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Neuromusicology and Combat-Induced Traumatic Brain Injury

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Introduction

Traumatic brain injury (TBI) affects millions of Americans each year—those who directly experience injury as well as families, caregivers, friends, and employers. Due to improved medical support, a higher percentage of severe TBI cases are no longer fatal, but can be treated with a plethora of treatment modalities. The most common causes of TBI in America include motor vehicle accidents, falls, violence, and sports-related incidents. While the spectrum of TBI severity ranges from mild to severe, concussions and other forms of mild brain injuries account for approximately 75% of all TBIs (Centers for Disease Control and Prevention, 2012). The symptoms and effects of mild injuries may be subtle, but they hold the potential to affect one's daily functioning.

Classification of TBI

Brain injuries are classified as mild, moderate, or severe. Severe injuries are further categorized into penetrating and closed head injuries. Penetrating head injuries involve the entrance of foreign objects into the brain causing localized damage. The location and route of the foreign object impacts symptomology. For example, damage to the frontal lobe can result in emotional lability, impaired judgement, and attentional deficits whereas damage to the occipital lobe is more likely to result in visual impairments. Penetrating head injuries also involve injury to the scalp, skull fractures, surface contusions, surface lacerations, intracranial hematoma, and raised intracranial pressure. (Silver, McAllister, & Yudofsky, 2005).

Closed head injuries may result from any incident involving the rapid and forceful backward and forward movement of the head. This occurrence is referred to as coup/contrecoup injury and causes focal brain damage at the points of contact. Unlike penetrating injuries, closed head injuries generally involve more shearing forces and less localized damage (American Speech-Language-Hearing Association, 2012). The movement of the brain within the skull causes stretching and/or shearing of nerve pathways, damaging the white matter that comprises the myelin sheath of neurons. Damage to the myelin sheath decreases the efficiency and effectiveness of communication between cells. This type of neuronal damage is commonly referred to as diffuse axonal injury. Diffuse axonal and coup/contrecoup injuries often occur simultaneously. Other common occurrences related to closed head injury include the stretching/shearing of subcortical pathways and the brain stem as well as vascular injury (Silver et al., 2005; Long & Ross, 1992).

Neurophysiological Effects of TBI

Neurophysiological effects of TBI also include changes to neurotransmitter systems. These changes commonly result in cortisol secretion abnormalities, leading to changes in the limbic system which influences the autonomic nervous system, pleasure systems, and memory function (Long & Ross, 1992). Changes in serotonin levels are also common following head injury. Fluctuating serotonin levels most commonly affect mood, balance, appetite, and muscle movement. Neurophysiological changes vary depending on the cause and severity of each individual TBI.

Conventional TBI vs. Combat-Induced TBI

As previously mentioned, millions of Americans are affected by TBI each year. However, research has focused primarily on conventional TBIs experienced by civilian Americans (Benzinger et al., 2009). In recent years, America's involvement in the Global War on Terror has shed light upon the contemporary concern of blast-related injuries and combat-induced TBI. In fact, TBI has become the "signature injury" of this war. Readily observed symptoms of combat-induced TBIs may appear similar to civilian TBIs, however, it has been observed that soldiers with TBI often experience a higher rate of hearing loss and tinnitus (Fausti, Wilmington, Gallun, Myers, and Henry, 2009). Researchers are beginning to investigate the specific structural components of combat-induced TBI. Though further research is required, it is currently recognized that combat-induced TBIs are unique due to the circumstances of injury acquirement and related outcomes (Benzinger et al., 2009).

Types of Combat-Induced TBI

The increasing use of improvised explosive devices (IEDs) in combat zones has resulted in more frequent encounters with blast-related injuries. In fact, a majority of combat-induced TBIs directly result from blast forces. Primary injuries, also referred to as barotrauma, are a direct result of atmospheric pressure changes due to blast waves. The explosion of an IED or other explosive device causes the immediate conversion of solids or liquids into gas, leading to brief extreme pressure in the surrounding environment. Following this intense pulse of pressure the gasses continue to expand, causing the pressure in the surrounding environment to drop and create a vacuum. These pressure changes occur instantaneously. During barotrauma, organs and tissues of varying densities accelerate at different rates within the body. The movement of these internal organs results in the displacement, stretching, and shearing of bodily tissues (Taber, Warden, & Hurley, 2006).

