

# Neuropsychological Testing

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**NEUROPSYCHOLOGY** (subspecialty of psychology) - studies **brain-behavior relationships** (neuroanatomical substrates of cognitive function).

- **clinical neuropsychologists** - **cognitive function assessment** in *brain damage* (incl. differentiation of psychiatric from neurological illnesses).
- neuropsychological testing is established adjunct to neurological examination.

**COGNITIVE FUNCTIONS** - processes by which individual:

- 1) perceives external & internal stimuli;
  - 2) selects pertinent stimuli and inhibits nonpertinent stimuli;
  - 3) records, retains, and recalls information;
  - 4) forms associations between stimuli and manipulates information in goal pursuit;
  - 5) outputs information through expression of *overt behavior*\*.
- \*clinical neuropsychology is based on premise that these *overt behaviors* provide information about CNS functional integrity (effects of brain damage on behavior).

Main approaches to neuropsychological assessment:

- A) **quantitative approach** - comparison of individual performance measures *against normative expectations*.
- B) **qualitative approach** - measures to elicit *pathognomonic signs*.

## AMOUNT OF TESTING

SCREENING EXAMINATION (requires < 1 hour of testing) - attention, orientation, short-term & long-term memory, expressive & receptive language, abstract reasoning, and intelligence.

FULL EXAMINATION (typically requires 3-12 hours of testing).

### **BATTERY approach**

- highly standardized structured approach; two batteries are most commonly used:

1. **HALSTEAD-REITAN battery** (most commonly used)
  - testing duration at least 6 hours.
  - adequate in discriminating brain-damaged individuals from neurologically healthy individuals.
  - not sensitive to mild cognitive impairment or to precise localization.
2. **LURIA-NEBRASKA neuropsychological battery**
  - testing duration 2-3 hours.
  - inadequate validity and reliability.

### **Disadvantages of battery approach:**

- 1) excessive time (fatigues patient, requires several visits);
- 2) include assessment measures that are not necessary for given patient;
- 3) do not provide comprehensive assessments of all cognitive functions

### **INDIVIDUALIZED TESTING approach**

- neuropsychologist uses pertinent patient information to guide test selection - chooses tests (either from existing batteries or tests designed to assess specific deficits) that assess cognitive functions relevant to given patient.

- > 700 tests of cognitive functioning are available!

**Disadvantage** - selection of tests introduces certain bias (some domains of good or bad function may be missed).

## INTERPRETATION OF TESTING RESULTS

- A) **Individual comparisons** - *previous* (e.g. premorbid) data are used to compare with *present* performance.
- B) **Population-based comparison** (most frequently used method) - comparison of individual patients' test scores to *population norms*; individual's performance is expressed:
  - a) standard deviations away from mean.
  - b) z- scores (individual's score minus mean of norm divided by standard deviation of norm).
  - c) percentile ranking (performance is defined as impaired when  $\leq 5\%$  in standardization sample)

## PRACTICAL ISSUES

- neurologist needs to *be as specific as possible* when formulating referral questions.
- if testing is to be conducted in hospital, patient's schedule needs to include blocks of time when **no other clinical tests are scheduled** (e.g. radiology, discharge planning) - patient may be tested without interruptions and when maximally alert and attentive.

## HIERARCHY OF TESTING

Any given cognitive function is composed of multiple discrete functions – examination proceeds in the following order:

1. **Level of consciousness** (if patient is comatose there is little need to conduct neuropsychological testing!).
2. **Primary sensory systems** (visual, auditory, tactile, proprioceptive)
3. **Effector system** (basic motor, vocal, praxis).

Once these three levels of abilities have been tested, testing of higher cognitive functions (such as intelligence, reasoning, language) can begin.

## INDICATIONS

- 1) *dementia* diagnosis
- 2) preoperative and postoperative evaluation in *temporal lobectomy* (for intractable epilepsy).
- 3) differential diagnosis of psychiatric and neurologic disorders.
- 4) stroke, cancer, head trauma.
- 5) toxic exposure.
- 6) evaluation of drug effects on CNS.
- 7) behavioral disorders, attention deficit disorder, autism, dyslexia, learning problems.

## MENTAL STATUS TESTS

- assess **overall level of cognitive functioning**.

