Using Virtual Environments to Improve Real World Performance in Combat Identification

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ABSTRACT

There is an increased understanding that training in virtual environments will play a key role in future force development (Department of Defense, 2010) – but there is still a need to better understand the interaction between classroom-based learning, virtual exercises to reinforce those skills and force-on-force field training. There is now a widening body of research on virtual environment performance as an effective preparation for force-on-force field training (Roman & Brown, 2009; De Leo, Sechrist, Radici, & Mastaglio, 2010). The question remains how to best use virtual environments to bridge classroom-based learning and the application of classroom acquired knowledge during tactical military execution.

An opportunity to explore virtual infantry training transfer came during Bold Quest 2011 (BQ11), a coalition combat identification event. Four infantry squads received five days of instructor-led Advanced Situational Awareness Training (ASAT) that focused on increasing their situational awareness and improving decision making; a fifth squad did not. Three of the squads who underwent ASAT training and the one squad that did not then conducted two days of virtual environment scenarios focused on training situational awareness and decision making skills in a combat identification environment. All five squads then performed two different, measured and observed force-on-force field scenarios. Our hypothesis was that initial practice in a virtual environment prior to the force on force scenarios would greatly enhance squad exhibition of the knowledge, skills and attitudes (KSAs) associated with the instructor-led ASAT class, as compared to those trainees who did not conduct the virtual missions. This paper is a follow on to Reitz and Reist, 2010, providing the results of the then proposed experiment. It will discuss squad performance throughout the BQ11 training event; provide the results of an analysis of the training transfer between classroom, virtual and field training environments; and propose broad requirements to improve the effectiveness of the virtual environment to support combat identification training.

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INTRODUCTION

There is now an established body of research on virtual environment performance as effective preparation for live military execution (Roman & Brown, 2009; De Leo, Sechrist, Radici, & Mastaglio, 2010). However, there are still significant areas for research on using a virtual environment as an effective bridge between classroom-based learning and live force-on-force training. An opportunity to explore virtual infantry training transfer came during Bold Quest 2011 (BQ11), a coalition combat identification event sponsored by the Joint Staff J8's Joint Fires Division. Combat identification is an area of military operations that relies heavily on both technical and non-technical situational awareness. It is possible that human failures in combat identification can be mitigated by thorough and intense simulation training targeted at the faults that cause the incidents in the first place – communication, cognitive biases, stress, and more (Shrader, 1982; National Audit Office [NAO], 2006; Kulsrud, 2003; Office of Technology Assessment [OTA], 1993).

Our hypothesis during the BQ11 event was that practicing combat identification-related decision making in a virtual environment prior to the live force-on-force scenarios would improve squad exhibition of the knowledge, skills and attitudes (KSAs) associated with instructor-led situational awareness training, as compared to those trainees who did not receive the virtual training and those trainees who received only the virtual training but were excluded from classroom training. This paper is a follow on to Reitz and Reist, 2010, providing the results of the then proposed experiment. It will discuss squad performance throughout the BQ11 training event; provide the results of an analysis of the behavioral training transfer between classroom, virtual and field training environments; and propose broad requirements to improve the effectiveness of the virtual environment to support combat identification training.

COMBAT IDENTIFICATION

Combat identification is the action of determining whether an individual on the battlefield is friendly, enemy, neutral or non-combatant. The U.S. *Department of Defense Dictionary of Military and Associated Terms* (Department of Defense, 2012) defines combat identification as "the process of attaining an accurate characterization of detected objects in the operational environment sufficient to support an engagement decision." The U.K Ministry of Defence takes this a step further, defining combat identification as "the process of combining situational awareness, target identification and specific tactics, techniques and procedures to increase operational effectiveness of weapons systems and reduce the incidence of casualties caused by friendly fire" (NAO, 2006). In this construct, combat identification is achieved through increased situational awareness and accurate target identification.

Situational awareness is an understanding of the location of units, both friend and foe, and the meaning of actions occurring in the environment over time.

Target identification is the accurate characterization of an entity or object sufficient to support an engagement decision.

Combat identification is accomplished through a mixture of human and technology solutions, with the current emphasis placed on technology. (Gadsden & Outteridge, 2006; Shrader, 1982). While combat identification systems can be highly accurate, human operators must typically be relied on to both activate the technology and then accurately interpret the system output. An error in either stage of the combat identification process can yield fatal results.

Accuracy in combat identification, especially for dismounted infantry, is challenging in all combat situations, but the complexity greatly increases when multiple Services from different nations operate in the same environment, each with potentially different weapons, communications methods, rules of engagement, and tactics, techniques and procedures (TTP) for conducting combat identification.

