"BABEŞ BOLYAI" UNIVERSITY CLUJ NAPOCA
FACULTY OF PSYCHOLOGY AND EDUCATIONAL SCIENCES

# SUMMARY

## DOCTORAL THESIS

### ASSESSMENT OF MEMORY FUNCTIONING IN CHILDREN WITH TRAUMATIC BRAIN INJURY BY USING TOMAL (Test of Memory and Learning)

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**SUMMARY**

## Foreward

*"If it hasn't been for the unifying force of memory, our conscieounsness would be divided into as many fragments as experienced seconds" Hering (1920)*

It is estimated that every 11 minutes, a child suffers from a brain injury which causes permanent disability or cognitive impairment[1]. In Romania, also, cranio-cerebral trauma are a leading cause occurring during life causing permanent disabilities. Children who survive these injuries and their complications, may occur later recorded cognitive, language, motor and sensory difficulties. Of these, the most frequently observed are the deficits in memory functioning, the research literature showing that the severity of the impact is closely related to the severity of subsequent disturbances in visual, verbal and memory functions. (Fay, Levin, Yeats, 2008).

The literature shows that previous studies assessing memory functioning in children with head trauma was limited to examining the basic aspects of memory (as learning list, selective recall, visual reproduction).

This study aims to evaluate the memory functionality by using TOMAL - Test of Memory and Learning battery in children who have suffered head trauma to determine if these determins difficulties in memory functioning and examine their nature. Also, the study aims to compare the performance of children with mild head trauma with those of children with severe head trauma in TOMAL Indexes to identify wether the severity of injuries sustained determins a level of severity of memory functionality.

**Keywords: memory functioning, assessment, TOMAL, brian injured, retrieval**

[1] Global Center for Injury Control and Prevention, USA, 2009

## CHAPTER I. INTRODUCTION

### 1.1. Introduction and research problem

In the etiological structure of acute brain injuries a leading place is taken by the brain injuries, followed by stroke (ischemic stroke sites, bleeding), brain tumors, postexcitement and poststrangulations diffuse cerebral hypoxia..

Traumatic brain inuries (TBI) are the leading cause of mortality and disability within the population structure[2]. Of the total number of patients with severe traumatic brain inuries (TBI), almost 100% cases and 2 / 3 of those who suffered a mild traumatic brain injruy will remain in the future with certain physical and mental disabilities and will not return to initial level of functioning[3].

It is assumed that every 11 minutes a child suffers from a traumatic brain injury theat causes significant disruption in the motor, cognitive linguistics and lifelong functioning.

In the literature, disruption of memory functionality is most often associated with traumatic brain injuries, affecting not only memory but also other cognitive functions such as learning.

Traumatic brain injuries are the most common cause of death for people with age average 15 - 44 years[4]. Currently, approximately 11.5 million of Europeans, who survived brain trauma is suffering from physical disabilities or mental deficiency, and in America the figure consists of 5.3 million people.

In U.S. are annually recorded about 500,000 to 600,000 cases of head trauma, from which more than 10% are fatal, and 200000-300000 require treatment and medical supervision. Of these 1 / 3 are the victims of a severe traumatic brain injury[5].

While the mechanisms of production of traumatic brain injury are varied, the most common causes are car accidents, direct falls, aggressions, injuries caused by sport activities and injuries caused by accidental guns operations. Car accidents account for about 50% of traumatic brain injuries the U.S., while in urban areas etiological structure is dominated by assassinations, direct falls and trauma by firearms[6].

At the resuscitation department of the County Hospital Emergency in the counties included in the study the annual average annual of hospitalized patients is 2200 - 2300 patients, of which approximately 60% come due to traumatic brain injuuries. Patients admitted to the intensive care ward are those with altered neurological status, with affected respiratory and / or hemodynamic functions, and require intensive care. In the etiological structure of lethality in these units traumatic brain injuries hold 45% of total cases.

Despite the prevalence of traumatic brain injury impact on cognitive performance, few studies have been conducted to compare the performance of retrieval in children who have suffered a traumatic brain injury.

This study aims to evaluate the memory functionality by using TOMAL - Test of Memory and Learning battery in children who have suffered head trauma to determine if the disruption of retrieval functions and examine their nature. Also, the study aims to compare the performance of children with mild head trauma with those of children with severe head trauma at TOMAL Indexes to

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[2] Joost W. Schouten. Neuroprotection in traumatic brain injury: a complex struggle against the biology of nature. In: Current opinion in critical care. 2007, vol. 13, p. 134-142.

[3] Leonardo Rangel-Castilla, Jaime Gasco, Fadi Hanbali et al. Closed head trauma. The medscape journal. Last update: February 7, 2008. http://emedicine.medscape.com/article/251834-diagnosis (citat 23.06.2008).;

[4] Jagvir Singh, Arabela Stock. Head trauma. The medscape journal [online]. Last updated: June 2009. http://emedicine.medscape.com/article/907273-overview (citat 15.07.2009).

[5] Philip A. V., Bradley H. R., Jonathan G. Neurological injury: prevention and initial care. In the book: Critical Care. 3rd edition, ed. by Joseph M. Civetta, Robert W. Taylor, Robert R. Kirby: Philadelphia. 1997, p. 1195-1217.

[6] Scott Shepard, David W. Crippen. Head injury. [online] Last Updated: august 6, 2008. http://emedicine.medscape. com/article/433855-overview (citat 23.10.2008).

identify the severity of injuries sustained determins a level of severity of disturbance in memory functionality.

"If there were no unifying force of memory, consciousness would be divided into as many fragments as experienced seconds," said Herring since 1920. Memory paradox is that although many phenomena collect a whole, ensuring continuity purposes Ego (Ey), it is itself a unitary mental process, consisting of a sequence of sub (imprinting, storage and update, or - in terms cognitivist - encoding, storage and retrieval) and systems / subsystems relatively autonomous, with brain locations more or less distinct, but integrated functions. Even in the study of psychological science, the detachment from isolated mental phenomena - sensations and their laws - was done by changing the center of gravity of scientific research on memory (Ebbinghaus, 1885) on intelligence (Binet, 1905) for the first half of the twentieth century marked a steadily growing interest. In the second half of last century but revived interest in his memory, defending a variety of psychological models of it, such as structural / modal Atkinson and Shiffrin's model (1968), the functional model with regard to the processing of information Craik and Lockhart's (1972) or memory model of Baddeley and Hitch Working (1974), complemented by Baddeley. For cognitive psychology the interest for memory has remained extremely high, the conceive of structural-functional memory producing explanatory-interpretative model classes: symbolic computational models and connectionist models. (Zlate 1999; Miclea 1999)

From a practical-applied point of view, although the memory psychodiagonsis is of huge importance, both in school and in the clinical psychology or organisational psychology, building cohesive memory battery was one of imposing appearance and further developed intelligence batteries. Thus, since 1939 Wechsler developed his first metric scale of intelligence (Wechsler-Bellevue, ie WB), followed by three standard scales, for children, adults and preschool children (WISC, WAIS and WPPSI), each with three revisions for bring them up to date. The memory battery - Wechsler Memory Scale, WMS - was developed only in 1945, revised in 1987 and the first time only the second time 10 years later. It is far from great popularity and interest on its intelligence batteries wake him among practitioners or authors of books about the testing and psychological evaluation and, moreover, the author and his descendants have not yet given a reply retrieval WISC battery for childhood ages, although they recognized the outstanding importance of memory in learning. This deficit was addressed among others by the TOMAL scale, called by its authors "Test Memory and Learning" (TOMAL. Test of Memory and Learning. By PRO-ED, 8700 Shoal Creek Boulevard, Austin, Texas.), consisting of 14 subteste, of which 8 verbal subtests and 6 nonverbal subtests.

The interest in child and adolescent memory testing has a variety of sources. Thus, most children and adolescents being tested in a laboratory by specialist child neuropsychiatry, over a period of over two decades, most often accused attentional and memory problems, and rare intelligence, and largely because of the immense social prestige is intelligence skills that had become somewhat the "fuel" of the modern world.

### 1.2. Current status of the literature

In the literature, researchers argue that memory is not just a single function, or an entity, but rather, the term "memory" includes a complex cognitive processes, including acquisition, storage, retention and updating information (Gross and McIlveen, 1999[7]). Reynolds and Bigler (1994) argue that there is no uniform terminology used to describe the functionality of memory. To date, specific aspects of memory have been identified based on the theoretical orientation of the researchers.

Some of these aspects include working memory, recognition versus updating, verbal versus neverbal, abstract and figurative. Whatever definition is considered, the memory is clearly centered as a cognitive process. Learning, in particluar, has a direct connection to memory, so it is considered "a relatively permanent change in behavior as a result of experience" (Gross and McIlveen, 1999), and with no memory of these experiences, learning could not take place. Figure No. 1 illustrates the role that memory plays in all higher cognitive processes.

[7] Gross, R., McIlveen, R. (1999). *Aspects of psychology: Memory*. London: Hodder & Staughton.

Memory processes amazed philosophers and psychologists for centuries. Study of memory and learning has its origins philosophical questions about how people get to know aspects of the world they live (Bower, 2000). Aristotle is recognized as the first to develop an essay on this topic sitematic bounding sensorimotor perception, attention and memory (Gaddes and Edgell, 1994). Scientific and systematic investigation of memory not only in the 1880s began with the pioneering work of Ebbinghaus on nonsense syllables memory. Since then, the study of memory has progressed over several phases including basic theory of association and contiguity (Warren, 1921) conceptualization of operant behavior of memory in terms of stimulus control (Skinner, 1968), and neo-behavioral studies of learning and forgetting (Underwood, 1961). These theoretical frameworks have established cognitive conceptualization stage for modern memory. Namely, the notion that experiences are considered as mental representations that are encoded, stored and recovered in a complex human information processing (Bower, 2000). Some of the prominent theories have as a starting point in terms of information processing functionality of memory: the multiple storage of memory (Atkinson and Shiffrin, 1968, 1971) working memory (Baddeley and Hitch, 1974) and levels of processing model (Craik and Lockhart, 1972). The multiple memory storage Atkinson and Shiffrin presented (1968, 1971) tried to explain the flow of information from one system to another (see Figure 2).

The memory divided into three structural components: sensory register, short-term memory (MSD) and long-term memory (MLD). Register sensory function is to retain information for a period of between 3-5 seconds for the person to decide whether information processing are or not interested. Register contains a copy of all sensory stimuli detected by the physical senses, both iconic (visual) and ECON (auditory). Stimuli that are recognized as significant changes are transferred to short-term memory

In 1956, Miller issued a hypothesis that short term memory capacity is seven plus or minus two bits of information, or greater, while the independent or irrelevant items are "reencoded" combine or "reconfigure" in a certain way . In the absence of repetition, short term memory is less than one minute (Brown, 1968, Peterson and Peterson, 1959). However, if repeated, the information may remain in short-term memory for a long time.

In the next phase information is analyzed, and if found to be significantly associated with information already known or will be transferred to long-term memory (MLD). In contrast to short-term memory, memory capacity is significantly improved long-term and duration is significantly increased (Shiffrin, 1999). In addition to these structural components, this system also incorporates a memory mechanism "process control", which refers to activities that are used in the operation and control of memory. These include attention, repetition, selection of indicators for long-term recovery, decision rules and strategies of rescue / recovery of encoded information (Shiffrin, 1999).

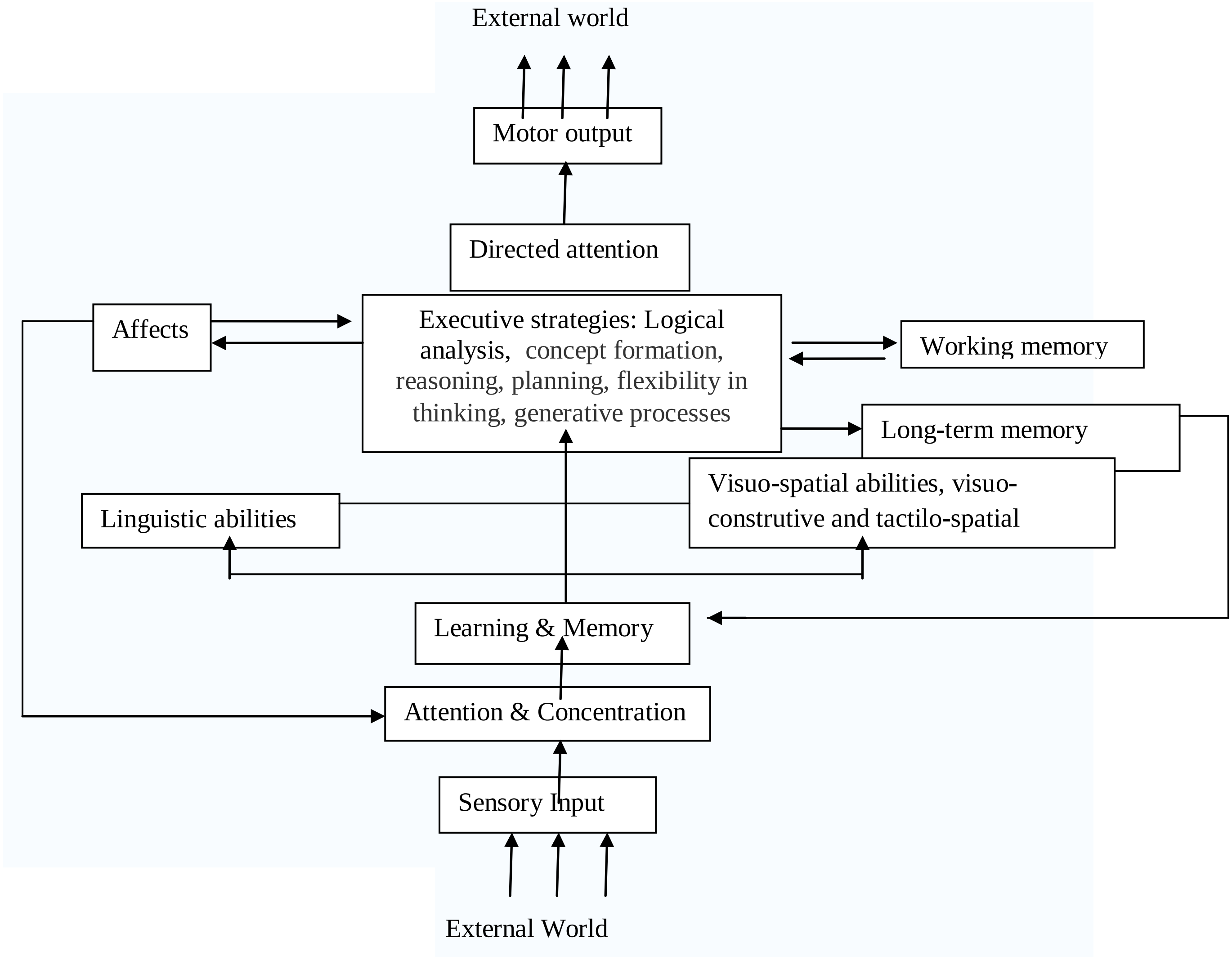


*Figure I.1. A conceptual model of cognitive functions dependent relationship with memory and learning, presented by Reynolds and Bigler (1994b, p.3)*

Clinical and experimental studies have supported the development of distinctions between short-term memory (STM) and long-term memory (LTM) models developed by Atkinson and Shiffrin. In 1962 Murdock developed a study in which participants submit a list of words to memory and found that those words were not recalled in order of memorizing (serial position effect). In fact, those words placed at the beginning and end of the list were more likely to be encoded (the primary and novelty effect) than those in the middle of the list. Novelty effect, the recent encoding explained by the fact that those words were reminding are those that currently are located in short-term memory (STM) system, where the primacy effect occurs since the beginning of the list items are subject to repetition and therefore transferred to the long-term memory (LTM) of which are evoked (Rundus and Atkinson, 1970).

