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Neuropsychological Profile at Three Months Post Injury in Patients with Traumatic Brain Injury

(Profil Neuropsikologi Tiga Bulan Selepas Kecederaan pada Pesakit dengan Kecederaan Trauma Otak)

RAMLI ALI, SUZAILY WAHAB* & ABDUL HAMID ABDUL RAHMAN

ABSTRACT

*This study looked into the rate and pattern of neuropsychological impairment in patients with traumatic brain injury patients at three months post injury. Forty patients attending the neurosurgery outpatient clinic were included in the study. Benton visual retention test (BVRT), rey auditory verbal learning test (RAVLT), digit span test, trail making test (TMT) and mini mental state examination (MMSE) were used for assessment. Forty five percent (*n*=18) sustained moderate to severe head injury. Twenty five percent (*n*=10) have abnormal MMSE result. Forty two and a half percent (*n*=17) have abnormal BVRT result. Seventy five percent (*n*=30) have abnormal RAVLT result while 35% (*n*=14) have abnormal digit span test result. Seventy seven and a half percent (*n*=31) have at least one neurological deficit. There was significant association between severity of head injury (GCS score) and neuropsychological deficit. This study highlights the point that in post head injury patients, there are high occurrences of cognitive dysfunction. MMSE and GCS play a significant and important role in assessing cognitive dysfunction. Severity of head injury as determined by GCS scores also influence the outcome in patients with head injury.*

Keywords: Cognitive dysfunction; head injury; neuropsychological impairment

ABSTRAK

*Kajian ini melihat kadar dan bentuk kelainan neuropsikologi dalam kalangan mereka yang mengalami kecederaan kepala tiga bulan selepas kemalangan. Empat puluh pesakit yang datang ke klinik pesakit luar neurosurgeri diambil untuk kajian ini. Ujian pengekalan penglihatan Benton (BVRT), ujian pembelajaran pendengaran verbal rey (RAVLT), ujian digit span, ujian membuat jejak (TMT) dan pemeriksaan keadaan mental mini (MMSE) digunakan untuk pengukuran. Empat puluh lima peratus (*n*=18) mengalami kecederaan kepala yang sederhana kepada teruk. Dua puluh lima peratus (*n*=10) menunjukkan keputusan MMSE yang tidak normal. Empat puluh dua setengah peratus (*n*=17) menunjukkan keputusan BVRT tidak normal. Tujuh puluh lima peratus (*n*=30) menunjukkan keputusan RAVLT tidak normal, sementara 35% (*n*=14) menunjukkan ujian digit span tidak normal. Tujuh puluh tujuh setengah peratus (*n*=31) mengalami sekurang-kurangnya satu kelainan neuropsikologi. Terdapat hubungan yang signifikan antara keterukan kecederaan kepala (skor GCS) dengan kelainan neuropsikologi. Kajian ini menunjukkan bahawa selepas berlakunya kecederaan kepala terdapat disfungsi kognitif pada kadar yang tinggi. MMSE dan GCS memainkan peranan yang signifikan dan penting dalam mengukur disfungsi kognitif. Keterukan kecederaan kepala yang diukur oleh skor GCS juga mempengaruhi kesan akhir pada pesakit yang mengalami kecederaan kepala.*

Kata kunci: Kecederaan kepala; kecelaan kognitif; kelainan neuropsikiologi

INTRODUCTION

Current research has shown that cognitive and behavioural consequences can occur even in mild head injuries. It is also a great concern that traumatic brain injury may result in significant psychiatric manifestations (Reekum et al. 2000; Thatcher et al. 2001). The nature of mental consequences of head injury depends upon severity of the blow and the varying mixture of generalized and focal injuries it produces. Lishman (1968) stated that severity of the injury reflects the volume of brain injured, especially in the case of focal brain damage. Whatever the nature of the head injury mechanism, the neuropsychological benefit which influence the psychological, behavioural and social consequences of this condition pose greater problem for patients and their relatives than do physical disabilities. McKinlay et al. (1981) observed an enormous emotional and social burden of the families of brain injured patients secondary to their disruptive behaviours.

Lishman (1988) also formulated that the initial risk factors precipitating new behavioural symptoms following head injury are mainly organic, whereas risk factors associated with the persistent symptoms are more psychological in nature. However, Deb et al. (1999), proposed that the occurrence of behavioural symptoms is more likely to depend on a complex interaction of many factors, including socio demographic variables (age, gender & social class), premorbid factors (premorbid personality, previous history head injury and history of

psychiatric illness), factors related to the head injury, post injuries factors and outcome factors (global outcome & presence of psychiatric illness).