Human Factors

Combat identification technologies have failed to sufficiently afford effective, error-free operation, as they have outpaced the training sophistication of the operators (Shrader, 1992; OTA, 1993; House of Commons, 2007). Because the soldier is the end point in the process of combat identification, there is increased interest in how humans can better utilize combat identification technologies (National Audit Office, 2006). Each source in the literature highlights factors related to humans as the predominant causes for failures in combat identification. Issues include communication failures, poor situational awareness, insufficient training, cognitive factors, misapplication of TTP, misidentification and poor leadership (Gadsden & Outteridge, 2006; Shrader, 1982; Wilson et al., 2007).

While technology has changed quickly, the types of fratricide themselves have not, which is indicative to some researchers that reduction of those incidents will depend on trained skills (OTA, 1993; Greitzer & Andrews, 2010). Instead of focusing on materiel solutions, this research emphasized the importance of training as a method to enhance the application of combat identification. While unseasoned personnel cannot become highly experienced veterans overnight, realistic and demanding situational awareness focused training can alleviate the need to learn all lessons on the ground in the heat of battle. To create true situational awareness, information shared must be rich in important details. Training personnel to quickly recognize what is happening around them and generate that richness of information has been shown to anecdotally enhance combat effectiveness in units which have deployed in recent operations (Spiker & Williams, 2010).

BQ11

BQ11 was a Joint Staff Deputy Director J8-sponsored event focused on improving coalition combat identification. It was conducted at Camp Atterbury Joint Maneuver Training Center (CAJMTC) and Muscatatuck Urban Training Center (MUTC) in Indiana from 6 to 23 September 2011. While past Bold Quest events have been focused on developing and testing material solutions to improve combat identification, Joint Staff Deputy Director J7 for Joint and Coalition Warfighting (JCW) supported an initiative during BQ11 to apply non-material human-effectiveness solutions to improve combat identification. This effort employed a sequence of mutually supportive training initiatives to create enhanced situational awareness and provide a basis for improved decision making (Reitz & Reist, 2011).

Leveraging previous research on the improvements to warfighter performance afforded by programs such as Combat Hunter, Border Hunter, and advanced situational awareness training (Schatz, Reitz, Nicholson, & Fautua, 2010), and the body of work associated with the Future Immersive Training Environment Joint Capability Technology Demonstration (FITE JCTD) (Muller, 2010), a suite of training enablers were offered.

TRAINING CAPABILITIES

The literature on training to close the gaps for combat identification emphasizes the need to create stress and realism. Greitzer and Andrews (2010) suggested that a phased style of training could enhance combat identification by increasing stress steadily through the duration of the training. This stress would, in theory, not cause a decline in performance, as the time-phased structure of the training would inculcate defenses to stress and cognitive biases in the trainees.

The training capabilities presented during BQ11 were a first attempt at identifying a phased sequence of training that could enhance situational awareness and increase combat identification proficiency, as well as overall combat effectiveness.

ASAT

A foundational element of this training was the Advanced Situational Awareness Training (ASAT) course, that focused on building small unit combat observation, profiling and decision making skills. ASAT is a training course similar to the U.S. Marine Corps' Combat Hunter course. Both ASAT and Combat Hunter focus on teaching trainees how to read and react appropriately to changes in the baseline of their environments, in multiple domains, to include human behavior (Spiker & Williams, 2010; Spiker, Johnston, Williams & Lethin, 2010). The version of ASAT conducted during BQ11 consisted of three days of classroom training and two days of observational range practice at MUTC.

Virtual Training

After participating in ASAT training, specific units moved to an immersive virtual training environment prior to live events at MUTC. The virtual technology solution for BQ11 consisted of the same system that had been used during Spiral 1 of the FITE JCTD: the ExpeditionDI wearable virtual system and the game engine software, VBS2. Expedition DI is a man worn immersive system, developed by Quantum3D, Inc. The system is made up of: a wearable computer, a head mounted display system, a motion tracking system, a weapon system, and simulated audio and radio capabilities. The configuration in figure 3 shows two fire teams and a squad leader as they navigated the virtual marketplace training area.

Rather than being a stand-alone demonstration of the state-of-the-art for virtual infantry training, as was done during the FITE JCTD (Muller, 2010), virtual training during BQ11 was part of a focused and integrated effort to demonstrate how human performance in combat identification can be improved by educating and training the participating units through a sequence of mutually supportive human-centric training initiatives. This included utilizing the same terrain for both the virtual and live training.

