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CLINICAL NEUROPSYCHOLOGICAL ASSESSMENT BY USING TEST OF MEMORY AND LEARNING (TOMAL) IN THE CASE OF CHILDREN WITH BRAIN INJURIES

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ABSTRACT. The aspects concerning memory from the point of view of clinical neuropsychology seem to be unclear. Almost every malfunction of the central nervous system (CNS) associated with problems in superior cognitive functions has also been associated with a type of memory impairment, this being a usual problem underlined by the patients (Reynolds, 2003; Fischer, 2004). In the cases of traumatic brain injury (TBI), memory impairments seem to be the most common among patients' problems (Mellick, 2004; Reynolds, 2005). This research emphasizes several aspects concerning the assessment of memory functionality in the case of children that suffer cerebral traumatic injuries, by using the assessment tool TOMAL – Test of Memory and Learning. It also underlines the way children's cognitive abilities change due to the traumatic injury.

Keywords: memory, traumatic brain injury, TOMAL, memory performance

ABSTRAKT. Klinische neuropsychologische bewertung durch gedächtnis- und lernenstest (TOMAL) bei kinder mit traumathischen kopfverletzungen.
Die Gedächtnisprobleme scheinen allgegenwärtig in der klinischen Praxis der Neuropsychologie. Fast allen Unordnungen des zentralen Nervensystems (SNC) assoziiert mit Störungen der höheren kognitiven Funktionen wird eine Form der Gedächtnisstörung assoziiert, registriert als ein übliches Problem bei den Patienten. (Reynolds, 2003; Fischer 2004;). In den Fällen von Schädel-Hirn-Verletzungen (LTC), die Gedächtnisstörungen sind die häufigsten von alle Problemen der Patienten. (Mellick, 2004; Reynolds 2005).Die vorliegende Studie versucht einige Aspekten der Bewertung der Abruf-Funktionalität bei Kindern, die Schädel-Hirn-Verletzungen erlitten haben, durch Benutzung der TOMAL – Test of Memory and Learning (Test für Gedächtnis und Lernen)-Testbatterie um die Veränderungen der kognitiven Leistungsfähigkeit von diesen Kindern nach der Verletzung zu markieren.

Stichworte: Gedächtnis, Schädel-Hirn-Verletzung, TOMAL, Abruf-Leistung.

Memory is almost always an important aspect for cognitive rehabilitation or retraining (Skeel and Edwards, 2001). However, to re-establish memory functions after a traumatic cerebral injury has taken place is less predictable than

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the way others, more general, cognitive functions can be rehabilitated, this probably being because of the attention deficits that are characteristic for cerebral injuries. Memory deficits are the most persistent impairments in TCI (Skeel and Edwards, 2001). While certain memory functions (for instance, immediate recall) are annulled both in the context of functional and organic impairments, other memory aspects (e.g. delayed recall or memory loss) can establish a clear difference between psychiatric impairments such as depression and TBI and other CNS injuries. Most of the TBI cases can be grouped in three distinct categories from the point of view of age-the first group refers to the age range between birth and 5 years of age; the second group, 15–24 years old; and the third, over 75 year old; males numerically exceed in females, 2 to 1. A car crash is the most common cause for TBI, while other accidents and violence, respectively, come second and third (Langlois, Rutland-Brown and Thomas, 2006).

Taking into account the importance of memory in daily tasks, especially during schooling period, as well as its importance while assessing brain functional and physiological integrity, it does not surprise us that memory assessment in children and adolescents is an extensively-studied aspect.

