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Distributed Team Training: Effective Team Feedback

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DISTRIBUTED TEAM TRAINING: EFFECTIVE TEAM FEEDBACK

by

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ABSTRACT

The United States Army currently uses after action reviews (AARs) to give personnel feedback on their performance. However, due to the growing use of geographically distributed teams, the traditional AAR, with participants and a moderator in the same room, is becoming difficult; therefore, distributed AARs are becoming a necessity. However, distributed AARs have not been thoroughly researched. To determine what type of distributed AARs would best facilitate team training in distributed Army operations, feedback media platforms must be compared. This research compared three types of AARs, which are no AAR, teleconference AAR, and teleconference AAR with visual feedback, to determine if there are learning differences among these conditions. Participants completed three search missions and received feedback between missions from one of these conditions.

Multiple ANOVAs were conducted to compare these conditions and trials. Results showed that overall the teleconference AAR with visual feedback improved performance the most. A baseline, or no AAR, resulted in the second highest improvement, and the teleconference condition resulted in the worst overall performance. This study has implications for distributed military training and feedback, as well as other domains that use distributed training and feedback.

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CHAPTER ONE: INTRODUCTION

Breakdowns in teamwork significantly contribute to soldier death on the battlefield (Wilson, Salas, Priest, & Andrews, 2007). Among other factors, breakdowns in teamwork have been attributed to lack of soldier experience and poor training. Sound training is a critical part of today's `Army and is imperative to combat success (Fowler, Norfleet, & Basebore, 2003). The United States Army is dedicated to improving training techniques and technologies so that training efforts are optimized, and soldier performance and safety are maximized. Through many years of practice, numerous tried-and-true training techniques and practices have been established. However, external industries have produced advances in training technologies that are disruptive to military training programs (Smith, 2006). Here issues associated with the integration of new technologies for team training will be discussed. Specifically, this discussion will focus on multidimensional characteristics of teams, team training, and the evolution of simulation based training.

Integrating new technology into established team training protocols represents a complex challenge for future developments in team training programs. In regards to team training, the process of integration will require systematic efforts that work to leverage human capabilities and that are accountable for the multidimensional characteristics of teams, and teamwork. With more than 130 models for team performance identified in the extant literature (Salas, Stagl, Burke, & Goodwin, 2007), the development of effective team training programs will continue to garner much attention into the foreseeable future. This investigation focuses on the challenges associated with distributed team training and centers on the role of media platform used during team feedback sessions. The types of team feedback investigated in this study were examined within a simulation-based training methodology that was rendered in a virtual environment.

The robust flexibility of virtual environment (VE) simulation-based training makes it an ideal team training methodology. For instance, the introduction of virtual environments (VEs) has extended training simulations beyond the confines of real-world settings. Virtual environments have gained wide acceptance as a training platform in many fields, such as medicine, law enforcement, and the military. In military training, VEs are particularly useful because they offer an inexpensive and safe way to train many military tasks while increasing training flexibility and accessibility. Moreover, simulation-based training methodologies are proven to be effectual because they allow team members to engage in the dynamic processes (e.g., social, cognitive, behavioral, etc…) of teamwork and receive feedback (Gorman, et al., 2007). Simulation also eliminates the need for elaborate training facilities with large real estate needs and the need for constant instructor supervision (Fowler, Smith, & Litteral, 2005). Additionally, VE simulations can be developed for any situation, or task, and then be reproduced and modified with minimal effort. While many benefits of VE simulations are readily apparent, the implementation of these technological advancements can alter traditional training practices and may confound training effectiveness. Therefore, scientific rigor must be applied in the adoption of new VE technologies so that advancements are leveraged for improvements.

Currently, an improvement in VE distributed networking capabilities has reconfigured how teams can be assembled. Cairncross (1997) coined the phrase “the death of distance” to describe how simple differences in geography will no longer prohibit the training of team tasks, this prediction is now becoming reality. Traditionally, team members had to travel to a common training facility and train together, face-to-face (FTF), on a common task. Now a common geographic location is no longer required as advanced networking allows distributed, geographically-separated, team members to interact in a common VE. Thus, team membership is reconfigured so that physically co-locating is no longer a requirement. Clearly, interpersonal interactions are different for distributed teammates. Allen (1977) showed that team coordination suffered when teammates are only separated by a few feet. In advanced distributed simulations teammate are separated by much greater distances and interactions are mediated via an interface linking software. Designing a software link that fully captures team communications is difficult because teams are social systems with high task interdependencies (Dyer, 1984). A media platform that encourages social interaction during team feedback benefits team training by bolstering shared cognition and improving team cohesion.

Among numerous other factors shared cognition has been identified as a key element in team performance (Salas & Fiore, 2004). Therefore, developing shared cognition between team members during team training is critical for effective team training. Team training that establishes shared cognition among team members for the situation and task environment have increased team performance in high stress situations (Entin & Serfaty, 1999). Moreover, breakdowns in shared cognition have been responsible for poor team performance in high stress situations (Wilson, Salas, Priest, & Andrews, 2007). Team feedback is an important component of current military training protocols and represents the best opportunity for facilitating shared cognition among distributed team members.

Feedback/reflection has been acknowledged as a cornerstone in the learning process by many prominent learning theorists (Beard & Wilson, 2002). In step with this basic learning tenet, the United States Army has established the after action review (AAR) feedback session within its protocol for team training. Currently, it is unclear how the AAR will be conducted for distributed team training exercises. Typically, AARs are conducted in a FTF style with either low, or no, technological aides. Given the dynamics of a distributed simulation, a number of AAR features will have to be modified, similar to the way features of the actual simulation have been modified. The current structure of an advanced distributed simulation consists of live participants, simulations, and an interface linking software to live players. In this structure, the traditional FTF interaction is supplanted with an “interface linking software”, which helps provide a sense of togetherness to team members. The challenge is to choose an interface linking software that will render a platform from which an effective AAR can be conducted for distributed teams.

