Revista Española de Neuropsicología **6**, 3-4:187-200 (2004) 
ISSN: 1139-9872

# Time and course of recovery of post-TBI cognitive disorders after neurorehabilitation

José León-Carrión[1], María Rosario Domínguez-Morales[2], Juan Manuel Barroso y Martín[1] & Fernando Machuca Murga[2]

*[1]Departamento de Psicología Experimental.*
*Facultad de Psicología. Universidad de Sevilla.*
*[2]Centro de Rehabilitación del Daño Cerebral, C.RE.CER, Sevilla*

**Abstract:** To evaluate the efficacy of outpatient cognitive rehabilitation after an intensive, holistic, and multidisciplinary rehabilitation program nineteen patients with severe TBI were studied as they underwent a holistic, intensive, and multidisciplinary neurorehabilitation program. Performance in each cognitive function was clinically scored daily. Baselines were compared at admission and at discharge. Results show that the course of cognitive recovery after TBI is not uniform, with many ups, downs, and plateaus on the charts. For a patient to achieve a score above 7 (good response and nearing normalcy), over 400 hours of rehabilitation, distributed over a continuous period of six months, are required. Consolidation of the progress made in cognitive neurorehabilitation requires time, and discharge is not recommended until the consolidation of cognitive improvement is established. **Key words:** Traumatic Brain Injury, neurorehabilitation, cognitive functions, neuropsychological rehabilitation.

## Tiempo y curso de la recuperación de los trastornos cognitivos en un TCE después de la neurorehabilitación.

**Resumen:** Evaluar la eficacia de la rehabilitación cognitiva del paciente despues despues de un programa de rehabilitación, integral, multidisciplinar e intensivo. Se estudiaron 19 pacientes con TCE severo mientras formaban parte de un programa de neurorehabilitación holistico, intensivo y multidisciplinar. El rendimiento en las funciones cognitivas clínicas se puntuo diariamente. Se compararon las puntuaciones base al ser adminitidos e cuando se les dio el alta. Los resultados indican que el curso de la recuperación cognitiva despues del TCE no es uniforme, con muchos altibajos y mesetas en los registros díarios clínicos. Para que un paciente



This research has been supported by a contract-agreement between the Center for Brain Injury Rehabilitation and the Human Neuropsychology Laboratory of the University of Seville, Spain

alcance una puntuación de más de 7 (respuesta buena y acercandose a la normalidad) se requieren más de 400 horas de rehabilitación, distribuidas en un periodo continuo de 6 meses. La consolidación del proceso conseguido en una neurorehabilitación cognitiva requiere tiempo y no se recomienda dar el alta hasta que se establece la mejora de la consolidación cognitiva.
**Palabras clave:** Traumatismos Craneoencefalico, neurorehabilitación, funciones cognitivas, rehabilitación neuropsicológica.

Neurocognitive and neurobehavioral disorders are frequent after severe traumatic brain injury (TBI). Impairment of memory, attention, reasoning, mental imagery, language, problem solving abilities and executive functioning are regular consequences of severe TBI for which patients and families seek rehabilitation. During the last several years some authors have raised questions concerning the effectiveness of cognitive rehabilitation after brain injury, bringing about a certain controversy. According to Hall and Cope (1995) the fact that rehabilitation of cognitive functioning impairment is controversial may be due to "unscrupulous behavior in portions of the rehabilitation industry… combined with poor scientific rigor in verification of the benefit of rehabilitation". Salazar et al. go as far as to suggest that the reason behind this could be that rehabilitation for traumatic brain injury has not received the same level of scientific scrutiny for efficacy and cost-efficiency that is expected in other medical fields (Salazar, Warden , Schwab , et al, 2000). These issues allow other authors to argue that cognitive rehabilitation programs are less effective than other rehabilitation programs (Benedict, R 1989) (Volpe & McDowell, 1990) and have triggered a search for clear evidence in the literature of the efficacy and benefits of cognitive rehabilitation. In so doing, Carney, Chestnut, Maynard, Mann, Patterson, and Helfand (1999) found in their 1999 review an absence of strong evidence for the effectiveness of cognitive rehabilitation methods (other than compensatory cognitive strategies). When Cicerone, Dahlberg, Kalmar, et al. (1999) conducted a search for evidence-based cognitive rehabilitation in 2000, they found, overall, evidence-based support for the effectiveness of several forms of cognitive rehabilitation for persons with stroke and TBI. After carrying out a randomized trial that same year, Salazar, Warden, Schwab, et al.( Salazar , Warden, Schwab K, et al, 2000), stated "in this study, the overall benefit of in-hospital cognitive rehabilitation for patients with moderate-to-severe TBI was similar to that of home rehabilitation."

