Assessing Engagement in Simulation-Based Training Systems for Virtual Kinesic Cue Detection Training

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Abstract. Combat Profiling techniques strengthen a Warfighter's ability to quickly react to situations within the operational environment based upon observable behavioral identifiers. One significant domain-specific skill researched is kinesics, or the study of body language. A Warfighter's ability to distinguish kinesic cues can greatly aid in the detection of possible threatening activities or individuals with harmful intent. This paper describes a research effort assessing the effectiveness of kinesic cue depiction within Simulation-Based Training (SBT) systems and the impact of engagement levels upon trainee performance. For this experiment, live training content served as the foundation for scenarios generated using Bohemia Interactive's Virtual Battlespace 2 (VBS2). Training content was presented on a standard desktop computer or within a physically immersive Virtual Environment (VE). Results suggest that the utilization of a highly immersive VE is not critical to achieve optimal performance during familiarization training of kinesic cue detection. While there was not a significant difference in engagement between conditions, the data showed evidence to suggest decreased levels of engagement by participants using the immersive VE. Further analysis revealed that temporal dissociation, which was significantly lower in the immersive VE condition, was a predictor of simulation engagement. In one respect, this indicates that standard desktop systems are suited for transitioning existing kinesic familiarization training content from the classroom to a personal computer. However, interpretation of the results requires operational context that suggests the capabilities of high-fidelity immersive VEs are not fully utilized by existing training methodologies. Thus, this research serves as an illustration of technology advancements compelling the SBT community to evolve training methods in order to fully benefit from emerging technologies.

Keywords: Kinesic cues, Engagement, Simulation-Based Training.

1 Introduction

Within the current tactical defense climate, Combat Profiling has put forth a critical Intelligence, Surveillance, and Reconnaissance skill set to assist the modern

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Warfighter in threat detection [1]. Combat Profiling skills enhance a Warfighter's ability to maintain vigilance, situation awareness, and perceptual sensitivity of potentially threatening individuals within a combat environment. Combat Profiling training aids Warfighters in adopting a more proactive role akin to a hunter [2]. Rather than reactive post-incident tactics, Warfighters are trained to detect and assess pre-event indicators of potential threats by recognizing anomalies in the environmental and behavioral baselines, thereby, providing pre-incident, preventative, tactical planning.

Kinesics is the study of how nonverbal cues, body motion, and actions convey meaning [3]. In Combat Profiling, kinesics involves the ability to identify and analyze an individual's body language and affect [4]. Whether voluntary or involuntary, kinesic cues convey a great deal of information about an individual (i.e., attributes, motivation, attitude, and status) and the environment. These movements can indicate behavior that is atypical from the baseline and can allude to an individual's emotional state or pretense. Examples of kinesic cues include hand gestures, facial expressions, body language, and posturing.

Traditional Combat Profiling training methods utilize photographs and video footage for initial instruction in identifying behavioral cues of threats within the human terrain [1]. Live role players act out scenarios for experiential learning and profiling practice exercises. Although current methods are successful, limited availability of image and cinematic sources coupled with the high cost of hiring and training live role players restrict the cost effectiveness of widespread training [5]. Furthermore, Combat Profiling training is primarily conducted within the military, but principles of this training are applicable to other domains, such as homeland security and law enforcement.

Emerging research and development efforts have begun to investigate Virtual Environments (VEs) to enrich training of Combat Profiling skills. VEs offer a cost-effective and safe alternative to live environments [6]. An existing U.S. Navy research program is developing a comprehensive Combat Profiling training platform that transitions from computer-based training modules for declarative knowledge to an immersive team trainer for practical application of knowledge and skills [7]. Such efforts are making significant strides to improve the cost-effectiveness and deployability of virtual Combat Profiling training, but also prompt a need for experimentation to identify specific design requirements to improve the quality and effectiveness of virtual training systems. The VE literature indicates that effective virtual training may be affected by immersion and engagement [8]. To promote immersion and engagement, a goal of VEs is to "provide a compelling and effective medium for experiential, 'learn-by-doing'" opportunities [9]. Compelling VEs promote a "willing suspension of disbelief" that separates trainees from the real-world, enabling them to focus more intently on the training experience [10]. Although the body of research concerning simulation design factors that affect immersion and engagement continues to grow, there are still aspects that remain to be explored, refined, or translated to other training domains.