Although some studies show that symptoms due to traumatic brain injury may lessen by 3 months (Carroll et al. 2004; Dikmen et al. 2001; Vanderploeg et al. 2005), the rate of recovery is varied among individuals.

The aims of this study were to identify cognitive dysfunction following head injury, pattern of the neuropsychological deficits and factors associated with the neuropsychological deficits.

Methods

This was a cross sectional study done among consecutive traumatic brain injured patients between 15 and 60 years old who attended the neurosurgery outpatient clinic. Inclusion factors included those diagnosed as having traumatic brain injury by neurosurgeons, with history of head injury within 3 months, without mental sub normality and both mentally and physically capable of understanding test instructions.

Socio demographic data were obtained from patients and relatives. Data including CT scan findings and recorded Glasgow Coma Scale were also obtained. Mini mental state examination (MMSE) Folstein et al. 1975), Benton visual retention test (BVRT) (Benton 1974; Sivan 1991), Rey auditory verbal learning test (RAVLT) (Rey 1964), trail making test and digit span test were used as instruments.

MMSE is the most widely used screening measure for cognitive impairment because of its brevity and ease of administration. It has a high test retest reliability (Folstein et al. 1975) and is also useful as screening test for dementia and delirium. In this study, a score of less than 24 was taken as cognitively impaired.

BVRT (Benton 1955) was used to assess the visual memory outcome in this study. It is a neuropsychological test of non-verbal memory to assess visual perception, visual memory and visuo-constructive abilities. It is sensitive in detecting cerebral disease (Sivan 1991) and can help determine specific acquired cognitive deficit (Thompson et al. 2007).

RAVLT is a commonly used verbal serial learning test (Spreen & Strauss 1998) that provides a measure of immediate recall evaluates learning over successive trials and assesses confabulation and susceptibility to interference. Its ability to measure memory validly has also been recognized (Rosenberg et al. 1984).

Trail making test (TMT) is a test of visuomotor tracking, conceptualization and mental 'set-shifting' which aims to provide information about visual search (speed, scanning and processing) and also executive functioning (Arnett & Seth 1995).

Digit span test is a widely used test of auditory verbal short-term memory. It consists of forward and reverse digit span. In this study, scores of 4 and below was regarded as abnormal for forward digit span while score of 3 and below was considered as abnormal for reverse digit span.

Results

Fifty percent of the study samples were in the 15 to 29 years age group. The majority (77.5%) were males and 57.5% Malays. Sixty seven and a half percent were married while 65% had upper secondary school education level. CT scan was abnormal in 80% of cases and 45% had more severe GCS level (3-12) (Table 1). Road traffic accident victims contributed to the largest portion of this sample (n=37, 92.5%). Fifty five percent (n=22) sustained minor head injury as defined by Glasgow coma scale (GCS) score of 13 and above.

TABLE 1. Socio demographic characteristics of patients

Characteristics	Variables	n (%)
Age groups (years)	15-29	20 (50)
	30-60	20 (50)
Sex	Male	31 (77.5)
	Female	9 (22.5)
Race	Malay	23 (57.5)
	Chinese	10 (42.5)
	Indian	6 (15)
	Others races	1(2.5)
Marital status	Married	27 (67.5)
	Single	13 (32.5)
Education level	Lower Secondary	14 (35)
	Upper Secondary	26 (65)
CT scan findings	Normal	8 (20)
	Abnormal	32 (80)
GCS	3-12	18 (45)
	13-15	22 (55)

The relationship between CT findings and GCS was found to be significant with x^2=8.182, p=0.004 (Table 2).

TABLE 2. Relationship between CT scan findings and GCS presented as *n*(%)

Group		GCS Score (3-12)	GCS Score (13-15)	Total
CT Scan findings	Normal	0 (0)	8 (20)	8 (20)
	Abnormal	18 (45)	14 (35)	32 (80)
Total		18 (45)	22 (55)	40 (100)

x^2=8.182, p=0.004

NEUROPSYCHOLOGICAL TESTS FINDINGS

MMSE

Twenty five percent (n=10) were found to have abnormal test result when the score of less than 24 was taken as abnormal. The relationship between GCS and MMSE was significant (x=16.296 and p<0.000) (Table 3). Other parameters such as education level, age group, marital status, race and gender also do not have significant relationship with MMSE results.