To a certain degree, assessing memory in children and adolescents must have been considered as being important beginning with the first modern test for intelligence (Binet, 1907) and continuing with a more important test for assessing intelligence, the Wechsler Scales. These tests, within their different variants for children, included at least one or two short assessment tasks for short-term memory. All in all, major texts about child neuropsychology written during the 1970s and 1980s (for instance Bakker, Fisk and Strang, 1985; Hynd and Obrzut, 1981) do not discuss about memory assessment, although it was pointed out that 80% of a representative group of clinicians who use memory assessments emphasized the fact that memory is an important aspect of the cognitive and intellectual functions assessment (Snyderman and Rothman, 1987). In 1995, only important textbooks took into account memory function assessment in children (for instance Rourke, Bakker, Fisk and Strang, 1983), as well as its relationship with different medical malfunctioning (Baron et al., 1995), or even neuropsychiatric ones (Gillberg, 1995) is commonly included in major papers about child neuropsychology.

Brain injuries (BI) and their effects represent a major problem for public heath, they being the cause for approximately two thirds from the post-traumatic deaths and the most frequent generator of permanent disability condition post-traumatically. Recent statistics from USA and Germany counted 200-300 cases of BI reported for 100,000, the incidence peak corresponding to the 15–24-years-old people. The ratio between the CCI in males and females is 2–4/1.

In the case of the patients with multiple injuries, 50% are Central Nervous System injuries, while brain injuries are present in the case of 75% of those who died in car crashes. In Romania, the data revealed by a preliminary investigation developed by *NeuroTrauma Group* of SRN in 1997 emphasized that brain injuries can be found in a proportion of 25-95% in the specialized department, with a mortality average of 60-90% in the cases of severe brain injuries, while the ratio corresponding to the same indicator in the European Community in 1996 was 31%.

Ever since the times of Hippocrates it was known that brain injuries in children are different from those in adults not only from the point of view of their frequency, of their producing mechanism or of their traumatic types, but also from the point of view of the brain reaction or the nature of the late traumatic consequences. These differences were better investigated during the last decades, especially in complex papers belonging to Matson (1969); Meally (1968); Jennett (1970); Arseni, Horvath, Ciurea (1980); Millan (1999); Zumann, (2001); Kirsch, (2006).

Memory neurobiology

Attention leaves traces or indicators in the brain, this becoming memory. Memory, in the most common perception, is the ability to recall an event or a piece of information of various types and forms. From a biological point of view, memory functions on two major levels, one of the individual cell, and the other of the system. Once memories appear, they imprint changes within the individual cells (Cohen, 1993; Diamond, 1990; Scheibel, 1990), inclusively within the level of the cell membranes and within synaptic physiology.

The median temporal lobe, especially the hippocampus and its connecting fibers within the limbic and para-limbic structures, is of great importance in developing associative memory. The limbic system (mostly the posterior regions of the hippocampus) also mediates the development of conditioned responses. Thus, certain patients with posterior lesions located in hippocampus do not respond to the operating paradigms when the bi-directional programs for consolidation are missing. The medial injury at the level of the temporal lobe and of its connecting fibers or at the level of median diencephalic structures causes difficulties in building new memories (retrograde amnesia), but these can also unlock recent memories, ones appeared before the time of the lesion (retrograde amnesia). Different regions within limbic and para-limbic structures play an important role in building certain types of memories and simply conditioned memories may appear at sub-cortical level. All the interactions taking place at the level of the above mentioned systems are to be controlled by the attention connected mechanism situated especially at the level of the brain stem and frontal lobes, this leading to directly and indirectly facilitating memory development. Memory is a complex function resulting from the interaction of different cerebral systems (with unequal contribution). If one of this system is injured may negatively influence the capacity of developing new memories.

In the case of right-handed persons, verbal and sequential memories may be affected to a greater extent as a result of the injury from the level of the left temporal lobe and its connected regions. Injuries in the right hemisphere interfere in a negative way, especially with visual and spatial memory.

Research objective:

Assessing the functionality peculiarities of the memory in the case of two brain injured patients by using TOMAL (Test of Memory and learning) probe.

Hypothesis:

Traumatic brain injuries highly interfere with memory performance in the case of children afflicted by this type of trauma.