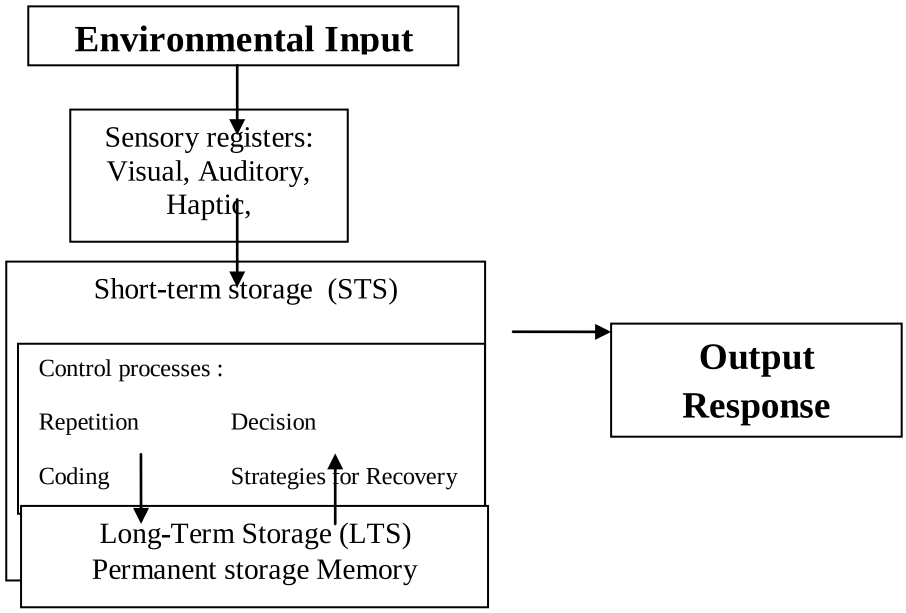


*Figure I.2. The multiple memory storage presented by Atkinson and Shiffrin*

Clinical studies focused on amnesia and on the individuals with memory loss supported the distinction between short-term memory and long-term memory. Patients who develop Korsakoff syndrome, which occurs mainly in patients with chronic alcoholism, have proper retrieval capabilities. However, the transfer of information from short-term memory and long-term memory is significantly disrupted (Gross and McIlveen, 1999). Nevertheless, these patients are able to engage in simple activities, such as normal conversation or reading[8].

Despite the important influence of this model in further research on memory, many researchers have argued that the distinction between structural components is not as important as understanding the flow of information (present or absent) from short-term memory to long-term memory (Baddeley and Hitch, 1974, Craik and Lockhart, 1972, Craik and Watkins, 1973).

Baddeley and Hitch in 1974 support the notion that the unit needs to be replaced short-term memory of a multicomponent system using active storage facility as part of its function to facilitate complex cognitive activities such as learning, understanding and reasoning (Baddeley). Their conceptualization, known as "working memory" consists of a central executive that is assisted by two systems: a phonological loop and a visuo-spatial sketch. (see Figure 3)

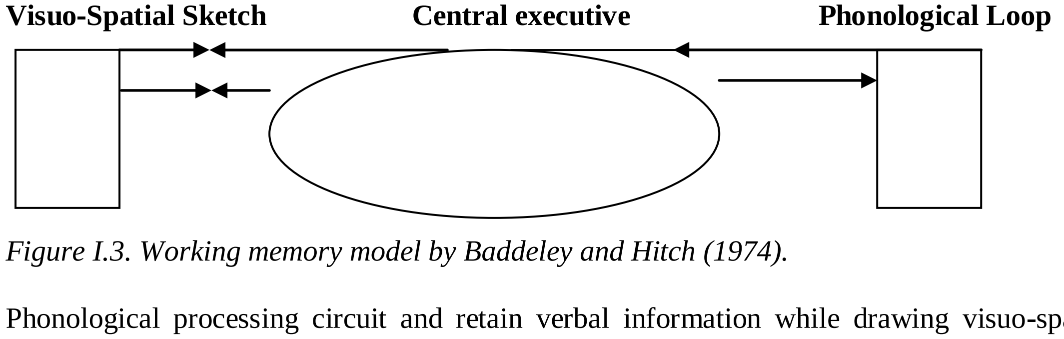


*Figure I.3. Working memory model by Baddeley and Hitch (1974).*

Phonological processing circuit and retain verbal information while drawing visuo-spatial processes and stores visual information. On the input record, Baddeley, Thomson and Buchanan discovered in 1975 that in the absence of a strategy participants can recall as many items as can say in

[8] In contrast, Shall and Warrington (1970) presents the case of K. F., a male person who suffered a brain injury after a motorcycle accident. In this case the short-term memory was affected in a significant extent, so that the subject he could not remember one or two digit figures test reminder, but long-term memory for events occurring after the accident was within the normal functionality.

two seconds. Currently, there is no consensus on the visual ability of short term memory (Baddeley, 1986).

Central executive controls focus, strategy and information retrieval from long-term memory (MLD). Baddeley in 1986 emphasizes the importance of attention in memory processing, noting that current studies indicate "Central executive as a pure attentional system ..." (p.22) significant number of Baddeley and Hitch work developed by the model focuses on memory circuit phonological construct. Clinical trials on patients with difficulties in the short-term memory have shown disturbances in the phonological storage (Vallar and Baddeley, 1984; Vallar and Shallice, 1990)[9]. Regarding vizuo-spatial sketch, Baddeley, Grant, Wight and Thomson shows that vizuo-space path, and not verbal encoding, interferes with performance based on visual memory without being charged with a verbal task.

Interestingly, the "question of how to analyze difficult issue remains central executive" (Baddeley, 2000), although some studies have examined this component of Medel. Based on studies carried out on patients suffering from Alzheimer's disease and acquired brain lesions, Baddeley (1986) and others (Baddeley, Bressi, Della Sala, Logie, Spinnler, 1991; Roberts, Weiskrantz, 1998) have suggested that central government appears to be dependent on the frontal lobes. However, in its reviews of studies on working memory, and collaborators Roberst (1998) concluded that given the complexity of the central executive, evidence of its existence can be obtained by developing functional studies based on imagery.

While Baddeley and Hitch model to examine the structure of the short-term memory, levels of processing model presented by Craik and Lockhart focused on process control that addressed to structural components Atkinson and Shiffrin proposed. Craik and Lockhart (1972) perceived "control processor" that is involved in processing information presented to compare the items above, identifying the presence of a cognitive set and focusing attention on the ability of the person.

This model was developed by Craik and Watkins in 1973 and distinguishes differences between maintenance (or mechanical memory) and recurrence developed (encoding development). In their studies have shown that what is truly important in retention of information is the type of rehearsal or processing, not quantity, volume. The model shows that the surface features of a stimulus (words in capital letters) are processed at a superficial level, while the characteristics of semantically are discussed extensively at a deeper level (Craik and Tulving, 1975, Craik and Watkins, 1973).

For example, Craik and Tulving (1975) showed participants a word followed by one of the four questions prepared by them being able to answer "yes" or "no." These questions ranged from the superficial level of processing significant. When asked to identify which words were presented above, participants showed better performance in recognizing words that were processed at a deeper level, such as search words rhyme or categorization. Critics of this model have recognized that these were added processing strategy certainly the understanding of memory (Gross and McIlveen, 1999). However, many scientists see with this model rather than a simple description of the phenomenon of supply an explanation on how in-depth processing results in better information processing (Eysenck and Keane, 1995).

| **Level of processing** | **Question** | **Yes** | **No** |
|---|---|---|---|
| **Structural** | Is the word written in capitals ? | BOARD | Board |
| **Phonetical** | Is the word “table” rhyming with “castle”? | rasa | |
| **Sentence** | Which of the words fills in “He met a ... on the street?” | FRIEND | Cloud |

Note. Adapted after Craik and Tulving (1975).

[9] Furthermore, participants with dyspraxia, which implies a fragmentation of production capacity based on speech, has a much lower performance due to the inability of these individuals subvocalizare, as demonstrated by researchers (Waters, Rochon, Caplan, 1992).

This overview of theories of memory functioning demonstrates the complexity of studying, and therefore memory assessment. Furthermore, it argues against memory as single entity that can be evaluated by a single measure. The literature suggests that retrieval performance requires conceptualization in the context of many other factors, such as the nature of stored material, whether information is required to be recalled or not for a longer period of time, and why the material retained. It is acceptable assumption that a comprehensive memory evaluation should include a variety of tasks that differ in demand, including attention, verbal versus visual presentation and semantic processing versus mechanical processing. This section will bring into question some of the latest memory approaches, approaches that align with several models on different retrieval processes: sensory filter visual information store (VIS), short-term memory (STM), three-dimensional processing, Craik and Lockhart's approach (1972) and working memory approach, of Baddeley et al. (Baddeley and Hitch, 1974).

# CHAPTER II. ASPECTS OF MEMORY FUNCTIONING IN CHILDREN AND ADULTS

## 2.1. Modern theories regarding the memory functioning in children

Memory defines the temporal dimension of our psychic organization, its integration in the three segments of the horizon - past, present, future.

With memory, our mental being, ego, identity becomes continuity over time. Without retrieval, we live only the present moment, we continually face with new situations, for which we have no experience developed, by any method of approach and solution, we always struggle to play trial and error, adaptation becomes practically impossible.

Memory function is therefore an indispensable condition for the existence and adaptation basal optimal temporal unity of our personality. It is due to brain plasticity - property to modify the internal state under the influence of external stimuli - and his ability to record, store and update the "traces" of these stimuli.

In humans, memory is not concentrated and localized in a single block, but is distributed mechanisms performing specific functions and psycho-behavioral acts. So, unlike the computer, the human brain has not a single block vade, but several, which have bilateral connections. Between the operation of memory and functioning of perception, representation and thought there is a mutual conditioning profound disturbance causes serious disturbances in vade verigii development processes that support (perception or thought), and disorders affecting the operation of the specific process of vade base.

Memory is characterized by several key features, which are printed in the structure of its integration process and specific activities. Memory is active, selective, contextual, mediated, logically and systematically organized.The investigation and assessment development and efficiency of memory are taken into account the following parameters: volume, durability, reliability, completeness, timeliness.

In children memory is suffering significant restructuring with the transition to primary education. In the pupil memory rises new and more complex tasks. New conditions under which the child must live and act, new requirements and may face and need to address as they draw the following major changes in memory: discipline and order of its development after a certain logic takes place, the memory becomes intelective in that it becomes to rely on reason, logic and understanding; it becomes voluntary by excellence; it gains a great plasticity due to great interpersonal memories exchange with other classmates; increase its volume, gaining flexibility and fidelity, becomes an object of the child meditation who is interested in increasing knowledge than his memory peculiarity of the opportunity to overcome some shortcomings.

General peculiarities of young children memory are determined by the development during pre-school memory processes, and specific forms of activity it carries the little pupil.

The development of the voluntary nature of memory starts from the pre-school period. The formation of intentional memory elements based on a specific goal set in advance is necessary prerequisite for learning in school activities. Concrete conditions of work require school children need to master and manage a conscious, voluntary memory processes and reproduction and in general the whole conduct.

At school age, logical memory is still underdeveloped. The scholar is unable to support any use enough memory in thinking activity. It often happens that, with the foreground task memorizing material, the child looses sight of the meaning and of its logical meaning.

From here derives another memory customization, young children prefer using textual memory. Older children use intelligible memorization. In addition to insufficient development of logical memory, another cause of small schoolchildren propensity towards textual memorization and reproduction is of course the absence of conscious abilities and learning skills.

The so-called mechanical memory occurs when the child have difficulty learning, so the teacher must pay sufficient attention to the development of logical memory. Gradually, under the action of appropriate guidance the logical storing starts to develop.

The children trend to verbally memorize is favored by certain factors. First, great plasticity of the brain, which makes a good storage trace previous excitations. On the other hand, the frequency of learning by heart issues lead to the formation of the habit of learning by heart.

Another important feature in children memory is its small concrete, intuitive characteristics. Although there is a net improvement of verbal-logical memory, the influence of assimilation of different knowledge, systematic concepts in education, intuitive memory, the image is still dominant at this age. The small schoolchildren stores more concrete images of objects and phenomena, and the material retained primarily verbal stories, descriptions containing concrete and emotive effect.

This is because on the one hand, the great receptivity of children, and on the other hand, the relative predominance of the first signaling system to the second. Intuitive material wealth contributes greatly to the development of intuitive memory.