While the AAR process has high face validity, and is widely accepted, the technique has not been thoroughly empirically tested. Morrison and Meliza (1999) outlined key features of the AAR process, but no specific mechanisms have been linked to training effectiveness; thus, it is not clear which elements of the AAR are necessary and sufficient to ensure training effectiveness when conducting AARs for distributed teams. As training platforms evolve, it has become increasingly important to sustain the effective aspects of current team training practices, and improve where possible. Within the emerging paradigm for distributed team training, there are a number of areas that require investigation. Given the amount of fallow ground in this area, the scope of this investigation was dedicated to feedback because it represents a fundamental aspect in training.

This investigation focused on the role of feedback within a distributed training task. Specifically, three feedback conditions were examined for training effectiveness. Teams’ improvements were tracked across training trials using objective performance measures and subjective self-report measures.

CHAPTER TWO: LITERATURE REVIEW

Military Training

The United States military relies on effective team training to maintain soldier readiness and safety and ensure mission success. Ultimately, training effectiveness is tested on the battlefield where soldiers must be prepared to perform team tasks under extreme stress. A stressful situation where workload is high is debilitating to teamwork and team performance and can undermine even the best team training. Among other battlefield stressors, soldiers are overwhelmed by cognitive demands, such as cue recognition, planning, and decision making (Cooke, Salas, Kiekel, and Bell, 2004). These cognitive impairments are often brought about by loss of sleep, high levels of physical and psychological activity, extended periods of vigilance, and an overwhelming sense of danger (Hancock & Hoffman, 1997). Unfortunately, these aspects of combat are a reality that is unavoidable, so measures should be taken in areas in which we can exercise control. Training is a domain that is controlled and significant improvements in team performance are possible.

Training techniques dedicated to reducing overall cognitive load placed on teams are likely to improve training effectiveness. Research has shown increased shared cognition, or shared mental models, improves team performance. Moreover, research has demonstrated that coordinated teamwork improves when shared cognition is increased through training (Entin and Serfaty, 1999). Training tools, and platforms, that might be useful in facilitating shared cognition are emerging from developments in simulation-based training.

Simulation-based training has garnered significant attention and is widely regarded as a robust team training methodology because of its flexibility. The instructional designer has control over nearly all aspects of the training environment in simulation-based training. This is particularly important for team training because it allows team members to engage in the dynamic elements (i.e., social, behavioral, and cognitive) of teamwork and receive feedback based on team performance (Gorman, et al, 2007). The various types of simulation-based training platforms currently include immersion, game-based training, and live exercises (Morris, Ganey, Ross, & Hancock, 2002; Morris, Hancock, & Shirkey, 2004; Fowler, Smith, & Litteral, 2005). Typically, most simulation-based training occurs in one location, and the training is dedicated to task performance. The new frontier in simulation-based training is raining distributed team members as a team. This new frontier is driven by technological advances in networking capabilities observed in commercial-off-the-shelf video games. This investigation serves as a first step at identifying the necessary elements for effective distributed team training.

Team Training

The development of effective training techniques and technologies for distributed teams must start with a literature review of team research and a definition of “team”. A widely accepted definition of team is, “ a distinguishable set of two or more people who interact, dynamically, interdependently, and adaptively toward a common and valued goal/objective/mission, who have each been assigned specific roles or functions to perform, and who have a limited life-span of membership” (Salas, et. al., 1992, p.4). The construct “team”, as described here, represents a complex dynamic system that requires a coordinated effort between two or more individuals. The development of an effective training program must account for the multidimensional characteristics of “team”.

In a recent review, more than 130 models of team performance were identified (Salas, Stagl, Burke, and Goodwin, 2007). These models explore, and explain, a wide array of team behaviors, processes and mechanisms; however, at least one commonality exists - each acknowledges the multidimensional nature of teams and teamwork. Attention should be given to the multidimensional and interdependent characteristics relevant in team training, for a more detailed review see Salas, Cooke, and Rosen (2008). For instance, teamwork is an important team characteristic that should be considered when developing team training technologies.

No team training method has been shown to be “best” for all situations; however, Klein et al. (2007) reported that approximately 20% of the variance across knowledge, affective, behavioral, and performance variables is accounted for by team training. Developing training methods that account for all elements of team, or teamwork, is difficult because of the inherent complexities in teamwork. Salas, Stagl, and Burke (2004) describe teamwork as a multidimensional dynamic construct that refers to interrelated cognitions, attitudes, and behaviors that occur as team members perform a task that results in a coordinated and synchronized team action. It is imperative that systematic efforts are taken to optimize training for improved teamwork, particularly, because catastrophic results can occur even if only minor disruptions in teamwork occur, as evidenced in a number of accidents in various domains, including aviation (Wiener, Kanki, and Helmreich, 1993). Among other factors that contribute to successful team performance, shared cognition has been identified as a significant factor in team performance (Salas and Fiore, 2004).

Shared Cognition

Some researchers argue that the most critical element in team performance is the degree to which team members have shared cognition, or share a common representation of the team task. The extant literature shows that a shared or team mental model among team members is required for effective team performance (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Converse, Cannon-Bowers, & Salas, 1991).

