Evaluation of a Novel Integrative and Intensive Virtual Rehabilitation Program for Service Members Post-TBI

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Introduction

From 2000 through September 2016, approximately 357,000 service members were diagnosed with traumatic brain injury (TBI) [1], and due to the increase of exposure to improvised explosive devices (IEDs) [2], experts call TBI the "signature" injury of recent OIF/OEF military conflicts. Due to the complex connectivity and functional versatility of the human brain, the clinical presentation of TBI is heterogeneous in nature. Symptoms and functional deficits associated with TBI include a combination of cognitive, emotional, behavioral, and even motor deficits, which can require a multi-disciplinary treatment plan and rehabilitation team.

Prior studies have confirmed the molecular plasticity of the brain, and previous research efforts have identified similarities between the molecular and cellular processes occurring in the injured brain and those occurring in the healthy, young, developing brain [3]. Rehabilitation literature suggests the potential of utilizing post-injury neuroplasticity to achieve improved functional outcomes [3].

Further, the literature also suggests that behavioral experience is the most influential modulator of neuroplasticity [3]. The factors that have been identified as variables that affect an intervention's ability to drive neuroplasticity include training intensity, repetition, and duration, along with participant motivation/engagement [4].

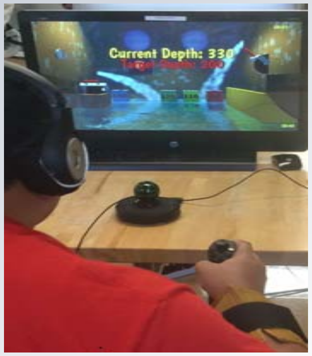

Figure 1: BrightBrainer Virtual Reality (BBVR^{TM}) system. The BBVR system features a Razer Hydra magnetic motion-sensing hub that simultaneously tracks the exact location and orientation of two controllers in three dimensional space. The BBVR^{TM} Active Treatment program contains 11 games that offer cognitive and motor therapy as well as positive reinforcement using both visual and auditory cues. Participants in the active treatment program complete 3 sessions per week for 6 weeks.

Virtual Reality, when appropriately created, provides a platform to combine cognitive and motor rehabilitation into a single, integrative treatment. The specific virtual reality intervention employed in this study is called the BrightBrainer Virtual Rehabilitation (BBVR^{TM}) system developed by Bright Cloud International®. By incorporating bimanual tasks that increase cognitive load, the system aims to facilitate neuroplasticity and improve executive function, attentive capacity, emotional regulation, learning and memory, as well as motor coordination. The games are scalable in difficulty, offer high repetitions and mild exercise, and provide positive reinforcement.

Aims and Methods

Primary Aim: Evaluate feasibility of BBVR^{TM} system in a Military Treatment Facility (MTF) rehabilitation clinic.
Secondary Aim: Determine BBVR^{TM} system efficacy in improving functional performance and alleviating neurobehavioral and affective symptoms associated with TBI.

Outcome Measures:
- Participant/Clinician Feedback Questionnaire,
- Technology Acceptance Questionnaire
- Neurobehavioral Symptom Inventory (NSI)
- Quick Inventory of Depressive Symptomology (QIDS-SR)
- PTSD Checklist (PCL-C)
- Automated Neuropsychological Assessment Metric (ANAM)
- Box and Blocks Test (BBT)
- Fugl-Meyer Assessment
- Gross Shoulder Strength Test
- Jebsen Taylor Hand Function Test (JHFT)

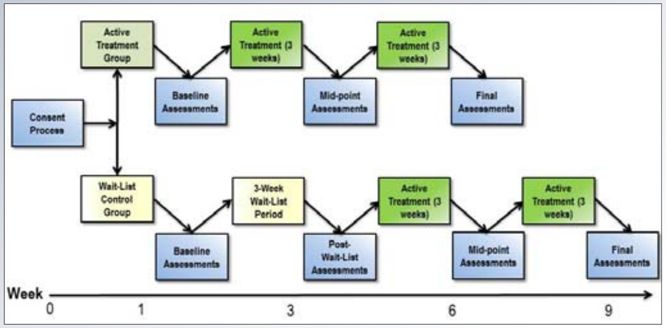

Figure 2: Flowchart Description of Study Methodology. Participants randomized to the Wait-List Control (WLC) complete an additional round of assessments following the 3-week waiting period. The midpoint and final assessment batteries include feedback questionnaires for the participant and clinician.