During small school develops and improves the understanding of material to memorize, the ability to link new and old knowledge. Also, under the guidance of the teacher, the child learns how to memorize material reasonably, rationally develop memory skills: separation of main ideas, draw up the plan of the stored material, the use of comparisons in the storage and reproduction.

# CHAPTER III. THE TRAUMATIC BRAIN INJURIES

## 3.1. The traumatic brain injuries

Of trauma, an increased frequency have the traumatic brain injuries (TBI) which is an important category of medical point of view, both the frequency and the implications for the life of the individual (from the death science point of view) or from the sequelae they cause. Thus, cephalic extremity is the most common target of aggression (85% after data IML Bucharest). In the lesions with fatal outcomes, have also traumatic brain injuries first place in mortality (35% in homicides, 60% in road traffic accidents, 40% in the accidents, 40-50% for suicide - in general by precipitation 80% for accidental falls). Generally, injuries that are interested segments of the nervous system (NS): brain, spinal cord, etc. have certain features related primarily to the structure and functions of the nervous system but also tend most often slow and incomplete remission as a result of reduced capacity for regeneration of the nervous system - SN.

The traumatic brain injuries (TBI) can be found in two types: open or closed

### a. Open traumatic brian inuries:

- " traumatic brain injury (TBI) opened directly" - traumatic injuries of the scalp, cranial bone and dura-mater with direct communication with the outside environment endocranian space with debris removal of brain and / or cerebrospinal fluid ( CSF).
- " traumatic brain injury (TBI) closed " - damage to the skull base - the ethmoid sinus and temporal rock - located away from the point of impact with adjacent dilaceraration and exteriorization of cerebrospinal fluid (CSF) or brain substance via the nose and / or ear.

Scalp wound without evidence of brain damage can be treated per the first in a general hospital, while traumatic brain injury (TBI) requires mandatory open guidance in neurosurgery service, given the high share of endocranial septic complications (9.5% after Miller and Jannet, 1968).

**b. Closed traumatic brain injury (TBI)**

Diffuse axonal injury include diffuse lesions (LAD) of varying intensity, which can reach clinical coma and is often at odds with poor data provided by CT scan.

Intracranial hematoma include traumatic injuries focused (epidural, subdural and intracerebral), and hemorrhagic contusion outbreaks without mass effect.

### 3.2. Traumatic brain injuries in children

Since Hippocrates knew that traumatic brain injury in children differ from those of adults not only by frequency or types of production mechanisms traumatic, but also in terms of the response of the consequences of traumatic brain or distant nature.

These differences were especially well known in recent decades, particularly on the broader works of Zumann (2001) and Kirsch (2006).

The *incidence* of cranio-cerebral trauma in children (0 to 15 years) varies depending on several factors, among which are the major geographical distribution, environmental conditions, educational factors, social, etc. European countries, and for our country, the incidence is on average 8% of all cranio-cerebral trauma admitted to specialized services. Accessibility to such services, however, is generally limited to severe cases and in part to the average severity, while minor injuries are virtually excluded. Overall percentage is not so on the real. The distribution by sex is predominantly for males compared to females in a 3:1 ratio, except for trauma in infants, where the proportion is almost equal between the sexes.

Geographical distribution is also different. Thus, in many countries in Europe and North America the percentage of traumatic brain injuries in children is almost equal to that in adults, while in some African countries, Nigeria, for example, the incidence is positive for almost half the children (Oduntan, 2003). These differences could be explained by differences that exist in terms of intensity of traffic, the degree of industrialization, educational level, the surveillance opportunities, etc. Distribution by age group indicates a maximum incidence between 5 and 10 years, yet there seems to be an increased incidence of traumatic brain injuries in the age group between 0 and 5 years so that some authors (Hendrik et al., 2000) consider that the incidence is almost equal to the age groups between 0-5 years and 5-14 years.

Infant and young child's individual characters determine skull fractures sometimes outstanding issues, some unprecedented in adults. In children skull fractures occur more frequently in contusive injuries are mostly linear and located in vault, and irradiation is based on less often. Bone lesions have a preferential localization in the parietal or frontal bose often have available radial from the fontanels.

There is a counter-stroke low incidence of lesions in children, which can be explained by exhaustion contusive wave as a result of plastic deformation of the skull and elasticity of vessels. Sutures dehiscence frequently observed without involving the bones or fractures or cracks of small extent. Vault bones that are separated by sutures and fontanelles that allow the baby's skull to be ossified expandable suture disjunction, explains the possibility of setting up giant intrauterine hematoma with minimal compression symptoms. When hitting with objects small area can produce a localized deformation, often clogging recovery (deformation "in the ping-pong ball") or cracks or fractures manufacture radial from the point of impact, but without clogging or production of dodge. Falling or hitting flat linear fractures appear localized (limited to sutures or around fontanels), dehiscence sutures.

Irradiation based on the exception, sometimes seen in the strong trauma. In contrast, if fractures of the skull compressions are large (due to its relative rigidity), often crossing the base of the skull and having a lower tensile canopy. Prevalent fracture location in the parietal or frontal bose or the vertex can be explained by the fact that at young ages, the skull has a higher elasticity, topography more uniform and smaller thickness differences between different regions.

Fractures holes, cutting produced objects - stinging, splitting, occur more easily because of lower bone strength and thickness of the skull child. The presence of skull fractures in children, how age is lower, showing a high intensity trauma, the injury meningo-cerebral, the often incompatible with life, is a general rule. Another way a particular fracture skull fractures in children is progressive. After closed brain injury with fracture and linear meningocerebral lesion, dehiscence can be increased gradually, leading to brain herniation in breach of the substance, thus constituting a cerebral fungus.

You can be trained and a lateral ventricle, and in extreme cases, the brain substance necrosis, can lead to ventricular opening to the outside through a cerebrospinal fluid fistula.

As the brain is immature, with some features still ungained and other imperfections. A lesion in these regions will be manifested by neurological signs, with a generally poor clinical picture.

Morphological features that distinguish the lesions seen in adult child are observed:

- Adherence low bone dura plan is taking off so more easily, favoring formation of superhard hematoma, which have a greater scope and range up faster;
- meninges vessel fragility, leading to bleeding more easily produce meninges or subdural hematomas, higher content of cerebrospinal fluid in the subdural space with protective effect on the brain by "damping" force trauma; special composition to that of adult brain by increased fluid content, and missing or incomplete myelination of determining a minimum difference between gray matter and white consistency. Customize this explains a number of aspects, mainly cortical and subcortical contusion in the absence of young global frequency response as brain edema, a diffuse contusion or intracerebral bleeding or ventricular.

Cerebral contusion, if limited, will almost certainly heal, but neurological sequelae, although the possibility of recovery at younger ages are very large. Coma sequelae are possible with on the biological response. Between 1-3 years, due to morphological characters mentioned above, there is no cortical or cortico-subcortical contusion, encountered cases are exceptions. Between 3-5 years contusion rarely occurs after this age can be observed only at impact and with a limited intensity and extent. Cortical contusion after 7-8 years is common and can highlight areas and riposte. Contusions manifest by large and persistent coma with seizures decerebrare exceeding therapeutic possibilities. Brain lesions appears in high intensity trauma (crushing the skull, intracranial penetrating injury) and is more rare (only older) in the focus of direct impact not only with broken bone or linear. If Aeschylus fractures, dilaceration appears as a direct intracranial mechanical penetration vulnerable object or bone fragments.

Cerebral edema is a constant change, frequent head trauma in children, often the only manifestation of his or meninges is associated with diffuse bleeding. Pathology of the newborn have not forgotten the possible association of trauma, usually mild, with some changes in type or perinatal asphyxia, a hemorrhagic syndrome, viral or abnormalities.

Infant injuries are mostly light, as a consequence of falling out of bed, the chair of the first attempts to walk, or hitting with a hard object by another child or the parent. Precipitation and road accidents are rare in the first age group, but common in preschool and school where the child is a specific pathology in terms of its integration into the family, school or social.

## CHAPTER IV. NEUROPSYCHOLOGICAL AND NEUROPHYSIOLOGICAL APPROACHES ON THE MEMORY FUNCTIONING IN CHILDREN WITH TRAUMATIC BRAIN INJURIES

### 4.1. Neuroanatomy correlations of memory

Until recently it was known that these correlations were derived from the neuroanatomy of memory developed neuropsychological studies on memory. Advanced techniques in neuroimaging, especially MRI and PET scans have increased the understanding of brain structures involved in memory function. Since the memory is full feature other cognitive functions including language, reasoning and emotion, researchers have observed that "location memory processing is difficult because neural networks, on the outskirts of cortical neurons to participate in this process integration "(Markowitsch, 2000, p. 265). Surprisingly, this statement has echoed the findings of Karl Lashey in 1950 after which they were issued neuropsychological considerations of the retrieval operation. Lashley's efforts to uncover the location of neural responsible for encoding, or hitting the habits learned, were held throughout their lives. After 45 years, concluded that the location was impossible (Kolb and Whishaw, 1990).

Many currently known issues related to memory processing are derived from studies conducted in patients with Korsakoff syndrome, cerebral palsy, Alzheimer's or brain injuries, including amnesia. Thus, the assumption on the memory functionality is derived from studies of pathological conditions and abnormal memory function.

One of the most cited studies on memory loss is the case H. M. (Scoville and Milner, 1957). To treat epilepsy H.M. underwent a series of surgeries to remove sections from each lobe are temporal parts of the hippocampus and amygdala including. As a result, pre-intervention experiences were never stored for a period of time (Thompson, 1988). Thus, H. M. lost his ability to recall their own experiences, symptom of anterograde amnesia. However, showed a relatively normal short-term memory and motor memory skills, such as tennis rules (Scoville and Milner, 1957). His case "has established the fundamental principle that the ability to achieve new memories is a distinct cerebral function, separate from other cognivite- perceptual skills". (Reeves and Wedding, 1994, p.27).

This finding, together with data obtained by studying anterodrage amnesia and Alzheimer's disease led to the identification of anatomical structures retrieval system known as the medial temporal lobe, including hippocampus, amygdala, and cortical structures more (Mishkin and Murray, 1994, Squire and Zola, 1997).

Essentially, medial temporal lobe appears to have an important role in establishing long-term declarative memory or explicit memory, while being aware and able to recall facts and events (Zola and Squire, 2000).

It is assumed that these structures are responsible for storage and retrieval of information from short-term memory to be transferred to long-term memory to be consolidated. Thus, lesions of this area causes difficulties in a person's ability to form new memories.

The severity of memory disturbance medial temporal structures depends on the number of compromised (Reed and Squire, 1998). Furthermore, it was found that unilateral lesions of the medial temporal lobes cause different results.

Left temporal lobe appears to be associated with verbal memory tasks involving recall of short stories and lists of words and right temporal lobe is associated with visual memory tasks and non-visual, and remembering geometrical figures, of human faces, musical tones (Aram and Whitaker, 1999, Reeves and Wedding, 2004).

Structural damage medial temporal lobes were not explained as results of other forms of anterograde amnesia (eg Korsakoff syndrome). Described for the first time in 1887, Korsakoff syndrome affect a person's ability to learn new information. These patients exhibit a symptom of the syndrome, called "confabulation" or the tendency to fill in gaps of memory with information derived from its own imagination (Reeves and Wedding, 1994).

Typically, intelligence and memory of past events are relatively unaffected. Korsakoff syndrome is the main cause deficiency of vitamin B (thiamine), and the most frequent cause of thiamine deficiency is alcoholism (Gale Resesarch, Inc., 2000.). Brain structure most affected in the Korsakoff syndrome is the diencefal, which is described as "a cluster of nucleus located in the center of the brain organized in two structures thalamus and hypothalamus known as" (Reeves and Weeding, 2004). Developed postmortem studies in patients with poor socioeconomic circumstances showed that Korsakoff syndrome affects mamelare structures. Researchers could not reveal which specific role it plays in the functioning of memory mamelare structures, but most agreed their importance by the existence of a link to the hypothalamus and thalamus of the previous nucleus (Bauer, 2002; Markowitsch, 2005). Few decades, it was thought that the temporal lobe and median diencefale blackouts are distinct disorders (Squire, 1999). But also suggested that the existence of connections to and from the hippocampus, the two may actually be parts of a single retrieval system.

Studies conducted on patients with and without retrieval disorders have turned to launch the idea of significant importance in the functioning of the frontal lobes retrieval. For example, Shimamura, Janowsky, and Squire (2001) demonstrated that patients with lesions the frontal lobes show deficits in short-term memory for numbers, numeracy and slow reminder, cumbersome. Moreover, those who have frontal lobe damage exhibit difficulties of long-term memory in free recall situations meaningless set of words several times, compared with the control group. Interestingly, this group showed a better performance (in memory of recognition of yes / no) for the same information. In contrast, those who have injuries diencefalului are performing compared to the control group. In a study comparing aim global amnesia patients with different etiologies and recent debuts of Alzheimer's disease, results revealed that both groups episodic memory deficits in long-term, but patients showed deficits Alzheimer additional implicit memory tasks, semantic and short term. The literature does not indicate that frontal lobe lesions produce anterograde amnezia observed in situations where time Medien and diencefalul areas are compromised (Reeves and Wedding, 2003).

Recent studies in neuropsychology integrated on neuroimaginative techniques have provided evidence of additional involvement of frontal lobes in memory. Yeo, Hill, Campbell, Virgil and Brooks (2005) showed that visual working memory skills in children are related to concentrations of creatine and N-acetyl-aspartate in frontal lobes as a measure magnetic resonance technique spectoscopiei protons (H-MRS). Left frontal cortex activation was observed in verbal working memory tasks (Petrides, Alivisatos, Meyer and Evans, 2000). Studies also show that functional imaginative episodic encoding, and storing a list of words depends largely on the left frontal region, while updating such a list of activities involving right frontal area (Fletcher and colab, 1999; Tulving, Markowitsch, Craik, Habib and Houlem 2006). In a review of numerous studies of the brain, Nyberg and Cabeza (2005) gave the conclusion that although "many details remain to be resolved, it is fair to say that a vast image was updated ... which indicates that the involved areas examined, namely prefrontal brain regions. "

In conclusion, recent studies indicate that the medial temporal lobes, diencefal, and frontal lobes are most commonly associated to memory functionality. In imaginative brain studies , these areas do not appear as operating independently of each other (Nyberg and Cabeza, 2005). Given the integrated nature of memory in these areas of functioning (cognitive, language, motor skills), memory is seen as "whole brain function activity" (Kolb and Whishaw, 2000). Although increased studies in understanding of the retrieval process in the field, most researchers argue that "memory processing in the brain still is one of the most fascinating mysteries in neuroscience" (Markowitsch, 2005).

