

Motivational Effects of Adding Context Relevant Stress in PC-Based Game Training

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This work was designed to examine the effects of contextually relevant stress on personal computer (PC)-based game training. Off-the-shelf PC-based games are being applied to many training situations because of their affordability, flexibility, and teaming capabilities. The ultimate purpose of training is to transfer superior performance to the real world. In this respect, 1 of the major drawbacks to using games as training tools, especially for military applications, is the absence of the surrounding context. In response to this omission, we examined the effects of adding context-relevant stress to infantry game-based training by exposing 1 group of participants to a graphically intense and stressful experience while the control group viewed an unstressful analog. Pre-post self-reported stress levels confirmed the efficacy of this manipulation. The stress condition produced significantly higher scores on "mission success"; however, no differences were evident in participants' use of trained tactics or game functions. Supplementing context-relevant stress in game training shows promise for enhancing individuals' motivation to succeed.

In the early 1930s, the U.S. Army Air Corps experienced a number of aviation fatalities due to encounters with hazardous weather conditions. The deaths were primarily the result of the pilots not having been trained to fly an aircraft using instruments alone. Safe operations were dependent on the occurrence of clear and visible flying conditions. With the need for round-the-clock operations, the military recognized the necessity for simulators to train operators for such hazardous conditions. Fortunately, Link had already developed the first simulator for instrument-based flight training in 1929 and was able to rapidly build more simulators for this purpose. This transition from the traditional classroom setting to simulated environments provoked a more rigorous examination of the field of training, and traditional instructional strategies were then criticized for merely providing training without practical application to real world contexts (see Rogers, 1969). Simulation-based training represented a promising response to this criticism, and as such simulators have been employed in military and commercial agencies worldwide.

Historically, training programs have had difficulty exposing individuals to unexpected stimuli and sources of task demands that are typically experienced in the real world counterpart. With recent advances in technology, however, the delivery of training in more realistic and high-stress settings has become feasible. The replication of the real world setting and the degree of operator stress imposed is suggested to be the driving component for effective skill acquisition and training transfer (e.g., Bowen, 1987). For this reason, the features employed in simulators (e.g., graphics, sound systems, haptics) are continuously being redesigned and improved for the replication of real world environmental conditions (Hancock, 2003).

Simulation-based training can only be feasible and cost effective when there is a high degree of "transfer" of the trained skills from the simulator to the real world. However, the ability of an individual to retain and transfer the skill to real world settings hinges predominantly on their "willing suspension of disbelief" and their degree of acceptance of recreated reality. The effective human state of immersion within the environment varies considerably with individual human's ability, desire, and motivation to temporarily suspend that disbelief (Brown, 1999). Being a subjective capacity, such achievement then is not necessarily contingent on the reality produced by the simulation system itself. The effectiveness of the duplication of the physical target environment using advanced simulator features, then, is relative, varying among individuals. Although advanced technologies may deliver realistic training scenarios in a simulated environment, they may not improve training (Kantowitz, 1988). Rather, the degree of a human's immersion within that scenario and their resultant level of emotional and behavioral reactivity are suggested to primarily generate effective training. These necessary human qualities that foster optimal immersion are found consistently in studies employing a "gaming" condition. When the elements of a game are present, part of the physical fidelity or reproduced realness of a simulated environment may be sacrificed while immersion itself re-

mains still at an optimal level for training effectiveness. Thus, personal computer (PC)-based gaming environments can be highly effective training tools.

