Norms & Commentary*, Oxford University Press

Verbal Description	Z Score Range	T Score Range	Scaled Score Range	Standard Score Range	Percentile Rank Range
Exceptionally high score	≥ +1.96	≥ 70	≥ 16	≥ 130	≥ 98
Above average score	+1.4 to +1.9	64 to 69	14 - 15	120 to 129	91 to 97
High average score	+0.7 to +1.3	57 to 63	12 - 13	110 to 119	75 to 90
Average score	-0.6 to +0.6	44 to 56	8 - 11	90 to 109	25 to 74
Low average score	-1.3 to -0.7	37 to 43	6 - 7	80 to 89	9 to 24
Below average score	-2.0 to –1.4	30 to 36	4 - 5	70 to 79	2 to 8
Exceptionally low score	≤ -1.96	21 to 29	2 – 3	< 70	< 2

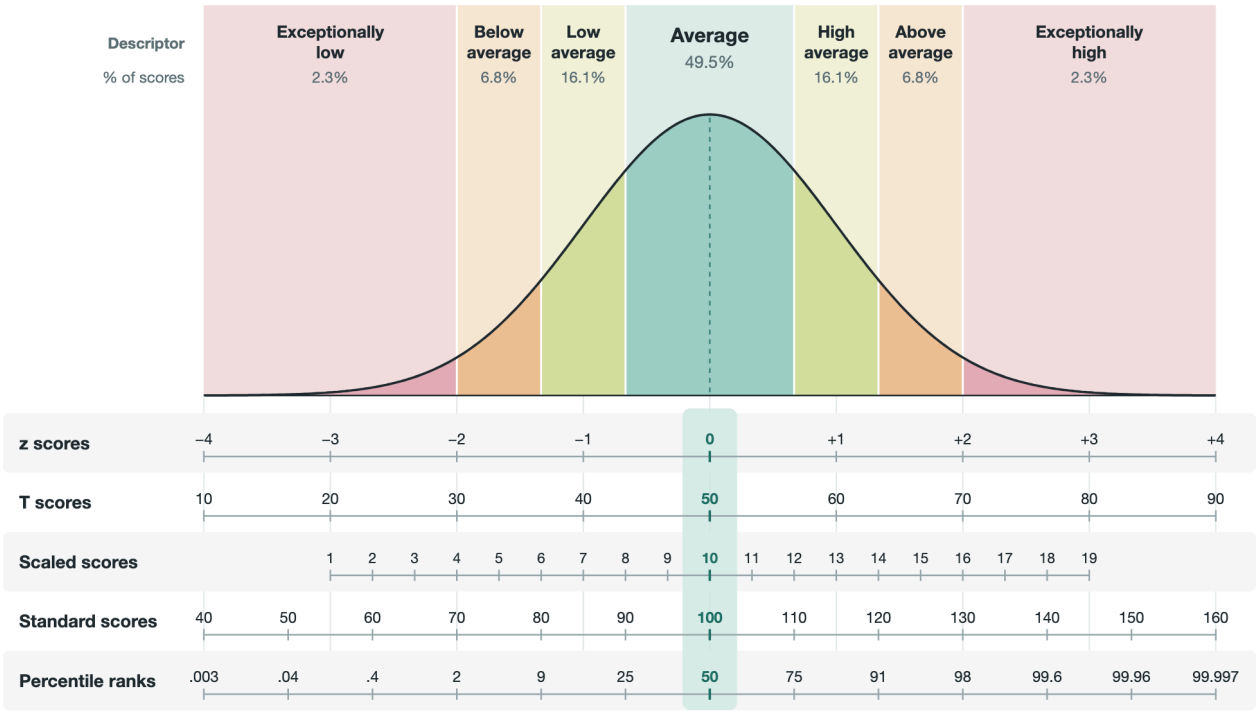


Figure 2: A normative curve, which displays the distribution of scores around the mean. The figure shows the relationships between different normative scores, with each having a different mean and standard deviation. Image based on and adapted from Dombrowski, S.C. (2020). Assessment Results. In: Dombrowski, S. (eds) Psychoeducational Assessment and Report Writing. Springer, Cham. https://doi.org/10.1007/978-3-030-44641-3_9

There is no set battery of neuropsychological tests which clinicians apply universally but rather more clinicians will use a fixed flexible approach[7]. In this approach clinicians will deliver a set of core tests across cognitive domains with demonstrated widespread applicability across possible diagnoses. As performance on each test is evaluated in the context of the clinical history, sociodemographic background and observed behaviours, hypotheses are formed and tested using further selected tests.

Neuropsychological evaluations extend beyond cognitive functioning and frequently employ measures of emotional functioning (especially anxiety and mood), personality questionnaires, sleep, pain and fatigue symptom scale ratings, as well as tests of

effort and consistency. These inform the validity of the testing, importantly driving diagnostic hypotheses, as all these features may impact test performance.

As well as informing the diagnosis, neuropsychological assessments typically also provide recommendations on optimal compensatory strategies and environmental modifications, and suggestions for management including discharge home, return to work or education. These recommendations are normally delivered to the patient in a separate feedback session in which the results of the tests are also given to them.