Mental models are cognitive structures that represent an individual's knowledge about their environment (Johnson-Laird, 1983). These structures represent a network of relationships between concepts for a given domain. Figure 1 shows a possible representation of the concept "dog." Though very simplistic, this model can be expanded to very complex concepts, such as "search and rescue" or "find a target."

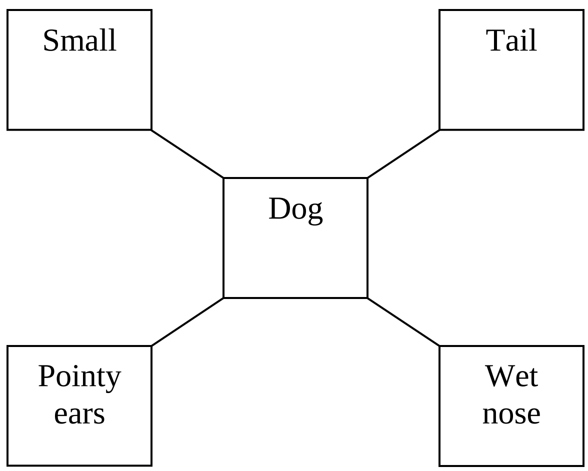


Figure 1. Representation of a mental model for the concept "dog".

Rouse and Morris (1986, p. 360) characterized mental models as, "mechanisms whereby humans generate descriptions of systems purpose and form, explanations of system functioning and observed system states, and predictions of future system states." Understandably, if team members employ similar strategies for perceiving, encoding, and processing information about the current environment, the team is more likely to be successful. Thus, shared mental models are extremely important to shared cognition. Figure 2 shows a representation of shared mental models for the same concept above, "dog." While some parts of the mental models overlap between persons, they are slightly different. When expanded to complex concepts, these differences can become serious errors. In situations like team training for combat, differences in mental models can result in loss of life and national security. During military training, it is imperative that all team members have shared mental models, or a mutual awareness of teamwork.

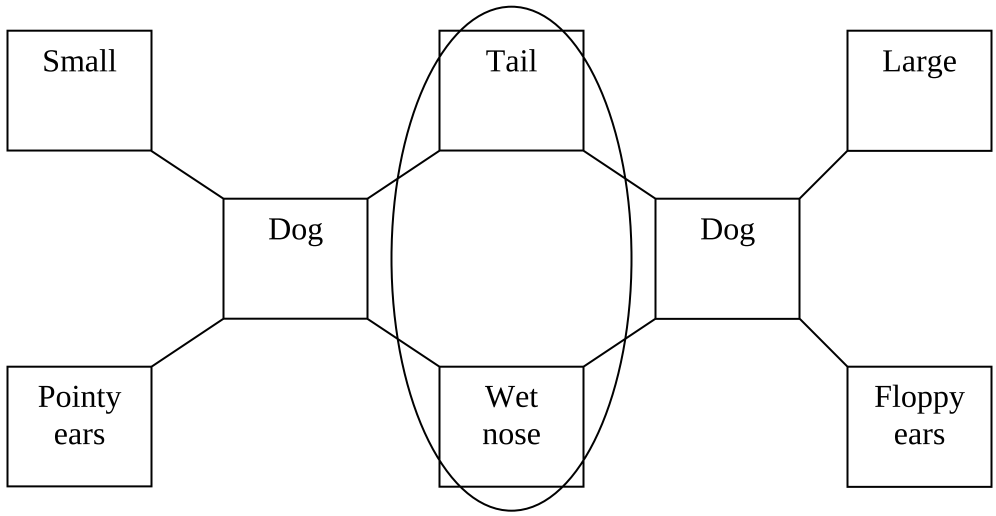


Figure 2. Representation of a shared mental model for the concept "dog".

This investigation focused primarily on the impact of media support during team feedback sessions and the factors that contribute to cognitive load demands. Facilitating good teamwork during training reduces stress by decreasing cognitive demands. When team members have shared cognition of teamwork, they are less preoccupied with communicating strategies and coordinating actions with other team members. The development of team coordination is not a given it requires all team members to make the correct contributions at the proper time (Kozlowski & Bell, 2003). While this is a challenge to accomplish in traditional teams, it is particularly difficult in distributed teams.

Distributed Team Training

Let’s consider the defining characteristic of distributed teams - physical separateness. Physical separateness represents a significant challenge for effective team training, as coordination is diminished by distance. Coordination between team members becomes more difficult when team members are only separated by a few feet (Allen, 1977), so one can imagine the coordination difficulties faced by a team separated by thousands of miles.

The development of advanced distributed simulations has added layers to the difficulties associated with coordination between team members. For instance, communication between distributed team members is mediated via a software linking interface. This mediation changes the context of team training and likely impairs the mechanisms required for effective training. While the context shift is pervasive across all aspects of the team training process, it is especially detrimental to the team feedback process. Among other issues, team interactions tend to be less frequent and spontaneous between distributed team members (Kraut and Streeter, 1995). These impoverished communications impact team feedback sessions (i.e., after action review session) and interfere with training effectiveness for distributed teams.

The majority of communication research in virtual/distributed teams has focused on office meetings within organizations. Anderson, McEwan, Bal, and Carletta (2007) found that communication patterns, across a communication link, are influenced by the number of people sharing each information technology (IT) facility. They showed that cross talk between distributed team members is promoted when each team member is provided their own IT facility compared to situations where multiple team members share one IT facility. Their results showed that when multiple people share a common communication IT facility, those people interacted more with each other compared to interacting with their distributed team member counterparts. Therefore, each team member should be given their own communication facility (e.g. desktop and headphones) during team feedback sessions to encourage communication between distributed team members. Promoting communication is only a first step for improved coordination and shared cognition during feedback sessions, teammates must also share common discussion platform.

