Inducing Stress in Warfighters during Simulation-Based Training

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ABSTRACT

Over the past decade, the U.S. Marine Corps has shifted its training focus towards enabling effective and efficient decision making in its small unit leaders. Small unit leaders with relatively little experience are increasingly required to make tactical decisions with critical second and third order effects. These near strategic level decisions are not being made in a Command Operations Center (COC), but in the heat of the battle, where the decision maker is surrounded by high levels of physical and emotional stress. Studies have shown significant adverse effects of combat stressors on cognitive performance (Lieberman et al., 2005) as well as persistent changes in brain functional connectivity (Van Wingen et al., 2012). To ensure military success, and the health and wellness of our veterans, it is critical that these small unit leaders receive training necessary to develop strategies which enable them to make effective decisions under stress and mitigate long term physiological and psychological impacts of stress. However, a challenge with implementing such training in the military is the ability to induce high enough levels of stress to elicit physiological and psychological responses similar (maybe not in magnitude, but in nature) to those experienced in combat. Simulation-based training provides a less resource-intensive alternative to live exercises and greater opportunity for variation in decision dilemmas, situations, and stressors. Unfortunately, there is little empirically-validated guidance on how to utilize simulation to train decision making under stress. An approach for integrating cognitive, emotional, and socio-evaluative stressors into simulation-based training was developed and evaluated in a study conducted with experienced Marines. The results found significant increases in both physiological stress response (i.e., increased electrodermal activity), and perceived stress (i.e., State Trait Anxiety Index responses) during this simulation-based training approach, suggesting the method may be an effective means of inducing stress in experienced Warfighters.

ABOUT THE AUTHORS

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Dr. Brent Winslow is Lead Scientist at Design Interactive, Inc., and has over 10 years of experience in studying the central nervous system (CNS) at multiple scales from a bioengineering perspective. His research has focused on studying the brain's reaction to injury and disease and producing therapeutic strategies and devices aimed at restoring normal function. Brent earned a PhD degree in Bioengineering from the University of Utah and did post-doctoral work at the Allen Institute for Brain Science in Seattle WA.

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INTRODUCTION

Over the past decade, the U.S. Marine Corps has shifted its training focus towards enhancing decision making in its small unit leaders. Small unit leaders with relatively little experience are increasingly required to make tactical decisions with critical second and third order effects. These near strategic level decisions are not being made in a Command Operations Center (COC), but in the heat of the battle, where the decision maker is surrounded by high levels of physical and emotional stress. Studies have shown significant adverse effects of combat stressors on cognitive performance (Lieberman et al., 2005) as well as persistent changes in brain functional connectivity (Van Wingen et al., 2012). Lieberman et al. (2005) followed veteran soldiers over a 53 hour mission in which they experienced stressors of heat, sustained exercise, lack of food and sleep deprivation. When assessed with cognitive tests following the exercise, reaction times plummeted and error rates tripled compared to pre-exercise cognitive performance. Van Wingen et al. (2012) followed soldiers who deployed to Afghanistan in parallel to a non-deployed group of soldiers to explore the impact of combat stress (exposure to enemy fire, armed combat, civilian and military casualty exposure) on cognition. Using functional magnetic resonance imaging (fMRI), they found that combat stress reduced midbrain activity and attention, with reduced functional connectivity between midbrain and prefrontal cortex (PFC) persisting at a 1.5 year follow-up. To ensure military success, and the health and wellness of our veterans, it is critical that these small unit leaders receive training necessary to develop strategies which enable them to make effective decisions under stress and mitigate long term physiological and psychological impacts of stress. Research has shown that strategies developed as a result of training, such as cognitive behavioral stress management training, have led to significant reductions in neuroendocrine stress response to acute stressors in healthy subjects (Gaab et al., 2003). A challenge with implementing such training in the military is the ability to induce high enough levels of stress to elicit physiological and psychological responses similar (maybe not in magnitude, but in nature) to those experienced in combat. Stress induction has been successfully accomplished in live military training exercises such as survival training (Morgan et. al., 2006, Taylor et al., 2007); however, the current fiscal climate has reduced the accessibility of live training. Unit leaders and instructors find it increasingly difficult to get ammunition and transport vehicles for live training exercises. Ironically, the draw down in Afghanistan and decrease in the operational tempo of many military forces has resulted in increased dwell times, and as a result, opportunities to train.

