Cognitive retraining in traumatic brain injury

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Abstract

Traumatic brain injury (TBI) is often associated with cognitive impairments. The psychological sequelae of cognitive deficits and emotional problems contribute significantly to the disability in the patient and to the distress of the family. The study aimed to develop a cognitive retraining programme to enhance cognitive functioning in TBI. 25 years old male presenting with history of left temporal hemorrhagic contusion with cerebral edema underwent 2 months of a cognitive retaining programme, addressing executive functions impairment. A single case experimental design with pre- and post-assessment was adopted to evaluate changes in the patient in response to the intervention. Improvements were found in cognitive functioning, and in symptom reduction and behaviour. The 2 months hospital based cognitive retraining programme was found to be efficacious in ameliorating symptoms and improving cognitive, social and occupational functioning post traumatic brain injury.

Keywords: Traumatic Brain Injury (TBI); Cognitive retraining; Cognitive deficits; Rehabilitation

1. Introduction

Traumatic brain injury (TBI) is a form of acquired brain injury that occurs when a sudden trauma causes damage to the brain, and is often associated with the interruption of a normal supply of oxygen. In India 30.000 persons die and 125.000 persons are disabled every year due to TBI, often in the 15-25 year age group (Sudarsanan, Chaudharly, Pawar & Srivastava, 2006).

Cerebral contusion or hemorrhagic contusion is a type of serious injury, usually associated with a brief loss of consciousness, can impair a wide range of brain functions, depending on contusion size and location. This may also be associated with swelling or edema and increased intracranial pressure (ICP). There are physical, psychological and social sequelae of head injury. Psychological sequelae of cognitive deficits and emotional problems contribute significantly to the disability in the patient (Bond, 1975). Commonly, cognitive impairments occur in attention and speed of processing, psychomotor skills, learning and memory, verbal and visuospatial skills, fluid intellectual functioning, and a range of executive functions (Lezak, 1995).

With the growing understanding and interest in neuronal plasticity, cognitive retraining is being recognized as an efficacious means of neurorehabilitation of patients with TBI. Neuropsychological rehabilitation is based on the concept of neuronal plasticity, involving the principle of re-establishment and re-organization of the lost functions of the brain (Robertson & Murre, 1999). Cognitive retraining are defined as those activities that improve a brain-injured person's higher cerebral functioning or help patients to better understand the nature of those difficulties while teaching him or her methods of compensation (Klonoff, O'Brien, Prigatano, Chiapello & Cunningham, 1989).

This method includes repeatedly practicing tasks that load on attention, memory, reasoning or other specific cognitive functions (Martindale, Mueser, Kuipers, Sensky & Green, 2003), with the goal of improving cognitive functions, with an underlying assumption that improvements in basic functions generalize to the improvement of overall functioning (Rao, 1990).

Substantial evidence to support cognitive rehabilitation for people with TBI, including strategies for mild memory impairment, training for post acute attention deficits, and interventions for functional communication deficits have been demonstrated (Cicerone, Dahlberg, Malec, Langenbahn, Felicetti, Kneipp, Ellmo, Kalamar, Giacino, Harley, Laatsch, Morse & Catanese, 2005), and proven its usefulness in improving the cognitive functions and day to day functioning (Nag & Rao, 1999).

In the present study, a retraining programme was developed to address executive functions impairment, involving tasks of attention enhancement, fine and gross motor control, temporal encoding, phonemic and category fluency, memory enhancement and response inhibition. The levels of difficulty and complexity being increased with improved performance on the task with a provision for scoring for error and time (Kumar, 2010). The programme lasted for 48 sessions, spanning over a period of 2 months. The patient and family were also psychoeducated and counselled.

2. Method

2.1. Participant's information

Patient RG, a 25 years old male, educated up to II year under graduation, previously working as a businessman, presented with a history of left temporal hemorrhagic contusion with cerebral edema, diffuse axonal injury, with loss of consciousness and vomiting in october 2009. He was admitted to a local hospital after sustaining polytrauma in a road traffic accident (RTA) with a Glasgow Coma Scale (GCS) score of 4 (GCS 4 = E1 V1 M3) classifying as severe injury.

The patient came to NIMHANS in january 2010, presenting with complaints of being unable to recall names of objects and people, misplacing things and personality changes such as impulsivity and anger outbursts. He was referred for neuropsychological assessment and rehabilitation in view of his cognitive deficits and personality changes.

