Erasmus+

Development of innovative training solutions in the field of functional evaluation aimed at updating of the curricula of health sciences schools

MODULE FUNCTIONAL EVALUATION: CONCEPT AND METHODOLOGY

Didactic Unit E:

Importance of cognitive abilities in the performance of motor task. Why it is important to include biomechanical analysis in cognitive impairments?

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E. Importance of cognitive abilities in the performance of motor task.

Why it is important to include biomechanical analysis in cognitive impairments?

1. Objectives
2. Cognition
3. Cognitive load addition to motor performance
4. Motor performance in people with cognitive impairment
5. Dual-task assessment
6. Key ideas
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Importance of cognitive abilities in the performance of motor task.

1. Objectives

1. OBJECTIVES

The objectives of this didactic unit are:

- Identify the principals cognitive functions and their brain bases.
- Analyze the implications of the impaired cognitive functions, its evaluation and preservation in the exercise the professional health activity.
- Know the interference caused by cognitive load in normal and pathological motor performance.
- Study motor performance in people who have impaired cognitive functions and mental disorders.
- Analyze how a motor gesture with cognitive load should be evaluated with biomechanical assessment tools.

Importance of cognitive abilities in the performance of motor task.

2. Cognition

2. COGNITION

- The action or mental process of acquiring knowledge and understanding through experience and the senses.
- The ability to perceive and react, store and retrieve information, process and understand such information, make decisions and produce appropriate responses that guide behavior to interact safely with the environment.
- It is necessary to extract the essential elements for daily functioning and survival.

2.1. COGNITIVE FUNCTIONS

- Higher order mental (brain) processes on which cognition depends.
- More specific, but no less complex that interact with each other.
- Jointly involved in the execution of any daily task or activity
- Making it possible for the human being to have an active role in the reception, storage, selection, elaboration, transformation and recovery of the information.
- Are not independent of each other
- Some can be explained separately, being a frequent object of research and practical applications in various areas of health.

2.1. COGNITIVE FUNCTIONS

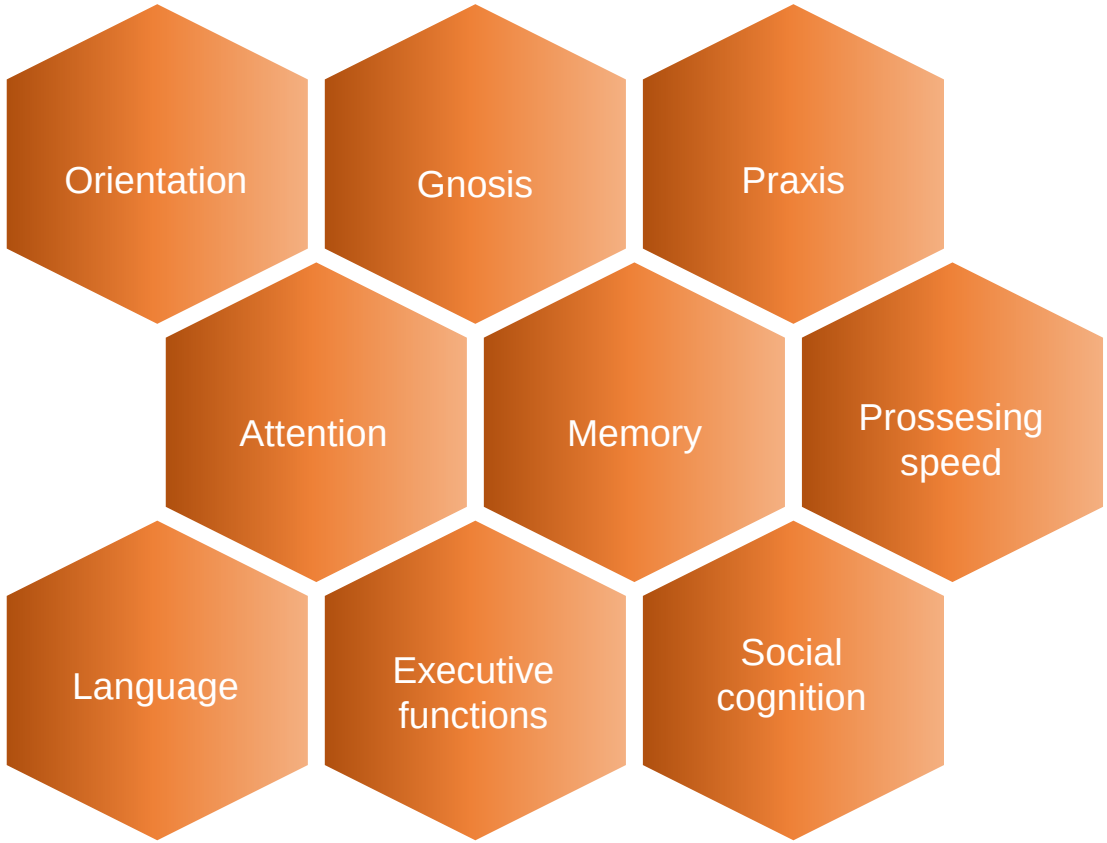


Figure 1. Main cognitive domains of humans

2.1.1. ORIENTATION DYSFUNCTION – DISORIENTATION

The ability that allows a person to be aware of himself, of others and of the context in which he is at a given time

To be able to develop the activities of that space / time situation.

There are three types of orientation:

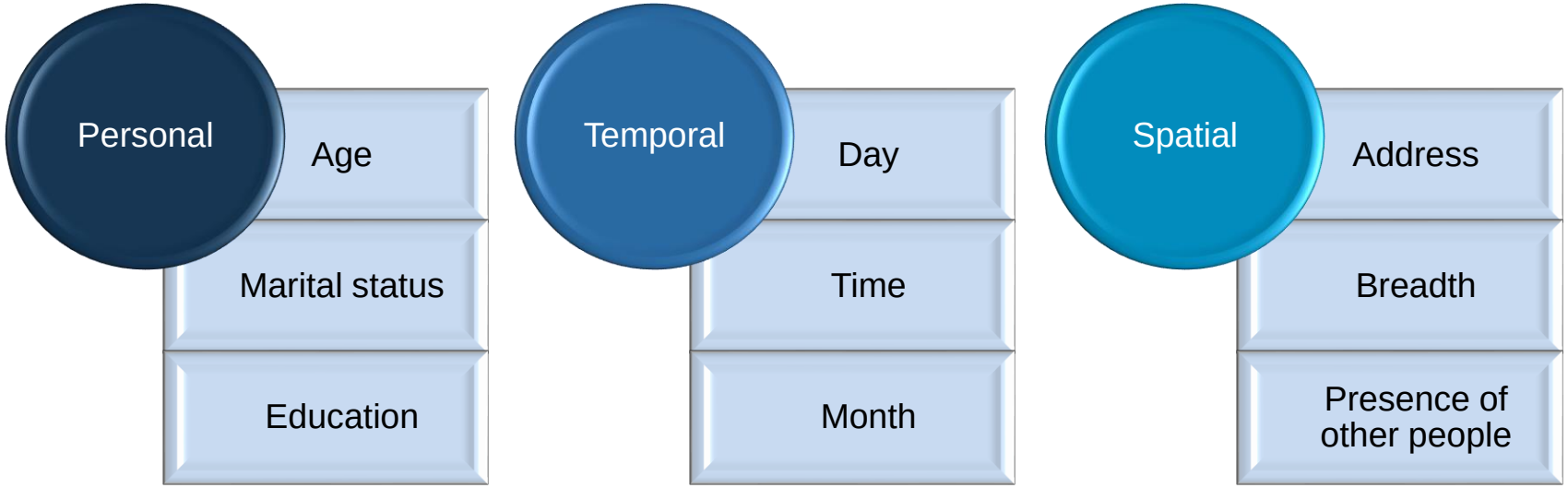


Figure 2. Examples of personal, temporal and spatial orientation.

2.1.1. ORIENTATION DYSFUNCTION – DISORIENTATION

- Symptom of different medical conditions: delirium and dementia.
- Some physical disorders may cause disorientation: cerebral arteritis, central nervous system infections, concussion, dehydration, sepsis, stroke, vitamin deficiency, vestibular disorders.
- Side effect of some drugs, including alcohol, marijuana, prescription medications.
- Withdrawal from certain drugs can also cause disorientation.

The treatment of disorientation should be based on the root causes.

2.1.2. GNOSIS

The ability to recognize elements, stimulus or any other previously learned information and attribute meaning to them.