Nonetheless, other authors and clinicians consider cognitive neurorehabilitation valuable and beneficial. Prigatano (1999) responded to the criticism of cognitive rehabilitation in 1999 saying that "presently, cognitive rehabilitation is labor intense. Patients must spend hours at cognitive remediation tasks before any notable change can be achieved. No

matter how well-randomized or designed, studies that employ less than 100 hours of cognitive rehabilitation will most likely be associated with minuscule results. This reality exists because we do not know how to deliver retraining activities systematically in a cost-efficient manner… The article by Carney et al. fails to review systematically the efficacy of cognitive rehabilitation for improving the lives of TBI patients".

In facing these arguments, the main questions at issue for insurance companies, health care professionals, families, and the patients, are how long neurorehabilitation will last and whether it will be worthwhile. Insurance companies want to know the amount they will have to pay for the recovery of the patient, and up to what point the rehabilitation which they are paying for will help the patient's recovery. It has long been known that a certain degree of spontaneous recovery occurs during the first few weeks, even months, after injury (Yu, 1976) (Black, Markowitz, & Cianci, 1975) The current need is to distinguish between spontaneous recovery and the effects of cognitive rehabilitation.

In this article, we report the results of a controlled trial which followed the course of 19 outpatients during neurorehabilitation treatment. In addition, we present the pre/post treatment scores obtained by this group of patients with severe traumatic brain injury after completing a holistic, intensive, and multidisciplinary program in a highly specialized center for neurorehabilitation in Europe.

## Method

### *Participants*

All 19 patients with severe head trauma were referred from different parts of Spain to the Centro de Rehabilitación de Daño Cerebral (C.RE.CER). Inclusion criteria were the presence of at least three impaired cognitive functions, and a Glasgow Coma Scale Score of 8 or less within the first 24 hours after hospital admission following a traumatic brain injury. 84% of the subjects were male, 16% female, with ages ranging from 14 to 39 years. All underwent neurorehabilitation treatment for an average period of 6 months.

***Treatment Program***

The CRECER Neurorehabilitation Program (León-Carrión,1997; Machuca, Martín-Carrasco, Martín González, Rodríguez-Duarte, León-Carrión, 1997; León-Carrión, et al., 1999) was applied to all patients. This program is holistic, intensive and multidisciplinary (León-Carrión,1998) and includes treatment specifically tailored to the physical, emotional, behavioral and cognitive needs of each patient, and, when needed, includes medication as reflected in a previous study (León-Carrión, Domínguez-Roldán, Murillo-Cabezas, Domínguez-Morales, Muñoz-Sánchez, 2000). The different cognitive disorders are treated simultaneously and with a specific timing and ordering sequence. Patients underwent a daily, four-hour, holistic rehabilitation session (with a mid-week break), which was ongoing for 6 months. Cognitive rehabilitation included, at least, exercises in orientation, memory, attentional mechanisms (automatisms and mental control), math and calculation, and planning and executive functioning. The duration of each session was between thirty minutes to an hour.

Outcome Scoring System: Each cognitive function was clinically scored daily on a scale from 1 to 10 by the same therapist that conducted the session with the patient. Baseline for each cognitive function were obtained through the CRECER Clinical Outcome Scale (CRECOSS) taken at admission and were obtained from the neuropsychological assessment made before starting the CRECER program. Patients received a score of normalcy when performance achieved pre-morbid levels of functioning. The pre-morbid level of normalcy was clinically established through interviews with the patients' families and closest associates. A score of 1-2 was assigned to subjects with severe impairment (almost no response) in a specific function (normalcy at 10-20%); a score of 3-4 was assigned to subjects who were very impaired but exhibiting some, although inconsistent, response (normalcy at 30-40%); a score of 5-6 was given to subjects with some consistent, but scarce, response (normalcy at 60%); a score of 7 was given to subjects exhibiting good response, but still too scarce to be considered a normal level (normalcy at 70%). A score of 8-9 was for subjects with near normal response in quantity and quality, but who themselves and the therapist felt was still not at the pre-morbid level (normalcy at 80%-90%). A score of 10 was assigned when the patient's performance showed either his/her

previous level of functioning (normalcy at 100%), or a statistical normalcy, or a normal level of functioning, but different from the particular way the participant functioned before the TBI.