PC-BASED GAME TRAINING

Although the effectiveness of replicating the real world in a fully simulated training environment has some advantages, there are also many unique benefits of training that utilize PCs. Among these are the portability, convenience of use, and the flexibility to quickly evolve and adapt to software improvements that become available. The benefits of interlinked PCs as well as their remote site capabilities guarantee PC-based systems to be the primary vehicle for advanced distributed learning environments. The most recent "off-the-shelf" (OTS) PC-based games have also immediately responded to distributed needs by providing remote multi-player capabilities through networks. These low-cost and networked gaming environments have been shown to be effective for training shared cognition, team skills (Baker, Prince, Shrestha, Oser, & Salas, 1993), situational awareness (Homan, 1998), enhancing interpretation of explicit and implicit information, inductive reasoning, metacognitive analysis, and problem solving (Ricci, Salas, & Cannon-Bowers, 1996). It is therefore unsurprising that most, if not all, military agencies are exploring the advantages of low-cost, OTS, PC-based games for their training requirements (Morris & Tarr, 2002). Traditionally, OTS PC-based games have been solely created and intended for entertainment purposes, although most recent developers of infantry games are designing their products according to reputable military data sources (Coleman & Johnston, 1999). The benefits of these efforts for doctrinally correct infantry games are twofold. First is the higher face validity for using their games in military training. Second is the increase in public knowledge, interest, respect, and awareness of military operations, especially for potential recruits and reservists.

Set against the aforementioned advantages of using games for training are some intrinsic drawbacks, one of which is the topic of this investigation. A major insight in behavioral research in the last decade of the 20th century concerns the importance of *context* in predicting human behavioral response (see Flach, Hancock, Caird, & Vicente, 1995). It has become progressively more clear that results from the sterile laboratory have only restricted applicability in predicting performance in the real world. The complicated tapestry of environmental influences are not merely "unwanted" variance to be isolated and excused from the experimental procedures. Rather, they are crucial interactive facets of the performance portraiture.

Research has shown that when PC-based training involves warlike activity as its objective, the context that the user experiences can determine the degree of stress provoked (Wilson, Skelly, & Purvis, 1999). For military contexts, the presenting

problem in using PC-based games for training is the transformation from the objectives, strategies, and goals inherent in entertainment to those of the intensely stressful military settings while capturing the motivational qualities of the games. Infantry subject matter experts (SMEs) have reviewed doctrinal and contextual correctness of emerging OTS infantry games and concluded that games cannot provide the level of realism needed to prepare individuals for tactics in the midst of real war (Tarr, Morris, & Singer, 2002). Most criticisms of using PC-based games for training, especially in the military environment, have argued that the behavioral models for the agents are unrealistic and the context is amusement rather than the preparation for stressful conflict. Essentially all crucial military tasks possess or occur in conjunction with a high degree of potentially intense and unpredictable stress, and training for these tasks mandates that advanced simulations produce similar conditions, generating similar stresses, as the real world task counterpart. Contextually correct simulations generate higher levels of stress during training, thereby reducing the user's level of stress in actual operational performance (see Driskell & Salas, 1991). Difficulties in games and simulations also arise when the real world environment is unpredictable, as is virtually always the case with stressful contexts such as combat (Driskell, Johnston, & Salas, 2001). When designing stress training, it is therefore crucial to design the stress conditions based on expected real world conditions (Johnston & Cannon-Bowers, 1996). However, stress is extremely difficult to operationally define, as evidenced in the variety of efforts across the literature (see Hancock & Desmond, 2001; Hancock & Warm, 1989). Accordingly, distinguishing how to apply the correct contextual elements of stress and naturally unpredictable tasks to games and simulations requires major empirical efforts. In consequence of these concerns, the purpose of this study was to determine if the effectiveness of PC-based game training could be improved by applying a supplementary stressful context. We hypothesized that the experience of stress will positively influence outcome performance. Specifically, we predicted that individuals who were exposed to graphically intense and technologically advanced realistic war scenes just prior to PC game-based training would perform better than a control group on the posttraining game-based task.

EXPERIMENTAL METHOD

Experimental Participants

Twenty-four undergraduate and graduate student volunteers (15 males and 9 females) participated in the study, with a mean age of 22 and no prior experience in the military. Of the individuals who were exposed to the stressful film condition, 5 reported having seen the film prior to the study. Of the individuals exposed to the con-

trol film condition, none reported having seen the film previously. Both groups were statistically equivalent on self-reported gaming habits and gaming experience.