2 below provide a comparative look at the live and virtual MUTC terrain. The level of fidelity greatly Deputy Director Joint Staff J8 sponsored JCW's development of a very high fidelity VBS2 terrain database of the central portion of the MUTC site. MUTC is an extremely complex urban training environment and, therefore, the virtual environment had to be comparably rich and complex. Figures 1 and increased the units' sense of "presence" as they operated in the virtual environment. That additional fidelity was expected to facilitate the transfer of KSAs between the virtual and live events.

BQ11 introduced a phased transition from virtual training to live training environments, to include a sequence of increasingly complex combat identification scenarios as the units moved from virtual

Figure 1. MUTC Live Marketplace Training Area

Figure 2. MUTC Virtual Marketplace Training Area (running in VBS2).

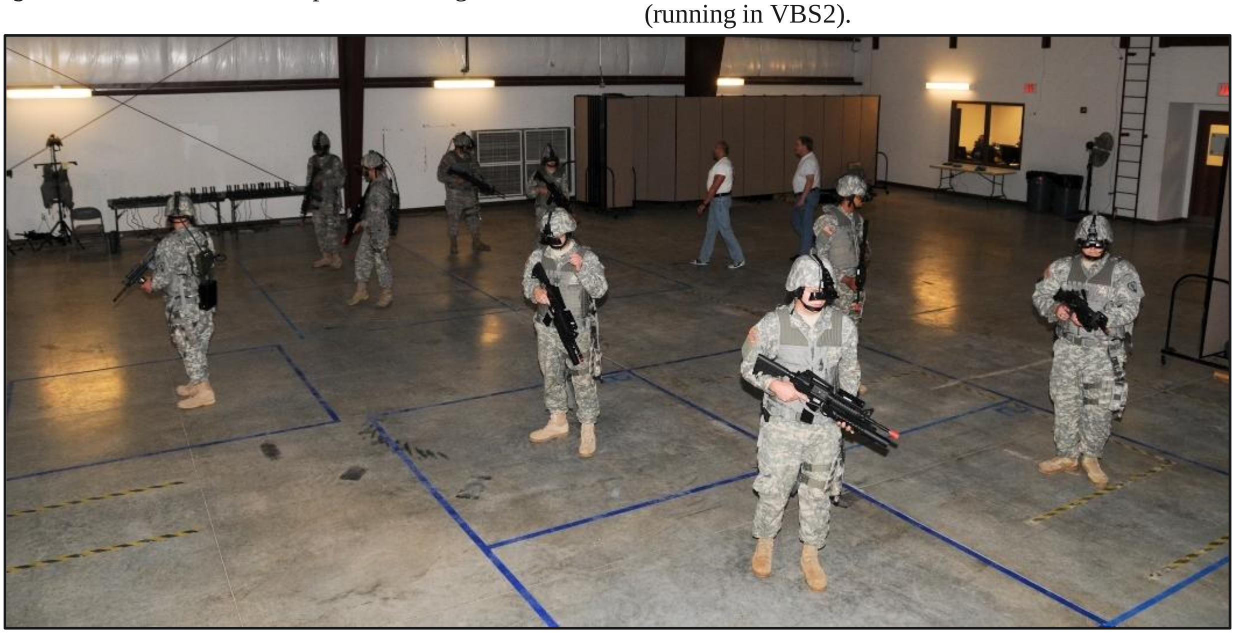


Figure 3. Guardsmen from 2nd Battalion, 151st Infantry Regiment train in the Virtual Marketplace Training Area at Camp Atterbury Joint Maneuver Training Center, Sept. 12. (Courtesy of U.S. Army/Staff Sgt. Matthew Scotten, 2010)

to live. The scenarios all focused on counter-insurgency operations from today's theater of operations. The initial virtual scenario allowed the squads an opportunity to establish the pattern of life norms in a rural village environment and interact with the civilian population. The second scenario involved a squad movement-to-contact to seize an insurgent leader. The two live scenarios conducted at MUTC involved progressively more complex and kinetic operations to exercise combat identification skills under increasing levels of stress. All scenarios, both virtual and live, included specific events and opportunities designed to stimulate the squads to use knowledge gained during the ASAT course.

To improve the transition between virtual and live scenarios, and to increase the potential for training transfer between the two environments, some elements of the exercise control staff played a role in both events. Additionally, background intelligence reports, human terrain in the village and rules of engagement were identical across both domains.