Participants:

Two participants were included in this research, using the following criteria:

a. participant diagnosed with acute isolated cerebral injury or with a brain injury part of an associated trauma, case in which the brain injury is responsible for the patient's serious health problem;

b. neurologic status situated between 12-9 ranges, it being assessed by using GCS (Glasgow Coma Scale);

c. neurologic status situated below or on the 9 range, it being assessed by using GCS (Glasgow Coma Scale) during the primary assessment, patient who required intubation.

Tools used during the research

a. Glasgow Coma Scale (GCS)

This scale assesses three distinct components of the conscience estate: the patient's ability to open his eyes, verbal, and motor response. The scores obtained on those three levels are added being obtained a total score between 3 and 15 points. The GCS score has a diagnosis and prognosis value. It is easy to be calculated by adding the score obtain for ocular reaction (OR), verbal (V) and motor (M) – the normal score is 15 points. Coma is corresponding to a score <8 points, going till lack of reaction, it being noted as GCS=O1V1M1=3 points.

b. TOMAL-Test of Memory and Learning

TOMAL is a complex battery of probes, composed of 14 memory and learning tasks (eight main sub-tests and six supplementary sub-tests), standardized for people with ages within 5 years 0 months 0 days and 59 years 11 months 30 days. Its eight main tests are divided into verbal and non-verbal memory content areas. These areas can be mixed, thus making up a composing test.

Specialized literature identifies two main researches that investigated the relationship between gender, ethnic variables and the performances scored in TOMAL test. Mayfield and Reynolds (1997) compared white and black children's performances with those obtained by the normative sample used for standardizing TOMAL. The results obtained proved that white and black children scored similar performances with those of the normative sample, by taking into account the main factors of the probe, Reynolds and Bigler (1996) suggesting that "the task is perceived similarly by two testing groups" (p. 120). Furthermore, the researchers investigated all those 14 sub-tests as a whole set, they showing global significance.

Mayfield, Lowe and Reynolds (1998) investigated in another research the performances obtained by males and females. The results proved that female participants obtained higher scores in verbal tasks, while male participants had higher scores in spatial tasks. Authors mentioned among their conclusions that the results obtained correspond to similar tasks used for assessing intelligence, these showing that despite the identified results "there is a common base both for male and female participants".

The standard TOMAL scores per age are made up of four main indexes and five supplementary indexes. The main ten sub-tests are divided into Verbal Memory Index (VMI) and Nonverbal Memory Index (NMI). The Composite Memory Index (CMI) is derived from the ten main sub-tests. The Delayed Response Index (DRI) is made up of the responses to the four sub-tests in the first 30 minutes after testing.

The supplementary indexes include Verbal Delayed Recall Index (VDRI), Attention/Concentration Index (ACI), Sequential Memory Index (SMI), Free Recall Index (FRI), Associative Recall Index (ARI) and Learning Index (LI).

The Verbal Memory Index (VMI) includes five sub-tests: Memory for Stories, Word Selective Reminding, Object Recall, Paired Recall, and Digits Forward. The optional sub-tests such as Letters Forward, Digits Backwards, and Digits Forward are considered to be verbal measurement instruments, but they are not included in the Verbal Memory Index as part of the Composite Memory Index. Each of these sub-tests is presented verbally and prompts for a verbal answer from the examiner. These sub-tests vary in terms of semantic complexity and/or need for language understanding. This allows the examiner to establish whether the language or the meaningful context improves or deteriorates the child's ability to recall the information he or she was presented.

The TOMAL sub-tests

The 8 core sub-tests, the 6 supplementary sub-tests, and the delayed recall trials take approximately 45 minutes for an experienced examiner to administer. The sub-tests were chosen in order to provide a broad evaluation of the memory functions and, when all are used, to provide the most comprehensive memory evaluation available.