Experimental Materials

An informed consent form, debriefing, and participant biographical questionnaire, which included gaming habits, were specifically designed for this project. A 15-min segment of the video *Saving Private Ryan* was used for the context enhanced group, while a 15-min segment of a black and white WWII–*Invasion of Normandy* documentary was used for the control comparison. Both film segments portrayed their respective versions of the beach invasion by US infantry. The Activation-Deactivation Checklist (ADC; Thayer, 1967) and the Emotional Assessment Scale (EAS; Carlson, Collins, Stewart, & Porzelius, 1989) were used to indicate changes in participants' pre and post stress, mood, and arousal levels. Methods used for the infantry training were developed by an SME, who also selected the PC-based game environment most optimal for exercising infantry operations and tactics. From the methods, training protocol and supplementary materials were prepared for a train-up session of infantry tactics such as cover and concealment. The arctic mission, novice level, in the Delta Force OTS game was used for the train-up involving performance goals, tactics, and game use. This same scenario was used as the task environment where performance was measured. The performance score sheet was developed by the SME for use by a human observer who was blind to the purpose of the study, but who had high expertise in gaming and who was trained on the infantry procedures, tactics, and protocols used during train-up.

Experimental Procedure

The participants arrived at the test facility where they completed the informed consent, the biographical questionnaire, the ADC, and the EAS and were randomly assigned to one of two training conditions. Those in the experimental group were asked to watch the 15 min of graphically intense war scenes from the beach invasion portion of the movie *Saving Private Ryan*. The participants in the control group viewed an alternative nonstimulating black and white war clip of the beach invasion. Immediately following the 15-min viewing, the participants completed the post ADC and EAS and were then trained for another 15 min on infantry tactics, weapon use, and mission objectives using the Delta Force environment. They were then asked to meet the mission objectives and reach waypoints in the mission, without their player being injured, but with the ability to restart the mission (when deaths occurred) as often as needed for a period of 20 min, during which they were observed and scored on mission success, game adaptation, and use of learned tac-

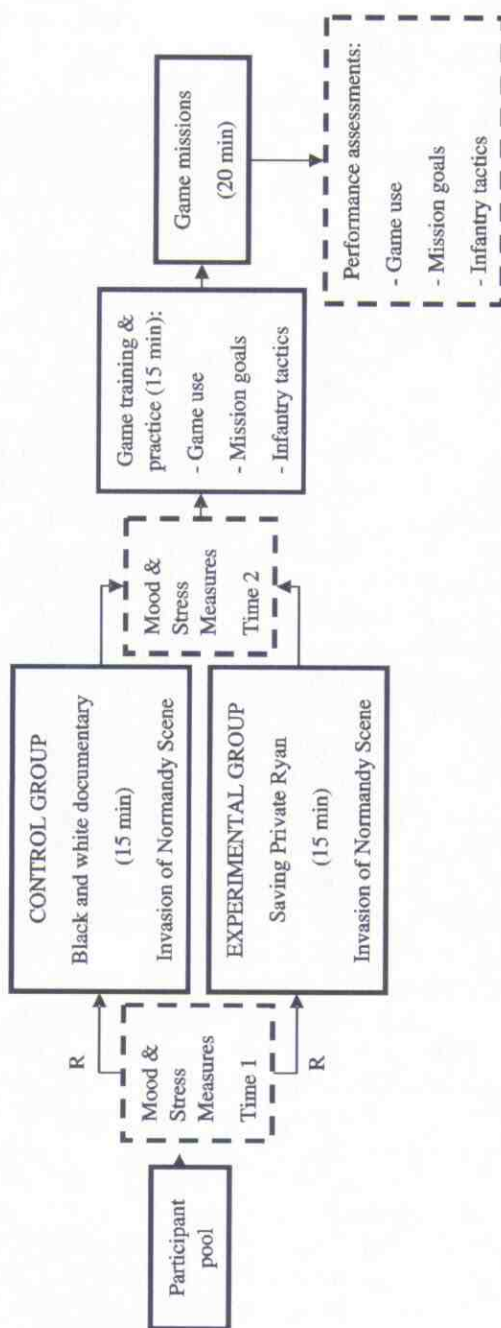


FIGURE 1 Experimental design.

tics by an game expert who was knowledgeable about infantry tactics and blind to the purpose of the study.