There are various types of gnosis:

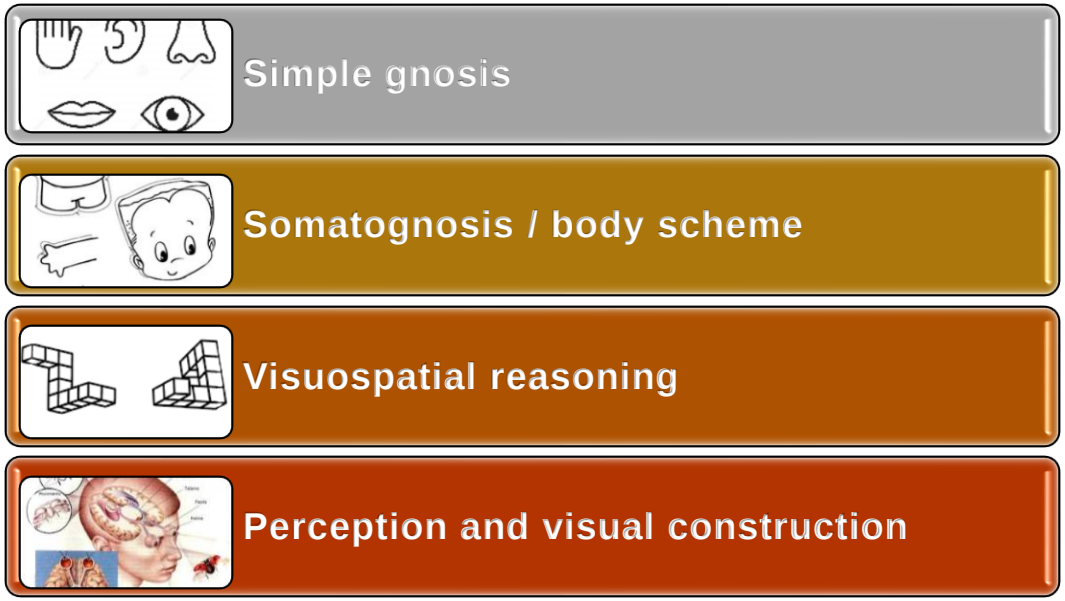


Figure 3. Type of gnosis.

2.1.2. GNOSIS DYSFUNCTION – AGNOSIA

- Visual agnosia: brain inability to recognize or understand visual stimuli.
- Prosopagnosia: inability to recognize faces that are familiar even our self in a mirror.
- Visuospatial agnosia: individuals can report objects in their visual fields, but not the spatial relationships of the objects to one another

2.1.2. GNOSIS DYSFUNCTION – AGNOSIA

- Tactile agnosia: inability to recognize objects through touch.
- Apperceptive agnosia: a failure in recognition that is due to a failure of perception. Perception occurs but recognition still does not occur.

Agnosia treatment: teach the patient to use the others intact sensory modalities and the awareness of deficits and its consequences.

2.1.3. PRAXIS

The ability to voluntarily execute organized, simple or complex movements, to perform a task, manipulate objects or achieve a specific objective.

There are several types of praxis :

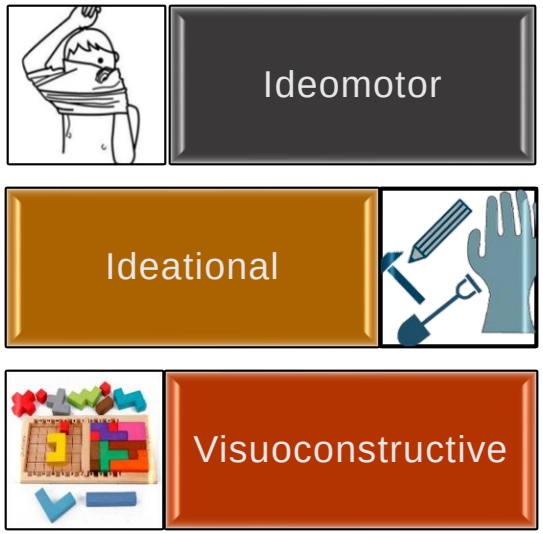


Figure 4. Type of praxis.

2.1.3. PRAXIS DYSFUNCTION – APRAXIA

- Inability to perform a previously learned skilled act that is unexplained by weakness, incoordination, dementia, or sensory loss.
- Ideomotor apraxia: inability to correctly imitate hand gestures and voluntarily mime tool use.
- Dissociation apraxia: inability to pantomime to command, with spared ability to imitate gestures and manipulate objects in the environment.
- Conceptual/ideational apraxia: inability to conceptualize a task and to complete multistep actions.
- Dyspraxia: when the deficits in skilled movement are not complete.

Treatment for apraxia includes physical, cognitive and or occupational therapy. If it is a symptom of another disorder, the underlying disorder it should be treated.

2.1.4. ATTENTION

State of observation and alert that allows awareness of what happens in the environment.

To carry out this process, it is necessary to focus on specific stimulus, ignoring other minor ones. The most traditionally studied types are:

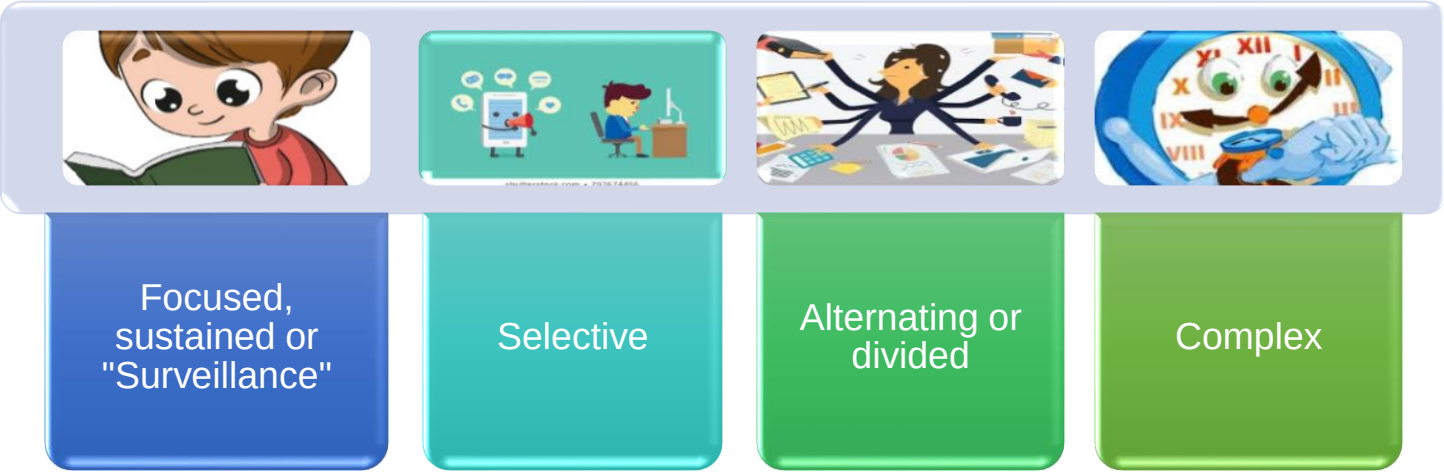


Figure 5. Type of attention.

2.1.4. ATTENTION DYSFUNCTION – INATTENTION

- There are several factors that affect an individual's ability to sustain their attention: the nature of the task, fatigue, stress, personality, etc.
- Inattention can directly interfere most activities of daily life.
- Has an important and negative effect on learning.
- The most important disorder related to attention is Attention-deficit/hyperactivity disorder (ADHD).

The best strategy for avoiding the problems associated with the vigilance decrement is to redesign the task/system to avoid this requirement.
More complex attention deficits such as ADHD may require pharmacological treatment.
The behavior intervention plans long term may result in permanent improvement in concentration skills.

2.1.5. MEMORY

Thanks to memory you can learn, evolve, and have personality.

Is the ability to encode, store and retrieve, effectively learned information or lived events.

Memory classification:

Figure 6. Memory classification.

2.1.5. MEMORY DYSFUNCTION – AMNESIA

- Everyone forgets things at times.
- Some degree of memory problems is a common part of aging.
- There is a difference, however, between normal changes in memory and memory loss associated with a disease.
- Some memory problems are the result of treatable conditions: lack of sleep, medications, head trauma, stress, anxiety or depression.
- Others are symptoms or characteristics of neurologic or neurodegenerative diseases: severe mental disorders, Alzheimer's, Parkinson's and other types of dementia.

Treatment may require pharmacological treatment.
Cognitive rehabilitation or the use of memory training techniques can be very useful for medium or lower memory deficits.

