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STRIVE: Stress Resilience In Virtual Environments: A Pre-Deployment VR System for Training Emotional Coping Skills and Assessing Chronic and Acute Stress Responses

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Abstract. The incidence of posttraumatic stress disorder (PTSD) in returning OEF/OIF military personnel is creating a significant healthcare challenge. This has served to motivate research on how to better develop and disseminate evidence-based treatments for PTSD. One emerging form of treatment for combat-related PTSD that has shown promise involves the delivery of exposure therapy using immersive Virtual Reality (VR). Initial outcomes from open clinical trials have been positive and fully randomized controlled trials are currently in progress to further validate this approach. Based on our research group's initial positive outcomes using VR to emotionally engage and successfully treat persons undergoing exposure therapy for PTSD, we have begun development in a similar VR-based approach to deliver stress resilience training with military service members prior to their initial deployment. The Stress Resilience In Virtual Environments (STRIVE) project aims to create a set of combat simulations (derived from our existing Virtual Iraq/Afghanistan exposure therapy system) that are part of a multi-episode narrative experience. Users can be immersed within challenging combat contexts and interact with virtual characters within these episodes as part of an experiential learning approach for training a range of psychoeducational and cognitive-behavioral emotional coping strategies believed to enhance stress resilience. The STRIVE project aims to present this approach to service members prior to deployment as part of a program designed to better prepare military personnel for the types of emotional challenges that are inherent in the combat environment. During these virtual training experiences users are monitored physiologically as part of a larger investigation into the biomarkers of the stress response. One such construct, Allostatic Load, is being directly investigated via physiological and neuro-hormonal analysis from specimen collections taken immediately before and after engagement in the STRIVE virtual experience.

Keywords. PTSD, Stress Resilience, Allostatic Load, Cognitive Coping, Virtual Reality

Introduction

War is perhaps one of the most challenging situations that a human being can experience. The physical, emotional, cognitive and psychological demands of a combat environment place enormous stress on even the best-prepared military personnel. Since the start of the

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Operation Iraqi Freedom/Operation Enduring Freedom (OEF/OIF) conflicts in Afghanistan and Iraq, more than two million troops have been deployed. As of December 2010, there have been 5836 deaths and 41,583 Service Members (SMs) wounded in action [1-2]. Moreover, the stressful experiences that are characteristic of the OIF/OEF warfighting environments have produced significant numbers of returning SMs at risk for developing posttraumatic stress disorder (PTSD) and other psychosocial health conditions. In the first systematic study of OIF/OEF mental health problems, the results indicated that "…The percentage of study subjects whose responses met the screening criteria for major depression, generalized anxiety, or PTSD was significantly higher after duty in Iraq (15.6 to 17.1 percent) than after duty in Afghanistan (11.2 percent) or before deployment to Iraq (9.3 percent)" [3]. Reports since that time on OIF/OEF PTSD and psychosocial disorder rates suggest even higher incidence statistics [2, 4-5]. For example, as of 2010, the Military Health System recorded 66,934 active duty patients who have been diagnosed with PTSD [2] and the Rand Analysis [5] estimated that at a 1.5 million deployment level, more than 300,000 active duty and discharged Veterans will suffer from the symptoms of PTSD and major depression. These findings make a compelling case for continued focus on developing and enhancing the availability of evidence-based treatments to address a mental health care challenge that has had a significant impact on the lives of our SMs, Veterans and their significant others, who deserve our best efforts to provide optimal care.

This challenge has also driven an emerging focus within the military on emphasizing a proactive approach for better preparing service members for the emotional challenges they may face during a combat deployment to reduce the potential for later adverse psychological reactions such as PTSD and depression. This focus on *stress resilience* training prior to deployment represents no less than a quantum shift in military culture and can now be seen emanating from the highest levels of command in the military. For example, in a recent article in the *American Psychologist,* Army General George Casey [6] makes the case that "…soldiers can "be" better *before* deploying to combat so they will not have to "get" better *after* they return." (p.1), and he then calls for a shift in the military "…to a culture in which psychological fitness is recognized as every bit as important as physical fitness." (p. 2). This level of endorsement can be seen in practice by way of the significant funding and resources applied to stress resilience training within the *Comprehensive Soldier Fitness* program [7]. The core aim of such approaches is to promote psychological fitness and better prepare service members for the psychological stressors that they may experience during a combat deployment.

