Enhancing the Identification and Treatment of Combat-Related Injuries with Virtual Environments

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Identification of Independent Predictors of PTSD and Post Concussive Syndrome (PCS) in OIF/OEF Veterans

Funding: Center for Neuroscience & Regenerative Medicine, Uniformed Services University
Study Rationale

• Many don’t endorse symptoms in initial “honeymoon” period
• Symptoms evolve or are manifest over time after return
• Treatment of full-blown disorders often ineffective or insufficient, return to duty infrequent
• If early identification proven feasible, early intervention may prove effective
Study Population & Intent

• Cohort of 81 service members consented and assessed w/in 2 mos postdeployment
  – No depression, PTSD or PCS
  – 85% male; 15% African-American, 8% Latino
  – No unstable medical or psychiatric problem

• Comprehensive Baseline Assessment
  – Serial follow-up at 3, 6, 12 months

• Identify best predictors of PTSD, Depression and PCS (risk stratification)
State of residence of participants
Baseline assessment

- Questionnaires, history and physical exam
- Biomarkers: BDNF, COMT, 5HTT, DAT, IL-10, S100B, myelin basic protein, neuron-specific enolase, neuropeptide Y
- Catecholamines & cortisol
- Imaging: functional MRI & DTI
- Brain synchronization (EEGs & ERPs)
- Olfactory and vestibular function
Psychophysiologic Measures

- HR, BP, RR, SC (GSR), EMG, HRV:
  - at baseline
  - in response to startle—40 ms, 108 dB white noise burst
- Monitoring with Virtual Iraq/Afghanistan
  - Three 2-minute sequences
  - Computer screen only
- Fear Acquisition and Extinction
  - Colored Squares (conditioned stimuli)
  - 108 dB noise for 40 msec (unconditioned)
  - 140 psi airblast to throat for 250 msec (unconditioned stimulus)
Psychophys Response to VR vs. Subthreshold PTSD symptoms

**Utility of Heart Rate:**
- **Re-experiencing**
  \[F(3,74)=7.99, p<.001, R^2=.24\]
- **Hyperarousal**
  \[F(3,74)=3.03 p=.035, R^2=.11\]
- **CAPS Total**
  \[F(3,74)=4.94, p=.003, R^2=.165\]

ViRTICo: Virtual Reality Therapy and Imaging in Combat Veterans

Funding: Office of Naval Research
ViRTICo Treatment phase

• Randomization to VRET or PE
  – PTSD with or without TBI
  – Those with shrapnel or other contraindications to fMRI taken directly into treatment, so fMRI not performed on all subjects
VR Exposure Therapy

- 12 to 20 90-minute sessions, 1-2 per week
- Manualized treatment adapted from Difede, in turn based on Virtual Vietnam
  - Begin with CBT approach
  - Homework, relaxation techniques
  - VR introduced @ 4th session, ½ of session
    - 1st person, present tense
    - Therapist choreographed, following SUDS, physiologic monitoring to guide progression
- Includes characteristic audio, video, and olfactory features of Middle East
Prolonged Exposure

- Manualized treatment, based on work by Edna Foa, UPenn
- Same length (90 mins) and number of sessions (12) and overall approach as for VRET arm
Study Questionnaires

• CAPS confirmed diagnosis at baseline; primary outcome measure at end of treatment and 12 week follow up
  – PCL-M and PC-PTSD for more frequent assessments
• BDI and BAI for depression, anxiety
• CAGE, AUDIT for alcohol
• SCID for other psych disorders
• SF-36: functional status
Functional MRI

- Blood oxygen level dependent (BOLD)
  - More oxygenated blood more intense on T2
  - Greater O2 use compensated by feedback vasodilation within 3-6 seconds
  - Easiest to interpret with rapid on/off stimuli
  - However, more complex processes interesting too
  - Differences between PTSD & controls in amygdala, hippocampus & frontal lobe
fMRI Task: Affective Stroop

Tasks Coupled with Validated Images

Negatively charged imagery

Positively charged imagery
fMRI pre- vs. post treatment: Activation across areas of interest

Average Beta Weight Change

Pre-treatment vs. post-treatment

Rostral Anterior Cingulate Cortex  Amygdala  Subcallosal  Insula (right)  Lateral Prefrontal  Lateral Prefrontal

Amygdala activation with emotional stimuli, pre and post treatment

Average Beta Weight Change

Pre-treatment  Post-treatment

Ventralmedial Prefrontal Cortex

Amygdala (right)

Anterior Cingulate Cortex (right)

Negative  Neutral  Negative  Neutral  Negative  Neutral
Main Effect of Time

Control subjects, with or without blast exposure, show no changes on repeat scan 3 months after initial scan.