RESULTS

Between-Group Comparisons

Prior to the video exposure, independent sample *t*-tests with an alpha of .05 revealed no initial pretest differences between the experimental and control group on any of the ADC and EAC self-report indicators of stress. Following the 15-min video exposure, the experimental group had significantly higher mean scores than the control group on self-reports of "feeling clenched," "intensity," "anxiety," and "disgust." Individuals who were in the experimental group and had seen the film before did not differ significantly from those who had not seen the film on any of the ADC or EAC indicators of stress (see Table 1).

Between-group multivariate analysis of variance was performed on three observed dependent variables: mission success, game adaptation, and use of learned tactics, with condition assignment (experimental or control) as the independent variable. With the use of Wilk's criterion, the combined dependant variables (DV) were significantly affected by condition assignment, $F(4, 19) = 7.15, p < .001$. The results reflected a strong association between condition assignment and the combined DVs, partial $\eta^2 = .60$.

Univariate analysis revealed that those in the context enhanced condition scored significantly higher on "mission success" (M adjusted success score = 16.38) than those in the control group (M adjusted success score = 12.66), univariate $F(1, 22) = 6.075, p < .025$. However, there were no differences between the groups on "game adaptation" scores ($p = .415$) or "use of learned tactics" ($p = .787$; see Table 2). We

TABLE 1
Means, Standard Deviations, Independent Samples T, and P Values for Post
Manipulation Stress Indicators in the Context Enhanced and Control Group

Stress Indicators	Control Group		CE Group		<i>t</i> (22)	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Activation-Deactivation Checklist						
Clenched	2.00	0.510	2.60	0.670	-2.05	.05
Intense	2.20	0.390	2.70	0.650	-2.28	.03
Emotional Activation Scale						
Anxiety	2.50	2.03	8.60	8.36	-2.48	.02
Disgust	1.62	1.97	6.94	8.72	-2.05	.05

Note. CE = context enhanced

TABLE 2
Mean Scores, F, and P Values on the Mission Performance Subscales for
the Control and Context Enhanced Groups

<i>Performance Subscales</i>	<i>Control Group</i>		<i>CE Group</i>		<i>F</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Mission success ^a	12.66	3.33	16.38	4.03	6.075	.022
Game adaptation ^b	24.27	3.37	26.28	5.46	0.689	.415
Use of tactics ^c	29.50	4.47	28.84	7.08	0.075	.787

^aSubscale items: second waypoint reached; avoided taking fire; use of alternative or creative ways to accomplish mission; skilled use of time; followed through with mission and objectives

^bSubscale items: use of provided functions of mouse and keyboard; switching between weapons; using full visual (e.g., nightvision, scope) and weapons inventory

^cSubscale items: use of strafing (sidestepping); cautious approaches into areas; used scope and maintained distance from targets when engaging; maintaining cover while engaging

subsequently performed an additional analysis on the experimental group alone that showed no performance differences between participants who had and had not previously seen the film.

Within-Group Prediction of Performance

A stepwise multiple regression was performed on data from all participants ($n = 24$) to determine which, if any, indicators from the postsession ADC and EAS along with the condition assignment contributed significantly to the prediction of the "mission success" scale. For the analysis, scores on the subscale "mission success" were used as the dependant variable, and the condition assignment along with the poststress indicators from the ADC and EAS were used as independent variables. Table 3 displays the most parsimonious, highly significant model of the three models yielded. R^2 for regression was significantly different from zero, $F(3,19) = 9.07$, $p < .001$, with three variables entered predicting 59% of the variance in performance on mission success (adjusted $R^2 = .524$).