Cognitive screening tests

Cognitive screening tests will be the main form of cognitive assessment for the non-neuropsychologist clinician. The Mini-Mental State Examination (MMSE)[8] is the most widely used cognitive test in the world and is the primary cognitive screening tool in many jurisdictions. It was originally designed to differentiate dementia related cognitive deficits from other psychiatric disease. It generally takes less than 10 minutes and scores of 25 or below (out of 30) are suggestive of cognitive deficits. It is heavily weighted towards memory/working memory (37%) and orientation (33%), while there are brief tests of language and visuospatial functions, assessment of executive functioning is ignored. Given this, the MMSE can be insensitive to executive and processing speed deficits seen in conditions such as Fronto-temporal dementia and subcortical Vascular Dementia[9].

The Montreal Cognitive Assessment (MoCA)[10] is similarly scored out of 30 and takes around 10 minutes but it has a more even distribution of scores amongst cognitive domains including visuospatial/executive (23%), orientation (20%), attention (20%), memory (17%), language (10%) and naming (10%). Compared to the MMSE, the MOCA has a higher cut-off of 26/30 for MCI with a sensitivity of ~90% and a specificity of ~87%.

The Rowland Universal Dementia Assessment Scale (RUDAS)[11] is another cognitive screening tool, scored out of 30, that has a particular strength of cross-cultural validity. It was developed in 2004 in response to criticism that extant cognitive measures were unfairly biased against those with English as a second language. The RUDAS has different spread of scores with emphasis on visuospatial skills (27%), memory (27%), language (27%), judgement (13%) and praxis (7%), without any direct measurement of executive function, attention or orientation.

The Addenbrooke's Cognitive Examination-III Revised (ACE-III)[12] is a more detailed brief cognitive screening test, that gives specific scores on cognitive subdomains. It is scored out of 100 and usually takes around 20 minutes. The subdomains tested include memory (26%), language (26%), attention (18%), visuospatial (16%), and fluency (14%). Cognitive impairment has traditionally been identified on the ACE-III using cut-scores, with scores below 88 yielding good sensitivity ranging from 86%-97% for dementia but variable specificity ranging from 50%-96%, while a more conservative cut-off of 82 yields sensitivity of 74%-93% and specificity of 96%-100%[13,14,15,16]. These cut-offs should be applied with caution, they are not singularly diagnostic, as cognitive screening tests are only one element of a dementia work-up. The broader range of scores in the ACE-III circumvents ceiling and floor effects and means that cognitive change can be more closely measured in repeat assessments. While there may be small "practice effects" (i.e. improvements on test scores because of repeated test practice), these have been found to be minimal in the ACE-III and a change of 5 points or more reliably indicates clinically meaningful worsening or improvement[17].

Testing Neuropsychological Domains

Neuropsychological assessment examines specific cognitive domains as a way of understanding the regions and networks more affected in brain pathology. Each cognitive test should be understood not as a "pure" measure of a single domain, but rather as a measure covering multiple domains, although one domain or subdomain is predominant. This comprehensive examination of cognitive domains may take 2 to 3 hours, and breaks are provided to address potential issues with motivation and cognitive fatigue. Sometimes the assessment will be provided over 2 or more sessions. It is important that referring clinicians explain that the assessment is comprehensive and therefore takes considerably longer than the brief cognitive screens used by non-neuropsychologists.

Assessment of premorbid intelligence

Performance on cognitive tests is associated with premorbid intelligence and cognitive decline may be masked in those with high baseline IQ. Therefore, an estimate of premorbid general cognitive function can be used as a benchmark against which performance on other cognitive tests is interpreted. The simplest method to estimate premorbid ability is to use vocational and educational achievement, although this provides only a rough approximation and is determined by many other factors (e.g. socioeconomic status, educational opportunity etc.). Other common approaches include using standardised tests of word-reading ability (e.g. the National Adult Reading Task (NART)[18], Test of Premorbid Functioning[19] and the Reading subtest from the Wide Range Achievement Test[20]). Each of these tests generally examine the pronunciation of words (e.g. cello, knead, gnat) that cannot be read correctly by the use of regular phonetic rules and so can only be understood by prior usage and exposure. This ability to read irregular words reflects lifetime learning/literacy, correlates well with general intelligence and shows relatively little decline with aging. While the decline in irregular word reading is relatively spared in aging it has been shown to decline in AD and MCI[21,22] and so should be considered alongside pre-morbid demographic factors (e.g. educational level, occupational complexity). These assessments can be used to estimate a baseline IQ against which other cognitive domain scores can be benchmarked. In neuropsychological assessment "scattering" of scores is often indicative of an abnormality, meaning that an individual with an estimated premorbid IQ, processing speed and attention scores all two standard deviations above the mean (i.e. 130), who then has a memory and learning score half a standard deviation below the mean but still within the average range, may be considered abnormal.

Memory and Learning

Memory is one of the most common subjective cognitive complaints by patients and carers seeking assessment. There are a range of subtypes of memory that are subserved by overlapping but distinctive areas and networks of the brain. Memory can be divided into Short-term, Non-declarative and Declarative[23], with further divisions of Procedural and Priming Implicit memory as well as Episodic and Semantic Explicit Memory (Table 4 and 5 for descriptions).