The presentation and the responses format in the administration of the TOMAL sub-tests vary systematically in such a way as to sample the verbal, visual and motor modalities and the combinations among them in the format of the presentation and of the response. Several tests are provided for a criterion made up of several sub-tests, including selective recall, in such a way as to determine learning or acquisition curves. Multiple tests are provided (at least five are necessary according to Kaplan, 1996) in the selective recall sub-tests for an analysis of the processing depth. In the format of selective reminding (in which the examinees are reminded only the ”omitted” or un-recalled stimuli, when the articles which have been recalled once will not be recalled in the subsequent tests, problems are revealed in the transferring of the stimuli from the working memory and the immediate memory to long-term storage. The insertion of cues is also allowed at the end of Delayed Word Selective Reminding. The reason for this is to increase the examiner’s ability to test the depth of the processing.

The established memory functions (for instance the memory for stories), which are related to academic learning, are included, along with tasks that are more common in experimental neuropsychology and which have a high (Facial Memory) or low (Selective Visual Reminding) ecologic relevance. Some sub-tests use very meaningful material (Memory for Stories), while others use very abstract stimuli (Abstract Visual Memory).

Apart from the review of the memory function, the purpose for including such a factorial series of tasks on multiple levels is to allow for a thorough and detailed analysis of the memory function and of potential memory deficits which could be discovered. The neurophysiologist’s task is to administer sub-tests which are very specific and variable in terms of presentation and response format and which sample from all the relevant brain functions in order to solve the complex puzzle of brain-behavior disorders. Kaufman (1979) was the first to present a detailed model for the analysis of test data in a comprehensive format (elaborated later, Kaufman, 1994), which make the clinician’s task similar to that of a detective. The detail, breadth and variety of the TOMAL sub-tests, together with their excellent psychometric properties, make TOMAL ideal for usage in a model for “intelligent testing”, especially in the analysis of brain-behavior relations associated to the memory function.

Case Studies

Case study no.1: Tiberiu

At the age of 14, Tiberiu suffered an acute carbon monoxide poisoning. The gas installation in the closed garage where Tiberiu was playing was not working properly, releasing carbon monoxide in the area. His mother found him unconscious, in cardiopulmonary arrest. An NMR revealed a basal ganglion lesion, which is a classic sign of carbon dioxide poisoning.

Before the accident, Tiberiu was in good health. He was a bright student, with grades averaging 9.8. Tiberiu is now in the 7th grade and he has difficulties in Mathematics and poor eye-to-hand coordination. It is believed that his current condition indicates a decline compared to the previous performance.

Figure 1 represents a summary of Tiberiu’s TOMAL scores 15 months after the accident. The format was obtained from score software designed by Szasz, Reynolds, & Voress, 2007. The first section of the summary presents the scaled score, the percentage hierarchy and a quality descriptor ranging from Very Deficient to Very

Superior for each sub-test. The details of the index scores are provided in the second section. This includes trust intervals for the index scores and comparisons of the various index scores. Tiberiu's DVRI (83) is below average and is considerably below the performance of immediate recall, as it is reflected on the VMI (107). This clearly indicates a significant deviation from his abilities before the accident and a common sign of an organic memory deficit associated with carbon monoxide poisoning. The Attention/Concentration Index is also low compared to other scores. Therefore memory indicates a general decline from the levels before the accident.

His WISC-III scores were VIQ = 109, PIQ = 82, and FSIQ = 95. The WRAT-3 indicated reading at 110, spelling at 107 and Mathematics at 95. Fluency was slightly below the expectations for his age. The TOMAL-2 learning curves showed an obvious inconsistency during the test, indicating a considerable variability in the attention processes. The learning curves are presented in the third section of Figure 1.