TABLE 3. Relationship between GCS score and MMSE presented as *n*(%)

GCS	MMSE		Total
	Normal	Abnormal	
Moderate to severe	8 (20)	10 (25)	18 (45)
Mild	22 (55)	0 (0)	22 (55)
Total	30 (75)	10 (25)	40 (100)

x^2-16.296, p<0.001

BVRT

Out of 40 subjects assessed, 42.5% (n=17) had abnormal BVRT results. There was significant relationship observed between age of subjects and BVRT results (x^2=5.0134, p=0.025) (Table 4). Significant difference were noted between GCS score and BVRT, p=0.001 (x=11.831) (Table 5). Other factors studied, such as gender, race, education level, marital status and CT scan findings has no significant association with BVRT result.

TABLE 4. Relationship between age of subjects (represented by age group) and BVRT outcome presented as *n*(%)

Age group	BVRT		Total
	Normal	Abnormal	
15-29	8 (20)	15 (37.5)	23 (57.5)
30-60	12 (30)	5 (12.5)	17 (42.5)
Total	20 (50)	20 (50)	40 (100)

x^2=5.0134, p=0.025

TABLE 5. Relationship between GCS and BVRT outcome presented as *n*(%)

Glasgrow coma scale	BVRT		Total
	Normal	Abnormal	
Moderate to severe (GCS 3-12)	5 (12.5)	13 (32.5)	18 (45)
Mild (GCS 13-15)	18 (45)	4 (10)	22 (55)
Total	23 (57.5)	17 (42.5)	40 (100)

x^2=11.831, p=0.001

RAVLT

Out of 40 subjects, 30 (75%) had abnormal RAVLT. No significant association was found between RAVLT and age group, gender, education level, marital status, CT scan findings or GCS score. However, there was significant association between ethnic status and abnormal RAVLT result (x^2=0.430, p=0.042) (Table 6).

TABLE 6. Relationship between ethnic groups and RAVLT presented as *n*(%)

Ethnic group	RAVLT		Total
	Normal	Abnormal	
Malay	3 (7.5)	20 (50)	23 (57.5)
Others races	7 (17.5)	10 (25)	17 (42.5)
Total	10 (25)	30 (75)	40 (100)

x^2=4.126, p=0.042

TMT

Fifty percent (n=20) were found to have abnormal TMT results. No significant association was found between TMT and age group, gender, education level, marital status or CT scan findings. However, significant difference was found between abnormal TMT result and GCS score (x^2=14.545, p=<0.01) (Table 7).

TABLE 7. Relationship between GCS and TMT score presented as *n*(%)

Glasgow coma scale	TMT		Total
	Normal	Abnormal	
Moderate to severe (3-12)	3 (7.5)	15 (37.5)	18 (45)
Mild (13-15)	17 (42.5)	5 (12.5)	22 (55)
Total	20 (50)	20 (50)	40 (100)

x^2=14.545, p<0.01

DIGIT SPAN

Thirteen (35%) of the patients had abnormal digit span result. Fourteen (77.8%) patients from the moderate to severe GCS score group had abnormal digit span, whereas

nine from the mild GCS group had this problem. There was significant association between GCS score and digit span findings (x^2=26.325, p< 0.01) (Table 8).

TABLE 8. Relationship between GCS score and digit span results presented as *n*(%)

Glasgow coma scale	Digit span		Total
	Normal	Abnormal	
Moderate to severe (3-12)	4 (10)	14 (35)	18 (45)
Mild (13-15)	22 (55)	0 (0)	22 (55)
Total	26 (65)	14 (35)	40 (100)

x^2=26.325, p<0.011

All 14 subjects who have abnormal digit span results had abnormal CT scan findings. Therefore there was significant relationship between CT scan abnormality and digit span results (x^2=5.385, p=0.02) (Table 9).

TABLE 9. Relationship between CT scan abnormality and digit span result presented as *n*(%)

	Digit span		Total
	Normal	Abnormal	
Normal	8 (20)	0 (0)	8 (20)
Abnormal	18 (45)	14 (35)	32 (80)
Total	26 (65)	14 (35)	40 (100)

x^2=5.385, p=0.02

MEASURES OF COGNITIVE DYSFUNCTION

The commonly used measure for cognitive dysfunction is mini mental state examination due to their easy usage and not time consuming. In this study, MMSE was found to correlate significantly with the occurrence of one or more neuropsychological test deficit (x^2=3.871, p=0.045) (Table 10).