- brief to administer and not very comprehensive (lack sensitivity to detect mild cognitive impairment, may be unable to distinguish psychiatric illness from neurological disorders).
- include a few questions on orientation, attention, memory, language, and sometimes praxis.

**Mini-Mental Status Examination (MMSE)** - "quick-and-dirty" assessment of overall cognitive function.

- maximum score is 30.
- cutoff score of 24 is considered to indicate impaired performance.

**Short-Portable Mental Status Questionnaire (SPMSQ)**

## NEUROPSYCHOLOGICAL TESTS

1. Orientation, Attention, Vigilance
  2. Intellectual Abilities
  3. Reasoning and Problem Solving Through Concept Formation
  4. Verbal Function
  5. Memory
  6. Perception and Construction Abilities
  7. Executive Function and Motor Performance
  8. Emotional Functioning
- neuropsychological testing is **extension of mental status examination**, i.e. more thorough and objective than mental status examination.
  - neuropsychological tests are **standardized** procedures (vs. mental status examination) with groups of healthy controls or patients that comprise COMPARISON GROUP - results are **quantitative** in nature (repeated comparisons over time, such as before and after neurosurgical intervention, may be used to evaluate changes).

## 1. ORIENTATION, ATTENTION, VIGILANCE

- regardless of localization of brain pathology, these abilities are often compromised.

**Performed first** – patient inability to attend to ongoing stimuli makes tests of higher cognitive functions difficult.

Special situations when these tests are especially useful:

- 1) **toxic** and **metabolic abnormalities**, which affect level of consciousness, sleep/wake cycles, memory functioning.
- 2) patients who evidence **neglect** or **dyspraxia**.
- 3) patients with **psychiatric presentations**.

## ATTENTION AND VIGILANCE TESTS

**Attention tests** - ability to attend to single stimulus (to focus attention on selected stimuli, to inhibit attention to inappropriate stimuli).

**Vigilance (s. concentration) tests** - active information updating in ongoing display requiring attention.

**Simple Reaction Time** - patient is required to respond, as quickly as possible, to stimulus.

**Choice Reaction Time** - patient is required to respond to one stimulus but to not respond to another (e.g. **Continuous Performance Test** - patient is asked to respond, as quickly as possible, to rare stimulus that is embedded in stream of ongoing similar stimuli - ability to maintain attention and vigilance for target stimulus + ability to inhibit responses to nontarget stimuli).

**Span Tests** - more standard form of assessing attention and vigilance (span tests also require working memory).

1. **Digit Span Test** - patients listen to random sequences of numbers presented in increasing length, and immediately repeat each sequence (two trials at each span length are presented) - maximum span is number of digits patient can correctly repeat on at least one trial (norma 5-9 digits).
2. **Letter Span Test** - identical to digit span performance.
3. **Corsi Block Test** - patient is presented with nine blocks array arranged in random order; examiner touches blocks in sequences of increasing length; patient is required to reproduce sequence at each length.

**Paced Auditory Serial Addition Test (PASAT)** - extremely sensitive measure of vigilance: patient listens to tape recording of digits presented one at time; patient must add each number to one immediately preceding it (e.g. recording presents numbers 1, 7, 5, 4 - patient adds first two numbers (1 + 7) and responds with number 8; patient then adds second two numbers (7 + 5) and responds with number 12; patient then adds third two numbers (5 + 4) and responds with the number 9); this continues for total of 61 numbers.

## ORIENTATION TESTS

- standard bedside mental status examinations always assess orientation to person, time, place.

**Orientation to time:** "What is today's date?" "Month?" "Day of the week?" "Year?"

**Orientation to place:** "Where are you now?" "What state are you in?" "County?" "City?" "What is the name of this place?"

**Orientation to person:** identify which finger has been stimulated by examiner under visual guidance, and in absence of visual input (**Finger Localization Test**).

N.B. loss of orientation to person as isolated symptom suggests malingering!

"A & O x 3" = alert and oriented to time, place, and person

N.B. orientation depends both on ATTENTION and MEMORY!

## 2. INTELLECTUAL ABILITIES

INTELLIGENCE is *culmination of cognitive abilities*.