2.1.6. PROCESSING SPEED

Ability to automatically and quickly process information, without consciously thinking. The rate to complete a task, or the time it takes between a stimuli is received, and a response is emitted.

- Slow processing speed:
- ➢ It manifests as the difficulty to keep up with the pace of learning from others, completing tasks on time, or in following directions.
- ➢ Play a part in learning and attention disabilities like dyslexia, attention deficit disorder, autism, dysgraphia, dyscalculia.

Treatment: Modifying and accommodation of the environment, differentiating the style of instruction or using compensatory strategies. The most serious cases should be evaluated and treated by an experienced neuropsychologist.

2.1.7. LANGUAGE

A higher order cognitive function. Result of a complex nervous activity. Symbolization processes: encoding and decoding.

Is composed of several cognitive processes:

Figure 7. Cognitive processes of language

2.1.7. LANGUAGE DISORDER

- Is an impairment in the processing of linguistic information that affects an individual's ability to receive and/or express language.
- Is commonly affected by both focal brain lesions and neurodevelopment or neurodegenerative disorders.
- Can be classified according to the aspect of language that is impaired, its severity, and whether it affects comprehension, production, or both.
- Types: alexia, agraphia, aphasia, dyspraxia, dyslexia, etc.

Treatment should be a multidisciplinary approach that involves speech-language therapists, audiologists, behavioral therapists and special education professionals, as well as physician to identify (or rule out) physical causes behind language impairments.

2.1.8. EXECUTIVE FUNCTIONS

Higher order cognitive processes, or complex mental activity. Include both cognitive and behavioral components. Allow to design plans, facilitate self-regulation, allow the resolution of complex problems, the decision-making and the selection of correct actions.

There are several types of executive functions:

Figure 8. Type of executive functions.

2.1.8. EXECUTIVE DYSFUNCTION

- Difficulties in any of its abilities or capacities.
- It can be a symptom of another condition.
- In everyday life: disability to change plans, difficulties doing homework, misplacing things, difficulty with time management, difficulty dealing with frustration, trouble with memory recall, etc.

The treatment depend on the conditions and the specific types of executive dysfunctions that are present.
Includes working with various kinds of therapists such as neuropsychologists, psychologist, speech or occupational therapists.
Medication can be helpful for the most severe cases.

2.1.9. SOCIAL COGNITION

It is the ability to think and make sense of ourselves, others and their behavior, and social relationships. It is necessary to regulate behavior and emotions in the social context and for empathy capacity.

Components:

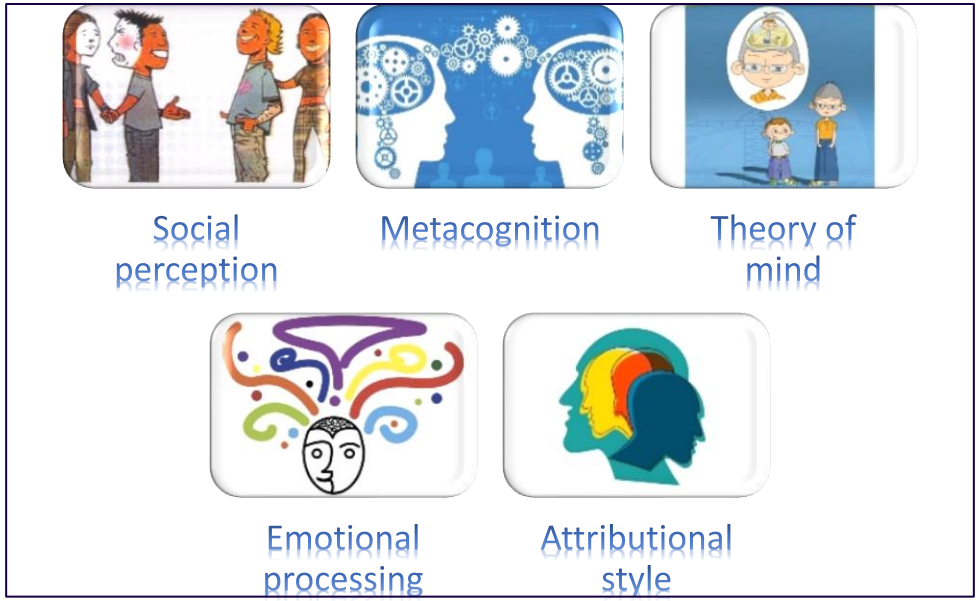


Figure 9. Components of social cognition.

2.1.9. SOCIAL COGNITION

Everyday life include: cooperate, compete, or simply to go about day-to-day business. Those interactions, must include the ability to understand and predict the actions of the other people in terms of beliefs, desires, and intentions. This process involves at least four levels of mentalizing:

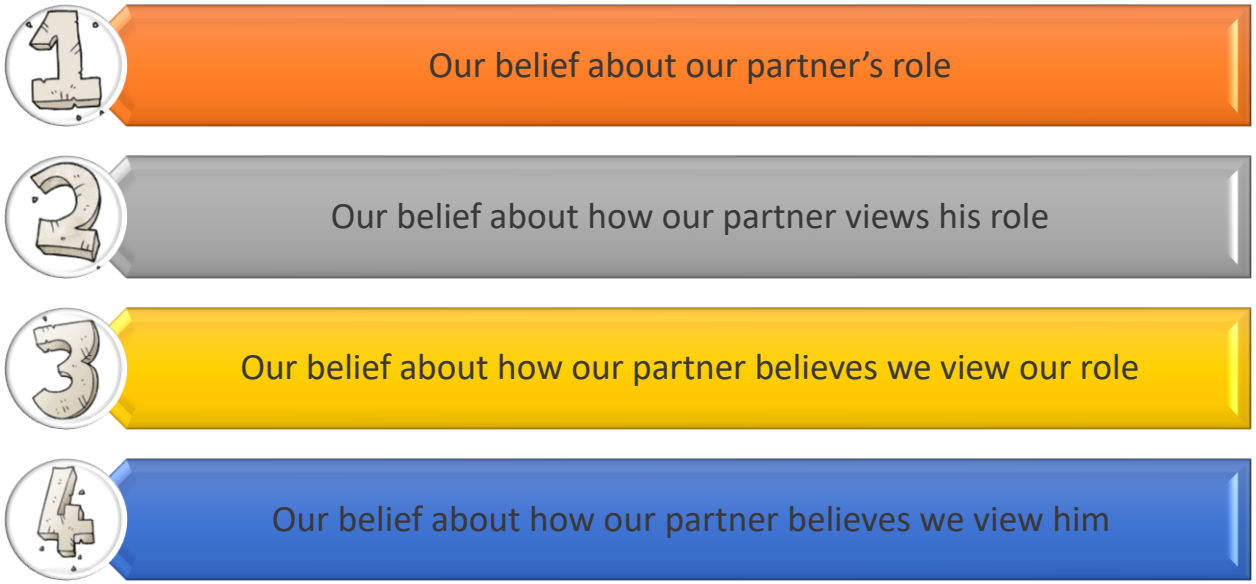


Figure 10. Levels of mentalizing.

2.1.9. SOCIAL COGNITION

- Social impairments are common and contribute a great deal to the burden of mental illness or disability.
- Disorders defined by social and communication impairment: autism, certain types of schizophrenia, psychopathic and borderline personalities.
- In patients with psychosis social disability play an important role in the etiology of both positive and negative psychotic symptoms.

Treating social disability may include socially-focused behavioral interventions, interaction training, cognitive-behavioral treatments, and pharmacological treatments for more severe cases.