2.2. Tools

(1) *NIMHANS Neuropsychology Battery* (Rao, Subbakrishna & Gopukumar, 2004): this comprehensive neuropsychological assessment, standardized for use in the Indian population, was carried out to assess cognitive functioning of the patient. The following cognitive domains were assessed: motor speed, mental speed, sustained attention, category fluency, working memory (verbal and visuospatial), planning, concept formation and set-shifting, response inhibition, verbal comprehension, verbal learning and memory, visuospatial construction, visual learning and memory and parietal focal signs.

(2) *Rivermead Post Concussion Symptoms Questionnaire* (*RPQ*) (King, Crawford, Wenden, Moss & Wade, 1995): this five point rating scale presenting 16 of the most common published Post Concussion Syndrome symptoms was used to measure the post concussion severity. The patient was asked to rate the degree to which these symptoms are any more of a problem compared with pre-morbid levels using values of 0-4.

(3) *Rivermead Head Injury Follow Up Questionnaire* (*RHFUQ*) (Crawford, Wenden & Wade, 1996): this brief questionnaire, comprising 10 questions was administered to the patient to obtain his subjective ratings of outcome in terms of work, relationships, social, leisure, and domestic activities.

(4) *The Neurobehaviour Rating Scale* (*NRS*) (Levin, High, Goethe, Sisson, Overall, Rhoades, Eisenberg, Kalisky & Gary, 1987): this 27 item, multidimensional clinician based assessment instrument was administered on

the patient to measure neurobehavioural disturbances resulting from closed head injury. NRS included questions under 5 domains: executive/cognition, positive symptoms, negative symptoms, mood/affect, and oral/motor.

2.3. Design

A single case experimental design with pre- and post-assessment was used, to evaluate the changes in the patient in response to the intervention.

2.4. Procedure

The baseline assessment or pre-assessment (i.e. pre-intervention) was carried out 3 months following the TBI. Based on the assessment profile, a cognitive retraining program was developed to address executive functions impairment, involving tasks of attention enhancement, fine and gross motor control, temporal encoding, phonemic and category fluency and response inhibition. The levels of difficulty and complexity were increased with improved performance on the task. The program consisted of sessions held 6 times a week for a period of 2 months, each session lasting on an average for 1.5 hours. A total of 48 sessions were conducted in the hospital setting on an out-patient basis. During this period, the patient and family were also psychoeducated and counselled. The completion of the program was followed by a post-assessment (i.e. post-intervention).

3. Results

The neuropsychological profile obtained from the baseline assessment revealed deficits on tests of motor speed, mental speed, sustained attention, category fluency, verbal and spatial working memory, concept formation and set shifting, response inhibition, verbal learning and memory, visuo-spatial construction, and visual learning and memory. Performance on tests of planning and verbal comprehension was noted to be in the average range, and parietal focal signs were absent. The post-assessment results, post the completion of cognitive retraining revealed marked improvement on tests of executive functions including mental speed, category fluency, verbal and spatial working memory, concept formation and set shifting, response inhibition, recognition, and visual memory. Slight improvement was noted on sustained attention, planning, verbal learning and visuospatial constructive ability.

Table 11. Neuropsychological assessment scores pre- and post-cognitive retraining

Tests	Function	Percentile scores		Outcome
		Pre	Post	
Finger Tapping Test (FT)	Motor speed	5^{th}	5^{th}	No change, impaired
Digit Symbol Substitution Test (DSST)	Mental speed	3^{rd}-6^{th}	21^{st}-24^{th}	Marked improvement
Digit Vigilance Test (DVT)	Sustained attention			
	Time	3^{rd}	3^{rd}	No change in time, impaired
	Error	3^{rd}	23^{rd}	Marked reduction in errors
Animal Names Test (ANT)	Category fluency	5^{th}	40^{th}	Marked improvement
Verbal N-Back (VNB)	Verbal working memory	5^{th}	25^{th}-30^{th}	Improvement
Spatial Span Test (SST) (WMS III)	Spatial working memory	5^{th}	40^{th}	Marked improvement
Tower of London Test (TOL)	Planning	70^{th}-75^{th}	80^{th}	Improvement
Wisconsin Card Sorting Test (WCST)	Concept formation	5^{th}	95^{th}	Marked improvement
	Set-shifting	3^{rd}	52^{nd}	Marked improvement
Stroop Test (ST)	Response inhibition	3^{rd}	36^{th}-39^{th}	Marked improvement
Token Test (TT)	Verbal comprehension	30^{th} -40^{th}	30^{th}-40^{th}	No change
Rey Auditory Verbal Learning Test (AVLT)	Verbal learning	5^{th}	30^{th}	Marked improvement
	Verbal memory	5^{th}	10^{th}	Improvement, still impaired
Rey Auditory Verbal Learning Test (AVLT)	Recognition	5^{th}	15^{th}-25^{th}	Marked improvement
Rey Complex Figure Test (CFT)	Visual learning and memory	5^{th}	15^{th}-20^{th}	Marked improvement

Table 1 gives the percentile scores obtained by the patient on test of neuropsychological functioning, at baseline (pre-assessment) and after the completion of cognitive retraining (post-assessment).