Table 4 – Subtypes of Memory

Time	Group	Subtype	Description
Long-term	Non-declarative	Procedural	Automatized motor tasks/skills (e.g. buttoning a shirt, walking, driving) and habits that are not consciously retrieved
		Priming	Past emotional experiences unconsciously shape the bodily and emotional reactions to new stimuli
	Declarative	Episodic	Ability to learn, store and recall stories, events or narratives, includes details about time, context and place
		Semantic	Memory for factual knowledge, such as historical facts, object features and categories, time and place information is typically not known.
Short-term	Working memory		Mental workspace that briefly holds and manipulates information in mind for ongoing use such as following instructions, keeping the thread of what is read or heard (30 seconds – 1 minute).

Table 5 - Mnemonic for types of memory

PESSt

Procedural/**P**riming (Long term-implicit)

Episodic (Long term-explicit)

Semantic (Long term-explicit)

Short-**T**erm (Working memory)

Long-term memory involves three distinct processes or stages (**Mnemonic - EnCoRe**) **En**coding, **Co**nsolidation and **Re**trieval[24].

1. Encoding – the uptake or learning of new information such as names, faces or a movie. In this step sensory and cognitive information (e.g. sights, sounds, meaning) is transformed into neural signals.
2. Consolidation – storage or maintenance of the new information. The neural signals are stored as physical and electrochemical changes in the neurons and synapses, with regular repetition/usage improving the consolidation of the memory.
3. Retrieval – the memory is recalled either automatically or with deliberate searching, using a memory trace and some executive functions. Retrieval can be supported by cues, reminders or associated concepts.

The particular type of memory and subprocess affected is important for differential diagnosis and will help guide the recommendations of the neuropsychologist on how to support patients. For example, the primary presentation of early-stage Alzheimer's disease are deficits in encoding and consolidation of new information (i.e. learning) and not in retrieval of older memories[25]. Given this, a neuropsychologist may identify strategies of repeating information, writing it down, and utilising clear visual displays to support encoding in such cases.

Neuropsychological tests of memory vary widely, examining non-contextual verbal information (e.g. random word lists), contextual verbal information (e.g. stories), simple visual figures (e.g. identifiable shapes), and complex visual figures (geometrically variegated images). The Rey Auditory Verbal Learning Test (RAVLT)[26] and California Verbal Learning Test (CVLT)[27] are both commonly used non-contextual verbal learning tests of 15 or 16 words, assessing encoding, consolidation and retrieval over multiple rounds of learning, immediate recall and then delayed recall and recognition memory. The Wechsler Memory Scale (WMS)-5th Edition includes a specific test of contextual story recall, amongst other subtests (e.g. word pairs, designs). The WMS Visual Reproduction Test examines memory of an array of simple shapes and figures, while the Rey-Osterrieth Complex Figure Test, assesses the immediate and delayed recall of a complex figure. As well as asking participants to recall content themselves (spontaneous recall), memory tests often provide cues (cued recall) or ask participants to discriminate previously seen material from new material (recognition). If participants are unable to recall spontaneously but can recall with cues or can recognise material, it implies memory consolidation has occurred and memory retrieval specifically is deficient. For example, in Alzheimer's disease, typically, retrieval cues are not helpful as the information is not stored in the first place while in Vascular Cognitive Impairment, cues will facilitate recall of the information that has been stored.

Executive Function

Executive functions are a range of related regulatory and control processes involved in the "selection, initiation, organisation, execution and monitoring of goal directed behaviour"[28] [29]. The functions include planning and organising activities towards an end goal, self-initiating decisions, inhibition of impulses and ability to flexibly switch between tasks when demands change. Monitoring and updating of working memory representations is also incorporated in some models of executive functioning[30,31]. It is an essential function for the higher order functions of judgement, choice and self-awareness.

There are many tests designed to examine these subfunctions of executive function. The Trail-Making Test B requires the individual to join circles containing either a letter or number in alternating, ascending order. The natural inclination after seeing a number is to look for the next number, and so the task tests inhibition and flexibility in requiring the participant to switch to looking for a letter[32]. The test, usually timed, also tests processing speed and attention function. The Stroop Colour-Word Interference Test[33] presents the names of colours written in incongruent colour text (e.g. the word green written in red ink) and requires inhibition of the impulse to read the word but rather say the colour that it is written in.

Most cognitive tests use structured tasks with detailed instructions but some complex executive tests provide less instruction and require self-initiation, planning, problem solving and flexible use of feedback, all elements of executive function. For example, the Wisconsin Card Sorting Test[34] requires participants to infer the rules by which a deck of cards should be sorted through pattern recognition, but without informing the participant the examiner changes the sorting rules requiring the participant to independently and flexibly shift their sorting behaviour. The Tower of London test[35] similarly examines working memory, planning and foresight, requiring the participant to move rings from one stack to another to match the configuration of the examiner while following particular rules (e.g. smaller rings cannot be under larger rings, only one ring can move at a time).

These tests are limited in that they do not examine all facets of executive function, they frequently rely on other domains (e.g. processing speed and attention) and they are rarely a direct test of one's ability to make "real-world", complex life plans and decisions[36]. Thus, those with executive dysfunction may still perform well on such tests. Tests such as the Behavioural Assessment of the Dysexecutive Syndrome[37], present participants with real-world scenarios and challenges to improve ecological validity. Similarly, the Behaviour Rating Inventory of Executive function[38] and the Frontal Systems Behaviour Scale[39] are standardised rating scales, usually completed by a carer or family member, and used for collateral evidence of executive dysfunction in everyday life. Executive dysfunction has been traditionally associated with frontal lobe damage, although there is increasing evidence that executive functions are subserved by a multiplicity of neural networks including the frontal, parietal and temporal lobes as well as subcortical regions.