An alternative to live training is simulation-based training. Simulation-based training may require fewer resources while providing greater opportunity for variation in decision dilemmas, situations, and environments. Unfortunately, there is little empirically-validated guidance on how to utilize simulation to train decision making under stress. There is little research into whether desktop-based simulations, such as videogame-based training, have the fidelity to induce sufficient stress in Warfighters. We hypothesize that by integrating cognitive, emotional, and socio-evaluative stressors, significant amounts of stress can be induced in Warfighters within a simulation-based training context. This paper presents this approach and a validation study.

BACKGROUND

The current effort is focused on developing simulation-based training packages to effectively train Marine Corps small unit leaders decision making skills under stress (see Carroll et al., 2013). The goal is to develop training packages that utilize simulation to provide the opportunity for trainees to consolidate decision-making skills learned in the classroom and to practice making decisions in stressful environments prior to entering resource intensive live exercises.

Stress induction techniques have been extensively studied and typically fall into the categories of physical (e.g., extreme heat, fatigue) and psychological (e.g., cognitive, emotional, socio-evaluative) stressors. Research on physical stressors is widely known to induce a stress response (e.g., Lieberman et al., 2005), while research on psychological stressors has found mixed results with individual stress induction methods such as time pressure (Driskell et al., 2001), task difficulty (Callister, Suwarno, & Seals, 1992), and emotion induction (Shilling, Zyda, & Wardynski, 2002). Dickerson and Kemeny (2004) conducted a meta-analysis of 208 studies and identified two key stressor characteristics that emerged as the most significant predictors of stress response across a range of stress induction techniques. As assessed by increased cortisol response, stressor characteristics of socio-evaluative threat (i.e., when others can negatively judge performance) and uncontrollability (i.e., the inability to change a situation) resulted in the most pervasive cortisol response and the slowest recovery rates.

It was therefore hypothesized that integration of socio-evaluative threat and uncontrollability, with other stressor characteristics shown to impact stress response (e.g., novelty; Rose, 1980) into a simulation-based training context would result in effective stress induction. To accomplish this, the five-step simulation-based training approach detailed in Carroll et al. (2013) was utilized as a foundation in which to embed the stressors. This approach includes: 1) presentation of a pre-training video that provides orientation and situation, 2) delivery of mission orders, tactical dilemma, and commanders intent, 3) opportunity for the trainee to plan the mission, issue orders to his team, and receive feedback/questions, 4) execution of the mission in the simulation, and 5) an instructor and peer-based After Action Review (AAR). Stressors were integrated into this approach in two ways. Socio-evaluative stressors were integrated within the planning and AAR steps via interaction with instructor and trainee peers. Cognitive and emotional stressors with characteristics including uncontrollability were integrated within the simulation scenarios.

Simulation Stressors

Each simulation scenario is comprised of five discrete decision events (some kinetic, some not) designed to elicit adaptive decision making behavior under stress. To develop these scenarios, researchers extracted stressful decisions experienced by Marine squad leaders during deployments, created a decision library and utilized this database as the foundation for scenario events. Cognitive and emotional stressors were then instantiated within these scenarios, including stressors shown effective in the literature (e.g., dead bodies, Morris, Hancock & Shirkey, 2004) and factors that Marines said made those types of decisions stressful in the field (e.g., time pressure, lack of information). To predict stress associated with each scenario event so that stress could be effectively varied, each stressor was then rated dichotomously (low = 0, high = 1) along five dimensions shown to impact stress response (Dickerson and Kemeny, 2004; Bouchard et al., 2010): 1) duration/volume, 2) unpredictability, 3) uncontrollability, 4) novelty, and 5) intensity. Stressor ratings were then summed for each event, and across events for each scenario, resulting in a quantifiable stressor score. These dimensions and the associated dichotomy are presented in Table 1.

Table 1. Stressor Analysis Dimensions

Stressor Dimension	***Description***	***Low***	***High***
Duration	Length of stressor	Less than 50% of event	More than 50% of event
Unpredictability	Degree to which stressor unexpected	Intel provided indicates potential for stressor	Nothing in intel indicates potential for stressor
Uncontrollability	Degree to which trainee action impacts stressor	Trainee action can impact stressor	No trainee action can impact stressor
Novelty	Amount of previous experience with stressor	Previous experience with stressor (hypothesized)	No previous experience with stressor
Intensity	Level of threat to (virtual) life/risk	Low threat level	High threat level

For example, in one event in which a Marine squad is moving towards a town to clear it of enemies, they find themselves surrounded by a technical vehicle on one side and a helicopter dropping off a group of enemies on the other side. The squad leader must quickly decide how to employ his squad. The cognitive stressor of time pressure is present as the technical vehicle quickly closes in (high in uncontrollability – no control over the vehicle movement, cannot move quickly enough to mitigate). The emotional stressor of loud gunshots is also present as they are engaged from both directions (high in uncontrollability – no action impacts rate or accuracy of enemy fire, high in unpredictability –armed enemies were not expected in the area, high in threat – Marines are outnumbered).