***Statistical and Data Analysis***

The following analyses were carried out: comparison of initial scores with scores after discharge; monthly mean scores; mean of number of sessions completed for each cognitive function; percentage of gain obtained after the program; and percentage of functionality at discharge compared to admission. The equation used for each of the cognitive functions to determine the percentage of functionality gain at discharge compared to admission follows:

$$FG\% = \frac{Ml - M0}{10\text{-}M0} \times 100$$

Ml is the score obtained by the patient in the last month. M0 is score at admission. FG% is the percentage of functional gain for that specific function in the last month evaluated.

## Results

Table 1 shows mean scores obtained for the group of patients month by month in each of the cognitive functions evaluated, the percentage of gain and the total number of sessions until the final score was obtained. Table 1 also shows the total number of sessions and hours that were necessary to achieve a score of 7.49, which is a 55.05% gain in recovery compared to the score obtained at admission.

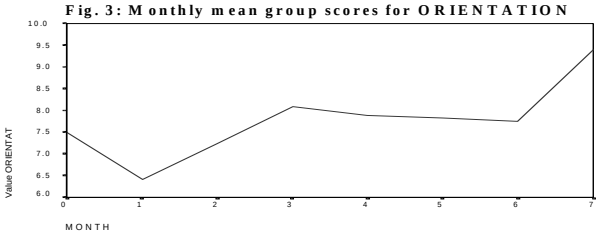
| **Months from admissio** | **Long term memory** | **Short term memory** | **Orientati** | **Calculati** | **Attention** | **Automati** | **Mental control** | **Planning** |
|---|---|---|---|---|---|---|---|---|
| **Month 0** | **4.20** | **3.80** | **7.50** | **4.30** | **4.50** | **4.50** | **3.20** | **4.30** |
| Month 1 | 4.92 | 4.60 * | 6.41 | 4.29 | 5.09 | 4.34 | 4.91 | 4.75 |
| Sessions | 10.90 | 11.90 | 13.00 | 9.10 | 11.40 | 10.20 | 9.20 | 12.60 |
| Month 2 | 5.84 | 5.81 | 7.23 | 5.61 | 5.70 | 5.31 | 5.78 | 6.25 * |
| Sessions | 11.40 | 12.20 | 13.40 | 10.50 | 11.90 | 11.60 | 8.60 | 12.30 |
| Month 3 | 6.14 * | 5.77 | 8.09 * | 5.88 | 6.15 | 5.44 | 6.47 | 6.47 |
| Sessions | 11.10 | 11.60 | 13.50 | 10.10 | 10.90 | 12.10 | 8.30 | 13.10 |
| Month 4 | 6.86 | 6.17 | 7.88 | 6.15 * | 6.39 * | 6.05 | 6.81 | 6.92 |
| Sessions | 11.20 | 10.20 | 12.40 | 8.10 | 9.70 | 11.20 | 8.00 | 12.40 |
| Month 5 | 6.68 | 6.33 | 7.82 | 6.28 | 6.34 | 6.13 * | 6.18 * | 7.22 |
| Sessions | 11.50 | 11.70 | 13.80 | 10.90 | 11.00 | 12.30 | 8.70 | 13.70 |
| Month 6 | 7.01 | 6.56 | 7.75 | 6.30 | 6.20 | 5.32 | 5.89 | 7.36 |
| Sessions | 11.00 | 10.60 | 14.10 | 9.90 | 10.30 | 13.50 | 4.40 | 15.10 |
| Month 7 | 7.70 | 7.40 | 9.40 | 6.80 | 7.00 | 7.00 | 7.20 | 7.40 |
| **Total % of gain** | **56.8%** | **58%** | **76%** | **43.8%** | **45%** | **45%** | **58%** | **54.3%** |
| **Total** sessions | **67.1** | **68.2** | **80.2** | **58.6** | **65.2** | **70.9** | **47.2** | **79.2** |

Table 1: *Monthly group scores for each cognitive function, and mean number of monthly sessions for each cognitive function. * indicates significant differences regarding month 0, ($p<0.01$) only obtained $p>0.013$.*

### *Recovery in orientation*

In our present study, we found that the highest gain in functionality (76%) was in orientation problems, with a final mean score of 9.4. This could be because participants received a mean of 80.2 sessions, the highest number of sessions in the study. Clinically significant improvements are observed by the third month of rehabilitation.

