

BrightBrainer Studies Annotated Bibliography

(as of April 22, 2020)

Burdea G, Namrata Grampurohit, Nam Kim, Kevin Polistico, Ashwin Kadaru, Simcha Pollack, Mooyeon Oh-Park, AM Barrett, Emma Kaplan, Jamie Masmela, Phalgun Nori. Feasibility of integrative games and novel therapeutic game controller for telerehabilitation of individuals chronic post-stroke living in the community. *Topics in Stroke Rehabilitation*. Early online Dec 25, 2019. (n=8 + 8 caregivers)

Individuals chronic post-stroke and their caregivers were recruited (n = 8 + 8) for this feasibility study. Each of seven participant + caregiver pairs completed 20 sessions of homebased therapy over 4 weeks. Standardized clinical outcome measures were taken pre- and post-therapy. Game performance outcomes were sampled at every session, while participant and caregiver subjective evaluations were done weekly. A 96% rate of compliance to protocol resulted in an average of 13,000 total arm repetitions/week/participant. Group analysis showed significant ($p < .05$) improvements in grasp strength (effect size [ES] = 0.15), depression (Beck Depression Inventory II, ES = 0.75), and cognition (Neuropsychological Assessment Battery for Executive Function, ES = 0.46). Among the 49 outcome variables, 36 variables (73.5%) improved significantly ($p = .001$, binomial sign test). Technology acceptance was very good with system rating by participants at 3.7/5 and by caregivers at 3.5/5. These findings indicate the feasibility and efficacy of the system in providing homebased telerehabilitation.

Buccellato K, M Nordstrom, JM Murphy, GC. Burdea, K Polistico, G House, N Kim, N Grampurohit, J Sorensen, BM. Isaacson, PF Pasquina. A Randomized Feasibility Trial of a Novel, Integrative, and Intensive Virtual Rehabilitation Program for Service Members Post-Acquired Brain Injuries. *Military Medicine*. 2020 Feb 12;185(1-2):e203-e211 (n=21)

Military healthcare beneficiaries with Acquired Brain Injury (ABI) diagnoses completed a 6-week randomized feasibility study of the BrightBrainer Virtual Rehabilitation system in an outpatient military Occupational Therapy clinic. Twenty one participants completed the study. The therapy utilized virtual reality and repetitive bilateral upper extremity training. This research was approved by the Walter Reed National Military Medical Center and Uniformed Services University of the Health Sciences Institutional Review Boards. All of the participants and providers reported moderate to high levels of utility, ease of use and satisfaction with the BrightBrainer system ($\bar{x} = 73-86\%$). Adjunct therapy with BrightBrainer trended towards statistical significance for the measure of cognitive function (ANAM [$\bar{x} = -1.07$, 95% CI -2.27 to 0.13, $p = 0.074$]). This research provides evidence for the feasibility of implementing the BrightBrainer system into an outpatient military setting for treatment of ABI symptoms.

Burdea G, Kim N, Polistico K, Kadaru A, Grampurohit N, Roll D, Damiani F. Assistive Game Controller for Artificial Intelligence-enhanced Telerehabilitation Post-Stroke. *Assistive Technology*. 2019. 1-12 pp. doi: 10.1080/10400435.2019.1593260 (n=2)

Off-the-shelf gaming technology is designed for young, fit, and motor-intact individuals. Artificial intelligence makes controllers and therapeutic games adaptable to the disabled. BrightBrainer™ Grasp novel hand controller adapts to arm and hand impairments post-stroke, and tracks relevant

outcomes. The newly designed controller uses BrightBrainer gamification system with AI technology to provide automatic adaptation, requiring minimal clinician input. Results of a usability study with healthy individuals and related design modifications are presented, with implications for future trials.

Burdea G, Polistico K, Kim N, Kadaru A, Roll D, Grampurohit N, Barrett AM, Nori P, Pollack S. Novel therapeutic game controller for telerehabilitation of spastic hands: Two case studies. *Proc. Int. Conf. Virtual Rehabilitation*, Tel-Aviv Israel, July 2019. (n=8) **Best Paper Award**.

Four-week feasibility study of BrightBrainer home telerehabilitation. One participant, 17 years post-stroke became 33% faster in his daily activities after playing our therapeutic adaptable games. A severely-impaired participant has a 25% increase in the grasp strength of her involved arm. Degree of independence improved dramatically in both participants. Cognitive function and mood improved as well.