BEHAVIORAL OUTCOMES

During BQ11, one U.S. Army squad from 4-17IN, 1/1AD (SBCT) and four squads from the Indiana National Guard made up the training audience. The entire study group had an average of nearly 6 years of military service, with the army participant group (n=13) having an average age of 26.38; an average of 6.23 years in service; and an average of 1.45 deployments during their career. The National Guard group (n=34) had an average age of 24.68; an average of 5.53 years in service, and an average of 1.04 deployments. Table 1 shows the demographics by treatment group, which includes participants from the larger Bold Quest exercise. The variances between treatment groups were not statistically significant.

Table 1 Demographics of Experimental Plan Participants, by Treatment Group

Treatment	Avg Age	Avg Yrs in Service	Avg. No. of Deployments
All Training (n =29)	25.38	5.93	1.26
No Virtual (n=9)	24.89	6.11	1
No ASAT (n =9)	24.67	4.67	1
No Training (n =33)	26.52	5.85	1.21

Four infantry squads received five days of ASAT; a fifth squad did not. Three of the squads who underwent ASAT training and the one squad that did not then conducted two days of virtual environment scenarios focused on training situational awareness and decision making skills in a combat identification environment. All five squads then performed two different, measured and observed force-on-force field scenarios.

To trace the development of changes in behavior through the training cycle, behavioral observation checklists were used to capture exhibition of the behaviors that were taught in the classroom portion of the training curriculum. This tool was particularly useful in assessing performance while executing the ASAT range days, each squad's time in the immersive environments, and during the force-on-force scenarios. Despite a lack of inter-rater reliability due to the widely spread raters, there was a wealth of solid data recorded for evaluating performance, collected through placement of audio recorders; video recordings of the force-on-force scenarios; and time space positional information (TSPI) provided through the trainees' Integrated Tactical Engagement Simulation System (ITESS) vests. The data collected was excellent for displaying trends in training developments as trainees progressed through the different stages of the training and began to assimilate portions of the training into their usual behavior patterns without being specifically instructed to do so.

KSAs

There are 33 KSAs currently associated with ASAT training. The ASAT KSAs are further organized into six objective areas, which had been observed during previous administration of the training (Spiker & Johnston, 2010a; Fautua, et al, 2010; Gideons et al, 2008).

- Use of enhanced observation techniques
- Identification of critical event indicators
- Interpretation of human behavior cues
- Synthesis of ambiguous information
- Proactive analysis and dynamic decision making
- Employment of cognitive discipline

The KSAs are considered key to improving intelligence flow, and allowing soldiers to act before a threat signal turns into an actual threat.