Methods: Randomized controlled trial (expected n=20) with a wait-list control (WLC) group (fig. 2). All participants (eligible age 18-67) require a diagnosed TBI. The Active Treatment program consists of 3 sessions per week for 6 weeks, and the BBVR^{TM} system tracks progress and automatically generates electronic session reports.

Preliminary Results

Currently, eight participants have completed the study. The sample contains six males (mean age = 36 years, range = 21-45) and two females (mean age = 58.5 years, range = 54-63). Relative to baseline, the sample of participants that provided valid neurocognitive test data (n=7) demonstrated a significant increase in post-intervention ANAM rank composite scores according to the Wilcoxen Signed-Rank Test (n=7, z=-0.237, p<0.018) (fig. 3). Functional performance relative to baseline on the Jebsen Taylor Hand Function Test (JHFT) for the non-dominant hand also approached significance in the Wilcoxen Signed-Rank Test (n=7, z=-1.52, p<0.128) (fig. 5), but no other measures approached significance. On a 7-point Likert Scale, the mean participant rating of the technology was 63.5 out of 77 (fig. 4), and the mean clinician rating was 63.3.

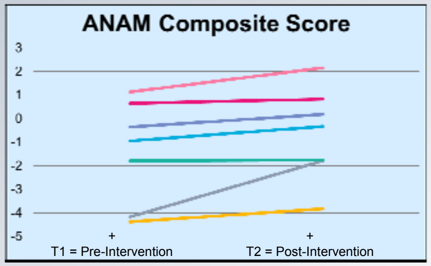

Figure 3: ANAM Composite Score Data. The sample demonstrated significant improvement in the post-intervention scores (T2) compared to the pre-intervention (T1) scores (n=7, Δμ = 0.76, p = 0.008). Pre-waitlist scores were not included in the preliminary analysis.

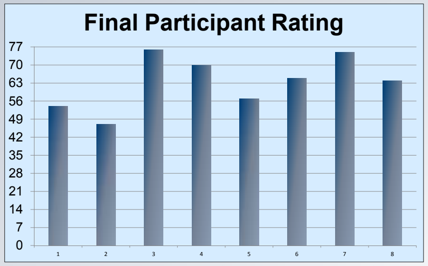

Figure 4: Final Participant Rating of the BBVR Technology. On a 7-point Likert Scale, participants rated the technology 63.5 out of 77 following the 6-week Active Treatment program.

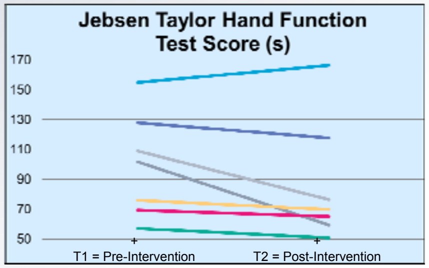

Figure 5: JHFT Performance for Non-Dominant Hand. The graph above displays performance on the JHFT in seconds. Fewer seconds represents increased performance. Functional performance for the non-dominant hand approached significance (n=7, Δμ = 7.78, p = 0.059).

Discussion/Future Directions

This study has demonstrated the logistical feasibility of employing virtual reality technology in an open clinic setting, and the ability to provide self-guided therapy to two patients simultaneously with a single supervising clinician. However, it should be noted that providing simultaneous treatment for two patients with severe memory deficits remains a challenge for one clinician and modified staffing plans may be required depending on patient census.

The preliminary results above suggest the potential for virtual reality applications to provide effective cognitive therapy. Although complete elimination of a "practice effect" on assessment performance is impossible, the ANAM software provides randomized stimuli across tests sessions, which creates an almost limitless number of alternative forms that help mitigate practice effects. Future analyses will examine rates of improvement during the wait-list period, for this data will enable the team to more definitively compare the effectiveness of BBVR system with that of standard cognitive therapy.

References & Acknowledgements

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