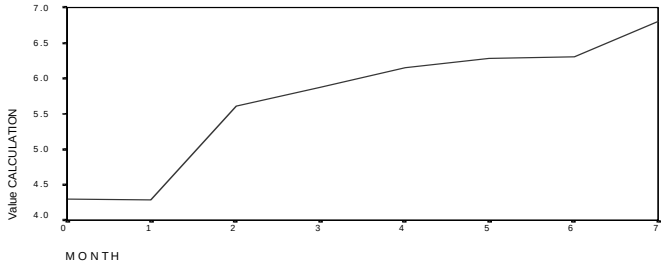
**Fig. 3: Monthly mean group scores for ORIENTATION**




### *Recovery in acalculia*

The lowest gain in functionality was in acalculia problems, with a gain of 43.8% with regard to admission (mean score of 4.3) and a final score of 6.8. Clinically significant improvements are observed by the fourth month of rehabilitation.

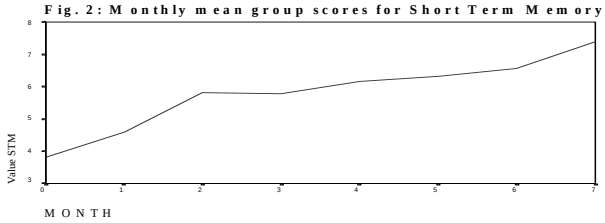
**Fig. 4: Monthly mean group scores for CALCULATION**



### *Recovery in mental control and short-term memory*

The mean recovery in both mental control and working memory was the same, 58%. This would seem to be coherent given that there cannot be an improvement in mental control without sufficient volume of memory. Clinically significant improvements are observed in mental control by the fifth month and short-term memory in the first month of rehabilitation.

**Fig. 2: Monthly mean group scores for Short Term Memory**




### *Recovery in long-term memory, planning, and executive functioning*

It was quite successful, all with a final mean score above 7. The rehabilitation of planning, however, required an important number of sessions (79.2). Clinically significant improvements are observed in long-term memory by the third month and in planning and executive functioning by the second month.

**Fig. 1: Monthly mean group scores for Long Term Memory**

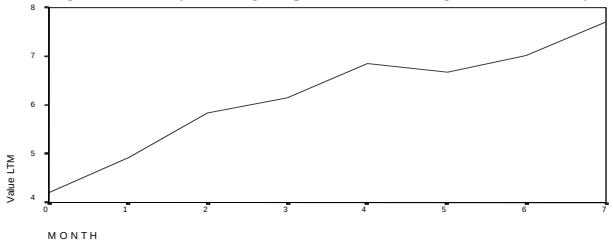


**Fig. 8: Monthly mean group scores for PLANNING**

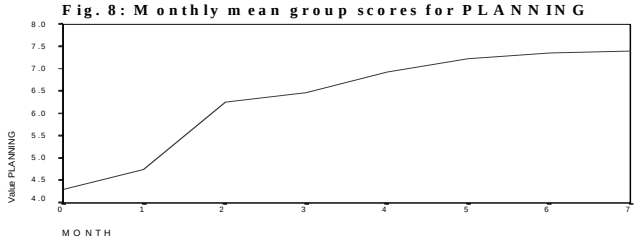
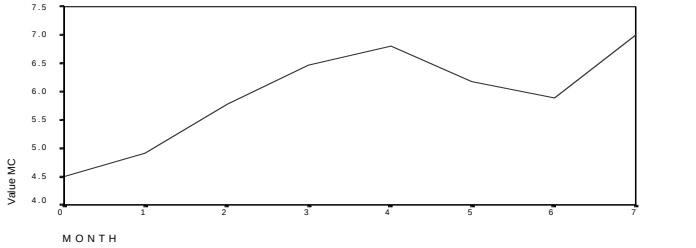



**Fig. 7: Monthly mean group scores for MENTAL CONTROL**




### *Recovery of attention and automatisms*

Important to note are data related to attentional deficits and the recovery of automatisms, both of which required a large number of sessions to achieve an improvement of only 45%, with a score of 7 on the scale. Clinically significant improvements are observed in recovery of attention by the fourth month and in automatisms by the fifth month, but not consolidated.