To explore the effectiveness of this stressor analysis method, a laboratory study was conducted with undergraduate participants utilizing proxy military decision making under stress scenarios. Participants performed in a series of complex decision making scenarios ranging from low to high stress per the analysis method described above. Perceived stress was measured via the State Trait Anxiety Index (STAI) and physiological stress response was measured via a suite of sensors including Electrodermal Activity (EDA), Electromyogram (EMG), Electrocardiogram (ECG), and a Respiration Strap. Results revealed that stress response varied as predicted by the analysis method. Scenarios predicted to have the lowest stress level resulted in the lowest perceived stress levels and physiological response, and these responses increased as predicted stress level increased (Winslow, Carroll, Chadderdon, Martin, and Squire, in preparation). Further, when preceded by a widely-accepted gold-standard socio-evaluative laboratory stressor, the Trier Social Stressor Task (TSST; Kirschbaum, Pirke, Hellhammer; 1993), perceived stress and physiological stress response associated with each scenario increased significantly compared to a control condition with no additional stress induction prior to the simulation scenarios. These results suggest that: 1) when designed with appropriate characteristics (e.g., uncontrollability), simulation stressors can induce stress, 2) this stressor analysis method may be effective in accurately predicting stress response, and 3) the combination of socio-evaluative threat with simulation stressors may provide the greatest opportunity for effective stress induction.

Socio-Evaluative Stressors

Socio-evaluative stressors were integrated with the simulation based training approach during the planning and AAR segments. The TSST has been shown to induce high levels of stress across a range of participants through anticipatory, public speaking and mental arithmetic (Kirschbaum, Pirke, Hellhammer; 1993; Hellhammer, Buchtal, and Kirschbaum, 1997). As compared to cognitive, emotion-induction, and noise-exposure based stressors, the TSST consistently shows the highest effect on the physiological response to stress (Dickerson and Kemeny, 2004). During the TSST procedure, participants are first given a limited amount of time to prepare a speech, then deliver the speech to a panel of judges they believe to be experts, and finally and unexpectedly, complete a difficult mental arithmetic task in front of the judges. Key to the procedure's success are the affective cues of the researchers acting as judges (i.e., maintaining neutral expressions throughout), and the participant's impression that the judges are expert judges trained in public speaking. The five-step simulation training approach described above provides a prime opportunity to create a military-relevant analogue to the TSST. During the planning portion of the approach, the trainee is given a limited amount of time to plan their mission prior to briefing it to their instructor (i.e., experts) and peers. Similar to the speech preparation phase within the TSST, this provides a degree of anticipatory stress as they prepare to brief their plan. Next they are required to stand at the front of the room and brief their plan for it to be judged by their instructor and peers. To mimic the affective cues utilized in the TSST, the instructor sits directly in front of the trainee, watching and taking notes (judging). The instructor does not smile or nod in affirmation and attempts to keep his affect as flat as possible. The instructor and peers then provide feedback and ask questions about the plan, ensuring it is not overly positive and affect remains flat.

Study Objective

The objective of this study was to determine the effectiveness of the previously-described simulation-based training approach, which integrates cognitive, emotional and socio-evaluative stressors, at inducing psychological and physiological stress response in Warfighters. Based on effectiveness demonstrated in a similar study with undergraduate students (Winslow et al., in preparation), it was hypothesized that Warfighters undergoing the training would have significant increases in perceived stress and physiological stress response compared to baseline levels. However, it was hypothesized that the intensity of the stress response would be diminished compared to undergraduates due to the intensity of real life stressors previously experienced by Warfighters.