IEDs may also induce secondary and/or tertiary blast injuries. Secondary injuries, also referred to as ballistic trauma, occur when people are hit with shrapnel and other objects put into motion by blast forces. Secondary injuries often lead to extensive internal and external bleeding, resulting in many casualties. Tertiary injuries occur when people themselves are forced into motion by blast forces. People forced into motion are thrown against solid objects and often experience a combination of blunt and penetrating trauma including bone fractures and brain injury.

Prevalence and Symptomology of Blast-Related TBI

The number of reported cases of TBI among American veterans is rapidly increasing. It is estimated that roughly 22% of wounded soldiers returning from Iraq and Afghanistan have suffered from a TBI, although the number may be larger due to a lack of diagnosis in many cases (Okie, 2005). The U.S. Department of Defense identifies TBI by the occurrence of one or more symptoms immediately following the event. These symptoms include loss of consciousness, memory loss, alteration in mental state, neurological deficits, and intracranial lesion. The results of blast-related TBI are often a combination of deficits in cognitive, physical, emotional, and behavioral functions (Rosenfeld & Ford, 2010). Each case poses unique challenges for all involved—soldiers, their families, and health care personnel.

Blast-Related TBI and Cognition/Affect

Research involving specific outcomes following blast-related TBI is limited. In a recent study Scheibel et al. found that soldiers who had experienced one or more blast-related TBIs exhibited higher levels and more diffuse brain activation during stimulus-response compatibility tests as compared to soldiers who had been deployed but had not been exposed to blast. Specifically, the anterior cingulated gyrus, medial frontal cortex, and posterior cerebral areas displayed increased levels of activation. These regions of the brain are involved in the integration of emotions and emotional stimuli, executive functions, and visual-spatial functions. The increased activation of these areas results from inefficient processing and acts as a form of compensation. Though accuracy did not differ between TBI and control groups, the TBI group appeared to exert significantly more effort in completing the task than did the control group

(2011).

The results from Scheibel's study provide slight insight into the underlying mechanisms which influence observable symptomology as depicted by Sayer in her review of military TBI. Cognitive, emotional, and behavioral symptoms displayed by military personnel with TBI include deficits in memory, attention, and concentration as well as irritability, anxiety, depression, fatigue, personality changes, sleep disturbances, headaches, and dizziness (2012). These symptoms, which impact the soldier individually as well as his or her interpersonal relationships, may resolve within weeks of initial injury or persist for years. Few studies involving the long-term effects of blast-related TBI exist, but prolonged EEG abnormalities have been observed (Rosenfeld & Ford, 2010).

Many recent studies have focused on the frequent comorbidity of blast-related TBI and psychiatric disorders—specifically, posttraumatic stress disorder (PTSD). The significant overlap in TBI and PTSD symptoms creates unique challenges in both the diagnostic and treatment processes. Currently, no strong evidence suggesting a direct relationship between TBI and PTSD has been documented. Researchers currently view the two phenomena in terms of a correlational relationship. The focus on comorbidity of TBI and PTSD speaks to the complex nature of TBI and the need for "clinical expertise that traverses the boundaries of the traditional medical disciplines" (Rosenfeld & Ford, 2010, p. 416).

Blast-Related TBI and Motor Functioning

While a few broad categories of physical deficits resulting from blast-related TBI have been mentioned, this section will strive to specify common outcomes pertaining specifically to motor skills. The physical alterations resulting from blast-related TBI can present in an overall decrease in motor function and control; sometimes manifesting in many areas of functioning or only a few. These are some of the possible outcomes: difficulty with ambulation, impaired postural stability, poor coordination, muscle spasticity, muscle weakness, and diminished executive functioning. Observable deficits following TBI relate to the area in which damage was incurred. Several outcomes pertaining to motor deficits can be seen in Table 1 (Lehr, 2011).