Visually representing Combat Profiling cues within Simulation-Based Training (SBT) systems requires investigation to support hardware and design requirements.

User immersion and engagement offer insight into developing threshold and objective requirements.

The experiment presented is one in a series investigating the role of immersive VEs and dynamic, high fidelity 3D virtual characters in deployable Combat Profiling training solutions. The use of kinesics or body language of virtual characters within a VE was empirically assessed to determine the effectiveness of virtual agent representations. The specific purpose of this research was to investigate the tradeoffs of training kinesic cues using a standard desktop or within a physically immersive VE system.

The following hypotheses were empirically assessed:

- H_1=Participants will experience higher simulator sickness in the immersive VE condition.
- H_2=Presence scores will be higher in the immersive VE condition.
- H_3=Engagement scores will be higher in the immersive VE condition.
- H_4=Technology acceptance subscale scores will be higher in the immersive VE condition.
- H_5=Simulator sickness and technology acceptance subscale scores will be predictors of engagement.
- H_6=Simulation engagement scores will be higher than pre-training engagement scores.

2 Method

2.1 Participants

Ninety students from the University of Central Florida's undergraduate population participated in this research experiment. Stipulations for participation included: U.S. Citizenship, age of at least 18 years old, and having normal or corrected to normal vision. Upon participation of the experiment, class credit was assigned accordingly.

2.2 Experimental Design

This experiment investigated levels of immersion and engagement between two SBT configurations for training kinesic cue detection during Combat Profiling tasks. One configuration used a standard desktop system with a 22-inch display. The second configuration involved an immersive VE known as the Virtual Immersive Portable Environment (VIPE). The VIPE presents high-fidelity visuals on a 120-degree screen standing seven feet high within an enclosed space. Both configurations relied upon Virtual Battlespace 2 (VBS2), the U.S. Army's primary SBT platform. In order to maintain operational integrity, the experiment used VBS2 to supply virtual and constructive elements within the two hardware configurations studied. VBS2 provided tools to visually represent kinesic cues in an operationally relevant manner and the ability to develop customizable scenarios.

2.3 Kinesic Cue Detection

Kinesic cue detection training aims to enhance a trainee's ability to identify kinesic cues such as hand and arm gestures, body language, and posture. Participants viewed pre-training content presented on PowerPoint slides. This included examples and descriptions of six kinesic cues—two cues per target affective state (Table 1).

Table 1. Kinesic cues displayed in experimental testbed

Target Affective State	Lying	Nervous	Aggressive
Kinesic Cues	Rubbing Neck Covering Mouth	Wringing Hands Check Six	Slapping Hands Clenched Fists

The mission environment (Figure 1) simulated a user walking on patrol with the task of identifying kinesic cues displayed and reporting each target's affective state (i.e., nervous, lying, or aggressive). For the experimental conditions, three scenarios were developed to display kinesic cues including desert, suburban, and urban environments. All scenarios were created within VBS2 to emulate real world environments and included general features such as houses, buildings, foliage, people, animals, and vehicles. The desert environment included a non-geo-specific Middle Eastern scene with structures such as construction equipment, trucks, and trees. The suburban scenario consisted of parks, homes, and parked vehicles. The urban scenario reflects a non-geo-specific Middle Eastern setting including businesses, apartments, a playground, restaurants, produce stands, and an industrial area.