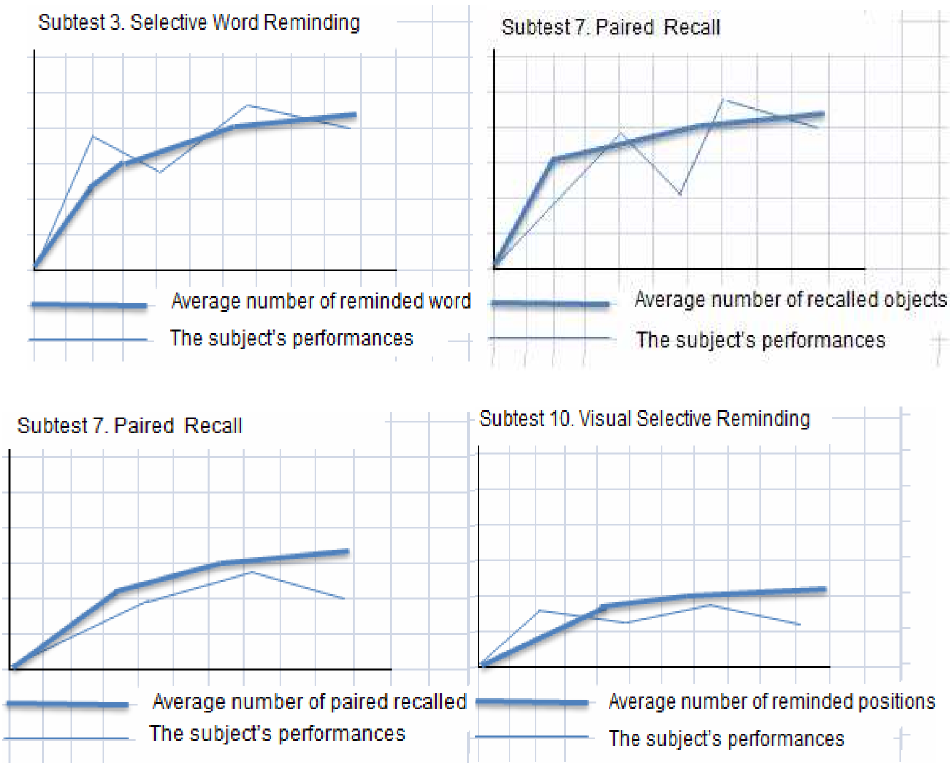

Figure 1. Subject Tiberiu's performances on the TOMAL Battery-Test of Memory and Learning

Case study no. 2 – Maria

At the age of 5, Maria was the victim of a car crash and suffered an acute closed head trauma. She was unconscious after the accident and she was in hospital for several weeks. The EEG testing indicated physiological abnormalities in the area of right temporal lobe. Before the accident, Maria went to kindergarten, and no difficulties related to school performance or behavioral attitudes were noted. Mary is now 7 years old; she is in first grade. Her teacher has indicated that Maria has difficulties related to visual processing and memory.

No intellectual assessment was performed before the accident, but considering the history of Maria's development, it was assumed that she had at least an average intellectual level before the accident. The recent WISC-III scores were VIQ = 95, PIQ = 112, and FSIQ = 102. Figure 2 shows Maria's scores on TOMAL-2. Maria's 88 VMI is below the average, against a 71 NMI, which is clearly in the below the average area of memory performance. The total CMI of 77 is situated in the deficient area of memory performance. The comparisons of the global scores indicate that the VMI differs significantly from the NMI. It is obvious that Maria's non-verbal test results are generally poorer than the verbal test results. The learning Index was lower than expected, considering Maria's educational history. The learning curves are presented in the third section of Figure 2. The low level of the Learning Index confirms the teacher's observation that Maria has difficulties in retaining new information.