Complex Attention

Attention is the act of focussing your mind, thoughts or senses on a specific thing, while ignoring other stimuli. The broad category of attention is comprised of **Di**vided, **Su**stained, **Se**lective, and **P**rocessing **S**peed (Mnemonic - **DiSuSe PS**):

- **Di**vided Attention – ability to split focus, share or allocate attention to two or more tasks performed simultaneously.
- **Su**stained Attention – the ability to stay alert to a single task over a long period of time.
- **Se**lective Attention – capacity to focus on and select relevant information and screen out distractors or competing stimuli
- **P**rocessing **S**peed – The speed at which tasks can be performed

Reduced processing speed and attention are commonly associated with normal aging as well as many pathologies including dementia, depression, schizophrenia and of course Attention Deficit Hyperactivity Disorder (ADHD). Most tests of attention engage more than one type of attention process and there can be considerable overlap with executive functions.

In the Paced Auditory Serial Addition Test (PASAT), participants listen to a series of numbers and add each new number to the one presented immediately before it. It has been described as a test of divided attention but also measures working memory, sustained attention and processing speed[40]**.** Sustained attention, often poor in ADHD patients, can be tested using the Conners' Continuous Performance Test[41], a 14-minute cognitive test requiring participants to respond quickly to presentation of letters on the screen but withhold their response when an X appears, testing for inattention and impulsivity over the testing period. Many tests of attention have time limits or are timed and thus also measure processing speed. The Digit Symbol Substitution or Coding test asks participants to translate as many digits to irregular symbols as possible within 2 minutes. The Symbol Search subtest of the Wechsler Adult Intelligence Scale (WAIS) uses a similar approach to test attention, processing speed, and visual pattern discrimination. Such timed tests, like many processing speed tests, are also influenced by motor speed (i.e. nerve/muscle function, dexterity and fine motor control) and visual acuity. These should be considered as potential confounders.

Visuoconstruction and Perceptual-Motor

Visuoconstruction (including visuospatial) abilities refer to the capacity to integrate visual-perceptual and spatial information, to reproduce or assemble drawings, copies or constructions. They require an understanding of how parts can be fit together using fine motor skills. They involve a range of brain networks, predominantly in the right hemisphere, including the parietal, occipital and posterior temporal lobes[42]. On average, males tend to have better visuospatial performance, while females have better language and episodic memory[43].

Visuospatial and visuoperception deficits can present clinically in a number of ways including visual distortions, object or facial agnosias, visual neglect, poor spatial navigation and topographic orientation. The most common visuoconstruction test is the Clock Drawing Test (Figure 3), which requires the correct drawing of clock contours, numbers and placement of hands. This is a complex task that can reveal visual attention and spatial distortions including visual neglect, degradation of semantic representation of a clock face, and disturbance to executive abilities like planning.

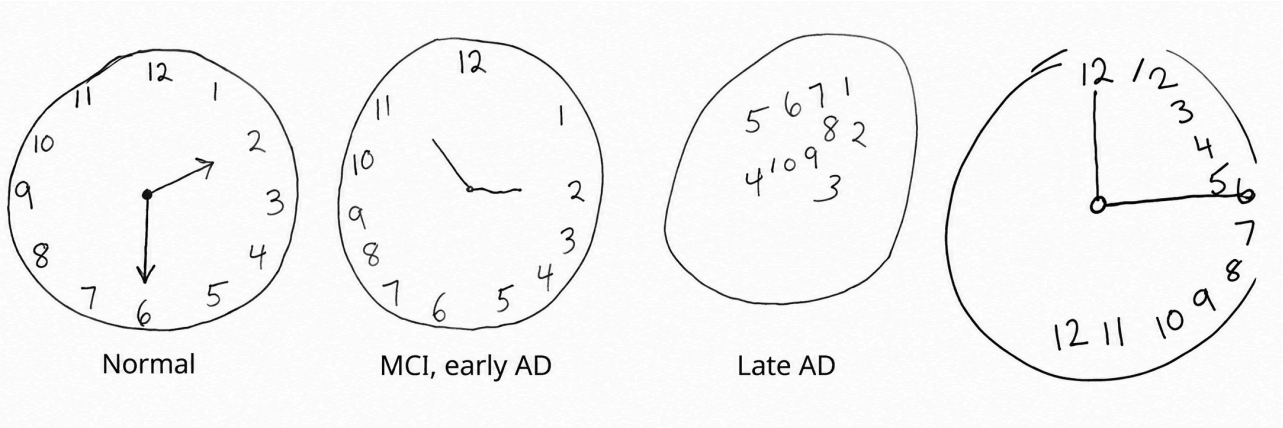


Figure 3: Clock Drawing Test examples showing normal, MCI, AD and (far right) hemi-neglect abnormalities. Attribution to Mattson M, CC BY 3.0, via Wikimedia Commons.