At the same time a virtual revolution has taken place in the use of Virtual Reality (VR) simulation technology for clinical and training purposes. Technological advances in the areas of computation speed and power, graphics and image rendering, display systems, body tracking, interface technology, haptic devices, authoring software and artificial intelligence have supported the creation of low-cost and usable VR systems capable of running on a commodity level personal computer. The unique match between VR technology assets and the needs of various clinical treatment and training approaches has been recognized by a number of scientists and clinicians, and an encouraging body of research has emerged that documents the many clinical targets where VR can add value to clinical assessment and intervention [8-12]. This convergence of the exponential advances in underlying VR enabling technologies with a growing body of clinical research and experience has fueled the evolution of the discipline of Clinical Virtual Reality. And this state of affairs now stands to transform the vision of future clinical practice and research to address the needs of both civilian and military populations with clinical health conditions.

This view has now seen endorsement in the variety of efforts that the DOD and VA have funded using VR to clinically address the psychological, cognitive, and physical wounds of war [10]. For example, researchers have recently turned to the use of VR to deliver Exposure Therapy (VRET) by immersing users in simulations of trauma-relevant environments in which the emotional intensity of the scenes can be precisely controlled by the clinician in collaboration with the patients' wishes. In this fashion, VRET offers a way to circumvent the natural avoidance tendency by directly delivering multi-sensory and context-relevant cues that aid in the confrontation and processing of traumatic memories without demanding that the patient actively try to access his/her experience through effortful memory retrieval. Within a VR environment, the hidden world of the patient's imagination is not exclusively relied upon and VRET may also offer an appealing, non-traditional treatment approach that is perceived with less stigma by "digital generation" SMs and Veterans who may be reluctant to seek out what they perceive as traditional talk therapies. Previous successful research applying VRET for the treatment of PTSD has been detailed elsewhere [13-14] and results applying a *Virtual Iraq/Afghanistan* VRET system for OIF/OEF combat-related PTSD have been encouraging in initial trials [10, 15], with four DOD-funded randomized controlled trials currently in progress.

This paper will describe the rationale and development of a VR stress resilience training application for use prior to a combat deployment that has evolved from the *Virtual Iraq/Afghanistan* exposure therapy system developed at the USC Institute for Creative Technologies [10]. The theoretical rationale and system approach will be detailed along with a brief summary of our method for studying stress biomarkers from an Allostatic Load perspective [16]. We hypothesize that VR stress resilience training with SMs in this format will reduce the later incidence of PTSD and other psychosocial health conditions.

1. The STress Resilience In Virtual Environments (STRIVE) Approach

Resilience is the dynamic process by which individuals exhibit positive adaptation when they encounter significant adversity, trauma, tragedy, threats, or other sources of stress [16]. The DOD has focused significant attention on this area with a variety of programs being developed for this purpose across the branches of the military [17-18]. Perhaps the program that is attempting to influence the largest number of service-members is the Comprehensive Soldier Fitness (CSF) program [7]. This project has created and disseminated training that aims to improve emotional coping skills and ultimate resilience across all Army SMs. One element of this program draws input from principles of cognitive-behavioral science, which generally advances the view that it is not the event that causes the emotion, but rather how a person appraises the event (based on how they think about the event) that leads to the emotion [19]. From this theoretical base, it then follows that internal thinking or appraisals about combat events can be "taught" in a way that leads to more healthy and resilient reactions to stress. This approach does not imply that people with effective coping skills do not feel some level of "rational" emotional pain when confronted with a challenging event that would normally be stressful to any individual. Instead, the aim is to teach skills that may assist soldiers in an effort to cope with traumatic stressors more successfully.

The STRIVE project aims to foster stress resilience by creating a set of combat simulations, derived from the *Virtual Iraq/Afghanistan* exposure therapy system [11], that can be used as contexts for the experiential learning of cognitive-behavioral emotional coping strategies in SMs prior to deployment. This will involve immersing and engaging SMs within a variety of virtual “missions” where they are confronted with emotionally challenging situations that are inherent in the OEF/OIF combat environment. Interaction by SMs within such emotionally challenging scenarios will aim to provide a more meaningful context in which to learn and practice psychoeducational and cognitive coping strategies that are believed to psychologically prepare them for a combat deployment. To accomplish this, STRIVE is being designed as a 30-episode interactive narrative in VR, akin to being immersed within a “*Band of Brothers*” type storyline that spans a typical deployment cycle. At the end of each of the graded 10-minute episodes, an emotionally challenging event occurs, designed from feedback provided by SMs undergoing PTSD treatment (e.g., seeing/handling human remains, death/injury of a squad member, the death/injury of a civilian child). At that point in the episode, the virtual world “freezes in place” and an intelligent virtual human “mentor” (selected by the user) emerges from the midst of the chaotic VR scenario to guide the user through stress-related psychoeducational and self-management tactics, as well as providing rational restructuring exercises for appraising and processing the virtual experience. The stress resilience training component is drawing on evidence-based content that has been endorsed as part of standard classroom-delivered DOD stress resilience training programs [7], as well as content that has been successfully applied in non-military contexts (e.g., humanitarian aid worker training, sports psychology, etc.).