METHODS

Participants

Study participants included 30 Marine Corps Sergeants (E-5) with squad leader experience participating in the six-week Marine Corps Infantry Small Unit Leader Course (ISULC) at the School of Infantry East (SOI-E). This paper focuses on 13 of the participants who served as squad leaders during the simulation exercise. These 13 participants were all male and ranged in age from 23 to 29 (average = 26). Participants' average time in military service was 7.5 years, with an average of approximately one deployment to Iraq (average = six months) and one deployment to Afghanistan (average = 10 months). Physiological data was collected for five of these 13 participants.

Experimental Design

The experiment was a between-subjects repeated-measures design. After receiving classroom instruction within the course curriculum, the participant pool was randomly assigned to two groups. The experimental group received the simulation-based training approach discussed above and the control group received simulation-based training as it is currently implemented within the ISULC training course. Unlike the simulation-based training described above, ISULC's current simulation-based training is developed in a more ad-hoc manner by the instructors.

Measures

Stress response was measured using a series of psychological and physiological measures. To assess psychological stress response, perceived stress was measured directly after each training scenario using the state portion of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, &Vagg; 1983). Additionally, the Connor-Davidson Resilience Scale (CD-RISC; Connor & Davidson, 2003) was administered to assess each participant's resilience, or ability to cope with stress. Participant reactions to the training were also captured via a questionnaire in which they were asked to rate, on a 10-point Likert scale, the stressfulness of the training.

Physiological stress response was measured via a series of measures, however the focus of this paper is on electrodermal activity (EDA) and heart rate variability (HRV) as these measures were best able to discriminate a stress response. Palmar EDA was recorded on the 4th and 5th fingers of the non-dominant hand with bandlimits set between DC and 10 Hz and wirelessly connected to the Biopac MP-150 running Acqknowledge software (Biopac Systems, Goleta CA), sampled at 500 Hz. Raw EDA data was averaged across segments as skin conductance level (SCL). The EDA data was also run through digital bandpass filters at 1 and 0.05 Hz, followed by thresholding between 0.05 and 0.051 μS to convert to electrodermal responses (EDR), which were quantified as a rate per minute. Heart rate was calculated from the R-R interval from the Electrocardiogram (ECG), with intervals <40 bpm and >180 bpm excluded from the analysis as they are outside the normal human range. Temporal-domain HRV was calculated as the standard deviation of the N-N (i.e., beat to beat) intervals (SDNN) from the ECG over 5 minutes.

Procedure

All portions of the study were run at Camp Geiger, in Jacksonville, NC, during regularly scheduled portions of the ISULC. Data was collected over the course of three days. The first study session included a brief introduction to the study and completion of an informed consent form. A portion of the participants then performed a baseline session in which they donned physiological sensors, and sat and relaxed for five minutes while baseline physiological data was collected. They then filled out the state portion of the STAI. Due to the limited number of sensors available and time constraints, baseline data was only collected for eight participants in the experimental group and nine participants in the control group. All participants completed a demographics form and the CD-RISC.

During the second portion of the study, which took place the day after the introduction, the two groups were split into experimental and control groups, and each received a day and a half of Virtual Battle Space 2 (VBS2) simulation training per their condition. Prior to scenario performance, participants in the experimental group received 45 minutes of VBS2 familiarization training on keyboard and mouse functions necessary to operate within the VBS2 scenarios. Control group participants did not receive this training as their training scenarios did not require first person interaction within the scenarios. During this time, the control group conducted movement to a different location and received a few statements regarding how to pan, zoom and rotate within their scenarios.

When training commenced, a portion of the participants rotated through leading a squad in a complex decision making mission per the task descriptions below. In both groups, the participant leading each mission donned the physiological sensors described above prior to executing the mission in VBS2. After each training scenario, each leader filled out the state portion of the STAI.