"Overall performance," the subscales taken together, was subjected to a hierarchical regression analysis (see Table 3). Of interest, 88% of the variance in "overall performance" could be accounted for by the experimental condition, along with the postvideo reports of higher energy, more tense, less clenched, less intense, and less restful, $F(6,16) = 19.01$, $p < .001$, adjusted $R^2 = .831$.

DISCUSSION

Advanced simulation-based training environments have the unique ability to produce human arousal and stress, thus offering promising contributions to the field of

training. Current simulations can provide both positive (e.g., entertainment-induced humor, energy, and/or motivation) and negative (e.g., conflict-induced fear and/or aversive physiological reactions) types of stress and arousal for a wide variety of realistic training applications. This ability is beneficial because both positive and negative stress has been shown to enhance skill retention as well as the transfer of training from the simulator to the real world (e.g., Mayer & Volanth, 1985; Williams, 1980). Advanced simulations can provide realistic conditions with stressful emergency situations and dangerously unexpected situations. Simulations, however, specifically developed to provide entertainment (as in OTS games) may inadvertently reduce the negative arousal or stress context that learners must experience during war preparation training. Specifically, simulations that are contextually defined as gaming may threaten training effectiveness in all domains that heavily rely on context-relevant stress and intensity as a formal part of the training (e.g., military, emergency responders). This study addressed the contextual conflicts of using OTS entertaining PC-based games for infantry training. By supplementing an OTS infantry game training session with an intense and vivid video depiction of a front-line infantry battle, we sought to influence the training and outcome performances of exposed participants. The success of the manipulation was confirmed because this experimental group produced significantly higher responses on self-reported stress indicators than the control group who were exposed to the unstressful video analog.

TABLE 3
Results of Regression Analyses*

<i>Variables</i>	<i>B</i>	β	<i>R</i> ²	<i>Adjusted R</i> ²	<i>F</i>	<i>df</i>	<i>p</i>
Hierarchical							
Constant	73.175		.877	.831	19.01	6,16	.000
Condition	13.626	.36					
Energetic	40.809	.994					
Tense	32.302	1.221					
Clenched	-47.962	-1.447					
Restful	-11.288	-.427					
Intense	-13.090	-.400					
Stepwise							
Constant	6.91		.589	.524	9.07	3,19	.001
Condition	5.69	.70					
Energetic	4.14	.47					
Intense	-2.72	-.39					

Note. ADC = Activation-Deactivation Checklist; EAS = Emotional Assessment Scale.

*Results of a Hierarchical Regression Model (The Most Parsimonious) Used to Predict "Overall Performance" from the ADC and EAS Stress Indicators after Entering Condition Assignment and Results of a Stepwise Regression Model (The Most Parsimonious) Used to Predict Performance on the "Success" Subscale When Considering Both the Condition Assignment and the ADC and EAS Stress Indicators

Motivation to Succeed

As expected, the experimental group had significantly higher scores on the post-training measure of "mission success." This subscale was composed of performance-related items such as completing mission objectives, number of hits, and waypoints reached. The scale represents the traditional measurements of gaming performance that are often found in the literature on practice. Conversely, the two groups did not differ significantly on the unique subscales "learned tactics" or "game adaptation." This is of special interest because the items in the "learned tactics" and "game adaptation" scales were associated with specific infantry and game training content (e.g., cover and concealment, use of equipment), whereas the "mission success" scores represented participant's performance or completion of mission objectives. Because initially there were no significant differences between the groups on items such as individual's gaming habits and initial stress, an important conclusion is that the experimental manipulation (stress context-relevant materials) produces more "motivation to succeed" in game training, but may not affect specific skill acquisition per se.