Table 1	Area of the Brain	Type of Functional Motor Deficits
	Frontal Lobes	• Loss of simple movements/paralysis • Inability to sequence complex movements
	Parietal Lobes	• Lack of awareness of certain body parts and/or surroundings
	Brain Stem	• Impaired balance and movement skills
	Cerebellum	• Inability to coordinate fine motor skills • Loss of functional walking skills • Inability to reach and grab objects • Inability to make rapid movements

Researchers in the area of TBI have found that motor recovery usually precedes cognitive and behavioral improvement (Keren, Reznik, & Groswasser, 2001). While discussing the rehabilitation of brain-injured patients, it can be noted that recent advances in neuroimaging and non-invasive brain stimulation have allowed researchers to find that the human cerebral cortex (the outermost layer of the brain) is able to produce functional plasticity (Cohen & Dayan, 2011). This means that undamaged parts of the brain are able to assume control over functions that have been lost due to injury of the responsible area of the brain. During the re-learning process of motor skills, other areas of the brain are able to develop the ability to gain new functions through repetitive practice. This adaptation of the cortex occurs in the weeks and months following injury (Nudo, 2003), which reminds us that immediate action is critical in order to achieve optimal gains in the rehabilitation of functional abilities. When direct action is taken to develop cortical plasticity, it has been found that some rehabilitative interventions can be successful in achieving success long after an individual has reached a plateau in their recovery because the brain has been primed to adapt (Nudo, 2003).

Looking more closely at the rehabilitation needs of soldiers with TBI, a study done by Fausti, Wilmington, Gallun, Myers, and Henry showed that a substantial amount of blast-related TBIs result in auditory damage such as peripheral hearing loss, central auditory processing deficits, and tinnitus (2009). A motor related outcome of auditory injury is vestibular dysfunction, which is associated with impaired balance. Because restoring functional and independent gait is often the primary goal of motor skill rehabilitation following combat-induced TBI (Scherer, 2007), this is a critical area in need of treatment options that are cost-effective and successful. Fausti et al. noted that the most probable solution to auditory rehabilitation would be a multidisciplinary team approach to therapy.

Neurologic Music Therapy and TBI

Neuromusicologists study the biological responses of the brain and nervous system to musical stimuli. From this field of study, the discipline of neurologic music therapy originated. Neurologic music therapy (NMT) is defined as “the therapeutic application of music to cognitive, sensory, and motor dysfunctions due to neurologic disease of the human nervous system” (Thaut, 2005, p. 126). Rationale behind NMT involves scientific models of music perception, production, and the influence of music on nonmusical functioning. Trained and certified practitioners apply standardized, evidence-based therapeutic music interventions in working toward individual nonmusical client goals and objectives (American Music Therapy Association, 2011).

One of the most extensively researched areas of NMT pertains to the effects of musical stimuli on neurological processes involving motor responses. Taking into account this research, clinicians have developed sensorimotor interventions which include rhythmic auditory stimulation (RAS), patterned sensory enhancement (PSE), and therapeutic instrumental music performance (TIMP). RAS and PSE utilize rhythmic and melodic cues to structure movement patterns and prime the motor areas of the brain while TIMP involves the playing of instruments to simulate functional movement patterns (Thaut, 2005). Therapeutic music interventions targeting motor function have proved effective in improving both gait and fine motor skills in patients with TBI (Hurt, Rice, Micintosh, Thaut, 1998; Paul & Ramsey, 2001)

Therapeutic music interventions involving speech and language functions have also been developed as a result of research involving the historically close relationship between music, speech, and language. While speech and language are processed primarily in the left hemisphere, music processing involves both the right and left hemispheres. Music interventions use strengths from undamaged parts of the brain to aid in rehabilitating areas of deficit. For example, melodic intonation therapy (MIT) facilitates the use of speech mechanisms through a series of ordered steps that move from musical intonations of spoken phrases to spoken dialogue. MIT is most often employed when working with clients who have experienced damage to Broca's area due to stroke or other forms of traumatic brain injury (Marchina, 2008). Rhythmic speech cuing, vocal intonation therapy, oral motor and respiratory exercises, and musical speech stimulation also target goals related to the physiological structures of speech production. Symbolic communication training through music may be used to develop alternative forms of communication when severe expressive language deficits are present (Thaut, 2005).