In this fashion, STRIVE provides a digital “emotional obstacle course” that can be used as a tool for providing more realistic and context-relevant learning of emotional coping strategies under very tightly controlled and scripted simulated conditions. Training in this format is hypothesized to improve generalization to real world situations via a state dependent learning component [20] and further support resilience by leveraging the learning theory process of latent inhibition. Latent inhibition refers to the delayed learning that occurs as a result of pre-exposure to a stimulus without a consequence [21-22]. Thus, the exposure to a simulated combat context is believed to decrease the likelihood of fear conditioning during the real event [23].

2. Stress Biomarkers and Allostatic Load

The STRIVE project also incorporates a novel basic science protocol. While other stress resilience projects incorporate one or two biomarkers of stress and or resilience, the STRIVE projects measures what we refer to as the “physiological fingerprint of stress,” commonly called Allostatic Load (AL). The theoretical construct of allostatic load, initially developed by one of the STRIVE collaborators, Bruce McEwen, is a measure of cumulative wear and tear on physiological symptoms due to chronic stress [16]. As a theoretical construct, it is a preliminary attempt to formulate the relationship between environmental stressors and disease, by hypothesizing mechanisms whereby multiple kinds of stressors confer risk simultaneously in multiple physiological systems. The construct of AL is based on the widely accepted response called allostasis. Sterling and Eyer [24] defined allostasis as the body’s set points for various physiological mechanisms, such as blood pressure or heart rate, which vary to meet specific external demands, e.g., emotional stress. McEwen and Stellar [16] furthered our understanding of allostasis by broadening its scope. Rather than discuss allostasis in terms of a single set point that changed in response to a stressor, they described allostasis as the combination of all physiological coping mechanisms that are required to maintain equilibrium of the entire system. Thus, allostasis is the reaction and adaptation to stressors by multiple physiological systems that brings the system back to equilibrium. The related concept of homeostasis refers specifically to system parameters essential for survival [25]. To place AL into the context of allostasis, allostasis does not always proceed in a normal manner. Any of the major physiological systems, e.g., inflammatory, metabolic, immune, neuroendocrine, cardiovascular, respiratory, can in the process of responding to stress exact a cost, or an allostatic load, that can result in some form of physiological or psychological disturbance. McEwen [26] identified four types of AL. The first is frequent activation of allostatic systems; (2) is a prolonged failure to shut off allostatic activity after stress; (3) is a lack of adaptation to stress, and (4) is an inadequate response of allostatic systems leading to elevated activity of other, normally counter-regulated allostatic systems after stress, e.g., inadequate secretion of glucocorticoid resulting in increased cytokines normally countered by glucocorticoids. Any of these types of AL intervene with the normal stress response of allostasis thus increasing AL. This will increase one's risk for disease in the long-term and may preclude the short-term development of physical hardiness and psychological resilience.

From a conceptual standpoint, the construct of AL is still undergoing development. More recent AL models posit the interaction of biomarkers on multiple levels. Juster et al., [27] theorize that by measuring multi-systemic interactions among *primary mediators* (e.g., levels of cortisol, adrenalin, noradrenalin) and relevant sub-clinical biomarkers representing *secondary outcomes* (e.g., serum HDL and total cholesterol), one can identify individuals at high risk of *tertiary outcomes* (e.g., disease and mental illness). Yet we argue this approach does not fully encapsulate the dynamic, nonlinear, evolving, and adaptive nature of the interactions between these biomarkers. Moreover, these markers are not purely physiological. Psychological processes, including appraisal of and reactions to various stressors, e.g., resilience, may constitute a separate but interdependent subsystem in the allostatic model. We support a case-based approach to analysis, which acknowledges that each allostatic system is unique in its configuration based on differences in (1) environmental context, including socioeconomic status and availability of psychosocial resources; (2) regulation and plasticity of bio-allostatic systems; (3) regulation and plasticity of what we term psycho-allostatic systems; (4) psychology, including personality and appraisal of stressors; (5) environmental stressors, which range from biological to sociological; and (6) health outcomes. AL will be measured via the development and integration of complex biomarkers known to indicate physiological dysfunction, and normal function, for numerous physiological systems (i.e., immune, cardiovascular, metabolic).