## CAPITOLUL V. THE OBJECTIVES AND THE METHOD OF RESEARCH

### 5.1. The research objectives:

The research aims:

1. To assess the memory functioning in children with traumatic brain injuries and identify the difficulties that may post-traumatic occur compared to children without traumatic brain injuries.
2. To determine the traumatic impact on the development of memory functions in children with severe traumatic brain injuries compared with memory capacities in children with mild traumatic brain injuries.
3. To analyze the retrieval difficulties in tasks that verifies the retrieval functions in children with traumatic brain injuries.

### 5.2. Research Hypotheses:

*1.* **To assess the memory functioning in children with traumatic brain injuries and identify the difficulties that may post-traumatic occur compared to children without traumatic brain injuries**.

- 1.1. It is assumed that a traumatic brain injury in children causes difficulties in solving **verbal memory** tasks;
- 1.2. S It is assumed that a traumatic brain injury in children causes difficulties in solving **nonverbal memory** tasks;
- 1.3. It is assumed that a traumatic brain injury in children causes difficulties in solving **verbal reminding** tasks;
- 1.4. It is assumed that a traumatic brain injury in children causes difficulties in solving **secvential reminding** tasks;
- 1.5. It is assumed that a traumatic brain injury in children causes difficulties in solving **asociative reminding** tasks;
- 1.6. It is assumed that a traumatic brain injury in children causes difficulties in solving **free reminding** tasks;
- 1.7. It is assumed that a traumatic brain injury in children causes **attention difficulties** in solving memory tasks;

2. **To determine the traumatic impact on the development of memory functions in children with severe traumatic brain injuries compared with memory capacities in children with mild traumatic brain injuries;**
    2.1. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **verbal memory** tasks than the existence of a mild traumatic brain injury;
    2.2. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **nonverbal memory** tasks than the existence of a mild traumatic brain injury;
    2.3. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **verbal reminding** tasks than the existence of a mild traumatic brain injury;
    2.4. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **secvential reminiding** tasks than the existence of a mild traumatic brain injury;
    2.5. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **associative reminding** tasks than the existence of a mild traumatic brain injury;
    2.6. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **free reminding** tasks than the existence of a mild traumatic brain injury;
    2.7. It is assumed that a severe traumatic brain injury determines significantly lower **attentional performance** in solving memory tasks than the existence of a mild traumatic brain injury;

3. **To analyze the retrieval difficulties in tasks that verifies the retrieval functions in children with traumatic brain injuries.**
    3.1. Memory performance in children with traumatic brain injuries are significantly lower, which determin learning difficulties in school activities.

### 5.3. Presentation of sample

The study included 140 participants aged between 5 and 19 years who met the criteria for inclusion in the study group, 70 participants had no traumatic brain injury, was taken from the normative sample TOMAL. Control group was selected to correspond as age and gender of each subject included in the clinical group.

Selection of participants included in the clinical group was performed using the following procedure: the first phase were selected those participants who have suffered a traumatic brain injury 6 months ago, resulting in a total of 220 participants. From a total of 220 children were registered during this period, only a total of 70 children met the selection criteria above. The remaining 150 children were excluded based on criteria such as the existence of a severe injury without the ability to response to test items, parents of childrenthat refuse to undergo a cognitive examination or disinterest.

To select participants from the normative sample was obtained TOMAL written permission of the owner of the database.

#### 5.3.1. Criteria for inclusion in the study group

a. Subject diagnosed with isolated acute brain injury or trauma associated with the part where the patient is determined by the severity of primary brain injury;
b. Status neurological appreciated 12-6 GSC balls accompanied by psychomotor excitation;

### 5.4. Measuring instruments

Traumatic brain injuries and their sequelae represent a major public health problem, is the most common trauma generating permanent disability. Recent statistics from the U.S. and Germany have an incidence of 200-300 cases per 100,000 inhabitants TCC, with peak incidence in the age group 15-24 years and prevalence of traumatic brain injury (TBI) male to female gender in relation of 2-4/1. In case of multi-injured patients, 50% experienced a damage of central nervous system (CNS).

### 5.4.1. Glasgow Coma Scale (GCS)

Glasgow Coma Scale (GCS) assesses three components of individual consciousness: the patient's ability to open eyes, verbal response and motor response. Scores obtained at three areas are summed, yielding total scores between 3 and 15.

**a. Scorul Glasgow (GCS)**

Opening eyes:

- Spontanous **4**
- On verbal command **3**
- Pain **2**
- Do not open eyes **1**

Verbal response:

- Oriented **5**
- Confused **4**
- Unproper words **3**
- Incomprehensible sounds **2**
- Do not respond **1**

Motor output:

- On command **6**
- Localize the painful stimulus **5**
- Uncoordinated move **4**
- Decortication **3**
- Decerebration **2**
- Non-reactive **1**

GCS score has prognostic value and evaluative. It is easily calculated by adding the score obtained for ocular reaction (A), verbal (V) and motor (M) - Normal 15 points. Coma is defined by a score <8, up to full areactivitate, denoted GCS = O1V1M1 = 3 points. The goal is to evaluate battery function in children and adolescents (Reynolds and Bigler, 1994b, p. 9).

### 5.4.2. Test of Memory and Learning (Reynolds si Bigler)

Until now there are few standardized psychometric instruments to assess memory functions in the pediatric population. One of these tools is TOMAL - Test of Memory and Learning.

- Age range: The test for children between 5 and 19 years;
- Duration of test: 45-60 minutes;
- Standardization: TOMAL was standardized on a sample of 1342 participants (children and adolescents)

TOMAL is a memory test, which measures the encoding, storing and updating abilities. The test has 6 phases, 5 and a reproduction of recognition. It can be used to measure both the retrieval capacity following a trauma, and memory performance in normal conditions.

TOMAL offers the most extensive coverage of memory assessment currently available in a standard battery. This assessment allows a direct comparison on a variety of aspects of memory in a single battery. This allows assessment of strengths and weaknesses and potential pathological indicators of memory impairment. This national standardized test assesses specific functions of memory using eight general basic subteste, six additional subtests and 2 delayed recall tasks.

### *5.4.2.1. Description of Memory and Learning Test Battery - TOMAL*

TOMAL is a comprehensive battery, composed of 14 memory and learning tasks (eight primary and six subteste additional subtext) standard for use between the ages of 5 years 0 months 0 days until the 59 years 11 months and 30 days. Eight main subtests areas of content are divided into verbal memory and nonverbal memory, which can be combined to derive a composite.

The literature identifies two studies that examined the relationship between demographic variables of gender and ethnicity and the TOMAL performances. Mayfield and Reynolds (1997) compared the performance of white children and color of the normative sample performance compared TOMAL. The results showed that factors derived separately from the white and black participants were similar to factor structure proposed by Reynolds and Bigler (1996) indicating that "testing tasks are perceived in a similar manner by the two groups" (p. 120). Furthermore, researchers have examined all 14 subteste as a set, demonstrating global significance.

Mayfield, Lowe and Reynolds (1998) examined in another study the performance of female and male genders. The results showed that female participants had higher scores on verbal tasks, while the male participants showed higher scores on spatial tasks. The conclusions of the study authors noted that the results found were consistent with results in other studies aimed at testing the performance of the tasks of intelligence and concluded that "There is a common substrate both to male participants and those of female."

# CHAPTER 6. DATA ANALYSIS AND PRESENTATION

## 6.1. Data obtained on groups of participants

This chapter contains the result of statistical analysis performed to verify the assumptions of this study. The participants included in this study summed 140 participants, 70 children with traumatic brain injury and 70 without traumatic brain injury. Of these 140 participants, 70 were male and 70 female. More specifically, each group consisted of 35 male individuals and 35 female individuals, of which the clinical group of 35 people suffered moderate traumatic brain injury and 35 participants suffered a severe traumatic brain injury.

Participants were selected from 10 counties in the country, their distribution is as follows: Alba - 19 participants, Bacau – 1 participant, Bistrita Nasaud - 7 participants, Cluj - 15 participants, Galati - 1 participant, Hunedoara - 14 participants, Ilfov - 1 participant, Ialomita - 1 participant, Sibiu - 10 participants, Timis - 1 participant. Figure 3 shows their distribution in percents.

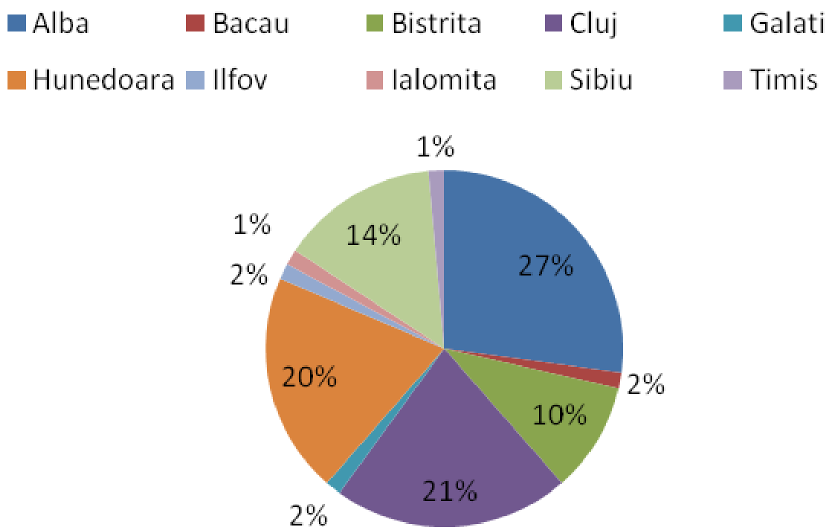


*Figure 1. Geographical distribution of the partcipants included in the study group*

Participants included in the study group were aged between 8 and 16 years, their distribution is as follows: 8 years - 8 participants, 9 years - 14 participants, 10 years - 16 participants, 11 years -

18 participants, 12 years - 11 participants, 13 years - one participant, 14 years - one participant, 16 years - one participant. Figure 4 shows their distribution percentages.

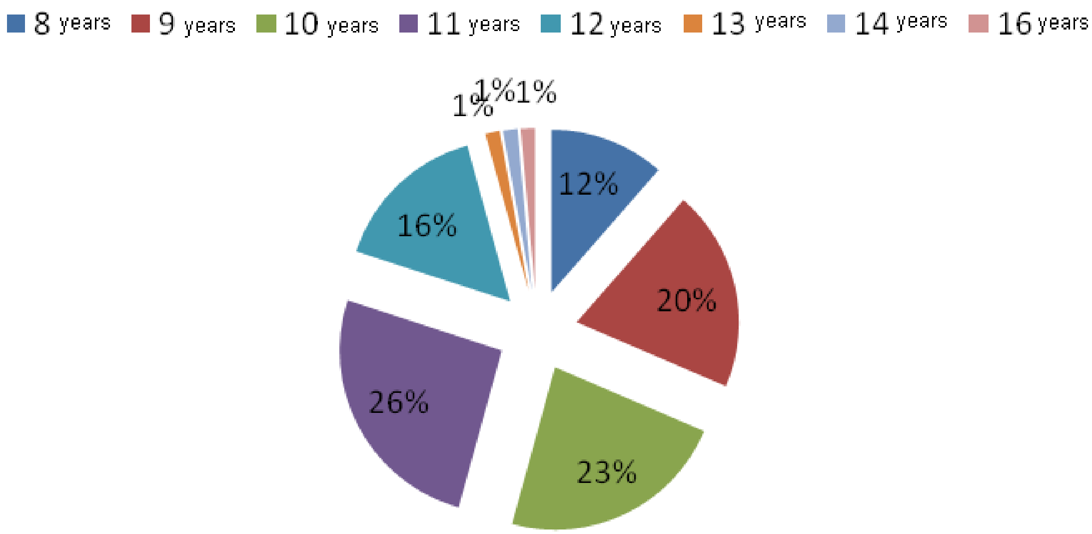


*Figure 2. The distribution of participants included in the age group studied levels*

Ways in which participants have suffered an injury or a traumatic brain injury are multiple. A number of 39 children were involved in a road accident, 19 were hit by a car, three were involved in accidents that involved a car with four wheels, one subject was involved in a bicycle accident, four participants were involved in accidents occurring in skiing, and four were injured in other ways.

Among those included in road accidents, 26 of them (representing a rate of 67%) did not wear a seatbelt. Finally, the average duration of suffering trauma and retrieval functionality evaluation, including memory, was 6 months.

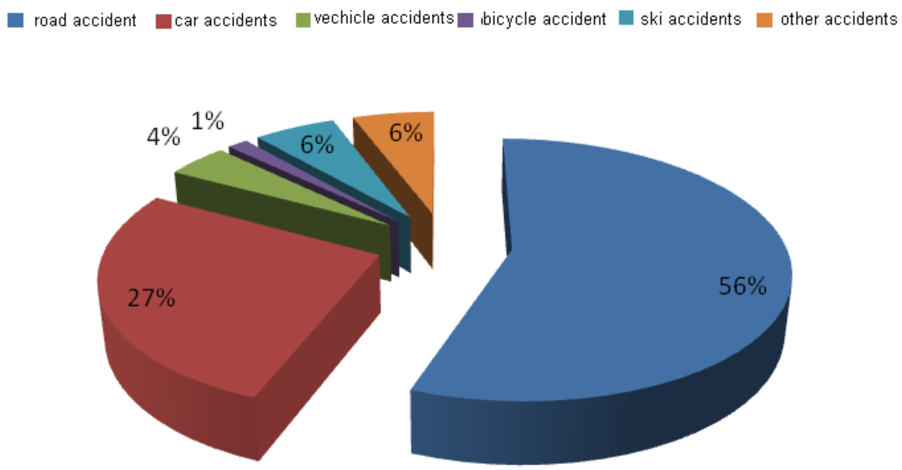


*Figure 3. Methods by which the traumatic brain injuries occurred to the participants included in the clinical group.*

The data presented in Table 4 show that in the age at which the injury occurred, children with severe injuries are more likely to show brain dysfunction and pathological symptoms of abnormal operation.