Establishing a common ground between team members regarding team roles, team tasks, and strategic planning will be more difficult in distributed teams. The AAR process, which will be described in more detail later, is an exploratory process, and it is structured around the exchange of information. Therefore, the media format that supports the AAR process will need to compensate for the impoverished communications associated with distributed teams. Arguably, shared visual displays are the best format for creating a common ground between team members. Shared displays have been used during team tasks to enhance performance and build shared mental models between team members (Bolstad & Endsley, 2000). Shared visual displays more effectively and accurately represent complex aspects of teamwork. Additionally, they reduce demand on cognitive resources by serving as a memory aid. In turn, team members are able to allocate more attention resources to team performance, and the prospects for effective team training are improved. The successful implementation of an effective team training methodology will be contingent on the appropriate application of technology with respect to learning.

Learning

Learning is a quandary for which a single learning model will likely never be ubiquitously applicable. Many human factors contribute to how knowledge is acquired and applied. For starters, limits on human capabilities restrict how much information can be handled (Miller, 1956), and there are limitations on how much information can be processed dependent on sensory channel input (Baddeley & Hitch, 1974). Moreover, widely accepted theories of mental resource distribution suggest functioning that is bound by relative constraints. Mental resource theories have evolved from a single pool of resources (Kahneman, 1973) to a supply and demand perspective of coordinated multiple resources (Wickens, 2002). In choosing a training tool, we must give serious consideration to how humans process information and choose techniques and technologies that facilitate learning.

Research on the science of learning is replete with theories and models describing how learning occurs. Typically, these theories are presented in a cyclical framework, as outlined by Menaker, et. al. (2007). This framework is as follows:

1) Experience or interact with the environment
2) Observe behavior and reflect on experience.
3) Generalize or form abstract concepts based on reflection.
4) Experiment and add to or modify concepts based on new experiences.

As outlined above, the role of reflection/feedback is relevant throughout the learning cycle. Providing distributed teams with effective feedback presents both a theoretical and a technological challenge. Within the distributed team paradigm, two or more people conduct all team processes while geographically separated. The crux of the problem is determining how to engage the team as a unit so that team members can learn from each other and learn together.

In team training, at least two processes must be considered - the learning process for the individual and the learning process for the team. Each process places some degree of demand, or load, on the mental resources of each team member. As these demands increase, team training effectiveness has been shown to diminish. Team performance effectiveness has been shown to be proportionally degraded by an increase in team training load. Morgan, Coates, and Kirby (1984) showed how team composition has a systematic impact on team performance effectiveness. Team performance effectiveness was best, in their study, when all team members received the same level of training. When team members were operating from the same level of training, the team training load was decreased and performance was improved. Therefore, it is important that team members are trained to the same level, so that team training load is reduced.

Team members can “get on the same page” during the feedback phase of the learning cycle. A team feedback session will allow team members to review actions taken during the mission together. The team feedback session is a comprehensive review in which team members can explore a multitude of topics including, but not limited to, their actions, their teammates’ actions, and the standard operating procedures. Ideally, feedback sessions are focused on a set of issues relevant to the task being trained; otherwise team members would likely become cognitively overwhelmed, and they would be less likely to learn. Thus, cognitive load is yet another factor that must be considered in learning.

Cognitive load refers to the “load”, or amount of processing requirements, placed on working memory during instruction (Sweller & Paas, 1998). Working memory has capacity (Miller, 1956) and processing limitations (Baddeley & Hitch, 1974) that are well researched and are integral during learning. There are three types of cognitive load, which are (1) intrinsic cognitive load, (2) extraneous cognitive load, and (3) germane cognitive load.

Intrinsic cognitive load refers to the inherent difficulty of the specific task (Chandler & Sweller, 1991). This is highly dependent on the task being performed as well as the operators performing the task. Extraneous cognitive load refers to the manner in which information is presented to the trainees. This is the area in which trainers can have the most influence. Germane cognitive load refers to a person’s ability to process and construct schemas. Like intrinsic cognitive load, this is highly dependent on the person performing the task.

According to cognitive load theory, learning is facilitated when the learner is focused on the learning task. The cognitive load theory states that learning is most effective when learners are not cognitively overwhelmed. Clark, Nguyen, and Sweller (2006) suggest that all learners, all content, and all instructional media are pertinent to cognitive load. In other words, cognitive load is mediated through multiple factors, and the amount of cognitive load placed on a team is dependent on each of those factors. Therefore, the choice of instructional media has a significant impact on the amount of cognitive load put on a team. Potentially, there is an optimal instructional media format that reduces cognitive load during team feedback and enhances learning.

Feedback and Learning

There is some debate on the amount of feedback and reflection needed when training personnel on various tasks. There is a general consensus that some feedback, or knowledge of results, is needed, but how much is needed remains to be determined (Salmoni, Schmidt, & Walter, 1984). This speaks to the issue presented earlier, in which the amount of feedback needed to form shared cognition adds an undesirable amount of cognitive load on the team members.

While more feedback over trials usually results in deeper learning when compared to no feedback, different effects have been seen with regard to frequency of feedback. It has been generally seen that when feedback is presented less frequently, learning increases. This is thought to be because as feedback is decreased, team members are forced to attend to other cues in the environment, which may lead to better learning. However, this leads directly to the problem of too much cognitive load. Thus, the theory termed the “guidance hypothesis” states that the learner must have a moderate amount of feedback so he/she will be guided to the correct information without becoming overwhelmed (Salmoni, Schmidt, & Walter, 1984). It is thought that AARs provide a moderate level of feedback to the participant.

