International Journal on Neuropsychology and Behavioural Sciences

Individuals with Traumatic Brain Injury Show Improvement with ~6 Months of Training in Number Search >Visual Memory>Attention Processing

Research article

Volume 5 Issue 4- 2024

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Article History

Received: December 1, 2024 Accepted: December 5, 2024 Published: December 06, 2024

Abstract

Traumatic Brain Injuries (TBI) can produce physical, cognitive and emotional symptoms that are termed post-concussion syndrome (PCS). Cognitive rehabilitation may help recover or forstall damaged abilities. It is important to clarify this because insurances companies can be reluctant to pay for this treatment. To test the efficacy of cognitive rehabilitation, 8 individuals with mild traumatic brain injury consented to participate in this experiment. Each person was administered attention processing training, visual memory, and number search, over a period of ~6 months and the latencies and accuracies for each participant on each trial was measured. There were significant reductions in latencies and improvements in accuracy from before training to after training with an effect size of greater than 2.0. Together, these data show that 6 months of cognitive rehabilitation significantly and robustly improved performance in all patients.

Keywords: traumatic brain injury, concussion, cognitive rehabilitation, attention, memory

Introduction

Traumatic brain injury (TBI) is the leading cause of disability and is the number one cause of death in young adults. Approximately 2.5 million people sustain a (TBI) and present at an emergency room annually in the United States, of which 11% result in morbidity and/or mortality. These epidemiological data do not include those treated in federal facilities (military base, Veteran's facility, prison), urgent care facilities, private doctors' offices or those who do not seek care. Blunt force trauma to the head from slipping and falling, car accidents, sports injuries, work accidents, domestic violence, and sports injuries are some common ways individuals acquire his/her TBI [1,2].

Traumatic brain injuries are diagnosed by the presence of symptoms that were not pre- existing prior to the TBI. Many people believe that if there are not changes visible using an imaging technique, such as a CAT scan or MRI it means they do not have a TBI. This is false. More than 90 percent of patients presenting to the emergency department with TBI or concussion have a negative CT scan. These imaging techniques are not sensitive enough to detect the shearing of brain cells that occurs in TBI. Scans using spectrophotometry and function can often pick up these brain changes but are typically not offered as an option. Given that the brain controls the body, and different parts of the brain control different physical, cognitive and/or emotional functions, up to 140 symptoms have been associated with TBI (see list in pamphlet produced by Brent Feuz) [3,4].

Because of the plethora of symptoms, and a sudden change in their capacity and self-identity, many people don't seek medical attention after a TBI. One minute they were one person (before the injury) and after the injury they are someone else. This trauma of loss of self can prevent people from seeking care and is the basis for much psychopathology. TBI brings other adverse side effects, including physical, cognitive and emotional challenges and medical trauma. This may include mild to moderate aphasia, visual problems, short and long-term memory problems, increased physical pain levels, frequent headaches and migraines, confusion, seizures, and mood disorders, such as depression and anxiety. In the absence of neurological evidence, only neuropsychologists can diagnose TBIs, based upon symptomatology and performance on standardized neuropsychological testing.

The hypothesis of this work is that cognitive rehabilitation will be beneficial for individuals who recently suffered a traumatic brain injury. As a way to evaluate the effectiveness of these specific treatment methods, a longitudinal study was performed, in which participants' latencies and accuracy were measured before and after exposure to cognitive rehabilitation that met the combination of their needs.

One kind of cognitive rehabilitation that is typically universally needed after a TBI is for attention. Attention refers to how one receives and processes internal and external information. Attention deficits after TBI, include problems in sustained attention/concentration, delayed reaction time, distractibility, decreased processing speed, and impaired dual or multitasking (e.g., walking and talking). Attention can be improved significantly with a specific skill training after acquired brain injury which target five components of attention: Focused attention, sustained attention, selective attention, alternating attention, and divided attention. The training program consists of tasks with a hierarchical progression of increasing attention demands, graduating from simple to complex distracters [5]. It is one of the first skills lost and that can return among TBI patients.

Methods

All data are described as (Mean + Standard Error of the Mean).

Overview of Demographic Information

There are 8 participants in this study. As a way to take demographics into consideration, the patient's gender (3males, 5females), age at injury (35.7+3.6years, range 17-53), months since injury (20.8+6.4, range 2-57month), handedness (all right-handed), and years of education (13.9+0.8, range 9-17years) are provided. All of the participants suffered a traumatic brain injury from a motor vehicle accident or a work-related incident.

Description of Tasks

Attention processing training: Attention processing training is a widely acclaimed technique used in cognitive therapy. Based on extensive research conducted to evaluate its significance and validity, results show that this technique targets difficulties with information processing and concentration. With consistent administration to individuals who suffer from cognitive deficits, attention processing training is shown to improve cognitive abilities, specifically attention and mental processing. Sohlberg and Mateer, 2008 revealed significant improvements among participants following attention processing training for 5-10 weeks. Attention processing can be administered at a slow or fast speed and evaluated for effects on selective or sustained attention [5-7].