Another commonly used test is the Block Design Subtest[44] of the WAIS, which requires participants to physically arrange coloured blocks to match increasingly complex 2-dimensional visual patterns. These tests, amongst others, may be confounded by motor impairment (e.g. arthritis or Parkinson's disease). As such the use of visuospatial tests that do not require motor ability may help differentiate such visuospatial deficits from motor ones. The Benton Judgement of Line Orientation[45], is one such non-motor visuospatial task, requiring participants to match an angled line to a line at the same angle from 11 possible options. Visuoconstruction/visuospatial abilities can be examined with a range of tasks including discrimination of forms, angles, faces and familiar objects or the spatial ability to integrate and arrange pieces into an identified whole.

Perceptual-motor tests may examine manual motor speed, dexterity, coordination and more generally praxis. Praxis refers to the ability to perform coordinated motor movements for the completion of a particular task (e.g. dressing, brushing teeth etc.). Perceptual-motor skills may be impaired in a variety of neuropsychiatric conditions including stroke, TBI, depression and Parkinsons Disease. The most commonly employed tests including the Finger Tapping Test[46] and the Grooved Pegboard Test[47]. In the Finger Tapping Test the participant simply presses a lever as many times

as possible within 10 seconds, with separate trials for the index finger on each hand. In the Grooved Pegboard test, the participant must insert pegs by correctly orienting into grooved holes as fast as possible, with the dominant then nondominant hand. Apraxia can be tested in the clinical examination asking participants to pretend to perform tasks such as dressing, driving, or washing dishes.

Language

Language is perhaps the most uniquely human element[48] of the domains and is an essential part of a cognitive assessment. Language tests examine the various subprocesses including confrontation naming, comprehension, expression, repetition and prosody. Aphasias may present as deficits in any of these capacities (e.g. anomic, receptive, expressive, and conduction aphasias) and represent lesions to particular regions of the brain. The Boston Naming Test[49] is a 60-item image-based confrontation naming test and is one of the most used in assessment. The Controlled Oral Word Association Test (COWAT)[50] requires participants to list as many words as possible starting with the letters F, A and S in one minute each, testing Letter Fluency. Similarly, Semantic (Category) Fluency tests ask participants to list as many animals, fruits or other category in one minute. A more comprehensive and focussed language test would be the Boston Diagnostic Aphasia Examination[51] which includes a battery of tests including measures of expression, comprehension, repetition, fluency, reading, writing, and naming.

Social Cognition

Social Cognition describes the processes by which individuals perceive, interpret and process social information[52,53]. These processes allow persons to attend to specific emotional/social cues (e.g. facial expression and tone), decode underlying intentions, behave in accordance with social mores, and apply heuristics to work within social roles. Broadly, it is categorised under four functions:

1. Social Perception – Recognising of emotional cues
2. Theory of Mind – Capacity to understand what others are thinking and feeling
3. Affective empathy – Emotional response to the perceived situation of another
4. Social behaviour – Communication and behaviour in social interactions.

Social cognition deficits are very common among a wide range of neuropsychiatric conditions. It is still emerging as a cognitive domain but has been increasingly recognised in formal diagnostic manuals as a critical element of cognition (e.g. the DSM-V[54]). Assessment of social cognition deficits are often not included in clinical neuropsychological examinations as well-validated comprehensive examination of all four domains are not readily available and tests are lengthy to administer. Briefer measures have been validated for schizophrenia disorders. There are a several validated social cognition batteries[55] (e.g. Brief Battery of the Social Cognition Psychometric Evaluation Study (BB-SCOPE)[56] validated for schizophrenia) which variously require participants to recognise emotions in facial expression and vocal tone, to evaluate

inferred intentions from social situations, to interpret conversations including sarcasm, lies and jokes and to make social decisions in challenging situations.

Tests of Effort, Consistency and Comorbid emotional difficulties

Within neuropsychological evaluations participants may present with test scores consistent with a neurocognitive disorder that may in fact be driven by primary psychiatric conditions (e.g. major depressive disorder, anxiety disorders, functional cognitive disorder, factitious disorder or malingering). As such it has become standard of practice to include assessments of test-taking effort or performance validity tests (PVTs), particularly in medicolegal or disability cases. The concept of most PVTs is that they appear cognitively difficult when actually they are simple for most healthy and even clinical populations, and as such very poor or inconsistent performance may suggest functional impairment, low effort, or deliberate mistakes (e.g. factitious disorders). Many testing batteries having embedded PVTs allowing for contemporaneous assessment of performance and effort (e.g. WAIS-IV Digit span subtest, the California Verbal Learning Test (CVLT) Forced-Choice Recognition and Trail Making Time A vs B completion times). There are also several stand-alone tests of effort including the Test of Memory Malingering (TOMM) and the Word Memory Test. In most neuropsychological evaluations a combination of stand-alone and embedded PVTs are recommended. Mood disturbances, anxiety disorders, and test-taking anxiety can also impact test performance and thus it has become standard to use validated measures of psychiatric symptom burden. Some of the most common include the Depression Anxiety and Stress Scale-21, the Beck Depression Inventory-II, the Geriatric Depression Scale and the Patient Health Questionnaire.

Typical Presentations and Example Datasheets

To give a more practical demonstration of the utility of neuropsychological assessment we have included four example datasheets (see after the Chapter Summary). These show examples of cognitive test profiles for the following neurocognitive disorders.