In a first study of its kind, we will determine if AL can predict acute response to stress (e.g., EEG, GSR, ECG, pupil dilation, etc.), when participants are exposed to the stressful VR missions. Further analyses will determine if AL can predict participants' responses to virtual mentor instructions on how the participants can cope with stress through stress resilience training. If we find that AL is capable of predicting either short-term response to stress or the ability to learn stress resilience there are numerous implications for the future use of AL, including identification of leadership profiles and for informing the development of appropriate training systems for all SMs.

3. Conclusions

The STRIVE program is designed to both create a VR application for enhancing SM stress resilience and to provide a highly controllable laboratory test bed for investigating the stress response. Success in this area could have significant impact on military training and for the prevention of combat stress related disorders. Another option for use of the STRIVE system could involve its application as a VR tool for emotional assessment at the time of recruitment to the military. The large question with such an application involves whether it would be possible (and ethical) to assess prospective SMs in a series of challenging combat-relevant emotional environments delivered in the STRIVE system, to predict their potential risk for developing PTSD or other mental health difficulties based on their verbal, behavioral and physiological/hormonal reactions recorded during these virtual engagements. To use such information for recruitment decisions would require a change from current military thinking, where doctrine dictates that anyone can be made into an infantryman. However, practical implementation of such an approach could advise that those who display reactions that predict them to be most at risk to have a negative stress reaction post-combat, could either be assigned non-combat duties, not accepted into the services, or more preferably, presented with the opportunity to participate in a stress resilience training program that could minimize their identified risk to post-trauma dysfunction. This is not a new concept. Since the early days of the Army Alpha/Beta, assessments have been routinely conducted that are designed to predict what role is best suited to the unique characteristics and talent of a given recruit. Moreover, potential recruits are not accepted into the military for many reasons that are more easily measurable (e.g., having a criminal record, poor physical fitness, significant health conditions).

For this effort, the pragmatic challenge would be in the conduct of prospective longitudinal validation research. This would require the initial testing of a large number of SMs within standardized virtual simulations (i.e., STRIVE), to record and measure reactions for establishing a baseline and for also determining if advanced data mining procedures could detect whether consistent patterns of responding do in fact exist. SMs in this large sample could then be closely monitored for their mental health status during and after their deployment. Once a large enough sample of SMs were identified as having stress related problems, it would be possible to go back to their physiological and behavioral data from the earlier simulation experience and analyze for a consistent reactivity pattern that could differentiate this group and then serve as a marker for predicting problems in future recruits.

The challenges for conducting this type of research are also significant beyond the pragmatics of conducting costly longitudinal research. These would include the pressure that an all-volunteer service puts on the military to attract and maintain sufficient numbers, the traditional view that all recruits can be trained to success, and the potential that some future service members could be misidentified as high risk (false positives) and be denied access to joining the military. This further suggests that in addition to simply identifying the emotional and physiological profile associated with long-term stress-related dysfunction, a further step would be to tailor stress resilience training for specific emotional and physiological profiles. More extensive and in-depth stress resilience training programs could then be clearly proposed for those identified as at risk for PTSD and other psychosocial health conditions. And, the implications for research into individual susceptibility to stress related disorders could have ramifications beyond the military community. As we have seen throughout history, innovations that emerge in military healthcare, driven by the urgency of war, typically have a lasting influence on civilian healthcare long after the last shot is fired.