Task

Experimental Group Task

Participants in the experimental group were trained on a complex squad leader decision making task. Five of the experimental group participants rotated through the position of leading the rest of the group as a squad through a VBS2 training scenario designed to elicit decision making under stress. Prior to each of the five scenarios, the trainee who had been chosen to operate as the squad leader for that particular scenario donned the physiological sensors. Each training scenario incorporated the segment process outlined above, however, mission planning and brief is split into multiple segments to allow for them to be analyzed separately. First, to orient the trainees to the situation, they viewed a two- to five-minute video designed to inform, engage, and motivate, and then were read a set of platoon-level mission orders by the instructor. Second, the squad leader was given approximately 10 minutes to develop a plan for the squad to execute their mission. Each squad leader went to the back of the room and sat at a desk containing a map of the scenario Area of Operations (AO) to complete his plan (Plan Segment). Third, the squad leader came to the front of the room and briefed the mission plan to the squad and instructor, using a map of the AO (Brief Segment). It was during this segment that socio-evaluative stress was incorporated per the description above (i.e., flat affect, etc.). Fourth, the instructor came up to the front of the room with the squad leader to put his plan "under fire", first asking the other students if they had any questions about the plan, and then providing feedback on both the plan and the brief, utilizing similar affect as in the previous step in order to extend the socio-evaluative stress (Fire Segment). Fifth, the squad was immersed in the desktop VBS2 simulation scenario, each participant with their own avatar. The squad leader led his squad in performing a mission as they encountered five discrete decision events designed to elicit adaptive decision making and induce increasing levels of stress per the simulation stressors described above. As the events unfolded, the squad leader was required to quickly decide how he was going to react to the event and quickly react and communicate to his team so they could react within the simulation (Scenario Segment). Sixth, the squad leader would come to the front of the room and debrief the rest of the squad on the execution of the mission, with the instructor and other trainees interjecting questions or comments (Debrief Segment). After the process was complete, the squad leader filled out the state portion of the STAI and the sensors were removed. Each scenario lasted approximately one to one and a half hours. This process was repeated for five different scenarios, over a two-day period. Five different participants acted as squad leader, each encountering five unique decision events. The total training time over the course of the one and a half days was approximately eight hours.

Control Group Training Task

Participants in the control group were also trained on a complex squad leader decision making task utilizing the VBS2 simulation, however, using the simulation training method currently instantiated in the ISULC course. Participants in the control group were split into three groups of five participants, each group representing an independent squad working in concert with the two other squads. One squad acted as the main effort (ME), one represented supporting effort one (SE1) and the other represented supporting effort two (SE2). Once the control participants were split into the three squads, the instructor delivered a platoon level mission order, tasking each of the three efforts. The squads then split up to plan their mission and a squad leader from each squad was assigned. The squads were in three separate parts of the room and were partitioned by cubicle dividers. Within each area, the squad had access to a large computer display showing a top-down view of the VBS2 terrain in which they would be operating. They could see the area around their location, their avatars and any additional scenario cues and could pan, rotate, or zoom their view to look around. They could not move their avatars or obtain a first person view. After planning their mission, they called the mission plan into the COC via radios. The instructors and facilitator then moved their avatars within the simulated world based on the plan they briefed and each squad watched the movement on the display. Each squad in the control group then encountered a series of decision events throughout the course of the mission/scenario. The events were mostly static representations of terrain and entities (e.g., sheep herders) with the exception of a few technical vehicles which did move across the terrain. Each squad leader was required to decide how he was going to react to the event and call into the COC to report the event and his planned action. Thus, there were several key differences between this training method and the one utilized in the experimental group, including lack of a first person view and interactivity. When the leader made the decision to perform tactical questioning of an individual, the training facilitator would act as a role player. While it was up to the squad leader to make the decision, the squads did work as a team to determine the best Course of Action (COA). Participants rotated through the squad leader position so each participant in each group had the opportunity to lead during one decision event. After each event, the instructor provided an AAR of their response to the event and planned COA. Each event and debrief lasted approximately 20-30 minutes. Over the course of the day and a half of training, all 16 control participants led during two decision events and participated as team members in eight additional decisions. In order to control for the confound of the experimental group performing while wearing sensors, eight control participants donned sensors for one decision event each. Actual physiological data was not collected due to access to only one BioPac MP150 system; however, participants were not aware that the data was not being collected. At the end of the one and a half day training session, an overall debrief was conducted for the group as a whole. The total training time over the course of the one and a half days was approximately eight hours.

RESULTS

Physiological Stress Response

In order to assess the efficacy of the above described method at inducing stress in Warfighters, physiological data was collected and analyzed for the five experimental participants who led a mission. The mean rate of electrodermal responses (EDR) and variance of skin conductance level (SCL) for the squad leaders throughout the five segments of the training as they led (all segments except the video portion) are shown in Figures 1 and 2, respectively. A repeated measures Multivariate Analysis of Variance (MANOVA) was performed for these two dependent variables over the course of the six segments (baseline, plan, brief, fire, scenario, debrief). The multivariate analysis revealed that segment had a significant effect (F (10, 40) = 3.95, p <.01, η^2 = .50) on physiological stress response. Univariate analyses revealed that these differences were significant for both EDR (F (5, 20) = 8.63; p <.01, η^2 = .68) and SCL (F (5, 20) = 7.28; p <.01, η^2 = .65). Post hoc paired comparisons revealed that the EDR rate and the SCL variance in each of the segments was significantly higher than during the baseline segment (p<.05).