Cognitive rehabilitation may address attention, memory, executive, and psychosocial functions. Taking into consideration the basic principles of cognitive rehabilitation, neurologic music therapists have created music interventions to improve mental abilities. These interventions include, but are not limited to, music attention control training, music mnemonics training, music executive function training, and music psychotherapy and counseling. Music provides a structural framework for intervention, a motivating and meaningful context, and is an aesthetically pleasing therapeutic medium (Thaut, 2005). Past studies have supported the use of music in cognitive rehabilitation following TBI, noting improvements in mood, affect, and other cognitive domains (Nayak, Wheeler, Shiflett, Agostinelli, 2000; Thaut, 2009).

History of Music Therapy in Military Facilities

Military facilities began incorporating music into treatment of soldiers between World War I and World War II. In its early stages, music in the hospital setting primarily focused on influencing patients' mood states. Music was incorporated in the treatment of patients through the following means: as an adjunct to functional occupational therapy and psychiatric treatment, as a direct aid to anesthesia, and as a psychological stimulus in the hospital environment. During WWII music therapy evolved and expanded its focus to include improving social functioning and building self-esteem in combat troops. Clinicians found that improving social functioning, establishing relationships, and increasing self-esteem allowed patients to more actively and effectively participate in other counseling sessions (Tyson, 1981).

Clinicians applied music in the treatment of WWII combat troops using three primary methods. The first, active participation, aimed to boost morale and supplement occupational therapy through group music-making and social experiences. The second, passive participation, utilized music listening and discussion to assist soldiers in transitioning to daily life following deployment. The third method, audio-reception, was more recreational in nature. Clinicians provided patient-preferred music to supplement educational activities and provide entertainment (Rorke, 1996).

Military leaders had observed positive effects of music on wounded soldiers, but scientific clinical studies supporting the formal use of music as therapy did not exist. The first official research study examining the use of music as a treatment modality to aid in working towards predetermined goals within the military began in 1944 and continued for three and a half years. Researchers formed experimental and matched-pairs control groups, taking into account presenting symptoms, musical background, demographic information, and duration and severity of illness. Each pair of participants was consistently evaluated by the same psychiatrist for the duration of their treatment. The music treatment provided utilized the iso principle, as clinicians aimed to first meet the soldiers in their current mood states and then gradually presented more stimulating or relaxing music based on the soldiers' needs. Soldiers participated by observing a live music performance and were provided with an opportunity to discuss their experience with both the musicians and their peers. Musical data including tempo, key, instrumentation, and musicians' comments were recorded during each session. Psychiatrists also recorded data regarding the soldiers' observable behaviors during and in between sessions. The published report drew data from 50 soldiers receiving music services. Psychiatrists noted significant improvements and reported that 74% of the 50 soldiers displayed noteworthy improvements, but did not include specific data. Results were also presented through the illustration of individual case studies. This study initiated a significant turning point in the field of music therapy, starting the movement towards higher levels of evidence-based practice (Rorke, 1996).

Current Research Involving Music Therapy in Military Facilities

Despite the efforts of early clinicians and researchers, current professional literature regarding the practice of music therapy in military environments is very limited. One of the most recent studies, conducted in 2008, explored the use of drumming in group therapy sessions for soldiers experiencing PTSD, which frequently coexists with TBI. This study, aside from its small sample size, effectively illustrates the high potential for music therapy to positively affect returning soldiers who have experienced both physical and emotional trauma. The six participants, male soldiers ages 20-23, had each witnessed highly disturbing events. Each soldier's experience was unique, but common themes included witnessing the death of friends and identifying their bodies, witnessing and aiding innocent civilians at the scene of a suicide attack, and directly killing enemy combatants. Led by a board-certified music therapist who was under the clinical supervision of another board-certified music therapist, a psychologist, and a social psychologist, the soldiers participated in sixteen 90-minute weekly group therapy sessions. Sessions consisted of instrumental group improvisation and verbal processing followed by 10-15 minutes of music assisted relaxation. Quantitative and qualitative data were collected in the areas of group cohesion, traumatic associations, rage and relief, and rhythmic categorization. Results displayed significant progress in each of these four areas. Soldiers found these sessions to be beneficial in facilitating a sense of togetherness and providing a safe environment in which traumatic memories could be accessed and discussed. Soldiers also stated that the sessions allowed them to express feelings of rage while simultaneously regaining a sense of control (Bensimon, Amir, & Wolf, 2008).