**Fig 5: Monthly mean group scores for ATTENTION**

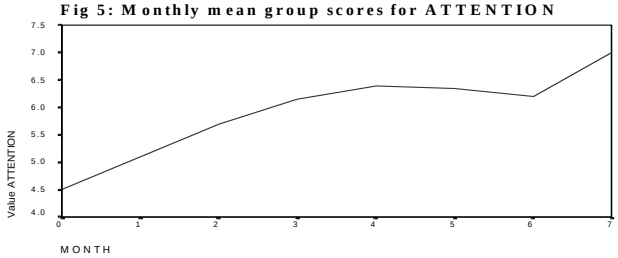
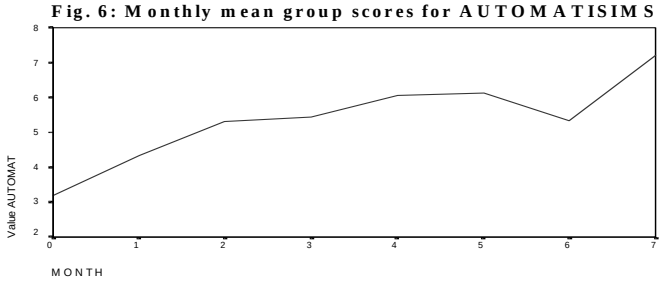



**Fig. 6: Monthly mean group scores for AUTOMATISIMS**




## Discussion

Data show that neurocognitive deficits due to traumatic brain injury improve significantly ($p < 0.05$) after an intensive, holistic, and multidisciplinary rehabilitation program. These cognitive improvements, nearing the threshold of normalcy, are achieved under specific conditions. A total mean of 536.6 rehabilitation sessions, directly addressed to the individual patient with TBI with more than three deteriorated cognitive functions, was necessary to place participants at the threshold of pre-

morbid normalcy (a score of 7 in the outcome scale). This means a gain of 55.05% in cognitive functionality after more than 402.45 hours of individual rehabilitation activities distributed over a period of six months. This data agrees with Prigatano (Prigatano, 1999) when he assured that effects from rehabilitation are not observed in patients who receive less than 100 hours of rehabilitation. In addition, our data agree with Cicerone, Dahlberg, Kalmar, et al [6] when, from a comprehensive review of the empirical literature on cognitive rehabilitation, evidence was found in support of cognitive rehabilitation and the advantages of cognitive rehabilitation over conventional forms of rehabilitation.

It could be argued that the gain obtained by our patients was due to a spontaneous recovery which would have been achieved independently, whether the subject had undergone the rehabilitation program or not. In response to such an argument we refer to one of our previous studies [16] which analyzes the course of post-TBI cognitive deficits after severe brain injury in patients who did not receive any type of neuropsychological rehabilitation treatment. In that study, we endeavored to establish the point at which cognitive deficits cease to present signs of spontaneous recovery. We studied twenty-eight subjects with severe traumatic brain injury who had been neuropsychologically assessed twice, once at the eighth month post-TBI and again nineteen months later. Results showed no significant differences between the two neuropsychological examinations. Data showed no spontaneous recovery beyond the eighth month after TBI. Hence, neurocognitive deficits consequential to TBI seem to be established within the first eight months post-trauma and it is therefore logical to assume that the 55.05% gain in functionality after neurorehabilitation in our study was not due to spontaneous recovery.

***Ups and downs during the course of recovery***

It is very important to be aware that patients' scores rise and fall throughout the six-month treatment program. The progress curve during any rehabilitation treatment, whether physical or cognitive, is not always upwards, there are various ups and downs throughout the process. This seems to be a normal part of the treatment process and in the case of cognitive rehabilitation is probably due to cognitive adjustments occurring throughout treatment. In our opinion this means that in order to consolidate progress after an initial climb in the score, more time is needed. If the patient is discharged as soon as s/he obtains a score of seven or eight, the possibility of a drop or regression persists. Each achievement must be consolidated, and this takes time. Treatment should not be abandoned if there is a short

period of time during which the patient does not show improvement, or even seems to regress somewhat. Time should be allowed for the structural and functional re-organization of the brain. Nonetheless, the possible causes of a persistent regression or stall should certainly be sought.