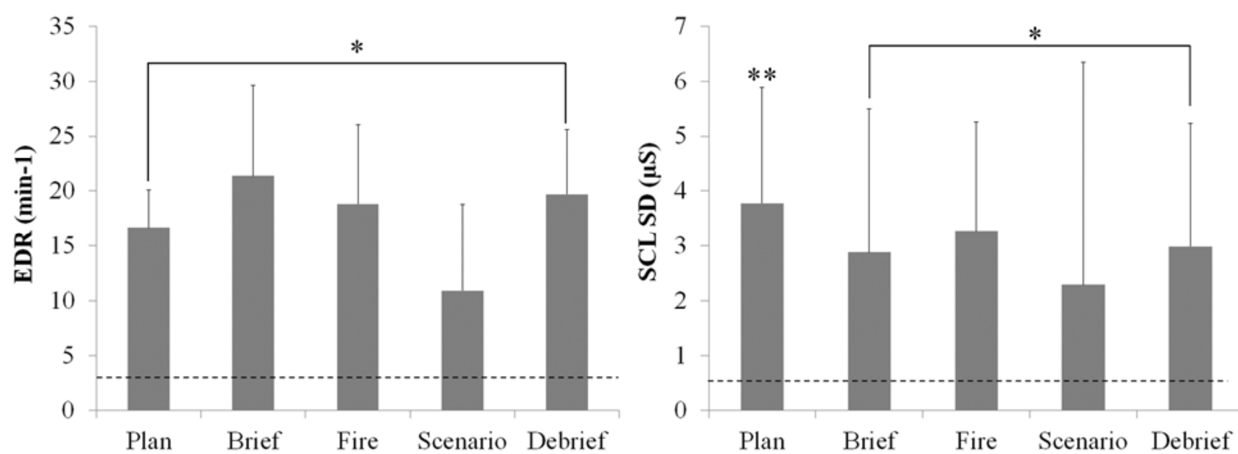

Figure 1. Segment differences in rate of electrodermal responses (EDR) and mean skin conductance variability (SCL) with standard deviation displayed. EDR and SCL were significantly higher than baseline throughout all training segments. Average baseline scores shown by dotted line. * $p \leq 0.05$; ** $p \leq 0.001$.

A repeated measures Analysis of Variance (ANOVA) was performed on temporal domain changes to heart rate variability (HRV) over the course of the six segments. Although the temporal domain HRV (SDNN) trended lower during the brief, fire, and debrief segments as compared to baseline, the differences did not achieve statistical significance (F(5, 20) = 1.56, p>.05, η^2 = .28). However, when compared to EDR, scatterplots indicate a clear separation between the baseline and brief/fire segments. The brief/fire segments were associated with higher EDR and lower HRV than either scenario or baseline segments (see Figure 2).

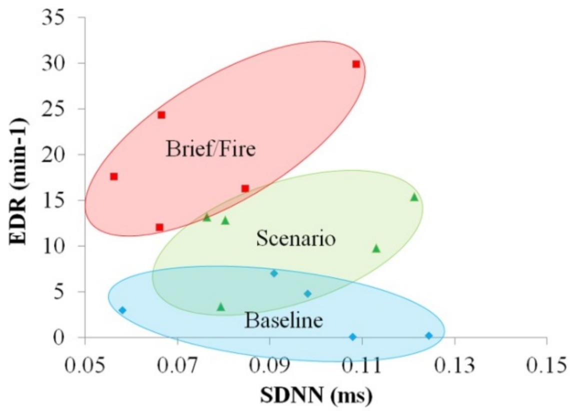

Figure 2. EDR and SDNN scatterplot showing individual differences in response to experimental segments. Electrodermal activity was significantly higher and HRV trended lower during the brief/fire segments than baseline, indicative of increased physiological reactivity and stress during the socioevaluative components.