References

[1] DOD. (2010, December 4). Retrieved from: http://www.defenselink.mil/news/casualty.pdf
[2] Fischer, H. (2010, December 4). United States military casualty statistics: Operation New Dawn, Operation Iraqi Freedom, and Operation Enduring Freedom, Congressional Research Service 7-5700:RS22452. Retrieved from: http://opencrs.com/document/RS22452/
[3] Hoge, C.W., Castro, C.A., Messer, S.C., McGurk, D., Cotting, D.I. & Koffman, R.L. (2004). Combat Duty in Iraq and Afghanistan, Mental Health Problems, and Barriers to Care, NEJM, 351, 13-22.
[4] Seal, K.H., Bertenthal, D., Nuber, C.R., Sen, S. & Marmar, C. (2007). Bringing the war back home: Mental health disorders among 103,788 US veterans returning from Iraq and Afghanistan seen at Department of Veterans Affairs facilities, Archives of Internal Medicine, 167, 476-482.
[5] Tanielian, T., Jaycox, L.H., Schell, T.L., Marshall, G.N., Burnam, M.A., Eibner, C., et al. (2008). Invisible wounds of war: Summary and recommendations for addressing psychological and cognitive injuries. Rand Report Retrieved from: http://veterans.rand.org/
[6] Casey, G. W. (2011). Comprehensive soldier fitness: A vision for psychological resilience in the U.S. Army. American Psychologist, 66(1), 1-3.
[7] Cornum, R., Matthews, M.D., Seligman, M.E.P. (2011). Comprehensive Soldier Fitness: Building resilience in a challenging institutional context. American Psychologist, 66(1), 4-9.
[8] Holden, M.K. (2005), Virtual Environments for Motor Rehabilitation: Review, CyberPsychology and Behavior, 8(3),187-211.
[9] Parsons, T. & Rizzo, A.A. (2008). Affective Outcomes of Virtual Reality Exposure Therapy for Anxiety and Specific Phobias: A Meta-Analysis, Jour. of Behav. Therapy & Exper. Psychiatry, 39, 250-261.
[10] Rizzo, A., Parsons, T.D., Lange, B., Kenny, P., Buckwalter, J.G., Rothbaum, B.O., Difede, J., Frazier, J., Newman, B., Williams, J. & Reger, G. (2011). Virtual Reality Goes to War: A Brief Review of the Future of Military Behavioral Healthcare, Journal of Clinical Psychology in Medical Settings, 18, 176–187.
[11] Riva, G. (2005). Virtual Reality in Psychotherapy: Review, CyberPsych. and Behav, 8(3), 220-230.
[12] Rose, F.D., Brooks, B.M., & Rizzo, A.A. (2005). Virtual Reality in Brain Damage Rehabilitation: Review, CyberPsychology and Behavior, 8(3), 241-262.
[13] Difede, J., Cukor, J., Jayasinghe, N., Patt, I., Jedel, S., Spielman, L., et al. (2007). Virtual Reality exposure therapy for the treatment of posttraumatic stress disorder following September 11, 2001, Journal of Clinical Psychiatry, 68, 1639-1647.
[14] Rothbaum, B.O., Hodges, L., Ready, D., Graap, K. & Alarcon, R. (2001). Virtual reality exposure therapy for Vietnam veterans with posttraumatic stress disorder, Journal of Clinical Psychiatry, 62, 617-622.
[15] Reger, G. M., Holloway, K. M., Rothbaum, B.O, Difede, J., Rizzo, A. A., & Gahm, G. A. (2011). Effectiveness of virtual reality exposure therapy for active duty soldiers in a military mental health clinic. Journal of Traumatic Stress, 24(1), 93–96.
[16] McEwen, B.S., Stellar, E. (1993). Stress and the individual: Mechanism leading to disease. Archives of Internal Medicine, 153, 2093-2101.
[17] Luthar, S.S., Cicchetti, D., & Becker, B. (2000). The construct of resilience: A critical evaluation and guidelines for future work. Child Development, 71, 543-562.
[18] Hovar, C. (2010, December 10). The Military Operational Medicine Research Program for the US Army. Retrieved from: http://www.donhcs.com/hsr/21_march/doc/presentations/Carl%20Hover%20MRMC%20MOMRP%208%20slides.pdf
[19] Ortony, A. Clore, G. & Collins, A. (1988). The cognitive structure of emotions. Cambridge University.
[20] Godden, D.R. & Baddeley, A.D. (1980). When Does Context Influence Recognition Memory? British Journal of Psychology, 71, 99-104.
[21] Feldner, M.T., Monson, C.M., Friedman, M.J. (2007). A critical analysis of approaches to targeted PTSD prevention: current status and theoretically derived future directions, Behav. Modification, 31, 80–116.
[22] Lubow, R.E., Moore, A.U. (1959). Latent inhibition: The effect of non-reinforced exposure to the conditioned stimulus, J Comp Physiol Psychol, 52, 415–419.
[23] Sones, H.M., Thorp, S.R., & Raskind, M. (2011). Prevention of Posttraumatic Stress Disorder. Psychiatric Clinics of N. America, 34, 79–94.
[24] Sterling, P., & Eyer, J. (1988). Allostasis: A new paradigm to explain arousal pathology. In S. Fisher, & J. Reason (Eds.), Handbook of life stress, cognition and health (pp. 629-639). New York, NY: Wiley.
[25] McEwen, B. S. (2002). Sex, stress and the hippocampus: Allostasis, allostatic load and the aging process, *Neurology of Aging, 23,* 921-939.
[26] McEwen, B. S. (2000). Allostasis and allostatic load: Implications for neuropsychopharmacology, *Neuropsychopharmacology, 22,* 108-124. doi:10.1016/S0893-133X(99)00129-3
[27] Juster, R., McEwen, B. S., & Lupien, S. J. (2009). Allostatic load biomarkers of chronic stress and impact on health and cognition, *Neuroscience and Biobehavioral Review, 35,* 2-16.