Burdea G, K Polistico, N Grampurohit, G House, N Kim, M Nordstrom, K Buccellato, J M. Murphy, COL Paul F. Pasquina. Concurrent Virtual Rehabilitation of Service Members Post-Acquired Brain Injury – A Randomized Clinical Study. *Proc. 2018 Int Conf Disabilities, Virtual Reality and Associated Technologies*. 2018. 22-31.

Feasibility of concurrent training with the BrightBrainer Rehabilitation System. Participants trained 6 weeks on a subset of BrightBrainer adaptable, therapeutic games. An occupational therapist (OT) supervised the one-on-one and concurrent (one-on-two) treatment interventions. Findings demonstrated that with continued practice, participants were able to increase the intensity of play (repetitions/min), and improve their performance on a subset of memory and attention games.

Buccellato K, Michelle Nordstrom, Abigail R. Hawkins, Grigore C. Burdea, Kevin Polistico, Nam Kim, Brad M. Isaacson, COL (ret) Paul F. Pasquina. Evaluation of a Novel Virtual Rehabilitation Program for Service Members Post ABI: A Feasibility Study. Fourth Federal Interagency Conference on Traumatic Brain Injury. Washington DC. June 2018.

This analysis was done to assess the clinical acceptance of the BrightBrainer Virtual Rehabilitation (BBVR) program, developed by Bright Cloud International, using participant and Occupational Therapist (OT) self-reports. Participants (n=16) completed experimental treatment in a large military hospital's outpatient clinic. Treatment lasted for 6 weeks, with participants and OTs completing measures of clinical acceptance at 3 and 6 weeks. Overall levels of usability and enjoyment were high (72-85%), and these perceptions were maintained from 3 to 6 weeks of treatment.

Michelle Nordstrom, Justin Murphy, Grigore Burdea, Kevin Polistico, Nam Kim, Namrata Grampurohit and Paul Pasquina. Integrative and Intensive Virtual Rehabilitation Program for a Service Member Post Severe TBI, *American Congress of Rehabilitation Medicine*, Atlanta October 2017. (Abstract)

A 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 underwent training on the Bright Brainer Rehabilitation System. Games induced high number of repetitions, trained memory, focusing, and executive function. The system was adapted to participant (screen magnification with left side positioning, and for weak left grasp). 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 4 lbs) and anterior deltoid (Left- 2.5 to 4 lbs), and JHFT total scores (Right - 283 to 258 sec). The subject improved in the

Automated Neuropsychological Assessment Metrics simple reaction time (from 732 msec pre- to 505 msec post-), learning (1941 to 763 msec), and delayed memory (1065 to 796 msec). Supervising therapist reported that he 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.

Murphy JM, Nordstrom MJ, Burdea GC, Polistico K, Kim N, Sharp WH, Isaacson BM, Pasquina PF. Evaluation of a Novel Integrative and Intensive Virtual Rehabilitation Program for Service Members Post-TBI. *Military Health System Research Symposium*, Kissimmee, FL. August 27-30, 2017. (Abstract)

Eight participants that completed the study were six males (mean 36 years, range 21-45) and two females (mean 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 Automated Neuropsychological Assessment Metrics rank composite scores according to the Wilcoxon Signed-Rank Test ($p < 0.018$). Functional performance relative to baseline on the Jebsen Taylor Hand Function Test (JHFT) for the non-dominant hand also approached significance ($p < 0.128$). The mean technology rating was 63.5/77, for participants and 63.3/77 for clinician.

Burdea G, K Polistico, G House, R Liu, Roberto Muñiz, N Macaro, and L Slater. Novel Integrative Virtual Rehabilitation Reduces Symptomatology in Primary Progressive Aphasia – A Case Study. *Int J Neuroscience*. 2015, 125(12):949-958.

A 51-year-old Caucasian male diagnosed with PPA had attended a Medical Adult Day Program for 18 months prior to BrightBrainer training. The computer simulations adapted difficulty level based on task performance. The clinical trial consisted of 16 sessions, twice/week for 8 weeks. The 6.5 h of therapy consisted of games targeting Language comprehension; Executive functions; Focusing; Short-term memory; and Immediate/working memory. The subject attained the highest difficulty level in all-but-one game, while averaging 1300-arm task-oriented active movement repetitions and 320 index finger flexion movements *per session*. The caregiver reported strong improvements in verbal responses, vocabulary use, speaking in complete sentences, following one-step directions and participating in daily activities.