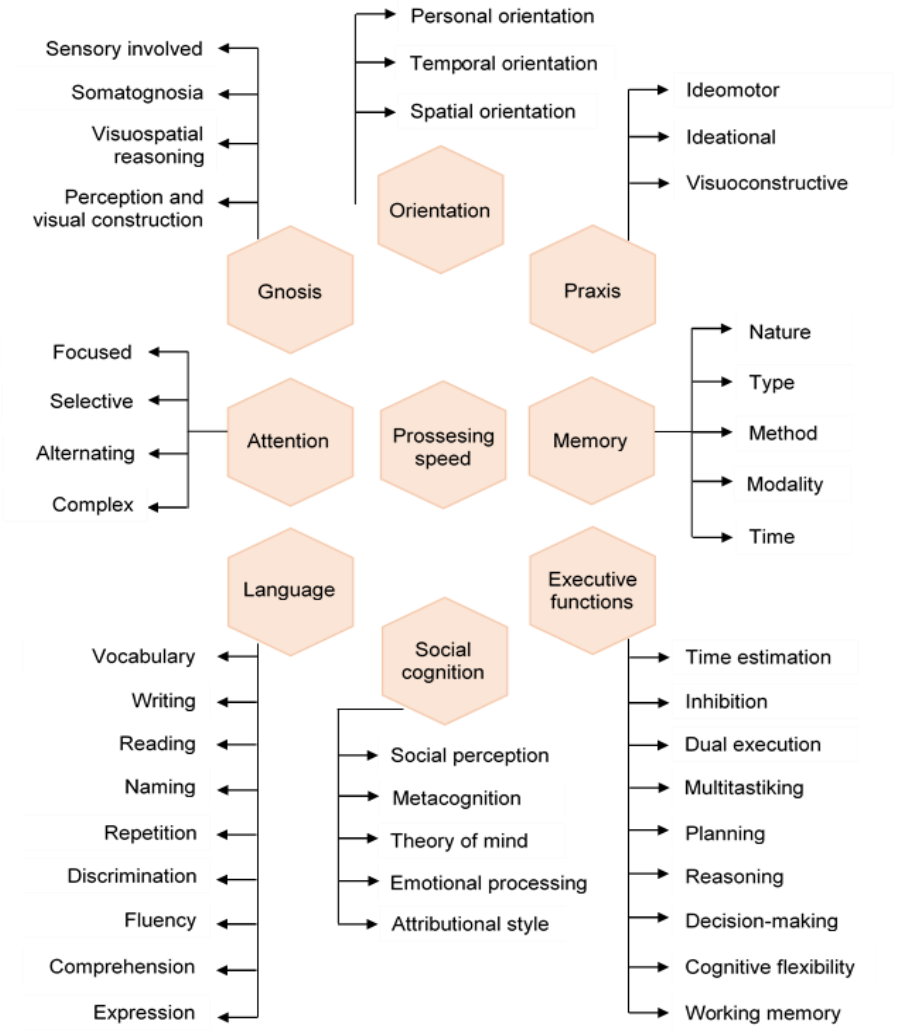


Diagram 1. Summary of the cognitive domains and subfunctions involved

2.2. BRAIN BASES OF COGNITIVE FUNCTIONS

- Traditionally, neuroscience has focused mainly on the topological organization of cognitive functions in specific brain regions.

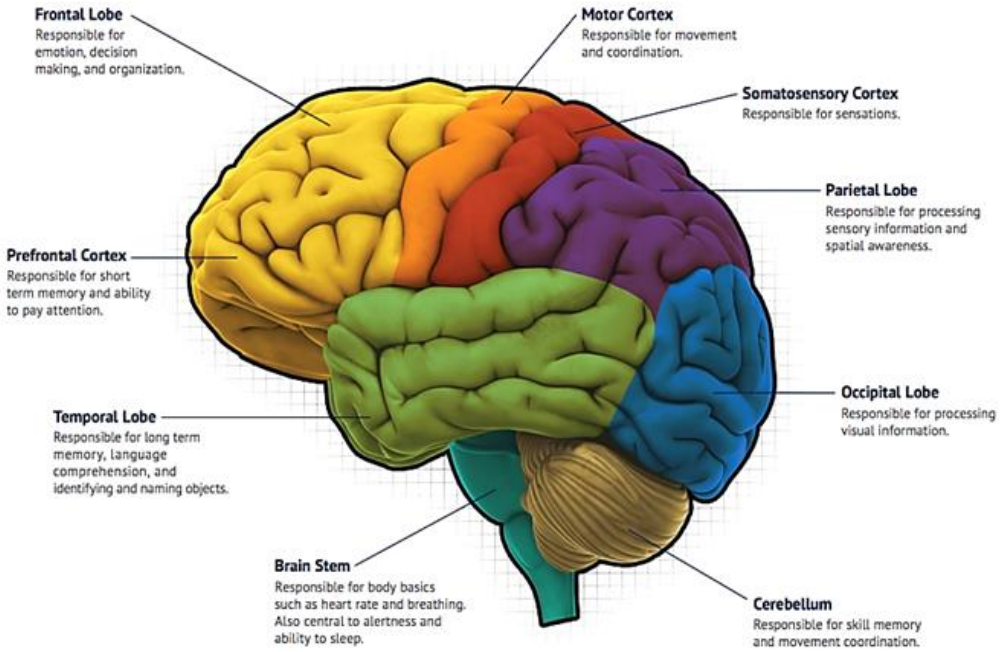


Figure 11. Brain mapping (from “North Jersey Health & Wellness”).

New "network paradigm“

- The human brain contains at least five major core functional networks (Mesulam, 1990):

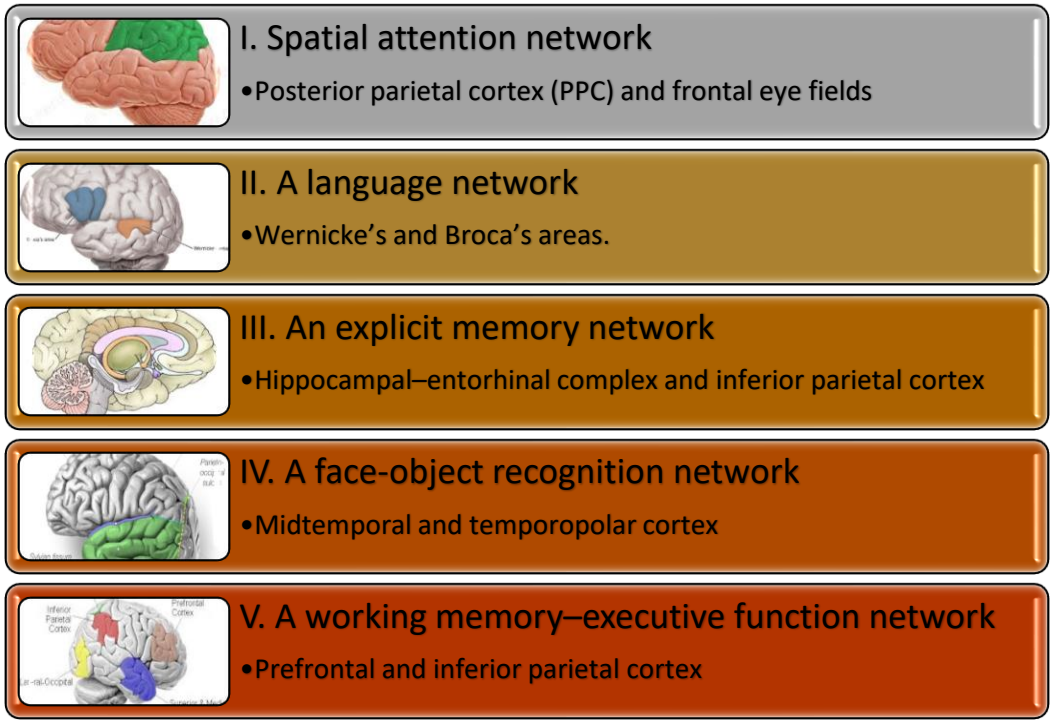


Figure 12. Five major core functional networks

Other new network modules

- (VI) An intrinsic connectivity networks involved in executive control, episodic memory, autobiographical memory, self-related processing, and detection of salient events.
- (VII) A sensorimotor network anchored in bilateral somatosensory and motor cortices.
- (VIII) A visuospatial attention network anchored in intraparietal sulci and frontal eye fields

Other new network modules

- (IX) A higher-order visual network anchored in lateral occipital and inferior temporal cortices.
- (X) A lower-order visual network anchored in the striate and extrastriate cortex.

Those network modules can vary their intraconnectivity and the intermodule connectivity.

Topology of the modular organization

- (A) brain regions are organized into cytoarchitectonically distinct areas
- (B) each cytoarchitectural configuration has structural properties with different implications for computational functions
- (C) cytoarchitectural regions can be represented as nodes in a network

Topology of the modular organization

- (D) the nodes have functional associations, represented as edges that extend beyond spatial boundaries evident in cytoarchitectural organization.