TABLE 10. Relationship between MMSE and the occurrence of at least one neuropsychological test deficit presented as *n*(%)

MMSE	Neuropsychological test		Total
	Normal	Abnormal	
Normal	9 (22.5)	21 (52.5)	30 (75)
Abnormal	0 (0)	10 (25)	10 (25)
Total	9 (22.5)	31 (77.5)	40 (100)

x^2=3.871, p=0.045

DISCUSSION

INJURY

The present study found that those at risk of all types of injury from mild to severe head injury were mainly young man. This was also observed in other studies (Bruns & Hauser 2003; Frankowski et al. 1985). Road traffic accidents also predominate the picture. Malays were observed to predominate the other ethnic groups.

In this study, the upper and lower secondary school education level represents the major portion of the study. These two groups also represent the working class in our local population. Studies in the west have shown contribution of the factors in the working class population in influencing the occurrence of head injury (Fenton et al. 1993).

THE RATE OF NEUROPSYCHOLOGICAL DEFICIT

In the absence of local population based prevalence of a control group, it is difficult to assess whether neuropsychological deficits shown by patients in this study were in any way related to their head injury. The presence of other difficult to control factors such as pre-existing cognitive impairment due to used of prescribed medications, poor cooperation with testing procedures and intentional exaggeration of impairment, could also affect performance on the neuropsychological testing done in this research.

However, this study had excluded those with mental retardation, substance abuse, and presence of major psychiatric disorders as a measure to optimize result of the neuropsychological testing.

A substantial percentage of patients were found to have at least one neuropsychological deficit and the rate of individual tests varied between 25% (MMSE) and 75% (RAVLT) in this research.

MINI-MENTAL STATE EXAMINATION (MMSE)

Only 25% of the subjects have abnormal MMSE. However, abnormal MMSE result was found to be significantly correlated with the occurrence of at least one neurological deficit. This finding should be treated with some caution as the cut off scores of MMSE tend to be different in different population studied. Scores below 24 which was chosen in this study is in fact considered abnormal for dementia and delirium screening. Higher cut off scores have been recommended for other conditions (27 for multiple sclerosis) (Beaty & Goodkin 1990) and 25 for well-educated Alzheimer's patients (Galasco 1990). MMSE is also age dependent and different scores have been used for different age groups. Further study is therefore necessary to determine the true cut off score for patients with head injury.

BENTON VISUAL RETENTION TEST

BVRT has been shown to be sensitive to neuropsychological dysfunction, in particular parietal lobe dysfunction (Thompson 2006). Levin et al. (1990) found that head trauma patients tend to make significantly more errors than matched control subjects. In this study, about 50% of subjects have abnormal BVRT results.

REY AUDITORY VERBAL LEARNING TEST

Patients with head injury tend to have lower recall for each measure but demonstrate a learning curve with little gain appearing on delayed recall but a near normal performance on the recognition trial, indicating a significant verbal retrieval problem (Brigler 1989; O'Donnel et al. 1998; Peck & Mitchell 1990).

In this research, 75% of subjects had abnormal RAVLT result. This high value could be attributed by the method of calculating result, whereby presence of abnormal result in anyone of the subgroups was taken as abnormal result.

TRAIL MAKING TEST

Any disease that can compromise brain may lead to deficit in TMT performance (Ashendorf et al. 2008; Periáñez et al. 2007; Stuss et al. 2001). In patients with mild head injury, TMT performance is also notably slower than control subjects. The slowing on both tasks were also reported in other studies (Clifton 1993; Dikmen et al.1995). In this study 50% of the subjects demonstrated abnormal TMT results.

+DIGIT SPAN

Digit span impairment has also been reported in patients with head injury. The impairment or reduction may be in both forward and backward digit span (Levin et al. 1982), or backward digit only (Mandleberg & Books 1975). In this study, less than half of the patients had digit span impairment. This impairment had shown significant association with CT scan findings and GCS score.

RISK FACTORS AFFECTING NEUROPSYCHOLOGICAL FINDINGS

Outcome findings following head injury have been often studied in an attempt to understand the risk factors behind their development. Some authors hypothesized that both biological and psychological factors have significant contribution in outcome of head injury. Lishman (1988), hypothesized that symptoms of post concussional syndrome in patients with head injury are often precipitated by organic factors in the beginning and later on perpetuate by psychosocial factors. The controversy regarding organic versus environmental aetiology has lasted ever since.

In this research, GCS score had significant association with 4 of 5 neuropsychological assessments done. The only assessment that had no significant association with GCS score was RAVLT. GCS score was also significantly associated with CT scan findings. This result in some way points more towards an organic aetiology for the neurological deficits.