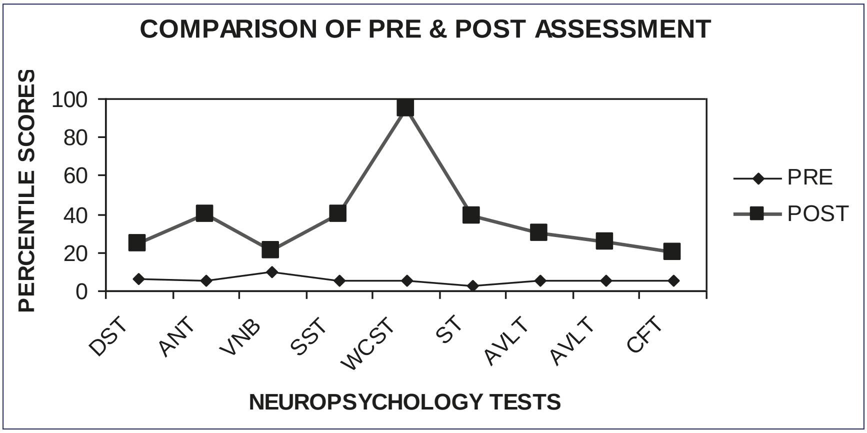

Figure 1. Percentile scores of pre- and post-assessment of neuropsychological functioning

Table 2. Scores of Rivermead Post Concussion Symptoms Questionnaire (RPQ), Rivermead Head Injury Follow Up Questionnaire (RHFUQ) and Neurobehaviour Rating Scale (NRS) pre- and post-cognitive retraining

Tools used	Pre-assessment	Post-assessment
Rivermead Post Concussion Symptoms Questionnaire (RPQ)	36	22
Rivermead Head Injury Follow Up Questionnaire (RHFUQ)	18	12
Neurobehaviour Rating Scale (NRS)	89	70

Table 2 gives the scores obtained by the patient on the outcome measure of Rivermead Post Concussion Symptoms Questionnaire (RPQ), Rivermead Head Injury Follow Up Questionnaire (RHFUQ) and Neurobehaviour Rating Scale (NRS), administered at baseline (Pre-assessment) and after the completion of the cognitive retraining programme (Post-assessment).

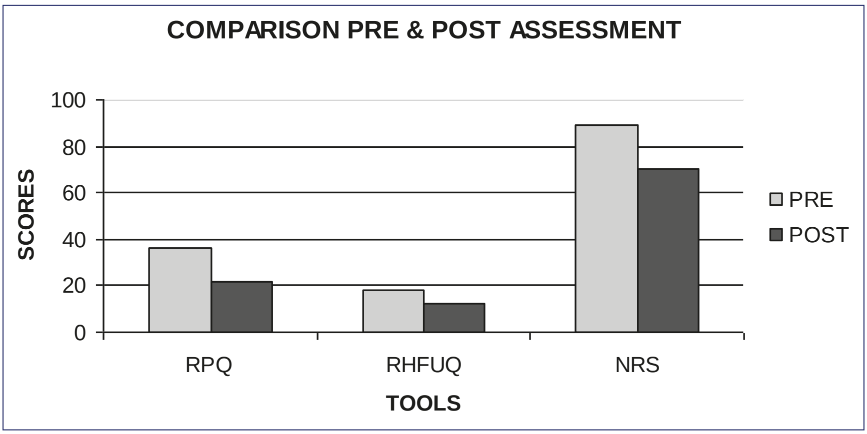

Figure 2. Comparison of pre- and post-assessment scores on outcome measures

No change was observed on tests of motor speed and verbal comprehension (Table 1, Figure 1). The 15th percentile score (1 SD below the mean) was the cut-off score (NIMHANS Neuropsychology Battery: Rao, Subbakrishna & Gopukumar, 2004). Based on the number of test variables falling below the 15th percentile, the severity of cognitive impairment was established.