## Conclusion

The rehabilitation of cognitive deficits presented by patients with traumatic brain injury is worthwhile when an intensive, holistic, and multidisciplinary program is applied; the course of cognitive recovery after TBI is not uniform, with ups, downs, and plateaus in progress observed; to gain more than 50% (a score above 7- good response and near normalcy) of a patient's possible recovery, over 400 hours of rehabilitation are required, distributed over a continuous period of six months; rehabilitation of planning and orientation require the highest number of sessions; establishing cognitive automatisms is a very slow task and requires a large number of sessions; the more severe the attentional deficits, the slower the rehabilitation process will be; problems in orientation are more easily recovered if the patient is spatially oriented; rehabilitation of memory requires a large number of sessions; the consolidation of progress in cognitive neurorehabilitation requires time; and discharge should occur only after cognitive improvements have been consolidated.

The work presented here is an approximation to recovery time after traumatic brain injury. More studies are called for, comprehending different technology and theoretical basis.

**Acknowledgments**

We especially thank JoEllen Wheelock and Jill Snow for their help in the English translation of this work.

## References

Black, P,. Markowitz, RS,. & Cianci, SN. (1975). Recovery of motor function after lesions in motor cortex of mon.key. In: Outcome of Severe Damage to the Central Nervous System. *Ciba Found Symp* ;34: 65-83.

Benedict, R. (1989). The effectiveness of cognitive remediation strategies for victims of traumatic head-injury: a review of the literature. *Clin Psychol Rev*;9: 605-626.

Carney, N., Chestnut, RM., Maynard, H., Mann, NC., Patterson, P., & Helfand, M. (1999) Effect of Cognitive Rehabilitation on Outcomes for Persons with Traumatic Brain Injury: A Systematic Review. *J Head Trauma Rehabil*;3: 277-321.

Cicerone, KD,. Dahlberg, C,. & Kalmar, K,. et al. (2000). Evidence-based cognitive rehabilitation: recommendations for clinical practice. *Arch Phys Med Rehabil;*12: 1596-1615.

Hall, KM., & Cope, N. (1995) The benefit of rehabilitation in traumatic brain injury: a literature review. *J Head Trauma Rehabil* 1: 1-13.

Machuca, F., Martín-Carrasco, JM., Martín González, A., Rodríguez-Duarte, R., León-Carrión, J. (1997) Training for social skills after brain injury. In *Neuropsychological Rehabilitation: Fundamentals, innovations and directions.* León-Carrión J (editor). Delray Beach, FL: St. Lucie Press; 453-468.

León-Carrión, J. (1997) Rehabilitation of Memory. In *Neuropsychological Rehabilitation: Fundamentals, innovations and directions.* León-Carrión J, (editor). Delray Beach, FL: St. Lucie Press; 371-398.

León-Carrión, J. (1997) An approach to the treatment of affective disorders and suicide tendencies after TBI. In *Neuropsychological Rehabilitation: Fundamentals, innovations and directions.* León-Carrión J (editor). Delray Beach, FL: St. Lucie Press; 415-430.

León-Carrión, J. (1998).Rehabilitation Models for Neurobehavioral Disorders after Brain Injury. *Brain Injury Source*; 2(4)16-32.

León-Carrión, J., Domínguez-Roldán, JM., Murillo-Cabezas, F., Domínguez-Morales, MR., Muñoz-Sánchez, MA. (2000). The role of citicholine in neuropsychological training after traumatic brain injury. *NeuroRehabilitation*; 14: 33-40.

León-Carrión, J,. Machuca-Murga, F. (2001) Spontaneous recovery of cognitive functions after severe brain injury: When are neurocognitive sequealea established? *Rev Español de Neuropsicol*; 3(3): 58-67.

Salazar, AM., Warden, DL., Schwab, K., et al. (2000) Cognitive rehabilitation for traumatic brain injury: A randomized trial. Defense and Veterans Head Injury Program (DVHIP) Study Group. *JAMA;* 283:23 3075-30781.

Volpe, BT., & McDowell, FH. (1990). The efficacy of cognitive rehabilitation in patients with traumatic brain injury. *Arch Neurol*;47: 220-222

Prigatano, GP,. (1999). Commentary: beyond statistics and research design. *J Head Trauma Rehabil*;3: 308-311; discussion 322-324.

Yu, JY., (1976) Functional recovery with and without training following brain damage in experimental animals: a review. *Arch Phys Med Rehabil*; 57:38-41.

Recibido, 17 de Noviembre del 2004
Aceptado, 15 de Diciembre 2004