Visual memory: A visual memory exercise is administered to improve visual memory and concentration. Using a computer, patients are shown an irregular checkerboard display and asked to recreate the checkerboard using the designated checkerboard blocks. To further enhance visual memory capabilities, two more checkerboards could be displayed at the same time; there is no indication on which checkerboard will need to be recreated.

Number search: The Number Search is a technique administered to enhance a patient's attention, visual scanning abilities, short-term memory, and speed in by which they process information [7]. The computer with 4 areas labeled A-D. Numbers 1-28 are randomly placed within the 4 boxes. The patient must identify in which area each sequential number is located. This visual memory exercise can be used with simple (3x3) or complex (4x4) displays. The length of time used to complete this task is measured by the computer, as are percentage of correct answers. (From: KLS Cognitive Educational System. Produced by Lambert Software Company. Portions copyrighted by Microsoft Corp).

Statistical analyses: Statistical Results of paired two tailed T-tests comparing group performance at time 1 and at the last performance. The alpha value was set at $p < 0.05$, the threshold probability for rejecting the null hypothesis, an indication of type I error rate. The β threshold was set at 0.200, the probability of failing to reject the null hypothesis under the alternative hypothesis, an indication of type II error rate. Given the small number of participants, we set the effect size criteria standard high at 1.0. Reaching this criterion would mean there would be at least 84% difference and 55% non-overlap between start and finish, which would demonstrate a large and potent interventions in a small sample [8,9]. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3444174/

Results

The performance of everyone improved significantly following cognitive rehabilitation. Details regarding aggregate performance on each task and statistical significance are indicated below.

Attention Processing Training

For the Attention Processing Training slow technique, there was a statistically significant (t=-2.1058381, df=16, p=0.03) reduction in latencies between performance at the initial testing (2.6+0.6 secs) and final cognitive rehabilitation (1.2+0.3 secs) session.

For the Attention Processing Training fast technique, there was a statistically significant (t=-|3.345671, df=16, p= 0.006) reduction in latencies between performance at the initial testing (6.2+1.7 secs) and final cognitive rehabilitation (1.2+0.6 secs) session.

Visual Memory

For the visual memory scores, there was a statistically significant (t=3.7238157, df=16, p=0.003) higher percentage of correct responses after receiving visual memory training (91.8 + 2.6 %) compared to performance at the begin of training (47.7 + 11.7 %).

Number Search

For the number search task there was a statistically significant (t=6.8706621, df=16, p= 0.0001) reduction in the average time it took for individuals to complete the task at their last test occasion (13.1+3.4secs) as compared to their initial testing (56.5+6.5secs).

Discussion

After receiving cognitive rehabilitation, it is evident that the patients improved. With the goals set for the number search task, patients' visual scanning, mental processing, attention and concentration improved significantly. Results from the study are consistent with the hypothesis that attention-based cognitive rehabilitation is beneficial for people with recent traumatic brain injuries. Cognitive rehabilitation improved performance among all individuals. For the attention processing training slow technique, all 8 participants had a decrease in number of errors. The same results are reflected in the attention processing training fast technique. Even though both versions of the training technique were administered at different speeds, participants were able to decrease the number of incorrect taps between their first assessment and last assessment. This is reflected by their improvement in attention and processing speed. The visual memory exercise saw overall improvements in correct answers for all 8 patients. With the purpose of the task being to improve visual memory and concentration, all 8 patients were able to advance their cognitive abilities. The Number Search task saw the most significant progress for all participants. This in turn may show that number search is better at working attention, memory and concentration for people with traumatic brain injuries.

The results stress the importance of immediate attention based cog-

nitive rehabilitation for individuals with mild traumatic brain injuries. The mission wasn't just to show how effective the different tasks are. It was to display how cognitive performance can be improved when tasks are chosen appropriate to the individuals' immediate need for rehabilitation. In 5-6 months, the participants showed excellent strides in her cognition. Combining these 3 techniques demonstrated improvements in memory, attention, concentration, and speed of mental processing, which are essential assets to functional cognitive performance and are typical deficits in people with traumatic brain injury.

Limitations of this study include other variables that should have been taken into consideration. The first limitation is there was no control group in this study. This is a criticism of most studies evaluating cognitive rehabilitation because it is untenable to withhold a potential therapeutic value. Second, the severity of participants' cognitive deficiencies were not taken into consideration, just the timing, immediate need. A third limitation is performance on pre-assessment and post-assessment should be included each test day. A sheet measuring the participants' pain levels, mental fuzziness, hours of sleep from the previous night, tinnitus levels, and headache levels could be provided for the start and end of sessions. It should have been taken into consideration how the client was feeling for these assessments, which may have affected their scores. We currently monitor patients' symptoms in between sessions with their reporting symptomatology via a computer system and have been working on the development of a symptom reporting application as is available for seizures and other conditions.