Team Feedback Session (AAR)

The AAR process developed and introduced by the United States Army in the 1970's has gained acceptance across many disciplines. Morrison and Meliza's (1999) *Foundations of the After Action Review Process* outlines the standards from which current military and organizational post-action/event review frameworks are based (Knerr, Lampton, Martin, Washburn, & Cope, 2002; Kramer & Sabin, 2002). The AAR is an exploratory feedback session that immediately follows team actions/events. In the context of military training, the AAR is a post-action review of team performance in which soldiers examine individual and team actions. During the AAR, soldiers freely interject comments and voice concerns regarding the previous mission. The AAR is an exploratory review with dynamic processes; however, it is not entirely a free form discussion. Each AAR focuses on three training objectives. These objectives are (1) identify what happened, (2) identify why things happened, and (3) identify how to sustain strengths and improve weaknesses.

While each AAR is not identical, an AAR facilitator systematically leads the AAR with respect to directed objectives. The role of the facilitator is to ensure that relevant issues are addressed during the review session. The facilitator achieves this by prompting the team with questions that are consistent with the threefold approach described above. While the AAR structure is systematic, the AAR content varies with regard to many factors, such as the team's experience level, the current level of performance by the team, and upcoming missions. The AAR facilitator guides the team through the AAR process while the team members generate the talking points. The AAR process provides a comprehensive review of team performance so that learners benefit from both good performance and poor performance, irrespective of performance outcome. Research on elaborative learning has shown that a guided student-generated question format promotes learning when compared to a lecture format (King, 1992). Additionally, the facilitator is responsible for keeping team members on track. The semi-structured AAR format is preferred for training as compared to unstructured, or discovery, learning methods that have notoriously been shown as inefficient and ineffective (Mayer, 2004). The AAR process is most accurately characterized as a guided feedback session that is semi-structured with clear objectives and is used in many domains.

Originally developed to address team performance during combat, the AAR process has been leveraged in training for various types of teams. Work structures within organizations are shifting towards team-based work in which two or more employees, each with a specific role, work interdependently towards a common goal (Salas, Dickenson, Converse, & Tannenbaum, 1992). In response, adaptations of the AAR process often referred to as After-Event Review (AER), can be found in industrial and organizational literature (Baird, Holland, & Deacon, 1999; Busby, 1999; Dwyer, Oser, Salas, & Fowlkes, 1999; Ellis & Davidi, 2005). Many organizations have applied the basic tenets of the AAR process within their team training models.

One such organization is the NASA Goddard Space Flight Center which utilized elements of the AAR process in the development of their “Pause and Learn” (PaL) initiative. NASA implemented PaL because they wanted to maximize lessons learned during their review sessions, “Without a process for learning from every activity regardless of ultimate outcome, we risk missing out on the bulk of the learning from our projects and potentially not really knowing why we actually succeeded.” (Rogers, E.W., 2004/06 p.2). As evidenced by its influence on other team training protocols, we recognize the AAR process as a highly-regarded and practiced process. However, it is an evolving process that changes according to team objectives and is affected by shifts in team training paradigms, such as the shifts in Army training.

U.S. Army leaders are considering new directions for the AAR process in response to the implementation of new training tools, such as VE simulations (Knerr, Breaux, & Goldberg, 2002). While the AAR process represents one element of a training program, it is an interdependent element that will require tailoring as training platforms change. With VE simulations gaining popularity as a team training tool, systematic differences between VE-team AARs and natural-setting AARs are likely to arise. It is important that researchers identify these differences and maximize them when possible. As it relates to the AAR process, VE training simulations offer data capture capabilities that could represent a useful resource, which is especially interesting when we consider:

> AAR aids display the unit's plan (what was supposed to happen), identify "what happened" during the execution, and stimulate player discussions on "why it happened." During these discussions... players learn from their mistakes and benefit from the lessons learned by other players. The AAR, in effect, becomes the bridge between the completed training event and the next training event, providing post-exercise learning on "how to improve" that enables leaders to fix training weaknesses. (Brown, Nordyke, Gerlock, Begley, & Meliza, 1998, p. 12)

Researchers are working toward developing an AAR system that will support training in VE simulations (Jenvald & Morin, 2004; Lampton, Clark, & Knerr, 2003; Knerr, Breaux, & Goldberg, 2002). The design of an effective AAR system should also address issues associated with distributed training simulations. Traditionally, the AAR process includes interpersonal interactions that will need to be bridged. In many ways, this shift is similar to the shift observed in other areas of education. In the past decade, the popularity of the internet has led to a drastic increase in distance learning. Instructional designers developing tools for distance learning environments were confronted with the transition from FTF communication to a communication that is supported by computers. Computer-supported collaborative learning has emerged as a popular instructional design. Initially, computer-supported collaborative learning was met with skepticism - its detractors emphasized only the drawbacks and failed to acknowledge benefits. However, advances in computing power have led to the development of collaboration tools that surpass traditional FTF interactions during instruction. Current collaboration tools allow learners to share ideas and review materials in real time on their computers; in traditional FTF lecture formats students did not have this advantage.