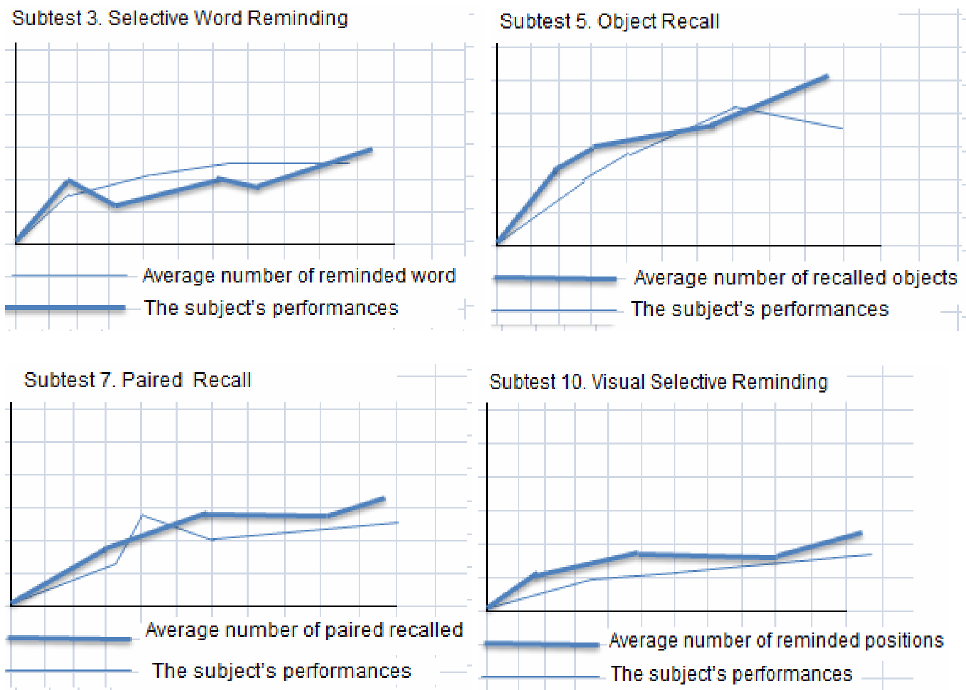

Figure 2. Subject Maria's performances on the TOMAL Battery- Test of Memory and Learning

Summary of findings

Memory evaluation has a lot to offer to the clinician who investigates the neuropsychological processing in children and adolescents, especially in those with CNS system. TOMAL is the most detailed and comprehensive test which allows also an attentive evaluation of the way in which children process and memorize information.

There are many things to be learned about children's memory and especially about the use of delayed recall indices, which have proved so valuable in the case of adults as well. The current efforts are focused on determining the diagnosis and the implications of the test results in the treatment, all with promising results. The crucial role of the clinical memory evaluation in the tasks of the neuropsychologist is determined by the nature of memory in everyday life and the problems related to memory in CNS disorders.

In the specialist literature, researchers claim that memory is not just a singular function, or an entity, but rather that the term "memory" encompasses a complex system of cognitive processes, including acquiring, keeping, memorizing and updating the information (Gross & McIlveen, 1999). Reynolds and Bigler (1994) claim that there is no uniform terminology used to describe the functionality of the memory. Up to now, specific memory elements have been identified based on the theoretical approach of the researchers. Some of these elements include the working memory, recognition versus updating, verbal versus nonverbal, abstract versus figurative. Irrespective of the definition taken into consideration, memory is clearly essential for the cognitive processes. Learning in particular displays a direct connection to memory. This is why it is considered "a relative, permanent change in behavior, as a result of experience" (Gross and McIlveen, 1999), and without a memorization of these experiences, learning could not take place.

On the systemic level there is a division between memory formation and memory storage. A large amount of evidence suggests that associative memory is stored distributively throughout the cortex, allowing for manifestation in a statistic function (Cohen, 1993). At the same time, there is evidence indicating a more localized storage of certain memories and the existence of localized centers for the formation of memory, both in the classical and the operating conditioning.

The entire brain takes part in the functioning of the memory through the distributive storage of the memory. The recall of strong memories tends to be one of the most robust neuronal functions, whereas the formation of new memories, prolonged attention, and concentration, tend to be among the most fragile neuronal functions. Most types of neurological disorders are associated with an abnormal decrease of memory performance along with dislocations of attention and concentration. This has more important consequences when temporal-limbic involvement appears, of the cerebral trunk or of the frontal lobe. However, different psychiatric disorders, particularly depression, can suppress the fragile anterograde memory systems. An attentive analysis of memory, forgetfulness, affective states and a comprehensive neuropsychological testing may be necessary before concluding that the memory related disorders are of organic origin.

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