Psychological Stress Response

To further assess the efficacy of the stress induction methods, perceived stress as measured by the state portion of the STAI was analyzed for both experimental (n = 5) and control participants (n = 8) who led a mission while wearing physiological sensors. A 2 X 2 between subjects repeated-measures ANOVA was performed with between-subjects independent variable of condition (experimental vs. control) and a within subjects independent variable of trial (baseline vs. post scenario). When controlling for individual differences in resilience by covarying CD-RISC scores, there was not a significant effect of trial (F (1, 10) = 1.27; p > .05, η^2 = .11) or condition (F (1, 10) = .272; p > .05, η^2 = .03). However, the interaction between trial and condition was approaching significance (F (1, 10) = 4.71; p = .055, η^2 = .32), wherein the experimental group's perceived stress levels increased from baseline while the control condition's perceived stress levels decreased (Figure 3).

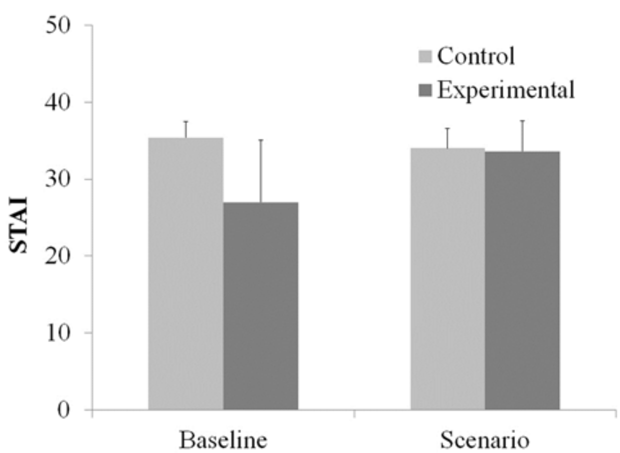

Figure 3. Average STAI responses for experimental and control groups at baseline and post scenario show experimental group increases and control group decreases in perceived stress from baseline.

Trainees' reported reactions to the level of stressfulness of the training scenarios were also analyzed. A one-way ANOVA was performed in which responses to the stress reactions question was compared between the two groups (experimental vs. control). There was no significant difference between the groups (F (1, 12) = .002, p >.05), with the two groups rating the stressfulness of the two types of training as virtually the same, moderate to low in stressfulness (4.4 out of a 10 point scale).

DISCUSSION

The results of this study, though preliminary, provide support for the ability to induce – and measure - stress in Warfighters during simulation-based training using the approach described previously. The simulation-based training scenarios led to significant increases in physiological stress response as indicated by increased electrodermal activity. Further, results suggest that when accounting for individual differences in baseline perceived stress (i.e., by covarying CD-RISC resilience scores), the simulation-based training scenarios led to greater increases in perceived stress as indicated by STAI responses. The results also suggest that the training segments which incorporate socio-evaluative stress resulted in the greatest physiological responses. During the brief, fire, and debrief segments of training, the squad leaders were in a position in which they were being publicly evaluated by both their peers and instructors perceived as experts, with socio-evaluative stressor characteristics similar to those in the TSST. This is in line with research which has shown that stressors which incorporate socio-evaluative threat result in the highest effect sizes compared to other stressor dimensions (Dickerson and Kemeny, 2004). This is a promising result for the military as incorporation of socio-evaluative stress can be accomplished with very few resources. Further, the ability to utilize simulation to induce stress, and the ability to capture stress response within Warfighters, provides the military a viable training tool for enhancing decision making under stress. The capability to identify times when a Warfighter is experiencing increased stress response, allows instructors to pinpoint factors contributing to performance decrements (e.g., competent performer, but performance unravels under stress) so as to effectively tailor future training to address individual's shortcomings (e.g., needs additional practice performing skills in stressful environment).

These results also suggest that the actual simulation scenarios induced the least amount of stress when compared to other training segments. This may reflect the lack of socio-evaluative threat during this segment as the focus is moved from evaluation of the leader's plan and performance to execution of the scenario. Perhaps Marines feel more comfortable in a dynamic scenario surrounded by gunshots and quick-paced communications than in a situation in which they are being evaluated by an expert and their peers. As illustrated in Figure 2, when multiple physiological measures are combined, the data trended toward a separation between physiological responses in segments, suggesting the ability to classify/quantify different levels of stress associated with different stressor tasks/characteristics. Such separation provides support for the potential to create classification algorithms to quantify stress response using multiple physiological measures (e.g., Plarre et al., 2011).