Current Music Therapy Practices in Military Facilities

Despite strong evidence supporting the use music therapy in addressing deficits experienced by TBI patients and the increasing need for effective treatment for returning veterans, few established programs utilizing music therapy exist. One program, Operation Oak Tree, serves many military families in the Chicago area. The program provides creative arts therapies for soldiers and their families in an effort to provide an emotional outlet and support during each stage of deployment. Therapies offered include drama, art, dance/movement, and music therapy, each offered by trained clinicians (Music Institute of Chicago, 2010).

Other documented uses of music as a therapeutic tool in the military are less formal in nature are most often not provided by board-certified music therapists. For example, the Warrior Transition Wellness Program in Schofield Barracks, Hawaii has incorporated music services (Robbins, 2009). However, unlike Operation Oak Tree, the services are not implemented by a board-certified music therapist and do not encompass the full potential of music therapy services. Music sessions in the Warrior Transition Wellness Program focus solely on music listening for relaxation purposes.

On a more personal level, the soldiers themselves have recognized and expressed their appreciation for music and the effects it elicits. Master Sgt. Isaac Alexis frequently performs original songs for his fellow comrades, using the music to connect with his audience and convey a positive message. Alexis also stated that he sets musical goals for deployment times. The most current goal is to revise around 30 songs and complete at least one more CD over the course of his next deployment (Sauret, 2008).

While Alexis' audiences enjoy listening to his music, Sgt. 1st Class Ted Bentley provides soldiers at the Fort Sill Warrior Transition Unit in Oklahoma with an opportunity to actively participate in music making. He shares his love for playing the guitar with wounded soldiers through not only performing, but also teaching lessons. Soldiers have reported experiencing therapeutic effects after successfully learning even just a few chords on the guitar (Sherman, 2012). The acknowledgement and appreciation for creative outlets among veterans is widening. However, it is important to distinguish between the benefits of personal uses of music and the formal application of music therapy by a certified clinician.

Conclusions

The rising number of combat-induced TBI and the holistic nature of TBI symptoms make the task of finding an effective yet cost-efficient treatment modality a difficult one. Research involving NMT and TBI suggests that it may prove beneficial to provide NMT services to address the cognitive and physical, as well as emotional needs of veterans (Thaut, et. al, 2009). More research concerning the use of music therapy in treatment of military and combat-induced TBI is necessary. However, the actual practice of music therapy with veterans and their families must also continue its growth. Through a combined effort of researchers and clinicians, it may be possible to create and implement successful programs to better serve our veterans.

Reference List

American Music Therapy Association (2011). What is music therapy? Retrieved from www.musictherapy.org

American Speech-Language-Hearing Association (2012). Traumatic brain injury (TBI). Retrieved from http://www.asha.org/public/speech/disorders/TBI/

Bensimon, M., Amir, D., Wolf, Y. (2008). Drumming through trauma: Music therapy with post-traumatic soldiers. *The Arts in Psychotherapy, 35*, 34-48.

Benzinger, T. L. S., et al. (2009). Blast-related brain injury: Imaging for clinical and research applications: Report of the 2008 St. Louis workshop. *Journal of Neurotrauma, 26,* 2127-2144.

Centers for Disease Control and Prevention (2012). Injury prevention and control: Traumatic brain injury. Retrieved from http://www.cdc.gov/traumaticbraininjury/statistics.html

Cohen, L.G., & Dayan, E. (2011). Neuroplasticity subserving motor skill learning. *Neuron, 72,* 433-454.