The scores of Rivermead Post Concussion Symptoms (RPQ), Rivermead Head Injury Follow Up Questionnaire (RHFUQ) and Neurobehaviour Rating Scale demonstrated reduction in symptom severity and improvement in functions of daily life in terms of work, relationships, social activities, leisure activities, and domestic activities, when compared pre and post retraining (Table 2, Figure 2). Results were corroborated by the family's report of the patient's daily functioning, where he was reported to be more confident, self reliant, spontaneous in giving responses, showed improvement in remembering recent events, was able to follow daily routine in a much organized manner and having lesser anger outbursts.

4. Discussion

The purpose of the present study was to examine the efficacy of a 2 months cognitive retraining program in a 25 years old patient with left temporal hemorrhagic contusion with cerebral edema in ameliorating symptoms and improving cognitive, social and occupational functioning post traumatic brain injury. The baseline assessment done 3 months following traumatic brain injury revealed deficits on tests of motor speed, mental speed, sustained attention, category fluency, working memory, set shifting, response inhibition, verbal learning and memory, visuo-spatial construction and visual learning and memory. In view of the deficits found at the baseline assessment, the cognitive retraining programme was developed to address executive functions impairment.

The mechanism of recovery of cognitive functions after TBI is explained in terms of neural plasticity, particularly, experience dependent plasticity. Neuroplasticity which refers to brain's capacity to change and alter its structure and function is particularly relevant to cognitive rehabilitation (Sohlberg & Mateer, 2001). Cognitive retraining utilizes this mechanism, thereby, allowing the brain to restore or compensate for the impaired cognitive functions that are lost because of trauma. In the present study, the direct training of cognitive processes approach was adopted involving repetitive stimulation of distinct components of damaged cognitive functions with an expectation of improvement in processing (Sohlberg, 2002). Evidence shows that even mild changes in the ability to attend to, process, recall, and act upon information can have significant effects on the completion of basic everyday tasks (Sohlberg & Mateer, 2001). The effectiveness of a retraining program involving only 1 hour of training in laboratory setting using tasks unrelated to the individuals' everyday lives has been demonstrated (Levine, Robertson, Clare, Carter, Hong, Wilson, Duncan & Stuss, 2000).

The compensatory mechanism of cognitive retraining has been demonstrated in studies. Studies using temporal encoding tasks with TBI patients showed more activation of the right anterior cingulated, bilateral occipital region and area 10 bilaterally, explaining this increased dispersion of activation as a compensatory mechanism for reduced mnemonic efficiency due to axonal injury (Levine, Cabeza, McIntosh, Black, Grady & Stuss, 2002). Patients with TBI were found to have dispersed activation during verbal working memory task, with right greater than left hemisphere involvement (Christodoulou, DeLuca, Ricker, Madigan, Bly & Lange, 2001). This was interpreted as evidence for compensatory mechanism due to reduced efficiency of the prefrontal and temporal regions. Study using inhibition task with TBI patients found a greater percentage of frontal tissue activation than the healthy controls (Scheibel, Pearson, Faria, Kotrla, Aylward & Bachevalier, 2003).

The cognitive retraining program developed in the study involved tasks of attention enhancement (e.g., grain sorting and divided attention tasks), fine and gross motor control (e.g., finger dexterity and hand dexterity), temporal encoding (4 lists of 12 words each with increasing level of difficulty), phonemic and category fluency (i.e., generation of words belonging to phonemic sounds and categories) and response inhibition (e.g., shading). The levels of difficulty and complexity were increased with improved performance on the task. The sessions were held daily for duration of approximately 1.5 hours (Kumar, 2010).

Subsequent to retraining the patient for a period of 2 months (over 60 hours), post retraining assessment was done. The results indicated improvement on tests of mental speed, sustained attention, category fluency, verbal and spatial working memory, planning, concept formation and set shifting, response inhibition, verbal learning and memory and recognition. Improvements were also found in symptom reduction and behaviour, as assessed by the outcome measures and corroborated by the family post retraining.

The study demonstrates that specific cognitive tasks, presented in increasing order of difficulty, over a period of time, enhance cognitive functioning in TBI. It is justified to expect that further significant recovery could have been expected, if retraining program had been initiated in the first three months after the patient suffered TBI as the period of the first 6 months is known to be most conducive for spontaneous recovery. Thus, the 2 months cognitive retraining programme was found to be efficacious in ameliorating symptoms and improving cognitive, social and occupational functioning post traumatic brain injury.

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