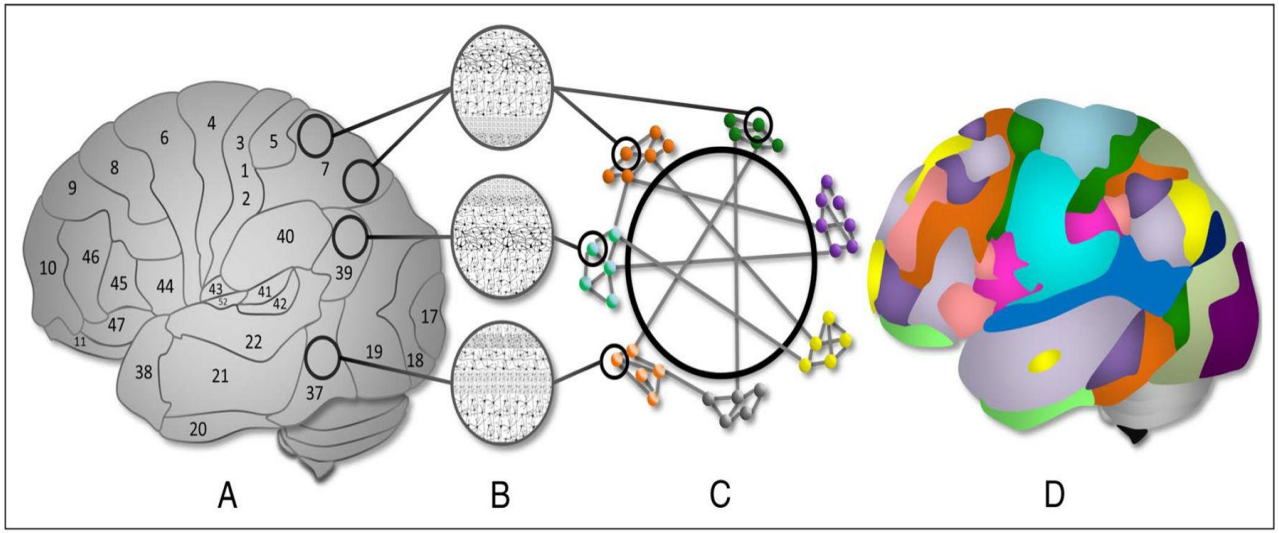


Figure 13. From nodes to networks (Medaglia et al., 2015).

2.3. IMPAIRED COGNITIVE FUNCTIONS

- As mentioned earlier, the loss of cognitive abilities is due to the natural aging process.
- The way in which this degenerative process develops depends on multiple conditions: health, functional capacity, genetic structure and environment.
- Other factors can alter cognitive abilities acutely or chronically: neurodegenerative diseases, neurodevelopmental disorders, intellectual disabilities, mental illnesses, addictions, severe physical or mental traumas, etc.
- The affectation in one or more of the cognitive functions has a direct implication on the daily functioning of people, individually or in interaction with others and the environment.

Implications in carrying out activities of daily life

Cognitive function	Activities of daily life
Recognition of the body scheme	Difficulties in dressing, using objects in relation to the body (comb, toothbrush, cutlery, etc.).
Sustained attention	Difficulties in following a movie or book, studying, etc.
Selective attention	Difficulties in working in an environment with other people, with noise or other possible distractions.
Divided attention	Difficulties in driving a vehicle, home care or children, etc.
Semantic memory	Forgetting previously acquired knowledge, forgetting the name of known people.
Episodic memory	Forgetting where you left your car, keys or glasses, forgetting itineraries (holidays, visits, etc.)
Prospective memory	Forgetting the next day's appointments, forgetting what you want to buy, etc.
Executive functions	Difficulties to plan and carry out the meal, to use the computer, to control expenses, to organize trips or trips, to solve problematic situations, etc.

Table 1: Implications of cognitive deficits in carrying out activities of daily life

Deficit reduction

- DETERIORATION CAN SLOW DOWN or
- MAKE COGNITIVE DEFICITS LIGHTER,
- maintaining an active and healthy life,
- in stimulating environments, and
- if it continues to stimulate or
- develop these functions
- through cognitive stimulation practices and exercises

2.4. EVALUATION OF COGNITIVE FUNCTIONS

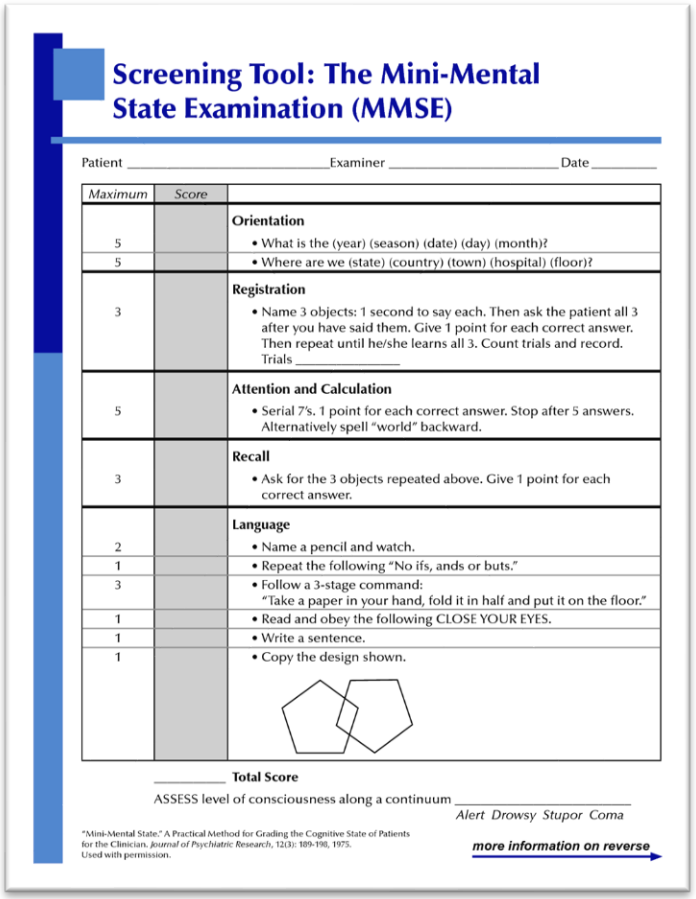
- An adequate cognitive or neurocognitive evaluation may involve
- Observation, interviews, clinical and psychosocial scales, cognitive tests, neuroimaging techniques, or any other appropriate form of evaluation.
- Focusing also on the specific treatment needs of the affected person.
- The neurocognitive evaluation should include at least the study of general intellectual performance, temporal and spatial orientation, attention, speed of information processing, learning and memory capacity, visuospatial abilities, perceptual and motor skills, language and communication, reasoning, the ability to solve problems and some of the executive functions.

Evaluation instruments

I. Short scales or cognitive tracking tests

- Tests easy to apply
- Little time for application (5 to 20 minutes).
- Allows obtaining a “cut-off point” between normal and pathological,
- Allows the remission to a more detailed neuropsychological evaluation.
- Limited to providing a quick view of the patient, monitoring patients, and establishing correlations between this global score and other relevant variables.

Evaluation instruments



Screening Tool: The Mini-Mental State Examination (MMSE)

Patient _____ Examiner _____ Date _____

Maximum	Score	
		Orientation
5		• What is the (year) (season) (date) (day) (month)?
5		• Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3		• Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat until he/she learns all 3. Count trials and record. Trials _____
		Attention and Calculation
5		• Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward.
		Recall
3		• Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
2		• Name a pencil and watch.
1		• Repeat the following "No ifs, ands or buts."
3		• Follow a 3-stage command: "Take a paper in your hand, fold it in half and put it on the floor."
1		• Read and obey the following CLOSE YOUR EYES.
1		• Write a sentence.
1		• Copy the design shown.

_____ **Total Score**

ASSESS level of consciousness along a continuum _____

Alert Drowsy Stupor Coma

"Mini-Mental State." A Practical Method for Grading the Cognitive State of Patients for the Clinician. *Journal of Psychiatric Research*, 12(3): 189-198, 1975. Used with permission.

more information on reverse

Figure 14: Mini-Mental State Examination (MMSE)

Evaluation instruments

II. General evaluation batteries

- Set of test that explore the main cognitive functions systematically.
- Advantages: to have a large database that facilitates obtaining a profile that characterize different levels of people cognitive domains, and variables control
- Identify not only the main deficits but also the skills preserved
- Essential for the establishment of a subsequent personalized rehabilitation program.