The incidence of traumatic brain injury in children (0 to 15 years) varies depending on several factors, among which are the major geographical distribution, environmental conditions, educational factors, social, etc. For European countries, and for our country, the incidence is on average 8% of all cranio-cerebral trauma admitted to specialized services. Accessibility to such services, however, is generally limited to serious and casual basis at the average severity, while minor injuries are virtually excluded. Overall percentage is not so on the real. The distribution by gender is predominantly for male to female in a 3:1 ratio, except for trauma in infants, which is almost equal proportion between the two genders. Geographical distribution is also different. Thus, in many countries in Europe and North America percentage of traumatic brain injuries in children is almost equal to that in adults, while in some African countries, Nigeria, for example, the incidence is close to half the children (Oduntan, 2003). These differences could be explained by differences that exist in terms of intensity of traffic, the degree of industrialization, education level, the possibilities for surveillance, etc.

Distribution by age group indicates a maximum incidence between 5 and 10 years, yet there seems to be an increased incidence of cranio-cerebral trauma in the age group between 0 and 5 years, so that some authors (Hendrik et al ., 2000) considers that the incidence is almost equal to the age groups between 0-5 years and 5-14 years.

### 6.2. Memory functioning in children with traumatic brain injuries and the difficulties that may post-traumatic occur compared to children without traumatic brain injuries.

The first set of descriptive analysis focused on identifying differences in clinical and control groups performance in TOMAL Indexes. As there are seven index scores in this section were examined seven hypotheses. Specifically, the analysis compared the clinical performance of participants with traumatic brain injuries and the clinical performance of participants without traumatic brain injury in Verbal Memory Index (VMI), Nonverbal Memory Index (NMI), Verbal Reminding Index (VRI), Secvential Reminding Index (SRI), Free Reminding Index (FRI), Associative Reminding Index (ARI), Attention / Concentration Index (ACI). Unifactorial dispersion analysis (ANOVA test) were used to compare the averages the two groups to determine significant differences between the two groups. It was selected a .05 alpha coefficient significance.

Given the number of completed tests, alpha level was reduced to .01 using Bonferonni procedure. Bonferonni procedure is a method of multiple comparison, also called the Dunn test, which involves a series of t tests that materiality is divided by the number of comparisons. For example, to keep the overall significance level to 0.05 in m comparisons, t test comparing each is made to the threshold of $0.05/m$. It follows that the procedure can be applied only when there are few comparisons, otherwise it is hard to find a significant difference (and increase the risk of errors type II).

Homogenity of variance analysis for each ANOVA test was performed using Levene Test. Levene test is a procedure to verify equalities complementary media when more than two populations considered. Sub-Manual Imitation test was not included in this analysis as only six of the participants included in the study group obtained scores on this item. Consequently, remembering sequential calculate indicators and attention / concentration scores did not include Manual Imitation Subtest. Table 1 presents the results of ANOVA tests and in Table 2 we find the results in Lavene test. The results of the seven hypotheses are presented below.

**Table 1. Univariate Fs and Means (standard deviation) obtained for the clinincal group and control grup at TOMAL Indexes**

| *TOMAL Indexes* | *Sample* | | *Univariate F* |
|---|---|---|---|
| | **Control (n=70)** | **Study (n=70)** | |
| Verbal Memory Index (VMI) | 99.6 | 79.1 | **70.17*** |
| | (12.4) | 16.3) | |
| Nonverbal Memory Index (NMI) | 100.7 | 84.1 | **47.50** |
| | (13.5) | (15.0) | |

| | | | |
|---|---|---|---|
| Verbal Reminding Index (VRI) | 97.9 | 86.3 | **37.08*** |
| | (9.2) | 12.9) | |
| Selective Reminding Index (SRI) | 98.0 | 83.5 | **32.71*** |
| | (16.6) | (13.1) | |
| Free Reminding Index (FRI) | 100.7 | 82.4 | **56.52*** |
| | (13.7) | (15.0) | |
| Associative Reminding Index (ARI) | 101.3 | 83.9 | **47.57*** |
| | (12.1) | (17.2) | |
| Attention / Concentration Index (ACI) | 99.2 | 82.7 | **42.03*** |
| | (18.3) | (11.0) | |

Note. n = 69 for clinical sample; *p<.0001.

Values marked indicate scores obtained by applying Bonferonni procedure.

**Table 2. Homogeneity test for comparing univariate proportions in ANOVA test for clinical group and control group**

| *TOMAL Indexes* | *Lavene Test* | *DF* | *Significance* |
|---|---|---|---|
| Verbal Memory Index (VMI) | 4.19 | 1,138 | **.04*** |
| Nonverbal Memory Index (NMI) | .90 | 1,138 | **.35** |
| Verbal Reminding Index (VRI) | 7.91 | 1,138 | **.01*** |
| Selective Reminding Index (SRI) | 1.20 | 1,137 | **.28** |
| Free Reminding Index (FRI) | 1.04 | 1,137 | **.31** |
| Associative Reminding Index (ARI) | 12.07 | 1,136 | **.001*** |
| Attention / Concentration Index (ACI) | 13.41 | 1,138 | **.001*** |

* indices indicate that the variant p <.05

In comparing the performance of children enrolled in the clinical group compared with the performance inluşi children in the control group were used Subtestele the Index TOMAL variation analysis tests. Averages and standard deviations were calculated as shown in Table 3 and graphically in Figure 4. Every analysis of general significance of differences were tested by creating lots of vectors of averages and comparing these TOMAL subtest scores vectors of the two groups. We used Hotelling's $T^2$ test because there were only two groups compared. In studies developed by Hair (1995) it is showned the existence of a preference in using test Hotelling's $T^2$ when compared only two groups since "causes the most significant difference between groups" (p. 264) and address inflation rate of Type I error coefficients in the next stage of Hotelling $T^2$ coefficients were converted into F statistics to determine statistical significance. Memory Composite Index was not examined by these procedures as indexes derived from the 10 Subgroup Index Index Memory verbal memory and nonverbal, which were analyzed separately. Also, the eight remaining subtests were evaluated. For each analysis to test for homogeneity of variances using M test (Box, 1949 cited by Weinfurt, 1995), and alpha adjustments coefficient in cases where violations of the assumptions held.

**Table 3. TOMAL Subtest means and standard deviations for clinical and control groups**

| *Subtest* | *Participants* | |
|---|---|---|
| | Control (n=70) | Study (n=70) |
| Memory for stories | 10.8 (2.4) | 7.8 (3.1) |
| Word Selective Reminding | 10.3 (3.2) | 8.0 (3.6) |
| Object Recall | 9.8 (3.0) | 5.8 (3.2) |
| Paired Recall | 9.3 (3.3) | 6.8 (2.5) |

| | | |
|---|---|---|
| Letters forward | 9.6 (2.8) | 6.7 (4.0) |
| Digits backward | 9.3 (3.3) | 7.3 (2.6) |
| Letters backward | 10.7 (3.3) | 8.2 (1.8) |
| Memory of faces | 10.3 (3.8) | 7.8 (2.0) |
| Selective Visual Reminding | 9.7 (3.4) | 6.8 (3.5) |
| Abstract Visual Memory | 10.2 (3.2) | 7.8 (3.3) |
| Secvential Visual Memory | 10.2 (3.2) | 8.3 (3.1) |
| Memory for locations | 10.1 (3.7) | 8.0 (4.0) |
| Memory for stories delayed | 10.2 (2.8) | 6.4 (3.3) |
| Memory for faces delayed | 10.0 (2.4) | 9.1 (2.2) |
| Word Selective Reminding Delayed | 9.2 (2.5) | 7.6 (2.9) |
| Selective Visual Reminding Delayed | 9.6 (1.8) | 8.7 (2.4) |

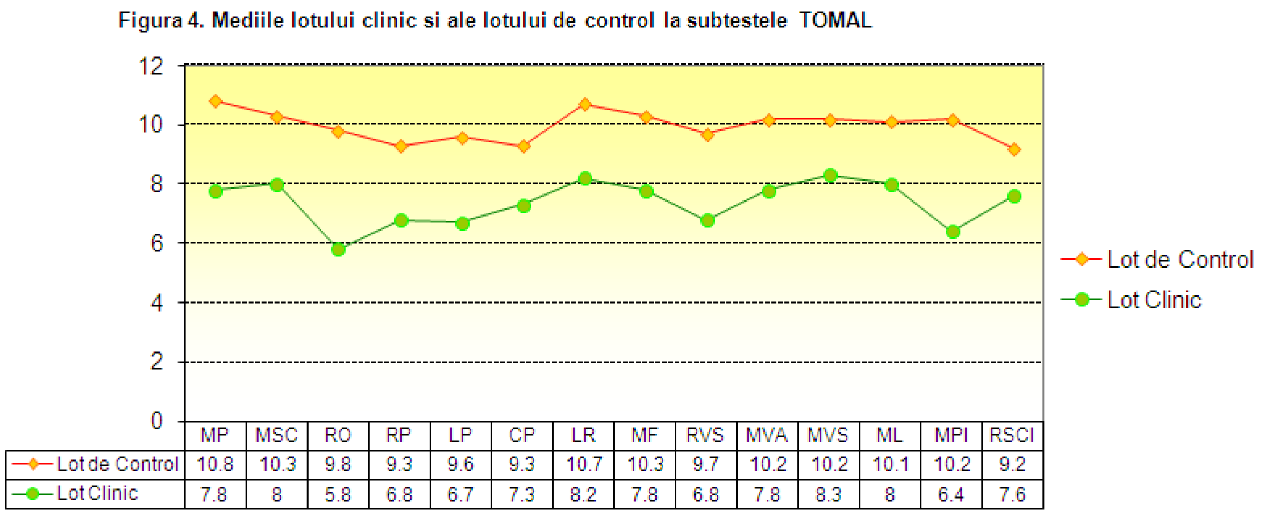


Figure 4. Control and clinical groups means on the TOMAL Subtests Scaled Scores.

Note: Memory for stories MS, Word Selective Reminding WSR, Object Recall OR, Paired Recall PR, Letters forward LF, Digits Backward DB, Letters Backward LB, Facial Memory FM, Selective Visual Reminding SVR, Abstract Visual Memory AVM, Memory for Locations ML, Memory for stories delayed MfSD, Memory for Faces Delayed MfFD, Word Selective Reminding Delayed WSRD, Selective Visual Reminding Delayed SVRD.

Where MANOVA test results were significant, subsequent tests were conducted to identify which of subtests contributed to overall differences. Manual Imitation Subtest was not included in the analysis since only six of the participants in the clinical group obtained scores on this subtest. Therefore, the calculation of Secvential Reminding Index and Attention / Concentration Index did not include the scores at Manual Imitation Subtest.

The seven hypothesis and their results are presented below:

*1.1. It is assumed that a traumatic brain injury in children causes difficulties in solving **verbal memory** tasks;*

It was noted that there is a significant difference in comparing the performance of two groups of participants in tasks that verifies Verbal Memory Index [F (1.138) = 70.17, p <.0001, eta $^2$ =. 26). Thus, the hypothesis was confirmed, showing that there is a significant difference between performance verbal memory skills in the two groups of participants. Children enrolled in the clinical group obtained significantly lower performance than children in the control group. Test results indicate a significant difference in Lavene variance analysis of the two groups (p <.05). Hopkins and Glass (2006) showed in a study that presents ANOVA tests in some cases resistance to alleged violations of homogeneity in cases of large samples and equal numbers, as is the case in this investigation.

There was a clinically significant difference between clinical group and control group in all of the eight subtest of the Verbal Memory Index [Hotelling $T^2 = .65$, $F(8, 124) = 10.08$, $p < .0001$]. It therefore confirms the hypothesis, taking into account the results create vector circles in eight verbal memory subtest of the Index. The results obtained in M Box test indicates a significant difference in the covariance matrix of the dependent variables, $F(36.56421) = 2.35$, $p < .01$. Given the size and equality of the two samples is considered ANOVA test shows strength in violation of the assumption of homogeneity (Weinfurt, 1995).

Significant differences were observed in all eight of the verbal memory subtest. In this case, children who suffered craniocerebral trauma are performing lower than the control group. The results remained significant after Bonferroni correction procedure (adjusted $\alpha = .01$). Table 5 summarizes the ANOVA results and Table 6 describes the results of ANOVA post hoc.

**Table 5. Summary of MANOVA contrasting clinical and control groups for the Verbal Memory Index**

| Source | $T^2$ Value | F | DF | Significance |
|---|---|---|---|---|
| Group | .65 | 10.08 | 8,124 | .0001 |

**Table 6. Univariate Fs for the clinical and control groups on the TOMAL Verbal Memory Index Subtests**

| *Verbal Memory Subtests* | *Univariate F* | ***Significance*** |
|---|---|---|
| Memory for stories | 34.36 | .0001 |
| Word selective reminding | 14.54 | .0001 |
| Object recall | 54.53 | .0001 |
| Digits forward | 26.56 | .0001 |
| Paired recall | 24.24 | .0001 |
| Letters forward | 16.61 | .0001 |
| Digits backward | 25.87 | .0001 |
| Letters backward | 21.13 | .0001 |

*1.2. It is assumed that a traumatic brain injury in children causes difficulties in solving **nonverbal memory** tasks;*

In testing this hypothesis the results showed a significant difference between the performances in clinical and control groups [$F(1,138) = 47.50$, $p < .0001$, $eta^2 = .20$). It confirms the hypothesis stated, the results indicate that the performance in tasks that verifies non-verbal memory in children with traumatic brain injury were significantly lower than the performance of the control group. The results of Levene statistic noted no significant difference in the variances of the two groups. ($p = .35$). Taking into account the five subtest of the Nonverbal Memory Index as a set, it was obtained a clinically significant difference between the performances of the lot and the control group [Hotelling $T^2 = .36$, $F(5,131) = 9.29$, $p < .0001$]. It therefore confirms the hypothesis stated, results indicating that the media vectors created for the five distinct verbal memory subtest of the clinical and the control group. M Box test was conducted to evaluate the homogenity of variants in this analysis. There was no significant difference in the covariances matrices dependent variables, $F(15.73070) = .33$, $p = .99$.