Leveraging benefits observed in computer-supported collaborative learning designs could lead to the development of an effective AAR support tool for distributed team training. Moreover, the development of an AAR support tool may lead to enhancements that would benefit co-located AARs. At this time, current findings suggest that distributed AARs are less valuable when compared to natural-setting AARs. Singer, Grant, Commarford, Kring, and Zavod (2001) demonstrated that a distributed AAR, when compared to an AAR with co-located team members, might be responsible for a decrement in team performance. These findings suggest that further research needs to be conducted to uncover why distributed AARs might cause poorer performance than traditional AARs. However, as observed in the computer-supported collaborative learning example, some advantages might be uncovered.

Identifying these advantages early is important as advances in networking capabilities, observed in the "gaming" industry, will likely encourage distributed team training. An inability to adapt to an external technological advance could have meaningful consequences - "These external disruptions have traditionally made significant contributions to the state of the art…in doing so they have negated millions of dollars in government funding…" (Smith, 2005). Future investigations should be dedicated to uncovering how emerging technologies can be leveraged in the AAR process to promote team training.

The Current Study

Because distributed AARs are projected to gain popularity in the military, this study investigated various levels of media support used during feedback for distributed training exercises. Since there is little research detailing the necessary elements of the AAR process, we established a baseline, or control, condition. The control condition represents a comparison point from which the usefulness of the AAR process can be evaluated. The control condition provided no feedback on performance. Participants were allowed to reread the procedures manual independently following each mission. Beyond the control condition, two experimental conditions were tested (1) the tele-AAR condition and (2) the DIVAARS condition. The tele-AAR condition was structured like a traditional AAR. Team members discussed the actions taken during the previous mission and the discussion was facilitated by a third party. This condition is similar to tele-conferences commonly conducted in offices, where communications are relayed over a phone system. The third condition, the DIVAARS condition, is most similar to computer-supported collaborative learning models commonly used in distance learning. The DIVAARS condition was structured the same as the tele-AAR condition except the review session was supported by a computer-generated playback of the team's mission. In the DIVAARS condition, participants reviewed their performance on a computer screen while they participated in a discussion facilitated by a third party. Through this study, the benefits of various support media were investigated and compared to determine the best methods for training distributed teams.

CHAPTER THREE: METHODOLOGY

Experimental Hypotheses

The extant literature on the science of learning indicates that feedback is among the critical elements of prominent learning models. To date, this element has not been adequately included in game-based training (i.e., distributed VE) instruction (Hays, 2005). Three hypotheses were created to this end.

Hypothesis 1: Distributed team performance is affected by feedback media.

> *Prediction 1.1*: Teams with AARs supported by any communication link will demonstrate better team performance than teams without an AAR.
>
> *Prediction 1.2*: Teams that get an AAR supported by a computer-generated playback with audio communications will demonstrate better team performance than teams that get an AAR supported by audio communications only.

Hypothesis 2: Rate of improvements for distributed team performance is mediated by feedback media.

> *Prediction 2.1*: Teams with AARs supported by any communication link will show improvements in team performance faster than teams without an AAR.
>
> *Prediction 2.2*: Teams with AARs supported by a computer–generated playback with audio communications will show improvement in team performance faster than teams with an AAR supported by only audio communication.

Hypothesis 3: Team feedback session affects teammate perceptions of team interdependency for distributed teammates.

Prediction 3.1: Team cohesion will be higher for distributed teams that receive an AAR supported by either an audio-only or a computer-generated playback with audio communications compared to distributed teams that do not receive an AAR.

Prediction 3.2: Team cohesion will be highest for teams that receive an AAR supported by computer-generated playback with audio communications.

Prediction 3.3: Mutual awareness of teamwork processes will be higher for distributed teams that receive an AAR supported by either an audio-only or a computer-generated playback with audio communications compared to distributed teams that do not receive an AAR.

Prediction 3.4: Mutual awareness of teamwork processes will be highest for teams that receive an AAR supported by computer-generated playback with audio communications.

Experimental Participants

The participants for this experiment were students from the University of Central Florida. Participants were recruited using the Psychology Department’s online experiment system, Sona. Compensation was extra credit for a course of the student’s choice, assigned through Sona, or $20 for the study. There were 66 participants in this study – 31 males and 35 females.

Experimental Apparatus

Dell XPS desktops with nineteen inch monitors were used for the missions, the demographics questionnaire, and team questionnaires. The informed consent and Simulator Sickness Questionnaire (SSQ) were administered via pencil and paper. Standard headsets were used for participants to converse during the missions.

Experimental Tasks

Participants completed team search missions in a virtual environment on a PC. Initially, participants were briefed on the experimental tasks (see Appendix A for an experimental overview). They were instructed to search several buildings together and look for a missing person and key items that may have been left behind by this person (see Appendix B for the mission descriptions that were given to participants). Participants were able to see their team member's avatar in the environment and talk to them through headsets. Additionally, participants were instructed to adhere to a specific set of standard operation procedures (SOPs) while conducting the search (see the team training manual for more detail, Appendix C).

Experimental Design

A 3 (No AAR vs. Tele-Conference AAR vs. DIVAARS AAR) X 3 (Mission 1 vs. Mission 2 vs. Mission 3) mixed factorial design was used to test these experiment hypotheses, see Table 1.

Table 1. Experimental Design.

Training Trial / After Action Review	**Mission 1**	**Mission 2**	**Mission 3**
None	*11*	*11*	*11*
Tele-Conference	*11*	*11*	*11*
DIVAARS	*11*	*11*	*11*
Number of Teams	*33*		

As illustrated here, the AAR conditions represent a between participants variable, where AAR conditions will be compared with each other. The mission trial variable represents the within participants variable, where team performance will be compared across mission trials for each team. The between subjects condition will indicate the relative value of each feedback condition. The within variable will indicate team performance over time.