An interesting finding was RAVLT was not influenced by any of the 'biological' variables but related significantly to the ethnicity of the subjects. The possibility of ethnicity as one of the strong psychosocial factors which may influence test performance in the RAVLT should be considered.

CONCLUSION

Although this study has its own limitation and weaknesses due to the small sample size and use of instruments with their built-in limitations, this study was able to highlight an important issue which was the high occurrence of cognitive dysfunction in post head injury individuals as measured by specific neurological tests. This study also highlighted the usefulness of using simple MMSE and GCS in assessing cognitive function which is fairly easy to do and also time saving. Finally, this research also supports findings of previous studies which showed severity of head injury determined by GCS score also influence the outcome in our local population with head injury.

REFERENCES

Arnett, J.A. & Seth, S.L.1995. Effect of physical layout in performance of the trail making test. *Psychological Assessment* 7(2): 220-221.

Ashendorf, L., Jefferson, A.L., O'Connor, M.K., Chaisson, C., Green, R.C. & Stearn, R.A. 2008. Trail making test errors in normal aging, mild cognitive impairment, and dementia. *Archives of Clinical Neuropsychology* 23: 129-137.

Beatty, W.W. & Goodkin, D.E. 1990. Screening for cognitive impairment in multiple sclerosis: An evaluation of the mini mental state examination. *Archive of Neurology* 47: 297-301.

Benton, A.L. 1955. *The Revised Visual Retention Test: Clinical and Experimental Applications*. New York: Psychological Corporation.

Benton, A.L. 1974. *The Revised Visual Retention Test: Clinical and Experimental Application*. 4th ed. New York: The Psychological Corporation.

Brigler, E.D. 1989. Rey auditory verbal learning and Rey-osterrieth complex figure design performance in Alzheimer's disease and close head injury. *Journal of Clinical Psychiatry* 45: 277-280.

Bruns, J. & Hauser, W.A. 2003. The epidemiology of traumatic brain injury: A review. *Epilepsia* 44(suppl 10): 2-10.

Carroll, L.J., Cassidy, J.D., Peloso, P.M., Borg, J., Holst, H.V., Holm, L., Paniak, C. & Pépin, M. 2004. Prognosis for mild traumatic brain injury: Results of the WHO collaborating centre task force on mild traumatic brain injury. *J. Rehabil. Med.* 36(43): 84-105.

Clifton, G.L., Kreutzer, J.S., Choi, S.C., Devany, C.W., Eisenberg, H.M., Foulkes, M.A., Jane, J.A., Marmarou, A. & Marshall, L.F.1993. Relationship between Glasgow coma scale and neuropsychological measures after brain injury. *Neurosurgery* 33(1): 34-39.

Deb, S., Lyons, I. & Koutzoukis, C. 1999. Neurobehavioural symptoms one year after a head injury. *British Journal of Psychiatry* 174: 360-365.

Dikmen, S.S., Machamer, J.E., Winn, H.R. & Temkin, N.R.1995. Neuropsychological outcome at 1-year post head injury. *Neuropsychology* 9(1): 80-90.

Dikmen, S.S., Machamer, J.E. & Temkin, N.R. 2001. Mild head injury: Facts and artifacts. *J. Clin. Exper. Neuropsychol.* 23: 729-738.

Fenton, G., McClelland, R., Montgomery, A., MacFlynn, G. & Rutherford, W. 1993. The postconcussional syndrome: Social antecedents and psychological sequelae. *Br. J. Psychiatry* 162(4): 493-497.

Folstein, M., Folstein, S. & McHugh, P. 1975. Mini Mental State: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research* 12: 189-198.

Frankowski, R.F., Annegers, J.F. & Whitman, S. 1985. Epidemiological and descriptive studies. Part 1. The descriptive epidemiology of head trauma in the United States. In: *Central Nervous System Trauma Status Report-1985,* edited by Becker, D.P. & Povlishock, J.T. Bethesda: NIH, NINCDS. pp. 33-43.

Galasko, D., Klauber, M.R., Hofstetter, C.R., Salmon, D.P., Lasker, B. & Thal, L.J. 1990. The mini mental state examination in the early diagnosis of Alzheimer's disease. *Archive of Neurology* 47(1): 49-52.

Levin, H.S., Benton, A.L. & Grossman, R.G. 1982. *Neurobehavioural Consequences of Close Head Injury.* New York: Oxford University Press.