Evaluation instruments

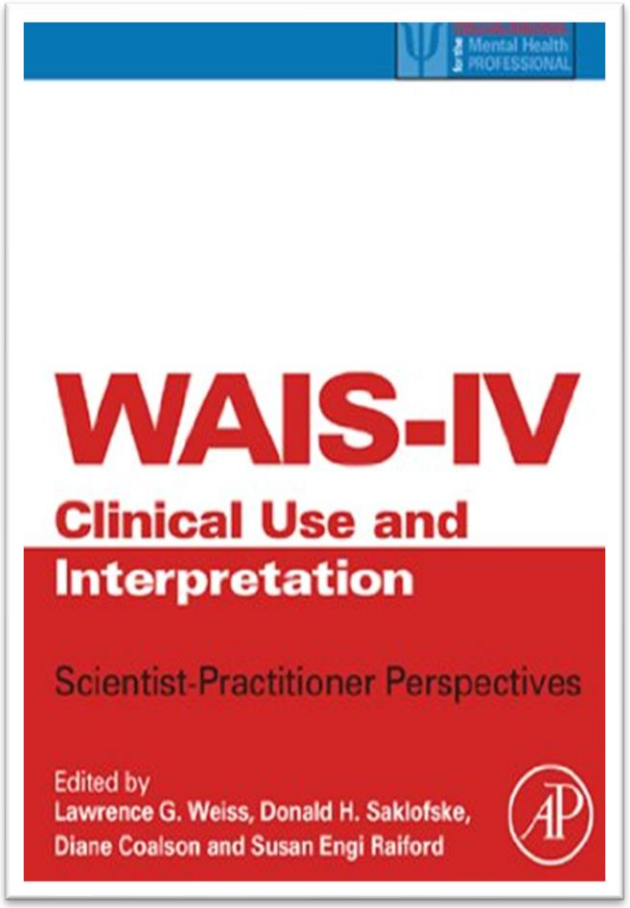


Figure 15: Weschsler Adult Intelligence Sacale (WAIS)

Evaluation instruments

III. Specific tests

- Focused on examining specific cognitive function deterioration.
- Used to develop a realistic work plan for the patient.

Cognitive or neurocognitive evaluation should be done by a neuropsychologist,

Cognitive screening tests, are accessible to all health professionals, who, with minimal preparation, and in a short time, can make a previous evaluation that allows them refer a patient.

Evaluation instruments

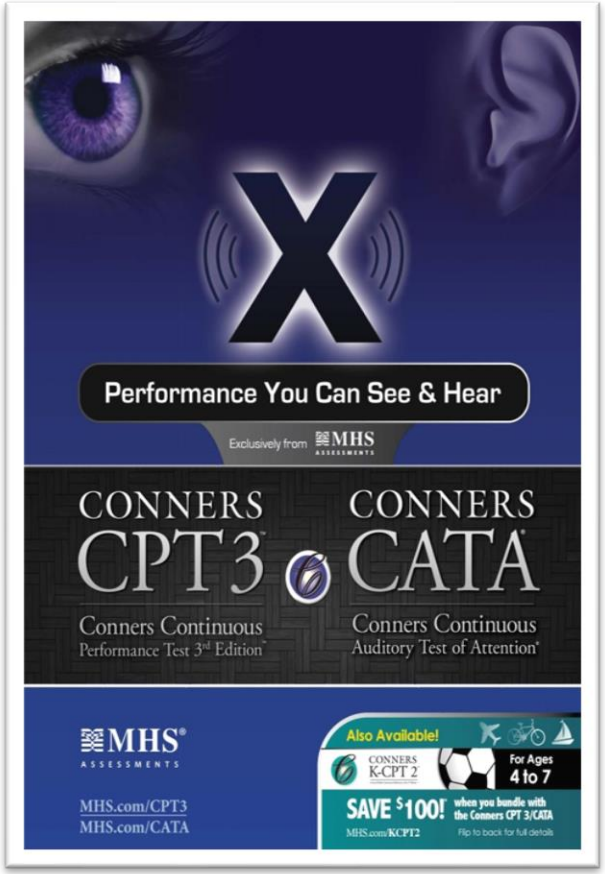


Figure 16: Conners CPT - CATA

2.5. PROGRESS TOWARD OBJECTIVE COGNITIVE ASSESSMENT

The cognitive evaluation has always been carried out through standardized tests and scales in which an observer scores the performance of the person evaluated while answering their questions.

Possible errors:

- The evaluator may have a mistake in the scaling of responses.
- The evaluated person may feel uncomfortable in presence of the evaluator. Meaning in a poor perform.
- In neurological disease, motor and verbal function is compromised. Meaning in a inferior results.

2.5. PROGRESS TOWARD OBJECTIVE COGNITIVE ASSESSMENT

The Eye-tracking is a non-invasive method to objetify the cognitve evaluator.

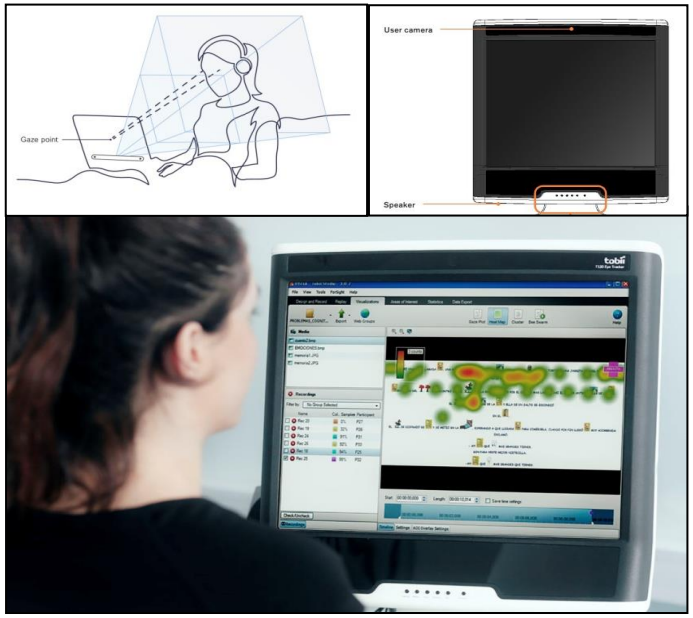


Figure 17: Eye gaze assessment with the eye-tracker system Tobii studio 120, software release 2.2. (Upper images from Tobii user manual).

2.5. PROGRESS TOWARD OBJECTIVE COGNITIVE ASSESSMENT

Outcome	Description
Number of gaze fixations	A high number of fixations indicates a lower search efficiency of items on the screen.
Average time of gaze fixation	Long fixations are usually indicative of the difficulty of the participant in extracting the stimulus information.
Number of fixations of the gaze in each area of interest	The number of gaze fixations in a special element of the stimulus should reflect the importance of that element. Most important elements will receive a greater number of fixations.
Time percentage of the gaze in each area of interest	The proportion of time looking at a particular element of the stimulus could reflect the importance of that element.
Spontaneous eye-blink rate	Correlates with levels of dopamine in the central nervous system and can reveal processes underlying learning and goal-directed behavior.

Table 2.1: Results from eye-tracking system assessment.

2.5. PROGRESS TOWARD OBJECTIVE COGNITIVE ASSESSMENT

Outcome	Description
Pupil dilation	The pupils of the eye not only constrict in response to light and dilate in response to darkness; in children as well as adults, they also dilate during autonomic arousal and mental activity. Thereason that the pupil responds to arousal and mental activity is thatpupil dilation is modulated by the noradrenergic locus coeruleus, implied on the regulation of physiological arousal and cognitive functioning.
Gaze trajectory	Circuit of the tracked look during a test. It allows obtaining an order of the places in which the person fixes the sight on the screen.
Blink rate	Frequency at which the eyelids open and close. Serve as a non-invasive, indirect measure of dopamine activity in the central nervous system. This neurotransmitter is involved in learning, working memory, and goal-oriented behavior.

Table 2.2: Results from eye-tracking system assessment.

Importance of cognitive abilities in the performance of motor task.

3. Cognitive load interference on motor performance

3. COGNITIVE LOAD INTERFERENCE ON MOTOR PERFORMANCE

The cognitive load can alter motor task development.

Several task at the same time examples:

- Multiple cognitive task.
  - While people walk and think about a destination.
  - While people walk and mantain a conversation.
  - While people walk and search for something.
- Maintain a conversation while planning what to say.
- Ordening the steps in a recipe while handing objects and cooking.

3. COGNITIVE LOAD INTERFERENCE ON MOTOR PERFORMANCE

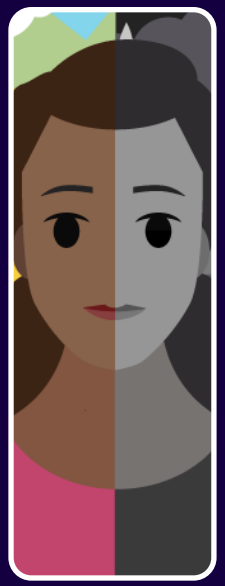
In healthy people, the cognitive load can be measured because the performance of the primary task is not the same as when a cognitive load in not included.