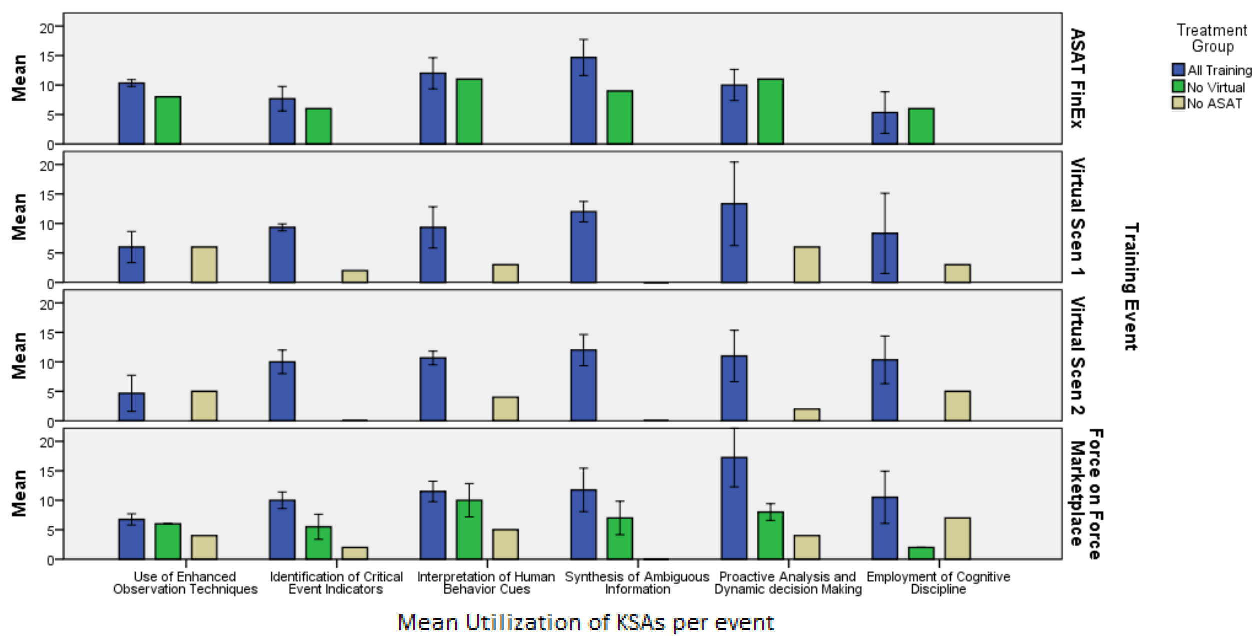
Methods

Behavioral observation checklists are a technique utilized for collecting information during field observations on individual and team performance (Spiker & Johnston, 2010b). The behavioral observation checklist employed was previously utilized at Border Hunter (Fautua, et al, 2010), focusing on the

Table 2 Trainee utilization of ASAT KSAs in scenarios, by treatment group

	Enhanced observation techniques					ID of critical event indicators					Interpreting human behavior cues					Synthesis of ambiguous information					Proactive analysis and dynamic decision making					Cognitive discipline				
Treatment Group	**FE**	**V1**	**V2**	**F1**	**F2**	**FE**	**V1**	**V2**	**F1**	**F2**	**FE**	**V1**	**V2**	**F1**	**F2**	**FE**	**V1**	**V2**	**F1**	**F2**	**FE**	**V1**	**V2**	**F1**	**F2**	**FE**	**V1**	**V2**	**F1**	**F2**
All Training (n=27)	10.3	6	4.7	6.7	7	7.6	9.3	10	12.7	3. 7	8.67	9. 3	10. 7	11. 3	7.3	14.7	12	12	12.5	2. 7	10	13.3	11	16.2	7. 7	5.3	8.33	10.3	10.3	6.67
No Virtual (n=9)	8			6		6			5.5		11			10		9			7		11			8		6			2	
No ASAT (n=9)		6	5	4	6		2	0	2	1		3	4	5	1		0	0	0	3		6	2	4	3		3	5	7	4

**Note: FE,V1, V2, F1 and F2 FE stands for the ASAT final exercise; V1 is virtual scenario 1; V2 is virtual scenario 2; F1 is the Afghan village force-on-force scenario; F2 is the layered house fight force-on-force scenario. Each number is the mean of observed instances of a particular KSA type, within each treatment group.*



**Note: Error bars represent one standard deviation.*

Figure 4 Observed Exhibition of ASAT Skill Groups, through Four Selected Scenarios, by Treatment Group

human terrain profiling knowledge skills and attitudes drawn out of that research, as first portrayed in Spiker and Johnston, 2010a.

The data associated to the observed scenarios was scored twice, weeks apart and under different conditions. Trainees participated in 7 ASAT scenarios, a final exercise, two virtual immersive environment scenarios utilizing the individually worn virtual systems, and two live scenarios, one of which was cleanly linked to the operational world created for virtual environment scenarios. Through the first seven ASAT scenarios, scoring was only available on Indiana National Guard Squad 2, the No Virtual training treatment group, during which data was collected by two independent observers. The scope of those two observers expanded to include squad 3 during the ASAT final exercise; observations on squads 1 and the Army squad during the final exercise were backfilled through the collected radio network traffic. Observations of the virtual and live scenarios were performed during execution of each scenario, and supported through the collected audio and video recordings of each squad's run through the scenarios.

Results

As exhibited in Table 2, the layered house fight did not provide opportunity for trainees to identify indicators of critical events, synthesize ambiguous information, or to exhibit proactive analysis at this point in the trainee integration of the ASAT KSAs into their normal tactical procedures. Unlike the village scenario, which was grounded very tightly to the virtual environment scenario, the layered house fight was a very kinetic scenario, focused on quick shoot-don't shoot decision making. There was little opportunity afforded to the squads to approach the situation with a more thought out response. Each squad performed twice in the village scenario, confronted with structured variations of a hostage recovery in the by then familiar village from the virtual environment. All live force on force performance was further complicated by the fact that all participating squads were aligning their tactical procedures together for the first time.

The results of changes of KSA exhibition over time in relation to each treatment group was statistically significant (Wilks' Lambda .119, $F(10, 16)= 3.047$, $p=.023$, Partial Eta Squared = .656). The between-subjects effects of treatment in regards to the KSA training objectives exhibited were also statistically significant ($F(2,12)=19.429$, $p=.000$, Partial Eta Squared=.764).