Significant differences were observed between the clinical group and control group in all five non-verbal memory subtest. Specifically, participants in the control group exceeded the performance of each clinical lot of visual or nonverbal tasks. Following the procedure Bonferonni adjusted alpha coefficient, these results remained significant (adjusted $\alpha = .01$). Table 7 summarizes the results of MANOVA and ANOVA Table 8 describes the results of post hoc analysis.

**Table 7. Summary of MANOVA contrasting clinical and control groups for the Nonverbal Memory Index**

| Source | $T^2$ Value | F | DF | Significance |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Group | .36 | 9.29 | 5,131 | .0001 |

**Table 8. Univariate Fs for the clinical and control groups on the TOMAL Nonverbal Memory Index Subtests**

| *Nonverbal Memory Subtests* | *Univariate F* | ***Significance*** |
|---|---|---|
| Memory for faces | 26.30 | .0001 |
| Visual Selective Reminding | 22.89 | .0001 |
| Abstrat Visual Reminding | 19.03 | .0001 |
| Secvential Visual Reminding | 11.19 | .001 |
| Memory for locations | 9.02 | .01 |

*1.3. It is assumed that a traumatic brain injury in children causes difficulties in solving* ***verbal reminding*** *tasks;*

In comparing the performance of verbal reminding of the two samples, it was found a significant difference in the performance of clinical group and control group [F (1.138) = 37.08, p <.0001, eta²=.21). Therefore, the null hypothesis was confirmed, the results showing that there is a significant difference in verbal reminding tasks, participants included in the clinical group obtaining lower quality performance than the participants included in the control group. Also, a significant difference was obtained in the analysis of variance of the two groups (p <.05). Given the sample size and gender, it is considered that the ANOVA test shows violation of the assumption of homogeneity resistance (Glass and Hopkins, 2006).

Considering the four tests of Verbal Reminding Index as a set itself it was obtained a significant difference between the two groups of participants. [Hotelling T ² = .42, F (4,135) = 14.31, p <.0001]. Therefore the hypothesis was confirmed, showing that when the intercorellations are taken into considerations, vectors means are significally different between clinical and control groups. M Box test results show a significant difference in covariance matrices derived from verbal remembering subtests, F(10.91047)=1.95, p <.05. The performance comparison of two groups of participants noted that there are significant differences in all four subtests, participants in the clinical group clinically experienced much weaker performance than participants in the control group in each of the four subtests. Considering the number of analyzes conducted, the coefficient alpha of .01 was adjusted by Bonferroni procedure. Following this procedure, only subtests Memory for Stories Delayed and Word Selective Reminding Delayed remained significant, these two subtest was associated with Verbal Recall. Table 9 summarizes the MANOVA test results, and Table 10 describes the results of ANOVA post hoc.

**Table 9. Summary of MANOVA contrasting clinical and control groups for the Verbal Reminding Index**

| Source | T² Value | F | DF | Significance |
|---|---|---|---|---|
| Group | .42 | 14.31 | 4,135 | .0001 |

**Table10. Univariate Fs for the clinical and control groups on the TOMAL Verbal Reminding Index Subtests**

| *Verbal Reminding Subtests* | *Univariate F* | ***Significance*** |
|---|---|---|
| Memory for Stories Delayed | 55.35 | .0001 |
| Word Selective Reminding Delayed | 12.41 | .001 |

*1.4. It is assumed that a traumatic brain injury in children causes difficulties in solving **secvential reminding** tasks;*

Sequential recall tasks provide test results showing a significant difference between clinical group and control group [F (1.137) = 32.71, p <.0001, eta ² =. 19). It confirms, therefore, the hypothesis, showing that there is a significant difference between the abilities of the two samples to render the information presented sequentially, participants included in the control group achieving better performance than participants included in the clinical group. There was no significant difference in Lavene test (p =. 28).

There was a clinically significant difference in performance between the clinical and control groups of all three subtests when these were measured simultaneously [HotellingT²=.22, F (3,134) = 9.62, p <.0001]. Accordingly, it confirms the hypothesis stated, results showing that when taking into consideration the intercorrelations within the Sequential Reminding Index the mean vectors differ significantly between clinical and control group. M Box test results show a significant difference in covariance matrices derived from Verbal Reminding subtests, F(6.133699)=1.34, p = .24. Post hoc ANOVA tests were performed to investigate the performance of the two groups at Sequential Reminding Index. Results of these analyzes indicated significant differences in the three subtest. Coefficient alpha was adjusted using Bonferroni procedure (adjusted α = .01), results remained significant following this procedure. Table 11 summarizes the results of MANOVA tests, and Table 12 describes the results of ANOVA post hoc tests.

**Table 11. Summary of MANOVA contrasting clinical and control groups for the Sequential Reminding Index**

| Source | T² Value | F | DF | Significance |
|---|---|---|---|---|
| Lot | .22 | 9.62 | 3,134 | .0001 |

**Table 12. Univariate Fs for the clinical and control groups on the TOMAL Sequential Reminding Index Subtests**

| *Sequential Reminding Subtests* | *Univariate F* | ***Significance*** |
|---|---|---|
| Visual Sequential Reminding | 11.74 | .001 |
| Digits forward | 25.07 | .0001 |
| Letters forward | 16.67 | .0001 |

*1.5. It is assumed that a traumatic brain injury in children causes difficulties in solving **associative reminding** tasks;*

In comparing the performance of two groups of participants to verify the associative recall tasks was observed that there is a significant difference [F (1.137) = 47.57, p <.0001, eta ² =. 26). The hypothesis is confirmed, the results showing that there is a significant difference in performance between two groups of participants recorded at reminding tasks of information associated with other materials or objects. Children enrolled in the clinical group showed significantly lower skills than those in the control group. Levene test results show a significant difference in variance analysis of the two groups (p <.05). However, taking into account sample size and their equality, ANOVA score was considered resistant to this lack of homogeneity of variances (Glass and Hopkins, 2006).

Taking into consideration the two subtests of Associative Reminding Index, there was a clinically significant difference in performance between the clinical and the control group [Hotelling T ² = .38, F (2,136) = 25.61, p <.0001]. It therefore confirms the hypothesis stated, results showing that when considered the intercorrelations on the Associative Reminding Index mean vectors of clinical and control group differ significantly. M Box test results show a significant difference in covariance matrices derived from Associative Reminding Subtests F (3.3401134) = .3.69, p <.05. Results of these analyzes indicated that there are significant differences in four subtest, control group performance is better than the study group. Coefficient alpha was adjusted using Bonferroni procedure (adjusted α = .01), results remained significant following this procedure. Table 13 summarizes the MANOVA test results, and Table 14 describes the results of ANOVA post hoc tests.

**Table 13. Summary of MANOVA contrasting clinical and control groups for the Associative Reminding Index**

| Source | $T^2$ Value | F | DF | Significance |
|---|---|---|---|---|
| Group | .38 | 25.61 | 2,136 | .0001 |

**Table 14. Univariate Fs for the clinical and control groups on the TOMAL Associative Reminding Index Subtests**

| *Associative Reminding Subtests* | *Univariate F* | *Significance* |
|---|---|---|
| Memory for Stories | 39.49 | .0001 |
| Paired Recall | 25.51 | .0001 |

*1.6. It is assumed that a traumatic brain injury in children causes difficulties in solving **free reminding** tasks;*

On Free Reminding Index, the results indicate a significant difference between control and clinical group [F (1.137) = 56.52, p <.0001, eta ² =. 29). Therefore, the hypothesis is confirmed, the results indicate that there is a significant difference in free evocation tasks of information (outside of a context) between clinical and control group. This case, traumatic brain injured participants showed significantly weaker skills than those included in the control group. Moreover, test results indicate no significant difference Lavene in the analysis of variance of the two groups (p =. 31).

There was a clinically significant difference in performance between the clinical and control groups in all three subtests when the Free Reminding Index was measured [Hotelling T ² = .55, F (4,134) = 18.45, p <.0001]. Therefore confirms the hypothesis stated, results showing that when taking into consideration the intercorrelations mean vectors of clinical and control group differ significantly. M Box test results show a significant difference in covariance matrices derived from Free Reminding Subtest, F(10.89689) = .58, p = .83. Results of these analyzes indicated significant differences in all the four subtests, control group performance is higner than clinical group performance. Coefficient alpha was adjusted using Bonferroni procedure (adjusted α = .01), results remained significant following this procedure. Table 15 summarizes the results of MANOVA tests, and Table 16 describes the results of post hoc ANOVA tests.

**Table 15. Summary of MANOVA contrasting clinical and control groups for the Free Reminding Index**

| Source | $T^2$ Value | F | DF | Significance |
|---|---|---|---|---|
| Group | .55 | 18.45 | 4,134 | .0001 |

**Table 16. Univariate Fs for the clinical and control groups on the TOMAL Associative Reminding Index Subtests**

| *Free Reminding Subtests* | *Univariate F* | ***Significance*** |
|---|---|---|
| Memory for faces | 28.38 | .0001 |
| Object Recall | 59.58 | .0001 |
| Visual Abstract Memory | 20.37 | .0001 |
| Memory for locations | 10.38 | .01 |

*1.7. It is assumed that a traumatic brain injury in children causes **attention difficulties** in solving memory tasks;*

The results obtained in attention and concentration tasks indicate that the existence of significant differences between the performance of clinical group and the performance of control group [F (1.138) = 42.03, p <.0001, eta ² =. 23). It confirms the null hypothesis, therefore, the results indicate that there are significant differences in tasks of maintaining attention and concentration on tasks that test these skills. The performance of participants included in clinical trial were significantly lower than the performance of participants from the control group. Levene test results indicate a significant difference between the variance of two groups. ($p < .05$). Given the sample size and gender, it is considered that the test has ANOVA assumption of homogeneity breach resistance (Glass and Hopkins, 2006).

In comparing the results obtained from the two groups, there was a clinically significant difference between the performance of clinical trial and the performance of control trail in all four subtests of Attention / Concentration Index measured simultaneously, [Hotelling $T^2=.28$, $F(4,128)=8.84$, $p<.0001$].

It therefore confirms the hypothesis, the results showing that when considered the intercorrelations within the Attention / Concentration Index, the mean vectors of clinical and control group differ significantly. M Box test results show a significant difference in covariance matrices derived from Learning Index subtests, $F(10.79970) = 4.64$, $p < .001$. Results of these analyzes indicated significant differences in the four subtests, control group performance is better than the study group. Alpha coefficient was adjusted using Bonferroni procedure (adjusted $\alpha = .01$), and following this procedure results remained significant. Table 17 summarizes the results of ANOVA tests, and Table 18 describes the results of post-hoc ANOVA tests.

**Table 17. Summary of MANOVA contrasting clinical and control groups for the Attention/Concentration Index**

| Source | $T^2$ Value | F | DF | Significance |
|---|---|---|---|---|
| Group | .28 | 8.84 | 4,128 | .0001 |

**Table 18. Univariate Fs for the clinical and control groups on the TOMAL Attention / Concentration Index Subtests**

| *Attention / Concentration Index Subtests* | *Univariate F* | ***Significance*** |
|---|---|---|
| Digits forward | 26.56 | .0001 |
| Letters forward | 16.61 | .0001 |
| Digits backward | 25.87 | .0001 |
| Letters backward | 22.89 | .0001 |

<u>Conclusions:</u>

Analysis of the results of all tasks included in all nine indexes TOMAL indicates that there are significant differences in each of the indexes tested. Moreover, the results continue to be significant after alpha coefficient was adjusted from .05 to .01 taking into account the analysis undertaken. These results show a general decline of retrieval abilities in children who have suffered traumatic brain injuries or head trauma. Specific areas examined by using TOMAL were: verbal memory and nonverbal skills, maintaining attention and concentration, learning skills, remembering sequential information skills with and without using contextual clues. In each of these skills, clinical trial results were significantly lower than the control group.

### 6.3. Determination of the traumatic impact on the development of memory functions in children with severe traumatic brain injuries compared with memory capacities in children with mild traumatic brain injuries;

This set of descriptive analysis focused on identifying differences in the performance of two subgroups of participants, one subgroup with severe traumatic brain injuries and one subgroup of participants with mild traumatic brain injuries in TOMAL Indexes. Because there are seven index scores in this section were examined seven hypotheses. Specifically, these analyzes have compared the performance of clinical group and the performance of control group at TOMAL Indexes as and Composite Memory Index (CMI), Verbal Memory Index (MVI), Nonverbal Memory Index (NMI), Verbal Reminding Delayed Index (VRDI), Sequential Reminding Index (SRI), Free Reminding Index (FRI), Associative Reminding Index (ARI), Learning Index (LI), Attention / Concentration Index (ACI).

Unifactorial dispersion analysis (ANOVA test) was used to compare the averages of both groups to determine significant differences between the two groups. It was selected an alpha coefficient of .05 significance. Homogeneity of variance analysis for each ANOVA test was done using Levene Test. Levene test is a procedure to verify equalities complementary media, when considered more than two populations. Table 19 presents the results of ANOVA tests and in Table 20 we find the Levene test results. The results of the nine hypotheses are presented below.