MacPherson (2019)	Chatain et al (2019)
• Stroop task / Congruent and incongruent reading task. • An increased cognitive load in incongruent condition associated with increased articulatory coordination variability and movement duration.	• Isometric quadriceps contraction. • Cognitive load can interfere with motor tasks that do not need cognitive functions for its development.

Importance of cognitive abilities in the performance of motor task.

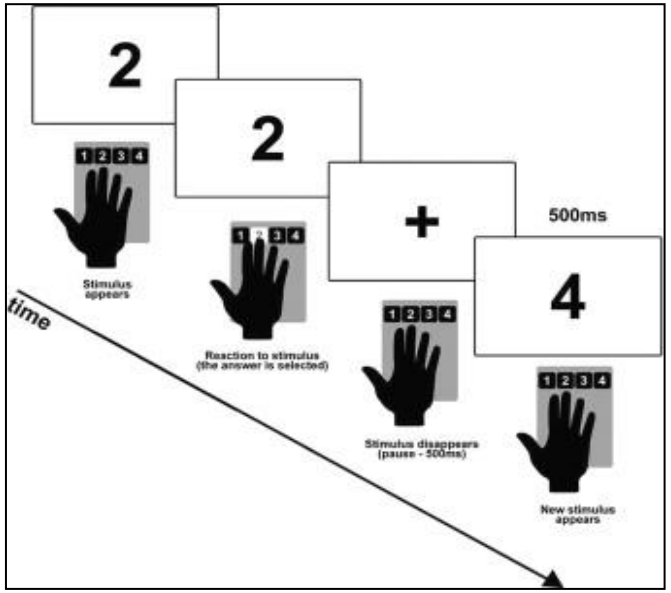
4. Motor performance in people with cognitive impairment and mental disorders

4. MOTOR PERFORMANCE IN PEOPLE WITH COGNITIVE IMPAIRMENT AND MENTAL DISORDERS



BIPOLAR DISORDERS AND MAJOR DEPRESSION

- Cognitive impairment stable and lifelong feature.
- Affected verbal memory, psychomotor speed, executive functioning, visual memory and attention
- Cognitive deficits affects social and occupational functioning.
- Motor signs such as lower speed gait, balance problema during gait ans sit-to stand and los of muscle forcé.



Picture 18: Serial reaction time task for implicit motor learning assessment. The task from the study of Chrobak et al.

4. MOTOR PERFORMANCE IN PEOPLE WITH COGNITIVE IMPAIRMENT AND MENTAL DISORDERS

SCHIZOPHRENIA

- Devastating disorder mainly results from cerebral pathology.
- Prevalence of motor symptoms such as catatonia, neurological soft signs, parkinsonism, involuntary movements.
- Poor comunication from motor cortex with nucleus of the basal ganglia circuit.
- Poor subcircuit control movement feedback.

HEPATIC DAMAGE

- Liver failure leading to hepatic encephalopathy (HE).
- Brain impairment due to amonia and inflammation. Generated metabolic toxicity alter bain functioning.
- Cognitive deterioration such as attention deficits and mild cognitive impairments.
- Trigger physical failty.

4. MOTOR PERFORMANCE IN PEOPLE WITH COGNITIVE IMPAIRMENT AND MENTAL DISORDERS

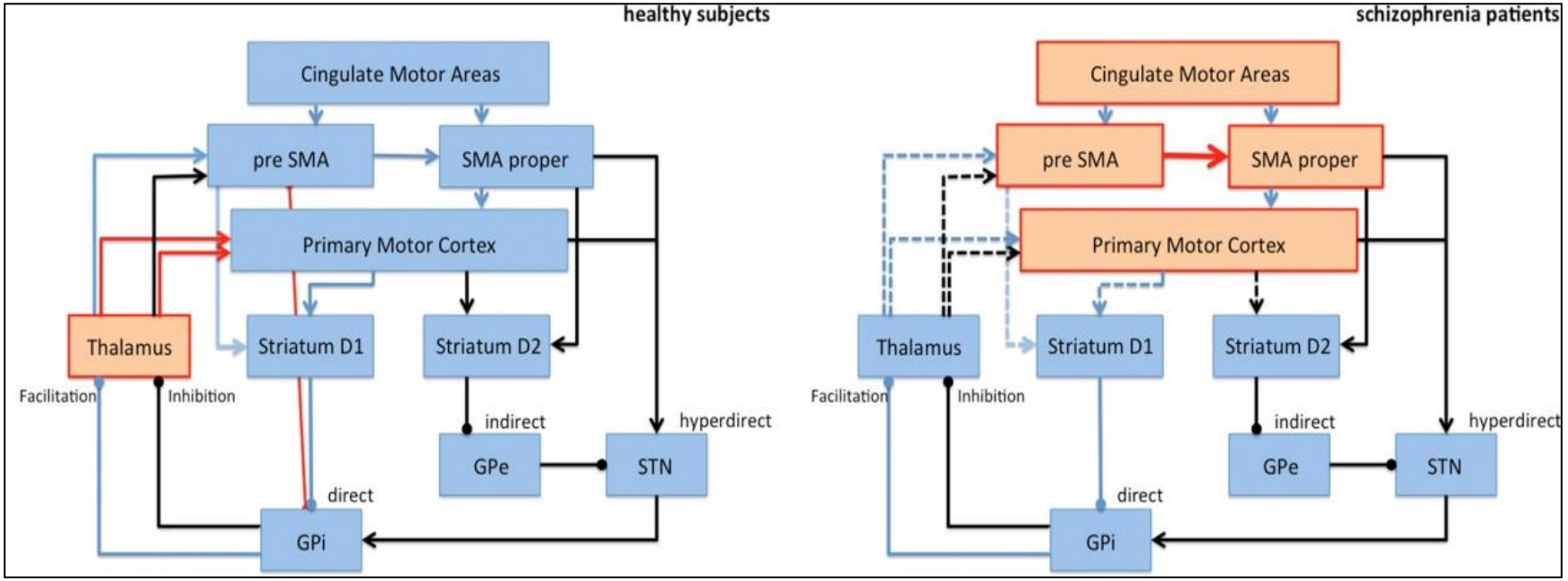


Figure 19: connections between cortical and subcortical components of the motor loop. (Left) Circuit of Healthy subjects, (Right) Altered circuit of people with schizophrenia. Image from Walther S. 2015.

4. MOTOR PERFORMANCE IN PEOPLE WITH COGNITIVE IMPAIRMENT AND MENTAL DISORDERS

CANCER

- Cognitive problems after chemotherapy.
- Cognitive impairment due to celular toxicity, reduced white matter integrity and inflamatory reactions.
- Mild to moderate cognitive problems.
- Cognitive problems such as motor impairment in activities and fuctioning.

Importance of cognitive abilities in the performance of motor task.

5. Dual-task assessment

5. DUAL-TASK ASSESSMENT

Dual-task or dual-tasking is refered as a simultaneous development of two tasks with diffferent objectives requiring attention for their execution.

- Proper way to assess cognitive load in a motor task.
- Assess used in older people or who suffer from motor impairment.
- Gait is the most evaluated motor gesture.
- Gait performance as a primary task and cognitive or motor performance as dual task using the arms.
- Assessment of patient focus attention.
  - Automatical gait perform by spine or mesencephalic center.
  - Gait adaptation perform by cerebral cortex area.

5. DUAL-TASK ASSESSMENT

Primary Task: GAIT

Secondary Task: motor task of upper limb

Figure 20: Dual-task assessment. In this example the primary task is the gait and the secondary task is the manipulation of the mobile phone. The gait assessment is performed with a photogrammetry system which allows register the cinematic outcomes of the evaluation, such as gait velocity, spatiotemporal parameters and joint angles.

Importance of cognitive abilities in the performance of motor task.

6. Key ideas

6. KEY IDEAS

- The cognitive functions in the human being allow to carry out effectively all kinds of activities, both mental, social and motor. Within cognitive functions, executive functions are widely studied because they allow the performance of multiple tasks efficiently and because of their involvement in the movement.

- The evaluation of cognitive functions is traditionally mediating scales and psychometric tests that have a subjective component because the response observed by the evaluator or given by the patient comes from a subjective perception. Tools such as the eye-tracker allow us to objectify a cognitive response through the monitoring of eye movement, identifying the pupil.

6. KEY IDEAS

- Cognitive burden has an impact on the motor performance of healthy people, elderly or with neurological disorders. The most studied functions under cognitive load are gait and balance, finding a worse performance when an additional task is performed at the same time.