Fig. 1. Suburban mission environment displayed on both desktop and immersive VE condition

2.4 Measures

The following measures assessed participants' feedback within the experiment. The Demographic Questionnaire gathers general biographical information from participants including age, gender, video-game experience, and computer competence. The Immersive Tendency Questionnaire is a measure used to determine individual differences in the tendency to become deeply involved, or immersed, in activities [11]. The Simulator Sickness Questionnaire comprises of 16 symptoms designed to monitor participants' health status before and after exposure to a simulated environment [12]. The Presence Questionnaire comprises of 20 items that are related to the participant's perceived level of presence within each configuration [11]. The Engagement Measure is a subjective measure where participants rate their level of engagement [13]. This measure was administered once after the pre-training portion of the experiment (i.e., pre-training engagement) and once after exposure to the simulation environment (i.e., simulation engagement). The Technology Acceptance Measure is used to assess the participant's level of cognitive absorption, or engrossment, while using simulation technology [14]. Several subscales of the Technology Acceptance Measure address aspects of engagement including: temporal dissociation (i.e., unawareness of the passage of time), focused immersion (i.e., disregard for non-simulation distractions), heightened enjoyment, control, curiosity, perceived ease of use, and perceived usefulness.

2.5 Procedure

Upon arrival, the experimenters greeted the participants and each was randomly assigned to the desktop or immersive VE condition. Based on the condition, each participant was escorted by their experimenter to a designated lab area. At the location, the participant was asked to read the informed consent. Following this requirement, the participant was asked to complete the following questionnaires. These include: the Demographic Questionnaire, Immersive Tendency Questionnaire, and Simulator Sickness Questionnaire respectively. After completing the questionnaires, the participant was briefly instructed on how to complete the performance pre-test to follow. The performance pre-test required the participant to view a series of photographs demonstrating the kinesic cues addressed in this research area and attempt to identify the affective state of each cue. The participant then viewed the kinesic cue pre-training PowerPoint presentation. A Training Engagement measure followed the training slides. A five minute break was administered and upon conclusion the experimental condition began. Each participant completed a practice scenario for task familiarization followed by the experimental scenarios. The performance data was logged using an automated computer processing system.

There were three experimental scenarios that each lasted 15 minutes. Following each scenario, the participant completed the Simulator Sickness Questionnaire. After the final scenario, the participant completed the Presence Questionnaire, Technology Acceptance Measure, and the Simulation Engagement Measure. Final completion of the questionnaires was followed by a debriefing. The duration of the experiment was approximately two hours.

3 Results

An independent samples t-test was conducted to compare the immersive tendencies of participants randomly assigned to each condition. Results showed that there was no significant difference in the immersive tendency scores between groups suggesting that the groups are representative of the same population. An additional independent samples t-test was conducted to compare the baseline simulator sickness of participants in each group revealing a significant difference between participants assigned to the desktop (*M*=5.56, *SD*=8.98) and immersive VE (*M*=10.45, *SD*=15.49) conditions; t (77)=-1.71, *p*=0.027, 95% CI [-10.58, 0.80]. There was also a significant difference in the baseline simulator sickness subscale scores for disorientation and nausea, but not for occulomotor issues (Table 2).

Table 2. Results for baseline simulator sickness

	Desktop		Immersive VE		t(77)	*p*	95% Confidence Interval	
Subscale	*M*	*SD*	*M*	*SD*			Lower	Upper
Disorientation	3.23	9.88	8.75	17.56	-1.72	.005	-11.93	0.89
Nausea	3.31	5.22	7.00	12.65	-1.69	.001	-8.05	0.66
Occulomotor	7.05	11.07	11.08	14.63	-1.38	.258	-9.85	1.80