Case 1 - Amnestic Alzheimer's Disease: A 74-year-old female with a bachelor's degree and high average premorbid intellectual function. The neuropsychological profile shows marked deficits in episodic memory (verbal and visual), with particularly poor learning (encoding, consolidation) on the verbal learning trials. Other domains including language, attention/processing speed, visuospatial ability and aspects of executive function are relatively better preserved. Episodic memory measures are among the strongest neuropsychological markers of Alzheimer's disease[57].

Case 2 - Subcortical Vascular Mild Cognitive Impairment (MCI): An 80-year-old male with a high school level of education and average to high-average level of intellectual function. He had a medical history of high cholesterol, hypertension, diabetes and smoking as well as an 18-month history of slowing gait and falls. Activities of daily living were generally preserved. Neuropsychological testing revealed cognitive slowing and a mild disturbance of executive functions affecting planning and organisation and complex attention. Learning of less well-structured information is slightly reduced however memory consolidation and retrieval are generally well preserved.

Case 3 - Frontotemporal dementia: A 69-year-old female with a middle-school level of education and an estimated high average level of pre-morbid function. There had been increasing apathy, impulsivity, disorganisation and paranoia. The pattern on memory testing suggested her memory impairments were secondary to high level difficulties with attentional and executive functioning rather than primary difficulties with memory encoding and storage. There are additional mild reductions in working memory, processing speed, and word retrieval. The picture is characteristic of a dysexecutive syndrome, evidenced by perseveration, distractibility, impulsivity and attentional dyscontrol during the assessment. She presents with features characteristic of behavioural variant fronto-temporal dementia, including the neuropsychological profile and change in alcohol consumption pattern, and apathy.

Case 4 - Logopenic primary progressive aphasia (PPA): A 59-year-old female with high school education and average level of pre-morbid cognitive function. The cognitive profile reveals severe deficits in memory and language particularly noted in tests such as the Boston Naming and Sentence Repetition. Executive function, attention and visuospatial test scores are relatively preserved. Logopenic PPA is a rare variant of AD pathology with prominent language deficits, “tip of the tongue” word finding difficulties.

Conclusion

Neuropsychological assessment provides a structured way of translating cognitive symptoms into clinically meaningful patterns of impairment, helping clinicians move beyond a single test score to understand how cognition, behaviour, emotional state and everyday functioning interact. The differing patterns of strengths and weaknesses of the six cognitive domains can assist with diagnosis as well as guide recommendations for optimising function. Neuropsychological tests are rarely “pure” measures of a single cognitive ability and must always be interpreted in the context of premorbid ability, demographic factors, psychiatric and physical health, effort, fatigue and functional history. For clinicians, the goal of this cognitive assessment is to understand which processes are affected, and what this means functionally for the patient in everyday life**.**

Chapter Summary

- **Neuropsychology links brain function with cognition and behaviour.** Neuropsychological assessment uses a range of tasks to examine cognitive abilities and identify patterns of impairment that may reflect dysfunction in particular brain regions or networks.
- **There are six DSM-5 cognitive domains (SAMPLE) S**ocial cognition, **A**ttention (complex attention), **M**emory and learning, **P**erceptual-motor abilities, **L**anguage and **E**xecutive function.
- **A good referral question is essential –** Referring clinicians should clearly define their referral question —whether this concerns diagnosis, behaviour, prognosis, functional abilities or decision-making capacity. A clinical history and an initial cognitive screen should accompany the referral.
- **Interpret scores against appropriate norms rather than in isolation.** Age, sex, education and premorbid IQ influence cognitive test performance, and results may be expressed as z-scores, T-scores, scaled scores, standard scores/IQ, percentiles, qualitative categories and scores relative to IQ.
- **Think of neuropsychological assessment as a "fixed-flexible" process.** There is no universally applicable battery. Core tests can be combined with additional tests selected according to the clinical history and emerging hypotheses. Assessment should also consider mood, anxiety, sleep, pain, fatigue, effort and performance validity.
- **Cognitive screening is not the same as comprehensive neuropsychological assessment.** The MMSE is brief but disproportionately assesses orientation and memory and may miss executive and processing-speed deficits. The MoCA provides broader coverage, while the RUDAS has particular cross-cultural utility and the ACE-III provides more detailed assessment of cognitive subdomains.
- **Memory tests examine a range of memory subprocesses.** Episodic and Semantic memory are long-term explicit forms; and short-term working memory provides a mental workspace for briefly holding and manipulating information.
- **There are three stages within long-term memory (EnCoRe): En**coding, **Co**nsolidation and **Re**trieval. Identifying which stage is impaired can guide both diagnostic formulation and practical recommendations.
- **Executive function is the brain's regulatory system.** It encompasses planning, organisation, initiation, inhibition, cognitive flexibility, monitoring and problem-solving. Tests such as Trail Making Test B, Stroop, Wisconsin Card Sorting and Tower of London assess aspects of executive functioning, but performance on these tests should not be assumed to directly represent complex real-world decision-making.
- **Assessment of complex attention includes multiple subdomains (DiSuSe PS): Di**vided attention, **Su**stained attention, **Se**lective attention and **PS**—processing speed. Timed attention and processing-speed tasks may also be influenced by motor speed and visual acuity, which should therefore be considered when interpreting results.
- **Interpret the cognitive profile as a whole –** The purpose of assessment is to understand domains of impairment to translate the cognitive profiles into diagnosis, prognosis, functional understanding and practical recommendations.