Fausti, S. A., Wilmington, D. J., Gallun, F. J., Myers, P. J., & Henry, J. A. (2009). Auditory and vestibular dysfunction associated with blast-related traumatic brain injury. *Journal of Rehabilitation Research & Development, 46*(6), 797-810.

Hurt, C.P., Rice R.R., McIntosh, G.C., & Thaut, M.H. (1998). Rhythmic auditory stimulation in gait training for patients with traumatic brain injury. *Journal of Music Therapy*, 35(4), 228-241.

Keren, O., Reznik, J., Groswasser, Z. (2001). Combined motor disturbances following severe traumatic brain injury: An integrative long-term treatment approach. *Brain Injury*, *15*(7), *633-638.*

Lehr, R. P. (2011). *Brain Function*. Retrieved March 14, 2012 from Centre for Neuro Skills: http://www.traumaticbraininjury.com/content/understandingtbi/causesoftbi.html

Long, C. J. & Ross, L. K. (Eds.). (1992). *Handbook of head trauma: Acute care to recovery*. New York: Springer.

Marchina, S. N. (2008). From singing to speaking: Why singing may lead to recovery of expressive language function in patients with Broca's aphasia. *Music Perception: An Interdisciplinary Journal , 25* (4), 315-323.

Music Institute of Chicago (2010). Military family services. Retrieved from http://www.musicinst.org/military-family-services

Nayak, S., Wheeler, B.L., Shiflett, S.C., & Agostinelli, S. (2000). Effect of music therapy on mood and social interaction among individuals with acute traumatic brain injury and stroke [Abstract]. *Rehabilitation Psychology, 45*(3), 274-283.

Nudo, R. J. (2003). Adaptive plasticity in motor cortex: Implications for rehabilitation after brain injury. *Journal of Rehabilitation Medicine, 41*, 7-10.

Okie, S. (2005). Traumatic brain injury in the war zone. *The New England Journal of Medicine, 352*(20), 2043-2047.

Paul, S. & Ramsey, D. (2001). Music therapy in physical medicine and rehabilitation. *Australian Occupational Therapy Journal*, 47(3), 111-118.

Robbins, D. (2009). FMWR and Tripler work together to provide wounded warrior programs. Retrieved from http://www.army.mil/article/24324

Rorke, M.A., (1996). Music and the wounded of world war II. *Journal of Music Therapy*, *33*(3), 189-207.

Rosenfeld, J.V., & Ford, N.L. (2010). Bomb blast, mild traumatic brain injury and psychiatric morbidity: A review. *Injury*, *41*(5), 437-443.

Sauret, M. (2008). Soldier's commitment to music impacts lives. Retrieved from http://www.army.mil/article/10649

Sayer, N.A. (2012). Traumatic brain injury and its neuropsychiatric sequelae in war veterans. *Annual Review of Medicine*, *63*(1), 405-419.

Scheibel, R.S. et al. (2011). Altered brain activation in military personnel with one or more traumatic brain injuries following blast. *Journal of the International Neuropsychological Society*, *18*(1), 89-100.

Scherer, M. (2007). Gait rehabilitation with body weight-supported treadmill training for a blast injury survivor with traumatic brain injury. *Brain Injury*, *21*(1), 93-100.

Sherman, B. (2012). Music helps soldiers begin healing process. Retrieved from http://www.army.mil/article/76880

Silver, J. M., McAllister, T. W., & Yudofsky, S. C. (Eds.). (2005). *Textbook of traumatic brain injury*. Arlington, VA: American Psychiatric Publishing, Inc.

Taber, K.H., Warden, D.L., & Hurley, R.A. (2006). Blast-related traumatic brain injury: What is known? *Journal of Neuropsychiatry and Clinical Neurosciences*, *18*(2), 141-145.

Thaut, M. (2005). *Rhythm, music, and the brain.* New York: Routledge.

Thaut. M.H. et al. (2009). Neurologic music therapy improves executive function and emotional adjustment in traumatic brain injury rehabilitation. *Annals of the New York Academy of Sciences*, *1169*(1), 406-416.

Tyson, F. (1981). Music therapy in hospitals. *Psychiatric Music Therapy.* New York: Creative Arts Rehabilitation Center, 7-12.