Interestingly, despite significant increases in perceived and physiological stress response in the experimental group, participants rated the training as being of low to moderate stressfulness. This reaction was likely due to the standard against which the training was being compared. The participants were experienced Warfighters who have been in the heat of actual battle and performed within numerous live training exercises with live rounds. Simulation-based training pales in comparison to these high stress environments. However, the physiological data provides evidence that the training did induce a degree of stress. How these compare to the intense stress levels felt during war time is unknown, but this provides foundational data in understanding how we can induce stress in Warfighters. Self-report measures may not always portray the complete story; more objective measures are needed to fully understand what is actually happening within the Warfighter.

Implications for the Military

This research has significant implications for the military. There is often resistance to simulation-based training because it does not immerse students in the scenario in the same way as live training. However, limitations in training resources increase the need for simulation-based training. Understanding how to improve upon simulation training to bring it closer to live training includes inducing stress during scenarios. The results, though preliminary, suggest different ways to increase stress and provide recommendations for scenario designers and instructors. Exposing students to stress in a simulation environment may not be as intense as when students are immersed in a live-training scenario, but controlled stress exposure will aid in stress inoculation and build resilience in Warfighters. By developing methods to induce stress in students during simulation, overall impressions of simulation-based training will improve and foster integration of simulation into the training curriculum. With increased simulation acceptance, simulations may be utilized more to teach skills such as decision making and adaptability. Unlikely scenarios, enemy tactics, and faulty equipment can be introduced, which forces students to act quickly, try novel things in a safe environment, and prepares students for the battlefield. Additionally, these simulation scenarios can be easily modified, repeated quickly, and tailored to student needs. In summary, increasing the stress that simulation-based training can induce will increase acceptance of simulations, which allow for courses to take benefit from the advantages of simulation in addition to live training.

Study Limitations

There were several limitations of the study. Collecting data with military participants during a military training course limited the control over the study design and execution. One primary limitation was the limited number of participants, a result of limited time to conduct the simulation training during the course. Despite this, moderate to high effect sizes resulted from the analyses. An additional limitation was the lack of physiological data for the control group, preventing a between groups comparison of physiological response. It was not possible to collect this data due to the lack of multiple Biopac systems and time/logistical constraints during the control condition training.

Recommendations for Inducing Stress in Training

Here we present a set of recommendations for incorporating stressors into training for Warfighters:

1. Incorporate socio-evaluative stress. Where possible, incorporate opportunities for an individual to feel he is being judged by a group of experts. Those acting as assessors/judges should attempt to maintain flat affect, maintain eye contact, minimize nodding and provide pointed feedback when possible. This can be done external to training scenarios, or within a virtual environment (Jonsson et al. 2010).
    a. Example(s): During classroom, virtual or live training exercises require trainee to publicly (verbally) brief a plan or perform a task. Ensure trainee is aware of performance being judged by expert instructors and peers and provide public and pointed feedback.
2. Incorporate uncontrollability. When designing live or virtual training scenarios, incorporate situations in which any action taken by the trainee does not seem to improve the situation.
    a. Example(s): Provide trainee with faulty weapon or tool which malfunctions when needed, or with little ammunition per clip, such that the trainee must reload often. Incorporate enemies with low vulnerability that are virtually impossible to overcome.
3. Incorporate unpredictability. When designing live or virtual training scenarios, incorporate unexpected situations for which the trainee likely did not have a contingency.
    a. Example(s): Incorporate highly unlikely enemy weapons, capabilities, or tactics. Incorporate situations that could not be anticipated based on the intelligence provided in the mission order, such as the presence of indirect fire after being told that the enemy did not have that capability.
4. Incorporate novelty. When designing live or virtual training scenarios, incorporate situations with which trainees have little to no previous experience.
    a. Example: Incorporate terrain features with which trainees have little experience or give enemies advanced weapons systems that trainees have no experience responding to. Incorporate enemy tactics and Rules of Engagement different than those used in recent AOs.

CONCLUSION

This study provides support for the ability to utilize simulation-based training to induce stress in Warfighters. Key to attaining this is incorporation of socio-evaluative stress wherein trainees feel they are being judged by experts. The ability to induce stress in Warfighters provides military practitioners an effective training tool to support in preparing Warfighters to perform under the stressful conditions of the battlefield. Further, it provides a paradigm to allow Warfighter performance under stress to be studied in a more controlled environment. Future research is needed to more fully understand the levels of stress which can be achieved by such techniques, but this study provides a foundation for research going forward.

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