After exposure to the simulation environments, there was a significant difference in the disorientation subscale scores for the desert scenario in the desktop (*M*=7.51, *SD*=17.41) and immersive VE (*M*=19.55, *SD*=32.12) conditions; t (77)=-2.06, *p*=0.042, 95% CI [-23.66, 0.96]. There was also a significant difference in the disorientation subscale scores for the urban scenario in the desktop (*M*=9.69, *SD*=12.91) and immersive VE (*M*=22.03, *SD*=36.14) conditions; t (77)=-2.01, *p*=0.048, 95% CI [-24.55, -0.11]. There was no significant difference in the disorientation subscale scores between conditions for the suburban scenario. However, the descriptive statistics reveal a consistent trend with a lower mean disorientation subscale score for the desktop (*M*=10.77, *SD*=17.73) compared to the immersive VE (*M*=15.73, *SD*=24.89) condition. There was no significant difference in the nausea or occulomotor subscale scores between conditions. Likewise, the overall simulator sickness scores revealed no significant difference between conditions for all scenarios.

Separate independent samples t-tests were conducted to compare the perceived level of presence and the perceived level of engagement in the desktop and immersive VE simulation environments. There were no significant differences between conditions for the perceived level of presence or engagement. However, an independent samples t-test comparing the subscale scores of the Technology Acceptance Measure revealed there was a significant difference in the temporal dissociation subscale scores with higher scores in the desktop condition (*M*=10.72, *SD*=3.87) than in the immersive VE condition (*M*=8.45, *SD*=3.62); t (77)=2.69, *p*=0.009, 95% CI [0.59, 3.95]. A regression model was used to analyze average simulator sickness subscales (i.e., disorientation, nausea, and occulomotor) and temporal dissociation scores as possible predictors of engagement. The results showed that simulator sickness subscales were not a significant predictor of engagement. The temporal dissociation subscale significantly predicted engagement scores, β=0.41, t (77)=3.97, *p*<.001. Temporal dissociation also explained a significant proportion of variance in engagement scores, R^2=0.17, F (1, 77)=15.72, *p*<.001.

Paired samples t-tests were conducted to compare the perceived level of engagement for the pre-training and the simulation for each condition. There was no significant difference between pre-training and simulation engagement scores in the desktop condition. Interestingly, there was a significant difference in engagement scores for the immersive VE condition with higher engagement scores in the pre-training (*M*=26.53, *SD*=4.75) than in the simulation (*M*=25.25, *SD*=5.52); t (39)=2.94, *p*=0.006, 95% CI [0.40, 2.15]. A regression model was used to analyze temporal dissociation scores as possible predictors of engagement in each condition. The temporal dissociation subscale scores significantly predicted engagement scores in the desktop condition, β=0.45, t (37)=3.06, *p*=0.004. Temporal dissociation also explained a significant proportion of variance in engagement scores in the desktop condition, R^2=0.20, F (1, 37)=9.38, *p*=.004. The temporal dissociation subscale scores significantly predicted engagement scores in the immersive VE condition, β=0.41, t (38) =2.79, *p*=.008. Temporal dissociation also explained a significant proportion of variance in simulation engagement scores in the immersive VE condition, R^2=0.17, F (1, 38)=7.79, *p*=.008. Spearman's rho correlations analyzed the correlation between simulation engagement scores and temporal dissociation overall and per condition. Across conditions, there was a positive, moderate correlation between simulation engagement and temporal dissociation, rs (77)=0.091, *p*=0.002. Furthermore, there was a positive moderate correlation between simulation engagement and temporal dissociation in the desktop condition, rs (38)=0.515, *p*=0.001. There was a weak positive correlation between simulation engagement and temporal dissociation in the immersive VE condition, rs (39)=0.306, *p*=0.054. Overall, there were positive correlated relationships between simulation engagement and temporal dissociation within the desktop and immersive VE conditions.