This provides more compelling evidence that the changes seen after treatment are the result of the therapeutic intervention.

Enhancing Exposure Therapy for PTSD: Virtual Reality and Imaginal Exposure with a Cognitive Enhancer

Funding: USAMRMC
Evaluation of a Novel Integrative and Intensive Virtual Rehabilitation Program for Service Members Post TBI

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3 Department of Rehabilitation, Walter Reed National Military Medical Center (Bethesda, MD)
4 Bright Cloud International Corp (Highland Park, NJ)
Rationale

• Bimanual tasks:
  - Require divided attention/task sequencing/dual-tasking
  - Increase cognitive load
  - May increase interhemispheric communication
  - May facilitate neuroplasticity

• Rehab efforts that incorporate these tasks may better utilize neuroplasticity to improve functional outcomes

Objective

• Evaluate feasibility of integrating a bimanual virtual rehabilitation platform in a Military Treatment Facility

• Quantify functional outcomes in service members post-TBI, stroke, and/or hypoxic injury
Virtual Rehabilitation Program

- Hand controllers track hand location in a 3D space and finger flexion
- Difficulty automatically scaled based on patient performance
- Immersive and provides UE exercise
- Three foci of application:
  - Attention/focusing
  - Short term Memory
  - Executive functions

Subject wearing wrist weights while training on the BrightBrainer™ Rehabilitation System
Ongoing Research Effort

- Recruiting service members with TBI, stroke, and/or hypoxic injury
- 6-week treatment program (3 sessions/week)
- Randomized Active Treatment group vs. Wait-List Control group
- Subjects in the Control group wait 3 weeks before VR treatment
  - Evaluated pre- and post-Wait-List before starting treatment program
- Pre/post Outcome Measures:
  - Symptoms (PCL, NSI)
  - Cognition (ANAM)
  - Mood (QIDS)
  - Upper Extremity Function (Box and Blocks Test, Jebsen Hand Function Test, Fugl-Meyer, Gross Shoulder Strength)
  - Ease of use for participant/therapist
- Initial results show increased ANAM score and patient desire to continue training once therapy ends.

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A Virtual Integration Environment for Phantom Limb Pain Treatment and Modular Prosthetic Limb Training

Paul F. Pasquina; Jack Tsao; Courtney Moran; Aimee Alphonso; Robert Armiger; Kassondra Collins; Kayla McFarland; Brett Monson; Briana Perry; Mikias Wolde
Virtual Integration Environment (VIE)

- Clinical testing of the Virtual Integration Environment (VIE) among users who sustained upper limb amputation
- Platform allows users to control movements of a virtual avatar using surface electromyography (EMG) signals from their residual limbs

Photo courtesy of Johns Hopkins University Applied Physics Lab
Clinical Trial within VIE

- **Objective:** to evaluate application of the VIE as:
  - Phantom limb pain (PLP) therapy option
  - method for screening and training for a novel myoelectric prosthetic arm
- Laptop based system with EMG input from user’s residual limb
- Output presentation displayed a rendered 3-D arm within the VIE environment
Training Protocol and Outcomes

- Twenty 60-minute virtual therapy sessions over the course of 1-2 months
  - Passive training – participants watched and mentally followed the virtual limb
  - Active training – participants actively controlled the virtual limb
  - Assessment of passive and active performance
- Phantom limb pain assessment
  - 10-cm Visual Analogue Scales (VAS)
  - Short-Form McGill Pain Questionnaire (SF-MPQ)
Preliminary Results and Conclusions

• Decrease in PLP and residual limb pain
• All participants were able to demonstrate high proficiency in basic arm movements

![Graph showing VAS PLP Score over sessions]

• User success within the VIE system confirms its application as a PLP therapy option for individuals with UE limb loss.
• The high degree of accuracy in pattern recognition control suggests that the VIE can be utilized to optimally train participants to use a novel prosthesis.
Publications


Questions?