A power analysis was performed to determine the number of participants for this experimental design. Based on prior research relevant to this investigation an estimated effect size of 0.55 was used with an alpha level of .05 to attain a power of .80 for this design. Research on modality of instructional features for PC-based games reported the following effect sizes in a pairwise comparison; 1.02 for graphics compared to text, 0.77 for speech compared to text, and 0.25 for graphics compared to speech (Belanich, Orvis, and Sibely, in press)

Experimental Conditions

The goal of this study was to address training effectiveness for distributed teams. Teams were trained to conduct a missing person search via a distributed network. Team members participated in a team task within a common VE. Specifically, we addressed the value of feedback for team training effectiveness. To address this issue we evaluated three levels of team feedback, which are as follows: 1) No AAR, 2) Tele-Conference AAR, and 3) DIVAARS AAR.

Control Condition

The first step in evaluating the value of feedback was to establish a no-feedback (control) baseline condition. In this condition, participants were allowed to review a team training manual (see Appendix C). It was important that the participant not be given any directed feedback concerning the mission in which they just participated. For this reason, participants were not allowed to ”review” any specifics of their team’s actions. Participants in this condition were only allowed to review the general SOPs detailed in the team training manual.

Tele-Conference Condition

The next step was to have a condition with specific mission feedback for participants. Compared to the no-AAR condition, this next step allowed participants to discuss the previous training session. In this condition, basic AAR guidelines were followed. The discussions were structured by the AAR facilitator, and participants were allowed to interact via audio communication. This condition represented an audio-only condition of the AAR review process.

DIVAARS Condition

The final condition included the Dismounted Infantry After Action Review System. This condition also followed basic AAR guidelines, similar to the "tele-conference" feedback condition. However, this condition provided a visual playback of the training mission using DIVAARS. DIVAARS is a computer generated playback system developed by the Army Research Institute for the Behavioral and Social Sciences (ARI) in collaboration with the Institute for Simulation and Training (IST). This system provides a functional replay of the mission with DVD like functionality; see Table 2 for a description of some of the system's functionality.

Table 2. System Functionality.

System Functionality	Description
Flexible DVD-like replay of missions/ exercises	- Adjustable speeds for playback and reverse. - Rewind and Fast Forward; 15x - Step Ahead and Step Back; 5 second increments. - Pause
Entity Views - Entity view - Entity top down	 -Entity view allows user to select any entity and view the action from their POV. -Entity top down allows user to select an entity and view actions from directly above that entity.
Group View	- Group view provides a 2-D top down view that automatically tracks the selected group through the scenario.
2-D	- Allows users to view actions from an overhead POV.
Flying (Orbit)	- Flying/orbiting allows user/controller to “fly” through the scenario. User can navigate through the terrain and within buildings.
Tracking (Path Lines)	- This option shows footprints for every step taken during simulation. - Each individual path line has a different color.
Tele-Strater	- Allows users to draw lines or shapes on the visual playback.
Tagging events	- User/controller can save a specified segment of time “event” and can retrieve this event at a later time.
Building Deconstruction	- User/controller selects building and can choose which floor of the building they will view.

This condition represented the most comprehensive level of feedback. In this condition participants were able to ”review” their team’s actions both through discussion and visual playback. The visual playback is a computer generated reproduction of the mission. The playback system does not render the same graphics presented during the missions; however it does reproduce detailed aspects of the missions, such as the mission environment, participant movements, and participant communications (see Figure 3 for a sample screenshot).

