Integrative and Intensive Virtual Rehabilitation Program for a Service Member Post Severe TBI

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Abstract

Objectives: Investigate cognitive and motor benefits of integrative virtual reality (VR) games for a service member post traumatic brain injury (TBI)

Design: 6-week intervention, three sessions/week, increasing duration and game difficulty (part of randomized controlled trial).

Setting: Outpatient clinic, large military medical center.

Participant: 44-year old male, 54 months post severe TBI and a subsequent stroke, with severe difficulty in left upper extremity (UE), memory, and visual tracking.

Intervention: UE/cognitive bi-manual training with custom adaptable VR games on the BrightBrainer Rehabilitation System™. Games induced high number of repetitions, and trained memory, focusing, and executive function. The system was adapted to participant (screen magnification with left side positioning, and for weak left grasp.)

Measures: Fugl-Meyer Assessment (FMA), Automated Neuropsychological Assessment Metrics (ANAM) Battery, Deltoid strength (lift arm with weighted cuffs), Jebsen Hand function Test (JHFT).

Results: Subject showed improved FMA-UE scores of 3 points on left (15 to 18) and 8 points on right (50 to 58) strength in lateral deltoid (Left—2 to 4lbs) and anterior deltoid (Left—2.5 to 4lbs), and JHFT total scores (Right—283 to 252 sec). The subject improved in ANAM simple reaction time (732 to 505msec), learning (1941 to 763msec) and delayed memory (1065 to 796msec). Supervising therapist reported that participant was "fully engaged" and cognitive cuing for games reduced from 75% to 10% over the intervention. The subject reported that the system was easy to use.

Conclusion: Case study shows benefits of bimanual intensive integrative VR games and system adaptability in a medical military setting for custom needs for a service member with complex severe deficits.

Introduction

From 2000 to 2016, approximately 357,000 service members were diagnosed with traumatic brain injury (TBI) [1]. Symptoms and functional deficits associated with TBI are heterogeneous in nature and include a combination of cognitive, emotional, behavioral, and motor deficits.

- Rehabilitation literature suggests the potential of utilizing post-injury neuroplasticity (similar to that of a healthy, young, developing brain) to achieve improved functional outcomes [2]. Training intensity, repetition, duration, and participant motivation/engagement have been identified as variables that affect the ability of the intervention to drive neuroplasticity [3].

BrightBrainer Virtual Rehabilitation (BBVR™)

- Developed by BrightCloud International
- BBVR Features:
  - Bimanual tasks to increase cognitive load
  - High number of repetitions
  - Mild upper extremity exercise that adapts to patient
  - Scalable difficulty
- BBVR Aims:
  - Facilitate neuroplasticity
  - Improve cognitive function, attentive capacity, emotional regulation, learning/memory, and motor coordination

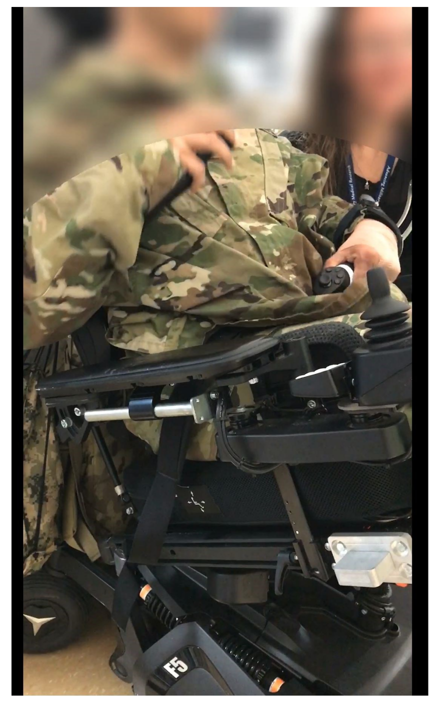


Figure 1. Participant training on the BBVR system. Bimanual pendants used as pictured.

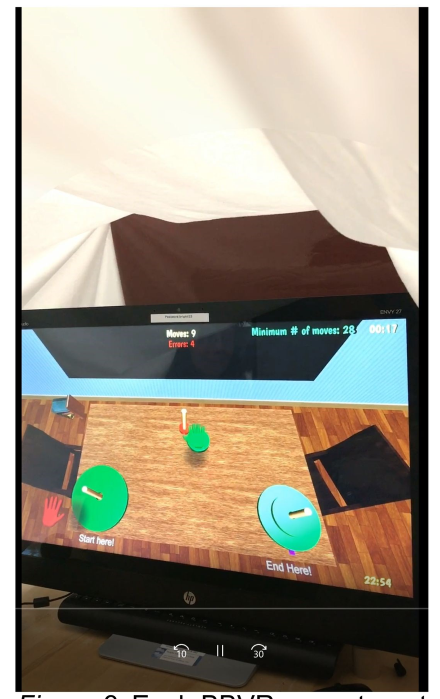


Figure 2. Each BBVR game targets various cognitive functions, and promotes repetitive arm movements and grasping.

Figure 3. Magnification used to accommodate participant's vision tracking constraints.

Design

Case report of a single participant. Part of a larger, randomized controlled trial (expected n=20) with a wait-list control (WLC) group. All participants (eligible age 18-67) require a diagnosis of Acquired Brain Injury (ABI). The Active Treatment program consists of 3 sessions per week for 6 weeks. The BBVR system tracks progress and automatically generates electronic session reports.

All parts of this study were conducted in the outpatient clinic of a large, military medical center.