Data Sheet 1 – Alzheimer's Disease Amnestic Type

Details	Age: 74	Sex: Female	Education: 15 years (Bachelor)	Estimated to be high average premorbid function	
TEST/ norms	**SKILL**	**RESULT**	**standard score**	**RANGE**	**COMMENT**

Orientation					
	Personal info, orientation, politicians	x year x date			Incorrect year (1911) & date (23rd)
Attention/Processing Speed					
Digit Span	auditory registration span				
	Basic attention span (forward span)	5	8 centile	Below average	
	Working memory	4	26 centile	Average	
Coding	Psychomotor speed		(8)	Average	
Memory					
Logical Memory Immediate	Immediate recall –structured verbal (stories)		(6)	Low average	
Logical Memory Delayed	Delayed recall		(5)	Below average	
Rey Auditory Verbal Learning Test	Verbal learning unstructured (15 word list)				
Trial 1		3	(7)	Low average	
Total Learning	Sum of recall over 5 trials	24	(3)	Exceptionally low	
Immediate recall		5	(8)	Average	
Delayed recall	Recall after 30-minute interval	0	(4)	Exceptionally Low	
Recognition	15 words + 15 distractors	7	(6)	Low average	

Visual Reproduction I	Immediate recall – geometric designs		(3)	Exceptionally low	
Visual Reproduction II	Delayed recall		(2)	Exceptionally low	
Rey Complex Figure	3-minute recall	2	<1 centile	Exceptionally Low	
Language					
Boston Naming Test	Confrontation naming	45/60	(7)	Low average	+9 after phonemic prompt
FAS	Letter fluency	42 (16, 12, 14)	(10)	Average	
Animals	Category fluency	13	(6)	Low average	
Verbal					
Information	General knowledge	15	10	Average	
Visuospatial					
Cube	3D- copying			intact	
Coils	Copying 3 coils			intact	
Clock	Construction/planning/semantic representation			Numbers well-spaced, incorrect time	
Block Design	Constructional skill	16	7	Low Average	
Executive					
Similarities	Verbal concept formation	24	12	High average	
Colour Form Sort	Concept formation & shifting				Able to do 1st sort, needed prompts to shift set
(Trail Taking Test A)	Connecting numbers	48 secs	30 centile	Average	

Trail Making Test B	Cognitive Flexibility – alternating numbers & letters	147 secs	5 centile	Below average	
Rey Complex Figure Copy	Planning (qualitative)			3 attempts, piecemeal approach	
Mood					
Geriatric Depression Scale		2/30		Normal	

Data Sheet 2 – Vascular Cognitive Impairment

Details	Age: 80	Sex: Male	Education: 12 years	Estimated average to high average premorbid function	
TEST/ norms	**SKILL**	**RESULT**	**standard score**	**RANGE**	**COMMENT**
Orientation					
	Personal info, orientation, politicians	x past PM			Adequate recount of news
Attention/Processing Speed					
Digit Span	auditory registration span				
	Basic attention span (forward span)	5		Average	
	Working memory	4		Average	
Coding	Psychomotor speed		(5)	Below average	
Trail Making Test A		87 sec	2nd centile	Exceptionally low	
Memory					

Logical Memory Immediate	Immediate recall –structured verbal (stories)		(11)	Average	
Logical Memory Delayed	Delayed recall		(11)	Average	
Rey Auditory Verbal Learning Test	Verbal learning unstructured (15 word list)				
Trial 1		3	(7)	Low average	
Total Learning	Sum of recall over 5 trials	18	< 1 centile	Exceptionally low	Flat learning curve
Immediate recall		4	(7)	Low Average	
Delayed recall	Recall after 30-minute interval	5	(4)	Below Average	
Recognition	15 words + 15 distractors	13	(10)	Average	
Visual Reproduction I	Immediate recall – geometric designs		(10)	Average	
Visual Reproduction II	Delayed recall		(7)	Low Average	
Rey Complex Figure	3-minute recall	7.5	34 centile	Average	
Language					
Boston Naming Test	Confrontation naming	51/60	(10)	Average	+4 after phonemic prompt
FAS	Letter fluency	31(12, 8, 11)	54 centile	Average	
Animals	Category fluency	17	80 centile	High Average	
Verbal					

Information	General knowledge	23	15	Superior	
Visuospatial					
Cube	3D- copying			Spatially okay, not accurate	
Coils	Copying 3 coils			intact	
Clock	Construction/planning/semantic representation			intact	
Block Design	Constructional skill	16	7	Low Average	
Executive					
Similarities	Verbal concept formation	22	12	High average	
Trail Making Test B	Cognitive Flexibility – alternating numbers & letters	241 sec	<1 centile	Exceptionally low	1 error
Rey Complex Figure Copy	Planning (qualitative)		6-10 centile	Very poor planning	
Mood					
Depression Anxiety Stress Scale				All scales in normal range	

Data Sheet 3 – Frontotemporal Dementia

Details	AGE: 69	Sex: Female	Education: 9 years	Estimated to be high average premorbid function	
TEST/ norms	**SKILL**	**RESULT**	**standard score**	**RANGE**	**COMMENT**
Orientation					
	Personal info, orientation, politicians	x day x date			