**Intelligence tests** - overview of cognitive function integrity.

**INTELLIGENCE QUOTIENTS (IQ)** - gold standard in intelligence testing:

1. **Wechsler Adult Intelligence Scale- Revised (WAIS-R)** - for ages 16 years ÷ 74 years 11 months.
  2. **Wechsler Intelligence Scale for Children-III (WISC-III)** - for ages 6 years ÷ 16 years 11 months.
  3. **Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R)** - for ages 3 years ÷ 7 years 3 months.
- Wechsler tests are composed of different **subtests** (each assessing different cognitive functions); results for subtests guide further (and more extensive) testing.
  - Wechsler tests provide three summary measures:

**Verbal IQ**

**Performance IQ**

**Full Scale IQ** (sum of Verbal IQ and Performance IQ).

$$IQ = (\text{mental age} / \text{chronological age}) \times 100$$

**Verbal IQ / Performance IQ** - assessment of **dominant (verbal)** and **nondominant (performance)** hemispheric function.

N.B. studies have not supported it:

**Verbal IQ** tend to require *overlearned abilities* (such as vocabulary knowledge and general information) - less affected by brain damage.

**Performance IQ** tend to require *novel abilities* (such as reproducing visual patterns using colored blocks) - more affected by brain damage.

Difference between verbal IQ and performance IQ > 10 points suggests **organic brain syndrome!**

N.B. children IQ (vs. adult IQ) changes with advancing age (children have remarkable developmental shifts as they mature and master important adaptive skills)

- due to extensive norms IQ measures may be generalized to US population.
- Wechsler tests have been translated into many different languages (adequate norms exist for most of these modifications).
- **summary IQ scores** are highly correlated with educational attainment in adults, and are often used to *predict academic abilities in children*.
- IQ scores need to be interpreted in context of complete neuropsychological examination (impairment in one of basic elements of cognitive function (e.g., attention/vigilance) will provide artificially low IQ performance).

$$\text{mean performance is } 100 \text{ (standard deviation - } 15)$$

- diagnostic criteria for **MENTAL RETARDATION** - IQ performance > 2 standard deviations below mean (e.g. IQ score < 70 on WAIS-R).  
N.B. statistical reliability for mental retardation is low - diagnosis of mental retardation must rely on **multiple assessments** and not on single measure!

#### PREMORBID INTELLECTUAL FUNCTION

- in order to provide useful information current IQ need to be compared with premorbid IQ.
- premorbid IQ is typically not available.
- basic approaches to estimation of premorbid IQ:
  - A) estimates derived from **life history variables** believed to be *correlated* with measures of cognitive functioning:
    - 1) developmental history
    - 2) medical history
    - 3) academic history (e.g. years of education)
    - 4) occupational history
  - B) measures of **best current cognitive functioning ("present abilities")** - estimate *minimum level of premorbid functioning*; neurologic damage does not affect all cognitive abilities equally and that individual's highest test score on current testing is most likely to reflect intact performance.
  - C) **comparison** of individual's test results **to population-based estimates of normal performance** (norm- based comparisons as discussed above).

#### TESTS OF ACADEMIC ACHIEVEMENT

- assess standard academic skills (reading, writing, arithmetic skills, spelling, etc).
- **LEARNING DISABILITY** is suggested when there is large discrepancy between *intellectual ability* and *academic achievement*.
- most commonly used tests of academic achievement:
  - 1) **Peabody Individual Achievement Test-Revised (PIAT-R)**
  - 2) **Wide Range Achievement Test-Revised (WRAT-R)**.

### 3. REASONING AND PROBLEM SOLVING THROUGH CONCEPT FORMATION

- highly related to intellectual functioning.

#### A. Tests of VERBAL reasoning and concept formation (subtests of WAIS-R):

- 1) **Comprehension** - test of verbal conceptualization - to answer questions or interpret proverbs that require problem solving (e.g. "What does 'a rolling stone gathers no moss' mean?").
- 2) **Similarities** - identify common elements between seemingly uncommon stimuli (e.g. "How are praise and punishment alike?").
- 3) **Arithmetic** - progressively more difficult arithmetic word problems.

#### B. Tests of NONVERBAL reasoning and concept formation

- 1) **Category Test** (part of Halstead-Reitan Battery) - tests visual concept formation: patients see slides with four stimuli and are required to identify concept presented on each slide.
- 2) **Raven's Progressive Matrices** - measure visual concept formation and problem solving: patients are presented with multiple designs that are linked by common conceptual pattern; final design is missing, and patient must choose which of six to eight alternative final designs is correct.
- 3) **Wisconsin Card Sorting Test** - test of visual concept formation adds cognitive set-shifting to concept formation: patients are presented with four "target" cards with simple colored designs that can be sorted by three concepts; patients match probe cards with identical colored design to target cards according to whatever concept they generate.