**Tabel 19. Univariate Fs and means (standard deviations) for clinical and contol groups in TOMAL Indexes**

| *TOMALIndexes* | ***Subgroup*** | | ***Univariate F*** |
|---|---|---|---|
| | **Mild (=35)** | **Severe (=35)** | |
| Composite Memory Index (CMI) | 81.6<br>(14.0) | 79.3<br>(14.4) | **.39** |
| Verbal Memory Index (MVI) | 80.6<br>(14.6) | 79.1<br>77.2) | **.71** |
| Nonverbal Memory Index (NMI) | 84.2<br>(14.7) | 83.2<br>(14.5) | **.07** |
| Verbal Reminding Delayed Index (VRDI) | 87.8<br>(12.2) | 84.5<br>12.5) | **1.01** |
| Sequential Reminding Index (SRI) | 85.5<br>(12.6) | 80.7<br>(12.3) | **2.18** |
| Free Reminding Index (FRI) | 82.4<br>(12.2) | 81.6<br>(15.5) | **0.5** |
| Associative Reminding Index (ARI) | 83.6<br>(15.4) | 83.7<br>(17.2) | **.00** |
| Learning Index (LI) | 80.3<br>(17.5) | 76.0<br>(19.2) | **.79** |
| Attention / Concentration Index (ACI) | 84.2<br>(12.3) | 81.5<br>(10.1) | **.83** |

**Tabel 20. Test of homogeneity of proportions comparing alternatives for univariate ANOVA test at mild traumatic brain injuries participants and severe traumatic brain injuries participants.**

| *TOMALIndexes* | *Lavene Test* | *Significance* |
|---|---|---|
| Composite Memory Index (CMI) | 0.3 | **.87** |
| Verbal Memory Index (MVI) | 0.7 | **.79** |
| Nonverbal Memory Index (NMI) | .00 | **.99** |
| Verbal Reminding Delayed Index (VRDI) | .00 | **.96** |
| Sequential Reminding Index (SRI) | .13 | **.72** |
| Free Reminding Index (FRI) | .81 | **.37** |
| Associative Reminding Index (ARI) | .01 | **.91** |
| Learning Index (LI) | .01 | **.92** |
| Attention / Concentration Index (ACI) | 1.05 | **.31** |

*2.1. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **verbal memory** tasks than the existence of a mild traumatic brain injury;*

No significant differences were obtained in comparing the performance of two groups of participants in the Verbal Memory Index (VMI) [F (1.57) =. 71, p =. 40). Therefore the hypothesis is innfirmed, these results showing that there is no significant difference in the retrieval operation to participants with mild traumatic injuries to the participants with severe traumatic brain injuries. Lavene test results indicate that are no significant difference obtained in variance two groups (p =. 79)

*2.2. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **nonverbal memory** tasks than the existence of a mild traumatic brain injury;*

No significant differences were obtained in comparing the performance of two groups of participants in the Nonverbal Memory Index (IMV) [F(1,57)=.07, p=.80). Therefore the hypothesis is infirmed, these results showing that there is no significant difference in the retrieval operation to participants with mild traumatic injuries to the participants with severe traumatic brain injuries. Lavene test results indicate that are no significant difference obtained in variance two groups (p =. 99)

*2.3. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **verbal reminding** tasks than the existence of a mild traumatic brain injury;*

No significant differences were obtained in comparing the performance of two groups of participants in the Verbal Reminding Index (VRI) [F(1,57)=1.01, p=.32). Therefore the hypothesis is infirmed, these results showing that there is no significant difference in the retrieval operation to participants with mild traumatic injuries to the participants with severe traumatic brain injuries. Lavene test results indicate that are no significant difference obtained in variance two groups (p =. 96)

*2.4. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **secvential reminiding** tasks than the existence of a mild traumatic brain injury;*

No significant differences were obtained in comparing the performance of two groups of participants in the Sequential Reminding Index (SRI) [F(1,56)=2.18, p=.15). Therefore the hypothesis is innfirmed, these results showing that there is no significant difference in the retrieval operation to participants with mild traumatic injuries to the participants with severe traumatic brain injuries. Lavene test results indicate that are no significant difference obtained in variance two groups (p =. 72)

*2.5. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **associative reminding** tasks than the existence of a mild traumatic brain injury;*

No significant differences were obtained in comparing the performance of two groups of participants in the Associative Reminding Index (ARI) [F(1,55)=.001, p=.98). Therefore the hypothesis is infirmed, these results showing that there is no significant difference in the retrieval operation to participants with mild traumatic injuries to the participants with severe traumatic brain injuries. Lavene test results indicate that are no significant difference obtained in variance two groups (p =. 91)

*2.6. It is assumed that a severe traumatic brain injury determines significantly lower performance in solving **free reminding** tasks than the existence of a mild traumatic brain injury;*

No significant differences were obtained in comparing the performance of two groups of participants in the Free Reminding Index (FRI) [F(1,56)=.05, p=.83). Therefore the hypothesis is infirmed, these results showing that there is no significant difference in the retrieval operation to participants with mild traumatic injuries to the participants with severe traumatic brain injuries. Lavene test results indicate that are no significant difference obtained in variance two groups (p =. 37)

2.7. It is assumed that a severe traumatic brain injury determines significantly lower **attentional performance** in solving memory tasks than the existence of a mild traumatic brain injury;

No significant differences were obtained in comparing the performance of two groups of participants in the Attention / Concentration Index (ACI) [$\underline{F}(1,57)=.83$, $\underline{p}=.37$). Therefore the hypothesis is infirmed, these results showing that there is no significant difference in the retrieval operation to participants with mild traumatic injuries to the participants with severe traumatic brain injuries. Lavene test results indicate that are no significant difference obtained in variance two groups (p =. 31)

Conclusions

There were no significant differences in memory performance between participants with mild traumatic brain injuries and those with severe traumatic brain injuries. Unfortunately, because participants were drawn from public health institutions were not included in the study participants who suffered light traumatic brain injuries, which could limit the information obtained from comparing the two subgroups of the clinical lot.

As noted in the literature, few investigations have analyzed the differences between levels of severity in traumatic brain injuries and performance in memory tasks. A consistent statement and often cited is that participants with severe traumatic brain injuries and disorders show significant difficulties related to memory fidelity control.(Fay and others, 1994, Levin and others, 1994). Moreover, children with severe traumatic brain injuries have demonstrated poor performance on verbal memory tasks, contextual image recognition, visual reproduction, learning a list of words, symbols and auditory learning than participants with mild traumatic brain injuries (Donders, 1990; Farmer and others, 1999; Levin and others, 1993; Yeates and others, 1995). Participants in pediatric samples were diagnosed with mild and severe traumatic brain injuries showed higher difficulties in immediate and delayed verbal memory tasks than participants with light traumatic brain injuries or without any traumatic brain injuries. (Fay and others, 1994).

After Fay (1994), none of pediatric studies did not compare directly the memory performance in mild traumatic brain injured participants and severe traumatic brain injured participants to determine whether differences in retrieval performance and what those differences. Based on current literature and based on findings of this study, we suppose, as Winogrom and colleagues (1984) noted that "injury severity defined as moderate neurological deficiencies do not cause mild substantial psychological defficiencies". It seems that, in TOMAL, no observable differences between these two groups, suggesting that the neuropsychological impact of a mild traumatic brain injury is as significant as a severe traumatic brain injury.

### 6.4. The analysis of the retrieval difficulties in tasks that verifies the memory functions in children with traumatic brain injuries.

*3.1. Memory performance in children with traumatic brain injuries are significantlyaffected, so that it determins learning difficulties in school performance.*

It was oberved a significant difference in memory performance comparing two groups of participants in learning tasks [$F(1,138) = 57.90$, $p < .0001$, $eta^2 = .30$). Therefore it confirms the hypothesis stated, results showing that participants who suffered a traumatic brain injury results were significant weaker than the participants in the control group in learning tasks. Levene test results indicate a significant difference in variance between the two samples ($p < .05$).

There was a clinically significant difference in performance between the clinical and control groups in all four subtest of Learning Index evaluated simultaneously [Hotelling $T^2 = .52$, $F(4,132) = 17.19$, $p < .0001$]. It therefore confirms the hypothesis stated, results showing that when considered the intercorrelations in Learning Index, media delivery of clinical and control group differ significantly. M Box test results show a significant difference in covariance matrices derived from Learning Index

Subtests, F (10.86744) = .1.43, p = .16. Table 21 summarizes the MANOVA test results, and Table 22 describes the results of ANOVA post hoc tests.

**Table 21. Summary of MANOVA contrasting clinical and control groups for the Learning Index**

| Source | $T^2$ Value | F | DF | Significance |
|---|---|---|---|---|
| Group | .52 | 17.19 | 4,132 | .0001 |

**Table 22. Univariate Fs for the clinical and control groups on the TOMAL Learning Index Subtests**

| *Learning Subtests* | *Univariate F* | *Significance* |
|---|---|---|
| Word Selective Reminding | 15.78 | .0001 |
| Paired Recall | 24.44 | .0001 |
| Object Recall | 56.03 | .0001 |
| Visual Selective Reminding | 22.89 | .0001 |

There was found a significant difference in performance comparing two groups of participants in learning tasks [F(1,56)=.05, p=.83). Therefore, the hypothesis is confirmed, the results showing that participants who underwent cranial trauma performed weaker results were obtained significant effect on learning tasks than participants in the control group. Levene test results indicate a significant difference in variance between the two samples (p=.92).

### 6.5. Presentation of case studies

There were developed seven case studies. The results obtained by each child memory functions assessment are analyzed in detail and interpreted qualitative case studies for seven of the children participating in this study.

Based on case studies we proposed future use of a Comprehensive rehabilitation retrieval functionality program by the teacher / professor, in relation to retrieval dysfunction of all subjects. Also, for each case study we have proposed a rehabilitation functions retrieval program by using various types of tasks in complex rehabilitation program retrieval functions.

## CHAPTER VII. DISCUSIONS AND INTERPRETATION OF OBTAINED RESULTS

Results showed that participants included in the clinical group are performing lower performance on tests and subtestele TOMAL, but two nonverbal tests contained in Verbal Reminding Delayed Index, which showed that clinical group showed significant differences when compared with control participants in immediate remembering verbal and nonverbal subtests and verbal information delayed remembering. However, the comparisons made between the group of participants who have suffered mild traumatic brain injuries and the participants who suffered severe traumatic brain injuries, there was no difference in their performance in TOMAL indexes or subtests scores.

The studies described above were aimed at providing useful hints in developing rehabilitation programs retrieval functionality. Also, this research sought to bring the methodology developed in this area, providing comment on the features disrupting retrieval and retrieval behavior of the participants who suffered traumatic brain injuries. As a practical implication, this research aims to investigate the types of post-traumatic disorders retrieval to develop coherent plans for rehabilitation complex. The studies presented above follow this line of research, clinical observations and results are presented below.

Generally, patients with traumatic brain injuires have difficulties in remembering the objects and abstract figures position, but also performances of memory tasks verified and human facial recognition and visual-spatial memory shows that it is deeply disturbed. Also, we have found disturbances in sensory-perceptual field, manifested by difficulties in visual exploration tasks, vague, incomplete and inaccurate perception picture presented in activism and insufficient management attention reduced. He noted the presence of difficulties in verbal memory tasks aimed at visual-spatial memory and organization, selective recall words, remembering pairs of words and objects recall presented.

Participants were not able to introduce encoding or learning strategies in the intellectual landmarks, the results showing that they have disturbances in the updating process of the material as compared both quantitatively and qualitatively, than that it was recorded. There is a dissociation between abstract and material saving material concrete memory tasks involving a verbal coding of the information, and low performance obtained by reminding participants subtestele position objects and abstract figures but also check the performances of memory tasks and recognition of human faces show that visual-spatial memory is disturbed.

He also noticed that there are disturbances in psychomotor level, subjects presenting ocular-motor coordination difficulties. Subject performance on visual memory tasks checked abstract visual sequential memory, showed that there are difficulties in recognizing spatial components, the subject's ability to imagine and mentally rotate some objects or figures, and the perception of temporal components targeting rate movements.

Results show that participants in subtestele TOMAL they have difficulties in verbal memory tasks aimed at visual-spatial memory and organization, selective recall words, remembering pairs of words and objects reamitirii presented.

Also, it was found that subjects tend to keep a low fidelity of the reproductions, citing false or double words to achieve a greater number of words, the present trend in Memory for Stories, and the Words Selective Remninding or Paired Recall.

Subjects performances in visual memory tasks checked abstract visual sequential memory, showed that there are difficulties in recognition of spatial components, the ability of the subject to imagine and mentally rotate some objects or figures, and the perception of temporal components targeting rate movements.

Traumatic brain injuries are considered the most common causes of disability occurrence in early childhood. While most of these injuries are considered moderate, consequences occur in developing cognitive functioning. Clinical research indicates residual difficulties in a wide area of skills, including intellectual abilities, attention and responsiveness, and ability to interact with environmental stimuli in the storage and updating of the information received.

The importance of head injuries and fractures in general, and especially children, is relative, depending on some type of fracture and, on the other hand, the meningo-cerebral lesions that produce or are associated. In several cases there is no direct relationship between the type or extent of skull fracture and degree of severity of brain injury, skull fracture so is only a test of head trauma radiology. On the other hand, there are types of skull fractures which by their very nature produce or amplify brain injury. Such comminuted skull fractures are uneven, able to produce cerebral compression, or fractures penetrating, able to produce direct brain dilaceretions.

## CHAPTER VIII . CONCLUSIONS AND APPLICATIONS OF RESULTS

### 8.1. Final considerations

In previous research, assessment of memory functioning in children with traumatic brain injury was limited to examining basic aspects of memory (list learning, selective recall, visual reproduction) or in a verbal dichotomy versus nonverbal dichotomy as in TOMAL (Sheslow and Adams, 1990). Although TOMAL (Test of Memory and Learning) maintain verbal and nonverbal dichotomy, battery facilitates highlighting additional data that is considered to influence the functioning of memory, such as attention and concentration and different ways to review information ( i.e. sequentially, associative or without breaks). Thus, TOMAL (Test of Memory and Learning) can extend explanation for observed results to provide more specific rehabilitation techniques. Thus, data obtained from the Additional Indexes supplemented the interpretation of TOMAL current investigation findings.

Scores obtained by participants at Glasgow Coma Scale (GSC, Teasdale, Jannett, 1974) were used to identify the severity of the injury suffered by participants in the control group. In the clinical group included 70 participants, 35 had suffered craniocerebral trauma moderate and 35 severe craniocerebral trauma. Of these, six individuals did not have the Glasgow score noted in medical records, and none of the participants did craniocerebral trauma suffered slightly. The time between the moment of trauma and memory functions of their assessment was 6 months.