Burdea G, K Polistico, A Krishnamoorthy, G House, et al. A feasibility study of the BrightBrainer™ cognitive therapy system for elderly nursing home residents with dementia. *Disability and Rehabilitation – Assistive Technology*. 2015;10(5):421-32. (n=10)

Group analysis for 10 participants who were elderly Skilled Nursing Facility residents showed statistically significant improvement in decision making ($p < 0.01$), with trend improvements in depression ($p < 0.056$). Improvements were also seen in processing speed ($p < 0.13$) and auditory attention ($p < 0.17$); Eight of nine neuropsychological tests showed changes in the improvement direction indicating an effective rehabilitation ($p < 0.01$). BrightBrainer technology was well tolerated with mean satisfaction ratings of 4.9/5.0 across participants.

House G, G Burdea, N Grampurohit, K Polistico, et al. BrightBrainer feasibility study in a medical adult day program. *Proc. 11th Int Conf Virtual Rehabilitation*, Spain. 2015, pp. 57-64. (n=12)

The system underwent feasibility trials spanning 8 weeks. Nine participants were evaluated pre-intervention, post-intervention, and at 8 week follow up using standardized neuropsychological

measures. Group analysis showed improvement in the cognitive domain of 1.4 points on Mini Mental Status Exam (MMSE) between pre-training and follow-up. One participant who started with MCI ended with normal cognition (max scores on MMSE and Brief Interview of Mental Status - BIMS). Caregiver feedback noted participants' increased ability to follow one-step directions, to perform ADLs and increased desire to attend the Adult Day Program. Most participants enjoyed the computerized training.

House G, G. Burdea, K. Polistico, et al. A serious-gaming alternative to pen-and-paper cognitive scoring - a pilot study. *Int Conf Disability Virtual Reality and Associated Technology*, Sweden, 2014, 231-239. (n=11)

The majority of cognitive virtual reality applications have been for therapy, not cognitive stratification/scoring. The paper describes the BrightScreener system and its first pilot feasibility study for evaluating elderly with various degrees of cognitive impairment. BrightScreener is a portable (laptop-based) serious-gaming system which incorporates a bimanual game interface for more ecological interaction with virtual worlds. A pilot study was undertaken to determine if BrightScreener is able to differentiate levels of cognitive impairment based on game performance, as well as to evaluate the technology acceptance by the target population. 11 elderly subjects were recruited by the Clinical Coordinator at the Memory Enhancement Center of America (Eatontown, NJ) site. They had an average age of 73.6 years, and averaged 14.5 years of education. Subjects first underwent clinical scoring with the standardised Mini Mental State Exam (MMSE). During the same visit they underwent a familiarization session and then an evaluation session on the BrightScreener. At the end of their visit, each subject filled a subjective evaluation exit form. Technologists were blinded to MMSE scores. Subsequent group analysis of the Pearson correlation coefficient showed a high degree of correlation between the subjects' MMSE scores and their Composite Game Scores (0.90, $|P| < 0.01$). Despite the small sample size, results suggest that serious-gaming strategies can be used as a digital technique to stratify levels of Cognitive Impairment. This may be an alternative to conventional standardised scoring for Mild Cognitive Impairment and for Dementia.

Burdea G, C. Defais, K. Wong, et al. Feasibility study of a new game-based bimanual integrative therapy, *Proc 10th Int Conf Virtual Rehabilitation*, Philadelphia, 2013, 101-108. (n=2).

The paper presents BrightBrainer first feasibility study on two subjects who were chronic post-stroke and had high spasticity. Pre-intervention Participant 1 had mild depression, which dropped into the minimal/normal range post therapy. His visual attention/working memory (NAB Dots subtest) showed a notable improvement (1.7 standard deviation) from low average at pre-treatment (T-score = 41) to high average at six week follow-up (T-score = 58). His psychomotor processing speed was severely impaired at pre-intervention (T-score = 12), but improved notably (1.9 standard deviations) and into the mildly impaired at the end of therapy (T-score = 31). His overall performance improved a total of 3.2 standard deviations, into the average range, at six week follow-up. Participant 2 simple auditory attention (NAB Digits Forward subtest) was average pre-intervention (T-score = 44), high average at the end of therapy (T-score = 58), and back to average at six weeks follow-up. Of note, her delayed recall improved from moderately impaired at pre-intervention (T-score = 30) to mildly impaired at the end of therapy (T-score = 32) and eventually low average at six week follow-up (T-score = 41). She showed a total of 1.1 standard deviation improvement across testing intervals. Participant's performance on the Trail Making Test part B was mildly impaired at pre-intervention (T-score = 34), average at the end of

therapy (T-score = 47), and average at six week follow-up (T-score = 47). She showed an overall 1.3 standard deviation improvement across testing intervals.