Throughout the training event, each squad not only improved in their ability to utilize the KSAs associated with the ASAT body of work, but employed those KSAs differently according to the scenario they were faced with. Compared pairwise, the Army squad performed statistically better than Squad 2, which did not participate in the virtual training, ($p=.023$), and Squad 4, which did not receive any ASAT training ($p=004$) in terms of exhibiting ASAT KSAs throughout the scenarios. Performance by Squad 3 was also statistically significant when compared to Squad 4 ($p=001$).

Scenarios that did not encourage an initial creation of a baseline also did not tax trainees in areas associated with deeper analysis. Yet the differences between scenarios, at least in terms of observed outcomes, were not statistically significant when viewed through a repeated measures analysis of variance (ANOVA).

FUTURE DEVELOPMENT

The data on transitioning classroom taught KSAs to live force on force training events through a virtual environment indicates the utility of virtual environments for reinforcing and sustaining the situational awareness and decision making skillsets taught in programs like Combat Hunter and ASAT. Additionally, the data shows the utility of the virtual environment providing a quick knowledge transfer to those who have not experienced the training, through the use of carefully crafted scenarios aligned with the skillsets.

Recommendations

To increase the realism of the virtual training, especially for more experienced units, several initiatives are proposed for future events using virtual environments to train combat identification skills.

First, participants in the virtual environment need to be subjected to more sensory stimulation in order to increase their cognitive load and improve their sense of immersion. During BQ11 there was little audio and no haptic stimulation available. We have already taken steps to improve audio input by providing higher quality, more realistic and relevant environmental background noise integrated with the scenarios. We are additionally looking at options for better area audio generation, including vortex cannon technology, to complement the individual audio inputs to the trainees and induce more stress into the scenarios. During BQ11, an industry partner demonstrated auditory stimulation capabilities that can induce a significant stress load in the trainees. These same capabilities could augment the existing virtual training environment and greatly improve its ability to create the demanding training environment required to hone combat identification skills. Additionally, we are exploring improved haptic feedback devices to improve realism and the ability of the virtual system to induce a sense of lethal responsibility.

Second, the results also support what we suspected was going to be a pitfall going into the research. In general simulation systems today lack the ability to model human behavior to the fidelity required to fully engage the trainees on the same level they would be engaged while working face to face with a real human. We therefore had to have a live exercise controller drive all interactions between trainees and virtual humans. For the more skilled trainees, this meant that we were unable to provide the realistic human interaction challenges that exist in real world operations and that are required to move past training sustainment and allow trainees to progress in their learning.

Third, using the virtual environment to train combat identification requires training cases that emphasize the cultural environment to provide opportunities for cross-cultural perspective taking. This is so that trainees can start to recognize and correctly interpret cultural cues that may indicate hostility or cooperation. For future events we intend to put an increased focus on the cultural environment, to include requiring the squad to interact with village leaders, providing more realistic human terrain built upon social network data available in the intelligence background, and some exposure to the local language. While greater emphasis on cultural context will require more from the exercise control team, it is nevertheless required to replicate the current operational environment, where complex combat identification dilemmas persist.

Finally, we see the need to expand the joint enabling capabilities available to the squad in the virtual environment. That is, specific capabilities that a squad in today's operational environment has access to, such as remote sensor feeds, close air support and MEDEVAC capabilities, were missing. We are well along on plans to introduce other virtual and constructive simulations to flesh out these missing pieces, to include integrating a virtual Joint Terminal Attack Controller (JTAC) simulator.

CONCLUSIONS

The mutually supportive training capabilities employed during BQ11 provided an initial step towards improving human performance of combat identification by squad and individual-level dismounts. During the period of execution, we were able to identify as many positive outcomes of the training as we did lessons learned – this is enough to warrant more structured research in the future. Where trainees were provided scenarios which were contextually rich and closely mirrored reality – whether in a virtual environment, or in field force-on-force events – the trainees significantly exhibited the classroom-trained behaviors, leading to increases in their ability to sort friends from enemies, and neutral and non-combatant actors. There are many developments which need to be made to increase not just visual realism, but functional realism of the central portions of the training. Despite the previously outlined functional shortfalls, virtual training can be an effective bridge between classroom learning and live training in the development of combat identification skills. Virtual training that is focused on observation and sense-making skills, recognizing and overcoming cognitive biases and developing the ability to deal with stress in a lethal environment can enhance situational awareness and improve decision making.

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