The results of this study indicated that participants who had suffered a mild or severe traumatic brain injury shows an general decrease in performance during all working memory measures. By using ANOVA were compared to control groups and clinical performance, and were found significant differences in all indexes, clinical group showing an overall decline in memory functions. Except for two non-verbal subtest of the Delayed Response Index, clinical group recorded significant differences in verbal and nonverbal subtests that check the immediately answer and delayed updating of the information presented. In comparing the performance of participants with moderate injuries versus those with severe trauma, showed that there is no difference, both subgroups of participants recorded similar performances.

Following comparisons between performance and the clinical batch control was observed that participants who suffered moderate and severe traumatic brain injuries have difficulties in verbal learning tasks, delayed response or recognition pairs. Also, clinical group obtained poorer performance on tasks that checked the immediate and delayed recall of information presented within or outside a default context or where the items proposed for reminder have been associated or presented sequentially.

Furthermore, the research has shown that participants with moderate or severe traumatic brain injuries have difficulties in visual remembering and visual learning items in tasks which checked the visual memory. Specifically participants in clinical group are performing worse on all tasks of visual reminder whether they were abstract (figures) or sense (human faces). Interestingly, when the participants included in the study group were asked to recall visual material stored after an interval of 30 minutes they are performing relatively similar like participants in the control group. This shows that once a child with traumatic brain injury is able to process and encode visual information he will be able to recall later.

No significant difference in performance between participants with moderate injuries to the participants with severe injuries was observed, which means that the severity of injury does not result in differences in terms of their performance, but the trauma itself causes these problems.

If we examine the results of this study in this way, we can say that complex cognitive processes (ie free recall data without context and learning) may be more likely to defect or disorder in children with traumatic brain inury. Moreover, because learning is a complex cognitive activity it was observed that the group of children diagnosed with traumatic brain injury requires larger encoding visual auditory and / or kinetic material presented and short and long term retention of the above information and incorporating these new concepts presented in a broad framework is made more difficult. Also, you can see and difficulty in maintaining attention and concentration process it. In a similar way compared to other ways of remembering information, free recall, as an essay, it is more difficult than remembering an idea when or context clue. Similarly, visual and verbal concepts are presented in a sequence, the steps are relatively easy to remember, because it is based on the evidence presented before and after the idea.

While the attention includes all the information they manipulate an individual (part of the information available in memory, sensation and other cognitive processes), includes only a limited awareness of information that the individual is aware that handling them. Attention allows us to use active and limited cognitive resources (due, for example, limits working memory) wisely, to respond quickly and accurately to stimuli that interest us and to remember information prominent. Conscious awareness allows us to monitor interactions with the environment, to relate past experiences of those present and confer continuity to our experience, to control and plan future actions.

### 8.2. Personal contributions to scientific research

The PhD thesis entitled “Assessment of memory functioning in children with traumatic brain injuries by using TOMAL (Test of Memory and Learning)” circumscribes the complex issues of the retrieval operation, analyzed from scientific pedagogical contexts, but with references to involve questions of other sciences, medicine, psychology and neurophysiology.

Complex, multidimensional and dynamic aspect, the retrieval function was and is being studied in single and interdisciplinary manner, the various human and social sciences exact correspondence in epistemological pedagogy, psychology, neurophysiology, anthropology, biological sciences.

In turn, architecture retrieval activities is complex, but has a national organization bearing the imprint of each individual peculiarities. Basically, each individual operates with a specific way to exploit the potential of retrieval, the retrieval of its strategy, the investment of acting and learning approaches of active and participatory type of work and systematic exercise.

The research aims to identify the existence of retrieval functionality differences in children who suffered traumatic brain injuries than those without traumatic brain injuries and to compare performance of two subgroups of participants with mild traumatic brain injuries and subgroup of participants with severe traumatic brain injuries.

a) *Contributions in thoretical frame :*
   - The scientific approach realistically addressing the current status, resulted in the four chapters of the theoretical part of the thesis, provides a comprehensive analysis of the literature in clinical psychology, and medicine neuropsychology.
   - Identifying research trends from the world retrieval. Starting from the wide range of approaches, we tried to fit the opinions of the authors recognized several major directions in the field.
   - Identification of research in international contributions to development of the retrieval functionality in patients with head trauma. This innovative research has a considerable inovative asset justified by the lack of empirical research and the criteria followed in the approach area. We believe that this research can be an important starting point for future research in this field. The research was based on many influences, from the examples of case studies to existing empirical research on both the retrieval functionality and in clinical psychology.

b) *Innovative contributions:*
   - Presentation and introduction of a comprehensive assessment battery retrieval functionality. TOMAL (Test of Memory and Learning) is a comprehensive battery, composed of 14 memory and learning tasks (eight primary and six subtest subtext more). The battery allows for complex and highly analytical evaluation functions and retrieval skills.
   - The work includes, in addition to materials delivered or processed in the literature, a number of considerations and personal opinions of the author in the introduction and each chapter presented in this research.
   - Also, the work contains a complex retrieval functions rehabilitation program designed by the author, explained and illustrated with an original script, on the types of retrieval strategies involved and examples of activities and interventions for each target separately.
   - The results obtained may be useful to support primary school teachers and secondary school teachers, special education teachers and the pedagogical education and intervention plans for individual students or participants with traumatic brain injuries or learning difficulties in organising and structuring school homework.
   - Comparisons presented in case studies provide significant information regarding the memory functioning in these participants.
   - Based on observations collected during the test it was developed a clinical picture of retrieval functionality in patients with traumatic brain injuries presented in Appendix 7.

c) *Contributions in enriching the literature :*
   - A theme of deep interdisciplinarity, this paper consists in a relevant contribution to the enrichment of literature. This work opens many opportunities for reflection, analysis and practical action, is also pioneering and comprehensive analysis of it drawing on multiple perspectives in investigating the complex process of retrieval functionality.

- The results of this study indicated that participants who had suffered a mild or severe a severe traumatic brain injury show an overall declined performance across all measures of memory functioning.
- There were no significant differences in performance between participants with mild traumatic brain injuries to the participants with severe traumatic brain injuries which means that the severity of injury does not result in differences in terms of their performance but the trauma itself causes these problems.
- Interestingly, the participants included in the study group were asked to recall visual material stored after an interval of 30 minutes, participants are performing relatively similar in the control group. This shows that once a child with traumatic brian injury is able to process and encode visual information, it will be able to take it later recall.

*f) Contributions in experimental and practival-applicative design :*

- Theoretical investigations are supplemented by practical approach structured in two types of research:

1. Quantitative research (statistical) conducted on a sample of 70 participants diagnosed with traumatic brain injuries, retrieval functionality to identify differences between the two groups, and between the two subgroups of clinical lot, seen in patients with mild traumatic brian injuries and patients with severe traumatic brain injuries.

2. Qualitative research by developing seven complex case studies that analyze in detail the performance of each subject at TOMAL Subtests..

Epistemic posture of the paper is provided primarily by elements of the author's contributions in terms of practical-applicative approach:

a. combination of theoretical and practical-applied approaches;

b. substantiating scientific investigations conducted on theoretical and practical considerations, respective the psychological research;

c. investment in its choice of research creativity and its operationalization in formalizing research hypotheses and verifying these results.

### 8.3. Limits of the research

This doctoral thesis has a pioneer in our country and we are aware that errors are inevitable in these circumstances.

Besides the contributions outlined in previous sections, it is important to mention the limits that restrict generalizabilitatea results. Beyond these limits, however, and the need to further research certain aspects related to the model used and the particular context and measuring instruments in the study, we are convinced that the research presented in this paper represents an evolution in this field, both in terms of reflective and critical analysis of the field in general and concepts that work, and in terms of results.

These limits can be classified into:

1. limits the type and number of participants,
2. limitations related to the experimental method.

The main limitations affecting the results of research in terms of type and number of participants are:

*a. The clinical group was not randomly selected, but the sample was an intact group of patients in several hospitals.*

In a random sample, every member of investigated population can be equally selected for the experiment (Keppel, 1991). If this is not done, means that there is statistical justification for "extending our results beyond the experiment itself" (Keppel, 1991, p. 17). Thus, the findings of this study may be unique to this population and may not be generalizable to a wider population with head trauma.

*b. The absence of light traumatic brain injuries cases.*

Although there were 70 participants with traumatic brain injuries included in this investigation, none of them had suffered a craniocerebral trauma easily. Researchers believe that up to 90% of all injuries are categorized as light traumatic brain injuries (Kraus, 2005); However, only few of them require medical attention or hospitalization. Boll (2003) argued that "light traumatic brain injury is a disease typically silent ... no need to drain the blood and without significant medical intervention." Thus, secondary aspect of the sample for this study from a pediatric medical facility was that there were children who require intensive rehabilitation after a traumatic brain injury. Failure of this group limits the generalization of these results.

In addition, if light traumatic brain injured cases were available, data should be shown a pattern of decline in pediatric samples, with slight pain, certain deficiencies of memory, but with better performance compared to groups with mild head trauma and severe. Results from this study suggest that, once a traumatic brain injury is identified as "moderate" memory operation reached asymptotic performance (flat) with installation deficiencies, similar to a severe traumatic brain injury.

*c. The reduced sample size for comparisons between subgroups with cranio-cerebral trauma moderate and severe*

Given the number of variables in ANOVA and MANOVA, samples with moderate head trauma (n = 35) and severe (n = 35) were relatively small. Keppel (1991) and Weinfurt (1995) recommends an approximate sample size of 80 as necessary to provide sufficient power to show differences, assuming a power of 80 and a medium effect. This level was reached in the analysis, contrasting the performance of the control samples (n = 70) and clinical (n = 70). As a result, the power of these comparative statistics can be mitigated. It is possible to observe more subtle differences between clinical subgroups where a higher value of the sample.

*d. The difference between the current test cases for control participants and those in the group clinically*

Since participants who suffered traumatic brain injuries are prone to fatigue and a lower concentration of attention, their performance in terms TOMAL be influenced.

The main limitations affecting the results of research in terms of experimental method are:

*a. Difficulties occurred in collecting the responses*

Retrieval functionality evaluation took place at more than 6 months after the trauma. From a total of 220 children who were registered during this period, only a total of 70 children met the selection criteria above. The remaining 150 children were excluded based on criteria such as the existence of severe traumatic with inability to respond to test items, parents or carers of children refusing to undergo a cognitive examination or disinterest.

*b. Adaptation tasks verbal-auditory memory check from English into Romanian*

Since this is the first Romanian research using TOMAL battery (Test of Memory and Learning) it was necessary the translation of the original version retrieval tasks from English to Romanian language. Therefore, we tried translating and adapting the equivalent transliterated verbal tasks while respecting the size and morpho-syntactic and lexical-phonological of tasks. This limitation applies to memory subtest stories. For the rest of the subtests covered by this limitation to transliterated equivalence used simple translation as Word Selective Reminding, Paired Recall.

*c. Adapting a battery for the Romanian population.*

Since there is no battery option TOMAL adapted and standardized for the Romanian population, the data analysis were used standardized psychometric characteristics of the original battery for American population both clinical group and the control group.

### 8.4. Future research directions

Research topic addressed in this PhD thesis has a high novelty, which allows opening an important way to deepen the scope of national researchers and the international. The results of our scientific effort will be published in magazines and books, which will facilitate access to our research results, and provide other researchers the opportunity to have a starting point to study retrieval functionality to patients who suffered traumatic brain injuries.

This paper can be successful in the future depth and our suggestions include the following:

*1. Extending geographical area surveyed nationally.*

We propose this to see how well it confirms the results and collaboration with other researchers in the field internationally, to allow the battery TOMAL (Test of Memory and Learning) in order to be able to compare results.

*2. The continuation of this study should include children with light traumatic brain injuries.*

Thus, these results can be generalized to all types of traumatic brain injuries, and not limited to the moderate and severe. Including participants with mild head trauma would also help to establish the existence of a possible relationship disruption after trauma retrieval performance, or if a current or differential decline of storage abilities related to severity.

*3. Conduct longitudinal studies to observe the operation of memory beyond a period of 6 months in children with head trauma.*

Generally, there are few longitudinal studies conducted in participants who suffered post-traumatic neurocognitive disruption. Gaidolfi and Vignolo (2000) have found the existence of persistent verbal memory deficits 10 years after injury and Fay (2004) found that at one and three years after traumatic brain injuries children showed moderate and severe declines in performance all areas assessed (intelligence, memory, motor speed, adjustment problems and academic achievements). They did not examine memory using a standardized instrument, adequate in terms of development, such as TOMAL. A longitudinal study can be particularly important in assessing recovery of memory and its re-education, and to identify areas where it remained weak. In addition, the results obtained in the present study, a longitudinal study may help to verify the hypothesis that children with moderate head trauma disorders continue to demonstrate significant memory operation as seen in the group with severe head trauma while, or if participants improve their performance compared to those with severe injuries.

*4. Examining the impact of other variables, such as pre-existing conditions, family circumstances and stress on memory functioning in children with head trauma.*

The study prepared by Ponsford (2007), showed that participants who are subjected to stressful events in life or premorbid functional difficulties, including learning difficulties, behavioral problems, or injury or head injury, developed weaker cognitive and behavioral outcomes. In other studies it was found that learning and attention difficulties have an impact on children's memory functions (Holifield, 1999; Willcutt and others, 2001). A traumatic brain injury may exacerbate the already scarce memory functions. A study that includes information on pre-existing conditions or one that compares tulburarările learning, attention, and groups diagnosed with traumatic brain injuries later models may elucidate the differential functioning of memory

In **conclusion**, multiple studies have implications for both theoretical and practical, is also new for the Romanian population, as we know. The implementation of complex analysis, multivariate studies consider making contributions to the field under study progress, including the fact that raises questions and dilemmas, as suggestions for future research. Case studies of thesis research ethics principles to meet the confidentiality of data collected, anonymity of participants and institutions where it made contact with them.

Interpretation of results was done so as not to constitute a basis for stigma and discrimination. Instruments used and the procedure is non-invasive work and, although some were busy, did not place participants in stressful or frustrating situations.

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