Individual Reactions to Warlike Stressors

The experimentally manipulated group produced significantly higher scores on the self-reported measures of stress overall (both positive and negative forms) as well as subsequent enhancement of mission success. However contrary to expectations, the "overall performance," or the three subscales combined, did not differ across the two groups. An explanation for this comes from similar research that suggests that if individual differences are not accounted for, performance during stressful conditions may yield ambiguous results (Driskell et al., 2001). Accounting for individual differences is important because of the differential reactions of humans to stressors. The average response observed in the "stress group" may not reflect the fact that some individuals were not effectively "stressed." To interpret the results of those participants who were effectively stressed (the manipulation was successful for) on outcome performance, a hierarchical multiple regression analysis was used. Indeed, when adding individual's stress-specific responses to the experimental manipulation, 88% of the variability in "overall performance" (the three subscales combined) was predicted. Specifically, the analysis showed that the 24 participants' overall performance was highest when they were (a) exposed to the supplementary context enhancement (the stress condition) and (b) reported higher motivational or positive stress reactions (higher energy, higher tenseness, less intensity, and less clenched).

Stress Adaptation

Overall performance (including unique measures of actual material trained) is best when exposed to a stressful condition that actually results in higher motivational or

positive stress of an individual in game-based training. The ability of an individual, however, to produce positive arousal under intense conditions varies in the population. It is suggested that individuals who can achieve and maintain an adaptation to these stressors, or are relatively positively influenced by the intensity of war like images, may be the most effective in the pursuit of rapid training and deployment in frontline infantry battle conditions. Performance outcome as a result of stress adaptation has also been supported by other studies. For example, Caterini, Delhomme, Descheumed-Moloinaro, and Dittmar (1995) described human performance outcome to be dependent on the individual's mastery of the stress (lower physiological responses) or adaptation to stimulus-induced emotions. Similarly, Brehm (1999) described adaptation as a motivational state derived by human moderation of emotional indicators. Further experimentation is required to examine the relationships between motivation from stressful conditions and stress adaptation from the conditions in an infantry context. Further research is also needed to seek reliable indices that include realistic warlike stressors and particularly measure types of stress that specific individuals experience as well as their rate of adaptation.

Summary

Advanced graphics and special effects have traditionally been suggested to increase immersion, thereby generating arousal and optimal human learning conditions, yet very little empirical evidence exists regarding the interplay of advanced realism or immersion, contextual arousal, and resultant transfer of training. To our knowledge, this is the first study to report the effects of contextually relevant supplemental material, in the form of warlike stress, to game-based training. The effect of the warlike stressor on game training and performance outcome is interpreted as an increase in performance motivation only. A change in motivation may be inferred because the scores of the experimental group on "mission success" were significantly higher than the control group, whereas the scores of actual training content (e.g., learned tactics and game use) did not differ between groups. Of interest, although increased arousal via movie-like special effects enhanced mission success, possibly through motivation, it may not have influenced specific training and retention as previously expected. At present we are also uncertain as to how long such motivating effects persist. Our experiment shows that short-term persistence is evident; however, whether this effect continues over periods of days and weeks is a phenomena that requires further experimentation.

Alternatively, additional analyses indicated that when individuals were both exposed to realistic warlike stress images and reacted with positive arousal, they effectively retained training and had higher performance scores overall. The optimal training, performance, and retention characteristics associated with response to realistic conflict should be screened for in recruits, especially when there is a need for rapid conflict training. Knowledge of these results can also aid in the design of effective adaptive instructional systems used for a wider variety of recruit charac-

teristics. The addition of context relevant stress, along with feedback from the learners as to the type of arousal occurring during training, can aid systems in adapting the context and motivational aspects to the users needs; we can thus proceed with high-stress contexts-based training at a rate fostering positive human arousal and thus effective performance.

To the present, our work has examined military naïve personnel whose transfer condition consists of SME-evaluated game mission success. With recent world events, it is evident that PC-based game training combined with effective supplementary stress might be used to assist rapid-deployment troops who will face immediate immersion in real world conditions. Although our results suggest this effect on university students, this may not be the case for military personnel. Should these findings be sustained for such personnel, the results can evidence a strong, positive impact on force readiness and response resilience. It is toward such a goal that our on-going work is directed.

ACKNOWLEDGMENT

This work was supported by the Department of Defense Multidisciplinary University Research Initiative (MURI) program administered by the Army Research Office under Grant DAAD19-01-1-0621. The views expressed in this work are those of the authors and do not necessarily reflect official Army policy.

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