4 Discussion

H_1 predicted that simulator sickness, presence, and engagement would be greater with the immersive VE than the desktop system. The immersive system was anticipated to cause more instances of simulator sickness because larger, immersive displays tend to cause episodes of disorientation, nausea, or occulomotor disruption [15]. Although the results for the disorientation subscale are consistent with expectations, the baseline difference between groups, with the immersive VE group's baseline significantly higher than the desktop group, may have skewed subsequent simulator sickness scores in the experimental scenarios. Contrary to the expectations of H_5, simulator sickness was not a predictor of engagement.

The results did not support the H_2, H_3, or H_4 predictions that presence, engagement, and technology acceptance would be greater in the immersive VE condition. However, H_5 was partially supported with the emergence of the temporal dissociation subscale on the Technology Acceptance Measure as a predictor of engagement. As suggested by results of the regression models, temporal dissociation, or the unawareness of the passage of time, may indicate the level of engagement during a simulation experience. The correlation results suggest that as temporal dissociation increases, the level of simulation engagement also increases.

The results did not provide sufficient evidence for H_6, which predicted that simulation engagement would be greater than pre-training engagement. The level of engagement from pre-training to the simulation did not change in the desktop condition. However, engagement decreased significantly from pre-training to the simulation in the immersive VE condition. Perhaps, this decline in engagement was due to limitations of the experimental testbed design. In order to maintain consistency between conditions, only scenario events that appeared the same on both simulation displays were included. Pre-training content may have caused participants to anticipate a more compelling experience in the immersive simulation, but the scenario constraints for experimental consistency inhibited full utilization of the simulation environment capacity. Future experimentation may assess the effect of scenario variability on the level engagement.

Upon review of the results, it would appear that a desktop simulation system is more engaging than the immersive VE for kinesic cue detection training. However, it would be erroneous to accept such a conclusion without further consideration. There is a disparity in the desktop simulation's ability to simulate a peripheral view of the environment compared to the immersive VE. Perhaps, the forward focus of a flat panel display promotes greater engagement because all visual resources are allocated to the frontal view and not to the peripheral view. This is inconsistent with the operational environment where Warfighters' attention is divided among forward and peripheral lines of sight during patrol missions. Although a desktop simulator may inherently promote engagement, an immersive system, such as the VIPE, may provide more realistic opportunities for training Warfighters to practice observational and attentional strategies to overcome visual limits.

This experiment yields two design implications for SBT of kinesic cue detection with respect to increasing engagement. In his nine events of effective instruction, Gagné identified that instruction should begin with gaining attention and prompting learner expectancy [16-17]. Engagement may elicit attention and expectancy during exposure to new content. Therefore, the forward focused view of a desktop simulator may be appropriate for highly focused initial instruction and practice of observing and identifying kinesic cues in the environment. Once trainees master a basic understanding of the concept, a peripheral view provided by an immersive VE could offer a more realistic level of difficulty, challenging trainees to employ observational and attentional strategies for cue detection. Future experimentation may investigate how to leverage immersive VE system capabilities to train specific observational, attentional, and visual search skills and strategies.

Regardless of the simulation platform, a second implication is that engagement may be maintained by ensuring all phases of training (i.e., pre, during, and post) are designed to be equally compelling. In order to prevent a decline in engagement from one phase of training to the next, training expectations elicited in pre-training should be fulfilled through compelling practice scenarios in the during training phase. Although this experiment did not address post-training, the assumption of this implication is that post-training activities should also include compelling elements or, perhaps, aspects that leverage the compelling features of the pre- and during training phases. This implication needs additional research to investigate strategies to maintain a consistent level of engagement throughout all phases of training.

5 Conclusion

This research paper compared engagement between SBT platforms for virtual kinesic cue detection training of Combat Profiling. Based upon the results, it is evident that software application is dependent upon the operational context and that the current training methods have not utilized such high-fidelity VEs for SBT. As such, research is needed to assess the capabilities of each platform and their ability to effectively train Warfighter's in detecting kinesic cues. Finally, developers of next-generation SBT systems need to consider how differing levels of engagement affect the Warfighter's ability to train effectively within a VE.

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