Levin, H.S., Gary, H.E. Jr., Eisenberg, H.M., Ruff, R.M., Barth, J.T., Kreutzer, J., High, W.M. Jr., Portman, S., Foulkes, M.A., Jane, J.A., Marmarou, A. & Marshall, L.F. 1990. Neurobehavioural outcome 1 year after head injury: Experience of the traumatic coma data bank. *J. Neurosurgery* 73(5): 699-709.

Lishman, W.A. 1968. Brain damage in relation to psychiatric disability after head injury. *British Journal of Psyhiatry* 114: 373-416.

Lishman, W.A. 1988. Physiogenesis in the 'post- concussional syndrome'. *British Journal of Psychiatry* 153: 460-469.

Mandleberg, I.E. & Brooks, D.N. 1975. Cognitive recovery after severe head injury. 1. Serial testing on the WAIS. *Journal Neurology, Neurosurgery and Psychiatry* 38(11): 1121-1126.

McKinlay, W.W., Brooks, D.N., Bond, M.R., Martinage, D.P. & Marshall, M.M. 1981. The short-term outcome of severe blunt head injury as reported by relatives of the injured person. *J. Neurol. Neurosurg. Psychiatry* 44(6): 527-533.

O'Donnell, J.P., Rasdtke, R.C., Leicht, D.J. & Caesar, R. 1998. Encoding and retrieval processes in learning disabled, head-injured, and non-disable young adults. *The Journal of General Psychology* 115: 355-368.

Peck, E.A. & Mitchell, S.A. 1990. Normative data for 538 head injury patients across seven time periods after injury. In: *Practitioner's Guide to Clinical Neuropsychology,* edited by Anderson, R.M. p. 235.

Periáñez, J.A., Ríos-Lago, M., Rodríguez-Sánchez, J.M., Adrover-Roig, D., Sánchez-Cubillo, I., Crespo-Facorro, B., Quemada, J.I. & Barceló, F. 2007. Trail making test in traumatic brain injury, schizophrenia, and normal ageing: Sample comparisons and normative data. *Arch. Clin. Neuropsychol.* 22(4): 433-447.

Reekum, R., Cohen, T. & Wong, J. 2000. Can traumatic brain injury cause psychiatric disorders? *J. Neuropsychiatry Clin. Neurosci.* 12: 316-327.

Rey, A. 1964. *L'Examen Clinique en Psychologie. [Clinical tests in psychology].* Paris: Press Universitaire de France.

Rosenberg, S.J., Ryan, J.J. & Prifitera, A. 1984. Rey auditory verbal learning test performance of patients with and without memory impairment. *Journal of Clinical Psychology* 40: 785-787.

Sivan, A.B. 1991. *Benton Visual Retention Test Manual.* 5th ed. San Antonio, TX: Harcourt Brace & Company.

Spreen, O. & Strauss, E. 1998. *A Compendium of Neuropsychological Tests: Administration, Norms and Commentary.* New York: Oxford University Press.

Stuss, D.T., Bisschop, S.M., Alexander, M.P., Levine, B., Katz, D. & Izukawa, D. 2001. The trail making test: A study in focal lesion patients. *Psychological Assessment* 13: 230-239.

Thatcher, R.W., North, D.M., Curtin, R.T., Walker, R.A., Biver, C.J., Gomez, J.F. & Salazar, A.M. 2001. An EEG severity index of traumatic brain injury. *J. Neuropsychiatry Clin. Neurosci.* 13(1): 77-87.

Thompson, S.B.N. 2006. *Dementia and Memory: A Handbook for Students and Professionals.* Aldershot: Ashgate.

Thompson, S.B.N., Ennis, E., Coffin, T. & Farman, S. 2007. Design and evaluation of a computerised version of the Benton visual retention test. *Computers in Human Behavior* 23: 2383-2393.

Vanderploeg, R., Curtiss, G. & Belanger, H. 2005. Long-term neuropsychological outcomes following mild traumatic brain injury. *J. Int. Neuropsychol. Soc.* 11: 228-236.

Ramli Ali
Department of Psychiatry
Hospital Selayang
Lebuhraya Selayang-Kepong
68100 Batu Caves
Selangor Darul Ehsan
Malaysia

Suzaily Wahab* & Abdul Hamid Abdul Rahman
Department of Psychiatry
Universiti Kebangsaan Malaysia Medical Centre (UKMMC)
Jalan Yaacob Latif
56000 Cheras, Kuala Lumpur
Malaysia

*Corresponding author; email: suzailywhb@yahoo.com

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