Attention/Processing Speed					
Digit Span	auditory registration span				
	Basic attention span (forward span)	9	94 centile	Superior	
	Working memory	5	54 centile	Average	
Coding	Psychomotor speed		(8)	Average	
Trail Making Test A	Psychomotor speed	69 sec	<1 centile	Exceptionally low	
Memory					
Logical Memory Immediate	Immediate recall –structured verbal (stories)		(3)	Exceptionally low	
Logical Memory Delayed	Delayed recall		(6)	Below average	
Hopkins Verbal Learning Test	Verbal learning (12 word list)				
Trial 1		5	14 centile	Low average	
Total Learning	Sum of recall over 3 trials	15	<1 centile	Exceptionally low	Multiple intrusions
Delayed recall	Recall after 20-minute interval	0	<1 centile	Exceptionally Low	
Recognition		-		Exceptionally low	Responded Y to targets & distractors
Visual Reproduction I	Immediate recall – geometric designs		(6)	Low average	impulsive

Visual Reproduction II	Delayed recall		(5)	Below Average	
Rey Complex Figure	3-minute recall	2.5	<1 centile	Exceptionally Low	Drew an unrelated diagram (from work)
Language					
Boston Naming Test	Confrontation naming	41/60	(5)	Below Average	+17after phonemic prompt
FAS	Letter fluency	27 (9, 8, 10)	(8)	Average	4 rule breaks 3 repeats
Animals	Category fluency	9	(5)	Below Average	Inefficient strategy
Visuospatial					
Cube	3D- copying			intact	
Coils	Copying 3 coils			intact	
Clock	Construction/planning/semantic representation			intact	
Block Design	Constructional skill	28	9	Average	
Executive					
Similarities	Verbal concept formation	18	7	Low average	
Colour Form Sort	Concept formation & shifting			Reduced set-shifting	Perseverative & random responses.
Trail Making Test B	Cognitive Flexibility – alternating numbers & letters	294 secs	<1 centile	Exceptionally low	
Rey Complex Figure Copy	Planning (qualitative)			Adequate	
Mood					

Depression Anxiety Stress Scale				All within normal limits	

Data Sheet 4 – Logopenic Primary Progressive Aphasia

Details	AGE: 59	Female	Education: 11 years/Secondary	Estimated to be average premorbid function	
TEST/ norms	**SKILL**	**RESULT**	**STANDARD SCORE**	**RANGE**	**COMMENT**
Orientation					
	Personal info, orientation, politicians	Oriented time & place			Unable to name PM or previous PM
Attention/Processing Speed					
Digit Span	auditory registration span				
	Basic attention span (forward span)	5	9.5 centile	Low Average	
	Working memory (backward span)	4	33 centile	Average	
Digit Symbol-Coding	Psychomotor speed/complex attention		7	Low average	
Trail Making A	Psychomotor speed		12 centile	Low Average	
Memory					
Logical Memory Immediate	Immediate recall –structured verbal (stories)		1 centile	Exceptionally low	Recalled only 1 item, repeated – recalled 2 items
Logical Memory Delayed	Delayed recall	NA			

Rey Auditory Verbal Learning Test	Verbal learning unstructured (15 word list)				
Trial 1		2			
Total Learning	Sum of recall over 5 trials	18	<1 centile	Exceptionally low	
Immediate recall		2	< 1 centile	Exceptionally low	
Delayed recall	Recall after 30-minute interval	4	2 centile	Exceptionally Low	
Recognition	15 words + 15 distractors	9	<1 %ile	Exceptionally Low	
Visual Reproduction I	Immediate recall – geometric designs		35 centile	Average	
Visual Reproduction II	Delayed recall		14 centile	Low Average	
Rey Complex Figure	3-minute recall	7	<1 centile	Exceptionally Low	
Language					
Boston Naming Test	Confrontation naming	42/60	(3)	Exceptionally Low	+9 after phonemic prompt
FAS	Letter fluency	43	59 centile	Average	
Animals	Category fluency	15	13 centile	Low average	
Cookie Theft Picture description	Expressive language				Clear articulation, fluent with hesitation/pauses
WAB sequential commands	Receptive language	72/80		Relatively intact	

Syntactically complex questions	Receptive language with greater working memory load	5/11		Exceptionally Low	
Word repetition (ACE-R)	Repetition	3/4			
Sentence repetition (Multilingual Aphasia Examination)	Repetition	5/14		Exceptionally Low	
Irregular word reading (ACE-R)	Reading	5/5		Preserved	
Spelling		10/14		Below expected level	Incorrect vowel or consonant
Spoken-word picture matching (PALPA)	Semantics	39/40		Preserved	
Written synonym judgement (PALPA)		58/60		Preserved	
Verbal					
Information	General knowledge	10	7	Low Average	
Visuospatial					
Cube	3D- copying			Preserved	
Coils	Copying 3 coils			Preserved	
Clock	Construction/planning/semantic representation			Numbers well-spaced, incorrect time	
Block Design	Constructional skill		8	Average	
Executive					

Similarities	Verbal concept formation		9	Average
D-KEFS Sorting	Concept formation & shifting			Average
Trail Making Test B	Cognitive Flexibility – alternating numbers & letters	137 secs	<1 centile	Below average
Rey Complex Figure Copy	Planning (qualitative)			Preserved
Mood				
DASS-21	Depression			Moderately elevated
	Anxiety			Normal
	Stress			Mildly elevated

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