The next steps should be measuring performance after the cessation of cognitive rehabilitation to ascertain if this causes regression in cognitive abilities. However, there are obvious ethical challenges with this as indicated above. Future studies would address the limitations stated above to show the efficacy of cognitive rehabilitation for individuals with traumatic brain injuries. Comprehensive Neuropsychological Services also aids clients with post-concussion syndrome, neurotoxicity, stroke, dementia, multiple sclerosis, anoxia, seizure disorder, brain tumors and other central nervous system disorders. Comprehensive Neuropsychological Services fosters a safe and supportive environment where patients learn about their physical, cognitive, and emotional status and to cope effectively. Adjusting to the consequences of brain injury is difficult and requires the support of multiple mental health professionals who are knowledgeable about brain functioning and injury and coordinate their care with the patient, family, and other providers. Therefore, CNS' program attends not only to the individual's specific cognitive impairments, but to the emotional, social, medical, and financial components of his or her condition. Cognitive rehabilitation at CNS uses various computerized programs, memory exercises, skill-building strategies, and games, such as math card games or board games, to engage clients in their treatment. It is important for the clinic to evaluate where each client is experiencing their deficits in order to create a unique treatment plan that focuses on rebuilding these skills. In addition to fun and educational activities, cognitive rehabilitation programs need to focus on everyday functional training, such as learning how to count money, how to read again., or cook. These strategies can help a brain-injured client regain simple occupational behaviors that are a necessity in their everyday life.

Many studies show that cognitive rehabilitation is not effective. A meta-analyses in the Lancet in 2009 of 90 studies pretty much summarizes the nay- sayers and this author is in complete agreement with their evaluation. Some of the features of programs that do not work are as follows. Programs that do not consider where the brain injury is, functions that are needed, and use rehab to gain back those function are less effective. Program that uses a one- size fits all approach do not work well. Programs that do not meet each individual patient where they are less effective. If cognitive rehabilitation providers could demonstrate treatment plans and convincing arguments that their approaches worked, more insurance company may be willing to support therapy for those with mild-moderate TBI. Most insurance companies in our region do not readily provide support for cognitive rehabilitation for mild TBI. However, the consensus is that the sooner a person with TBI can get attention-based rehab the more affective it can be [10].

What works at CNS? First, evidence-based practice continues to be emphasized. There is a theme or reading for each week, that is part of educating patients and practioners about TBI. Much of this has to do with how to tap into neurogenesis in areas of the brain that are damaged. The initial research on neuroplasticity was conducted to understand how the brain develops from birth until early adulthood; however, continued research on neuroplasticity shows that growth of new neuronal tissues is possible in adults, not just in children, in areas of the brain that involve learning, memory, affect and olfaction. We use proven techniques of environmental enrichment to tap into neurogenesis, such as aromatherapy, light, and exercise (yoga). We encourage familial, social and sexual relations at home that improve brain function and neurogenesis. Second, there is no question that the immediate environment plays a large role. The facility has been completely updated to be more simple, relaxing, hygienic, and to emphasize features of nature in this beautiful home built in the early 1900's. Patients are made comfortable with blankets and couches for napping as needed, as well as refreshments. There are two waiting rooms at CNS. One that can be closed off if a person needs to time out and sleep. The other is adjacent. Third, CNS is now much more than a doctor's office. It has become a retreat for people with TBI.

Because of the past success of their approach, CNS has thousands of patient records that are being analyzes for factors associated with recovery from TBI. Preliminary data show all other things being equal, those who had more roles a priori, engaged in cognitive rehab sooner and more rigorously, were discharged earlier with a better prognosis. We have currently observed a pattern for total cholesterol signaling to be elevated with recovery from mild to moderate TBI and believe this is due to its production as a building block for trophic factors for repair. The physical and cognitive impairment caused by brain injuries can be reduced with cognitive rehabilitation9. In a study on cognitive rehabilitative strategies, it is stressed that different techniques, as well as other forms of treatments, are beneficial approaches to repairing cognitive insufficiencies. Techniques used in cognitive rehabilitation target memory, speech concentration, and attention. With consistent quality sessions, it is possible for someone to improve their cognitive abilities and recover from a situation, such as a brain injury. It is an exciting period to be working in cognitive rehabilitation now that biomarkers, such as GFAP [11] and others may be available to quickly identify TBI [12,13]. It is also exciting given that NY has passed a proclamation stating that TBI is a priority in NY State [14]. I look forward to guiding CNS into the future and continuing my ongoing research on effects and mechanisms of neuroendocrine factors involved in the biological basis and treatment of social, cognitive, affective aspects of neurodegenerative disorders, such as TBI [15].

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