Primary Outcome Measures:

- Fugl-Meyer Assessment (FMA)
- Automated Neuropsychological Assessment Metrics (ANAM) Battery
- Deltoid strength (lift arm with weighted cuffs)
- Jebsen Taylor Hand Function Test (JHFT)

Intervention:

The BBVR system utilizes bi-manual pendants and custom, adaptable VR games to facilitate UE/cognitive training. (*Figure 1.)* The pendants are tracked via the Razer Hydra magnetic motion-sensing hub, which simultaneously tracks the position/orientation of both controllers in 3D space, as well as index finger flexion/extension.

The adaptable nature of the game allows the supervising therapist to adjust game difficulty, controller sensitivity, trigger use, etc. as necessary, based on participant ability and range of motion.

The system was adapted for this participant through screen magnification with left side positioning, and trigger controls were modified for a weak left grasp. (*Figures 2 & 3)*

Participant

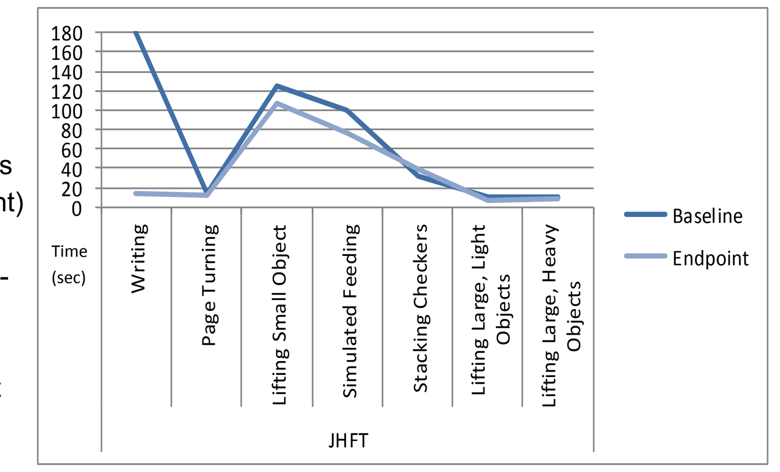
- 44- years old
- Male
- 54 months post severe TBI and a subsequent stroke
- Severe motor difficulty in left UE
- Severe deficits in memory and visual tracking
- Right hand dominant

Results

Motor Task Improvement

- FMA-UE scores
  - 3 points on left (15 to 18)
  - 8 points on right (50 to 58)
- Strength in left lateral deltoid (2 to 4lbs)
- Strength in left anterior deltoid (2.5 to 4lbs)
- Fig. 4 Right JHFT total scores (283 to 252 sec)

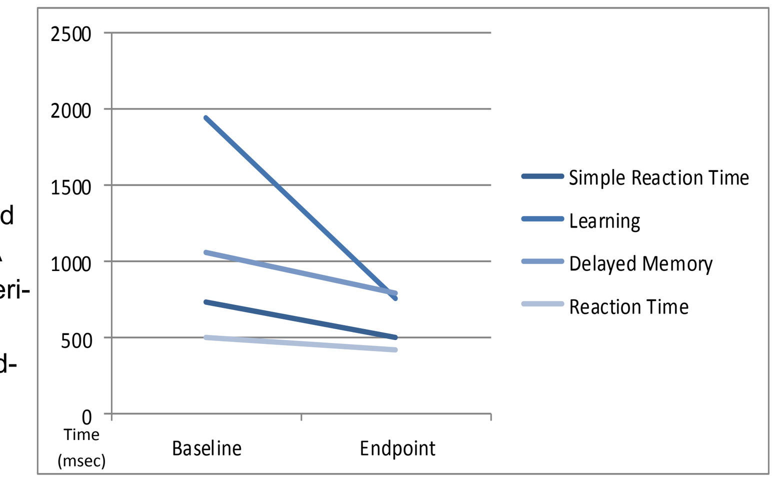
Figure 4. Participant showed slight improvement in four of the seven JHFT tasks on the right (dominant) hand. The 'Writing' task was not attempted at Baseline, but was completed at Endpoint on the right hand.



Cognitive Tasks Improvement (ANAM) (Fig. 5)

- Simple reaction time (732 to 505msec)
- Learning (1941 to 763msec)
- Delayed memory (1065 to 796msec)

Figure 5. Participant showed decrease in reaction time in the ANAM domains of 'Simple Reaction Time', 'Learning', and 'Delayed Memory.' A floor-effect was experienced for % correct from Baseline to Endpoint.



Feasibility and Engagement

- Supervising therapist reported that participant was "fully engaged" and cognitive cuing for games reduced from 75% to 10% over the intervention.
- Subject reported that the system was easy to use

Discussion

- This case study provides preliminary support for the potential benefits of bimanual, intensive, integrative VR games for improving cognitive and UE motor functioning in patients with acquired brain injuries.
- The program was able to be fully adapted to meet the specific physical needs of this participant.
- Based on patient and occupational therapist reports, this system is feasible to implement in a military medical hospital setting, and engaging for participants.

Future Research:

This case report highlights one participant from a larger (anticipated n=20) randomized controlled study. While it is useful in demonstrating the versatility and customizability of BBVR, analysis of data from the randomized controlled study are needed in order to statistically demonstrate the efficacy of the system as a rehabilitation device. The randomized controlled study will also be important in determining the feasibility of implementing side-by-side BBVR devices for running simultaneous treatment with two participants. Being able to train multiple co-located participants simultaneously will improve access to care and allow for greater clinician efficiency.

References/Disclosures

References:

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