### 4. VERBAL FUNCTION

1. **Boston Diagnostic Aphasia Examination (BDAE)** - comprehensive assessment of verbal function.
2. **Multilingual Aphasia Examination (MAE)** - comprehensive assessment of verbal function.
3. **Neurosensory Center Comprehensive Examination for Aphasia (NCCEA)** - detailed assessments of reading, writing, articulation, visual abilities, tactile abilities; (administration time is < 2 hours - practical in everyday clinical use).

### 5. MEMORY

1. **Wechsler Memory Scale-Revised (WMS-R)**
2. **Ray Auditory Verbal Learning Test (RAVLT)**

3. **California Verbal Learning Test (CVLT)**
4. **Rey-Osterrieth Complex Figure**

## 6. PERCEPTION AND CONSTRUCTION ABILITIES

- ability to perceive stimuli is one of basic requirements for assessment of cognitive function.

### I. VISUAL PERCEPTION AND CONSTRUCTION

- assess color perception, object recognition, visual organizational abilities, visual scanning, differentiation of figure from ground.

- most neuropsychological assessments assess color perception informally (*Color Vision Screening Inventory* is occasionally used by examiners - screening of color blindness).

1. **Peabody Picture Vocabulary Test-Revised**
2. **Benton Facial Recognition Test**
3. **Judgment of Line Orientation (JLO).**
4. **Hooper Visual Organization Test (HVOT).**
5. **Picture Arrangement.**
6. **Letter Cancellation Test.**
7. **Line Bisection Test.**
8. **Embedded Figures Test.**
9. **Rey-Osterrieth Complex Figure.**
10. **Clock Drawing Test** (patient is required to draw a clock with all the numbers and "set" the clock at 20 minutes to four o'clock) - has been a part of bedside mental status testing for long time.
11. **Developmental Test of Visual-Motor Integration (VMI).**
12. **Three-Dimensional Block Construction.**

### II. AUDITORY PERCEPTION

- acuity, perception of organized sounds, rhythms.

1. **Sensory Examination** - examiner stands behind patient and gently rubs two fingers together next to each ear.
2. **Speech-Sound Perception Test.**
3. **Seashore Rhythm Test.**

### III. TACTILE ABILITIES

- limited to hands.

1. **Sensory Examination** - examiner traces number on each finger and asks patient to report number without visual guidance.
2. **Face-Hand Test**
3. **Tactile Form Perception**

## 7. EXECUTIVE FUNCTION AND MOTOR PERFORMANCE

**EXECUTIVE FUNCTION** (traditionally, ascribed to *prefrontal cortex*): ability to assess ongoing stimuli for relevance to specific goals, formation of goals, planning action to achieve goals, ability to evaluate plans for efficacy, executing plans. *ability to plan, sequence, and monitor behavior*

1. **Proteus Mazes** - trace path through progressive difficult mazes without entering any blind alleys - sensitive to frontal-lobe damage.
2. **Design Fluency.**
3. **Stroop Word-Color Interference Test.**

### MOTOR PERFORMANCE TESTS

- simple motor speed, strength + complex motor/dexterity abilities.

1. **Finger Tapping Test** (primary motor speed of index finger of each hand) - tap finger as quickly as possible for five consecutive 10-second trials; large differences between left and right finger speed may reflect lateralized hemispheric dysfunction.
2. **Hand Dynamometer** - grip strength in each hand.
3. **Purdue Pegboard Test** - place pegs in vertically arranged holes.

## 8. EMOTIONAL FUNCTIONING

- most assessments are conducted during interview with patient.

A) PROJECTIVE TESTS.

B) OBJECTIVE TESTS:

1. **Minnesota Multiphasic Personality Inventory-2 (MMPI-2)** - can suggest many different emotional disorders, ranging from mild depression to psychotic conditions.
2. **Beck Depression Inventory** - assesses depressive symptoms experienced within past week.
3. **Geriatric Depression Scale** - designed for use in elderly patients.

N.B. emotional disturbances can affect cognitive functioning!

BIBLIOGRAPHY for ch. "Diagnostics" → follow this [LINK >>](#)