- People with diseases that implies to cognitive impairment show motor impairment for two reasons mainly: 1) because altered cognitive functions are involved in motor activities such as work or driving, and 2) because, in addition to the brain abnormalities that show cognitive damage, there are mechanisms where motor circuits are also affected. Examples of these pathologies are bipolar disorder, schizophrenia, chronic liver damage and patients with cancer and chemotherapy treatment.

6. KEY IDEAS

- The way to evaluate the cognitive load in a motor task, or vice versa, is through a dual-task, where the attention of the person evaluated fluctuates between the development of the primary task and the secondary task. The indicator of this interference is the *dual-task cost parameter*, which indicates the percentage of deterioration of the additional load to the primary task.

- The importance of biomechanical evaluation under dual conditions is that, on the one hand, they are a functional and habitual context for people, and on the other hand, many mental or cognitive pathologies, in turn, cause motor damage, may require medical attention in this domain.

Importance of cognitive abilities in the performance of motor task.

7. Bibliography

BIBLIOGRAPHY

1. Adams R, Parsons O. Neuropsychology for clinical practice: etiology, assessment, and treatment of common neurologic disorders. Washington, DC: American Psychological Association; 2003.

2. Alvarez JA, Emory E. Executive function and the frontal lobes: a meta-analytic review. Neuropsychol Rev 2006;16:17-42.

3. American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: Author.

4. Baddeley A. Modularity, Mass-Action and Memory. The Quarterly Journal of Experimental Psychology Section A, Volume: 38 issue: 4, page(s): 527-533. November 1, 1986.

5. Ballesteros, S. (2001). Habilidades cognitivas básicas: Formación y deterioro. Madrid: UNED.

6. Ballesteros, S. (2002). Psicología General. Atención y percepción. (Vol. II). Madrid: UNED.Ballesteros, S. (2014). La atención selectiva modula el procesamiento de la información y la memoria implícita [Selective attention modulates information processing and implicit memory]. Acción Psicológica, 11(1).

7. Chatain C., Radel R., Vercruyssen F., Rabahi T., Vallier JM., Bernard T., Gruet M. Influence of cognitive load on the dynamics of neurophysiological adjustments during fatiguing exercise. Psychophysiology. 2019 Jun;56(6):e13343.

BIBLIOGRAPHY

8. Collette F, Hogge M, Salmon E, Van der LM. Exploration of the neural substrates of executive functioning by functional neuroimaging. Neuroscience 2006;139:209-221.

9. Dorfman J. Problem solving, inhibition and frontal lobe function. In: Raz N, editor. The other side of the error term: aging and development as model systems in cognitive neuroscience. Amsterdam, The Netherlands: Elsevier Science; 1998. p 395–448.

10. Dosenbach NU, Fair DA, Cohen AL, Schlaggar BL, Petersen SE. A dual-networks architecture of top-down control. Trends Cogn Sci. 2008 Mar;12(3):99-105. doi: 10.1016/j.tics.2008.01.001. Epub 2008 Feb 11.

11. Eckestein M., Guerra-Carrillo B., Miller Singley A., Bunge S. Beyond eye gaze: What else can eyetracking reveal about cognition and cognitive development? Developmental Cognitive Neuroscience 25 (2017) 69–91.

12. Fox MD, Raichle ME. Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging. Nat Rev Neurosci. 2007 Sep;8(9):700-11.

13. Fritz NE., Cheek FM., Nichols-Laren DS. Motor-cognitive dual-task training in neurological disorders: A systematic review. J Neurol Phys Ther. 2015 July ; 39(3): 142–153.

14. Greicius MD, Krasnow B, Reiss AL, Menon V. Functional connectivity in the resting brain: a network analysis of the default mode hypothesis. Proc Natl Acad Sci U S A. 2003 Jan 7;100(1):253-8. Epub 2002 Dec 27.

BIBLIOGRAPHY

15. Greicius MD, Krasnow B, Boyett-Anderson JM, Eliez S, Schatzberg AF, Reiss AL, Menon V. Regional analysis of hippocampal activation during memory encoding and retrieval: fMRI study. Hippocampus. 2003;13(1):164-74.

16. John D. Medaglia, Mary-Ellen Lynall, and Danielle S. Bassett. J Cogn Neurosci. 2015 August; 27(8): 1471–1491.

17. Kopelman MD. Disorders of memory, Brain, Volume 125, Issue 10, October 2002, Pages 2152–2190.

18. Lachman, R., Lachman, J. L., & Butterfield, E. C.Cognitive psychology and information processing. An introductory. Hillsdale, NJ: Erlbaum.1979.

19. Lezak MD, Howieson DB, Bigler ED, Tranel D. Neuropsychological assessment. Fifth edition. New York: Oxford University Press; 2012.

20. Light, J., & McNaughton, D. (2013). Putting People First: Re-Thinking the Role of Technology in Augmentative and Alternative Communication Intervention. Augmentative and Alternative Communication, 29(4), 299-309.

21. Lynne Beal A., Holdnack James A., Saklofske Donald H., Weiss Lawrence G. Chapter 3 - Practical Considerations in WISC-V Interpretation and Intervention in WISC-V Assessment and Interpretation Scientist-Practitioner Perspectives Practical Resources for the Mental Health Professional. 2016, Pages 63-93.

22. MacPherson MK. Cognitive Load Affects Speech Motor Performance Differently in Older and Younger Adults. J Speech Lang Hear Res. 2019 May 21;62(5):1258-1277.

BIBLIOGRAPHY

23. Menon V (2010) Large-Scale Brain Networks in Cognition: Emerging Principles. In: Analysis and Function of Large-Scale Brain Networks. (Sporns O, ed) pp. 44-53. Washington, DC: Society for Neuroscience.

24. Meehan TP, Bressler SL. Neurocognitive networks: findings, models, and theory. Neurosci Biobehav Rev. 2012 Nov; 36(10):2232-47. doi: 10.1016/j.neubiorev.2012.08.002. Epub 2012 Aug 18.

25. Mirsky, A.F., Anthony, B.J., Duncan, C.C. et al. Analysis of the elements of attention: A neuropsychological approach. Neuropsychol Rev 2, 109–145 (1991).

26. Morice R and Delahunty A. Frontal/Executive Impairments in Schizophrenia. Schizophrenia Bulletin, Volume 22, Issue 1, 1996, Pages 125–137.

27. North Jersey Health and Wellness. Comprehensive and Prreventive Health Care. Brain Mapping. Cited: January 2020 (Available from: https://njhwllc.com/brain-mapping/).

28. Persad C., Jones JL., Ashton-Miller J., Alexander NB. and Giordan B. Executive Function and Gait in Older Adults With Cognitive Impairment. Journal of Gerontology: 2008, Vol. 63A, No. 12, 1350–1355.

29. Ridderinkhof KR, van den Wildenberg WP, Segalowitz SJ, Carter CS. Neurocognitive mechanisms of cognitive control: the role of prefrontal cortex in action selection, response inhibition, performance monitoring, and reward-based learning. Brain Cogn 2004; 56:129-140.

BIBLIOGRAPHY

30. Seeley W, Menon V, Schatzberg AF, Keller J, Glover GH, Kenna H, Reiss AL, Greicius MD. Dissociable intrinsic connectivity networks for salience processing and executive control. J Neurosci. 2007 Feb 28;27(9):2349-56.

31. Seeley WW1, Allman JM, Carlin DA, Crawford RK, Macedo MN, Greicius MD, Dearmond SJ, Miller BL. Divergent social functioning in behavioral variant frontotemporal dementia and Alzheimer disease: reciprocal networks and neuronal evolution. Alzheimer Dis Assoc Disord. 2007 Oct-Dec;21(4):S50-7.

32. Squire LR. The organization and neural substrates of human memory. International Journal of Neurology, 01 Jan 1987; 21-22:218-22.

33. Stuss DT, Alexander MP. Executive functions and the frontal lobes: a conceptual view. Psychol Res 2000;63:289-298.

34. Tirapu J (2007) La evaluación neuropsicológica. Intervención Psicosocial, Vol. 16 N.° 2. Págs. 189-211. Colegio Oficial de Psicólogos de Madrid.

35. Witlox L., Schagen S., Ruiter M., Geerlings M., Peeters P., Koevoets E., van der Wall E., Stuiver M., Sonke G., Velthuis M., van der Palen L., Jobsen J., May A., Monninkhof E. Effects of physical exercise on cognitive function and brain measures after chemotherapy in patients with breast cancer (PAM study): protocol of a randomised controlled trial. BMJ Open 2019;9:e028117.

36. Yogev G., Hausdorff JM., and Giladi N. The Role of Executive Function and Attention in Gait. Mov Disord. 2008 Feb 15; 23(3):329-472.

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