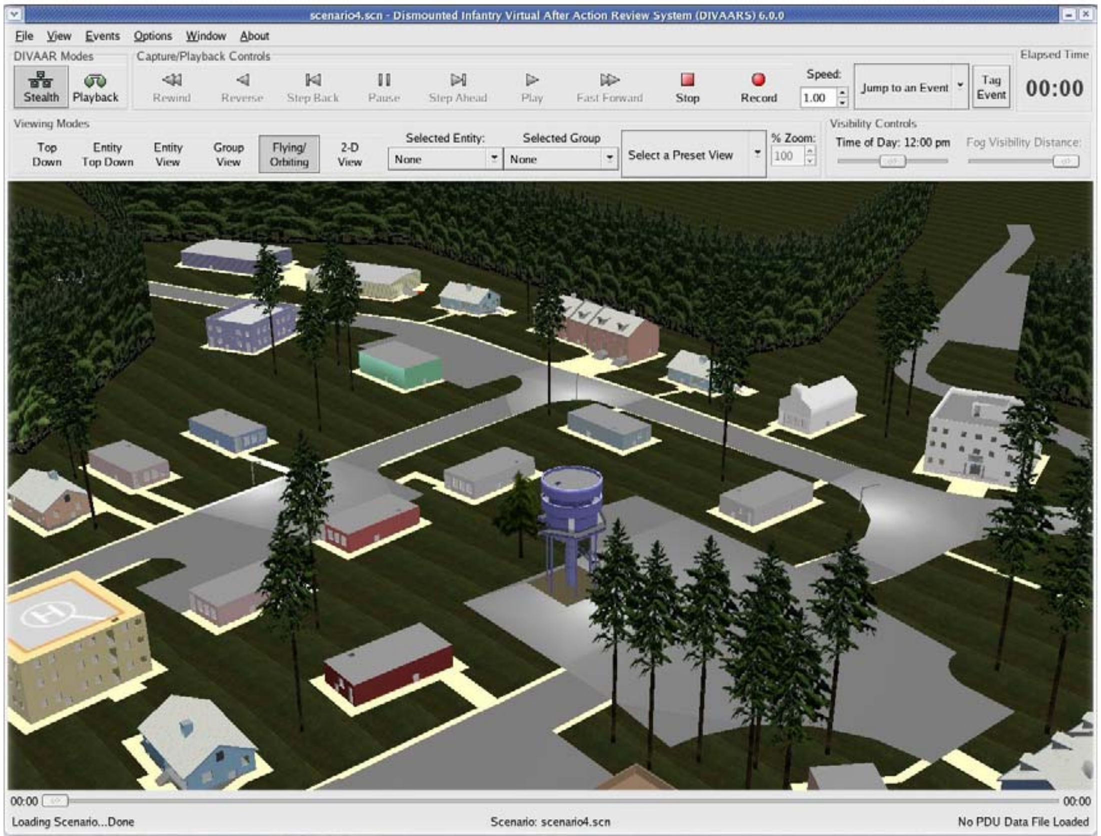


Figure 3. DIVAARS Screenshot of town.

Rationale

The continuum of conditions outlined above is systematically laid out so that at one end there is a control-baseline condition and at the other end there is an elaborate review system. In the middle there is a feedback condition that relies on traditional technology (audio communication).

Performance Measures

Several measures were used in this experiment, including pre-experiment, objective, and subjective measures. A list and short explanation of these measures can be seen in Tables 3-5, respectively. The pre-experiment measures can be seen in Appendices D-F and J-L, and the subjective measures can be seen in Appendices G, H, and I.

Pre-experiment measures were collected to ensure that our sample population was homogenous across experimental condition. A demographics survey was used to collect simple biographical data. A video gaming experience survey was administered to collect data on participant's experience in the gaming domain; this data was used to ensure that measures on performance related data are not misinterpreted. Finally, a knowledge test of mission related standard operating procedures was administered to ensure that all participants had a reasonable understanding of the search task.

Table 3. Pre-experiment Measures.

Demographic (see Appendix D)	*Capture basic background information on each participant.*
Video Game Experience Survey (see Appendix E)	*Measures participant's video-game play experience through self report.*
Knowledge Test of SOPs (see Appendix F)	*5-item multiple choice of the standard operation procedures for a team search task.*

Six objective measures of team performance were included; room count, search accuracy, target item count, target item accuracy, target item identification score, and search technique score. The search count is the total number of rooms that were entered and reasonably searched by at least one team member, each room could only be counted as searched one time. The search accuracy metric measures how well teams searched buildings. This measure is comprised of the total number of rooms searched divided by the total number of rooms in the searched area. The target item count is the total of target items each team found during their search. Target item accuracy is comprised of the total number of target items found divided by the total number target items in the searched area. The target item identification score measured how well teams coordinated during the search task. For this score participants were assigned points for following the SOPs outlined in the team training manual. Additionally, teams were scored on how well they performed the search technique described in the team training manual (see Appendix C).

Table 4. Objective Measures.

Measurement Descriptions	
Room Count	*Total number of rooms searched.*
Search Accuracy	*Total number of rooms vs. Number of rooms missed during the search.*
Target Item Count	*Total number of target items found.*
Target Item Accuracy	*Total number of target items found vs. the number of target items missed during the search.*
Target Item Score	*Measured team performance on a target item identification task.*
Search Technique Score	*Number of times the team successfully demonstrated the "leap frog" search technique described in the training manual.*

Additionally, three self report measures were used to collect various types of subjective data, they include, the simulator sickness questionnaire (SSQ), the team cohesion index, and the teamwork awareness questionnaire. The SSQ was used to ensure that participants were not experiencing excessive levels of simulator sickness while participating in this experiment. This measure was administered prior to any exposure to the VE and following each of the three search missions, if participants reported high levels of simulator sickness they were not allowed to continue in the study. The team cohesion index was used to assess how cohesive teammates felt their team was, this was given after all three search missions had been completed. The team cohesion index consisted of 25 items that were rated using a likert scale ranging from (1-9), where "1"= "Strongly Agree" and "9" = "Strongly Disagree" (see Appendix G) The final metric employed was a measure of teamwork awareness. The teamwork awareness was a four item questionnaire. Participants rated their team using a behaviorally anchored likert scale.

Table 5. Subjective Measures.

Measurement Descriptions	
Simulator Sickness Questionnaire (Kennedy, Lane, Berbaum, & Lithienthal, 1993) (see Appendix H)	*Self-report measure of symptoms related to simulator sickness.*
Team Cohesion Index (see Appendix G)	*Self-report measure of cohesiveness between teammates.*
Teamwork Awareness Questionnaire (see Appendix I)	*Ratings of team members on four dimensions of teamwork processes; Communication, back-up, coordination and information-management, and team orientation.*

Experimental Procedure

Teams consisted of two participants. Upon arrival to the study, participants were randomly assigned, as determined by the flip of a coin, to one of two team roles (i.e., Team Leader, or Forensics Officer). Next, participants completed an informed consent (see Appendix J), demographic questionnaire (see Appendix D), and the Simulator Sickness Questionnaire (see Appendix H). Participants were then trained to use system controls (see Appendix K for a checklist of training objectives). Participants were seated at a computer workstation and were given a chart of the controller functions and they were required to perform each function from the chart at least one time (see Appendix L). An experimenter watched them perform each function to ensure that participants could manipulate controllers appropriately. After the participant demonstrated that they could successfully perform each function, they were allowed to proceed in the experiment. Next, they reviewed the standard operating procedures described in the team training manual (see Appendix C) for eight minutes. Following the training manual read through, participants completed a 5 item multiple-choice knowledge test (see Appendix F) to ensure a certain level of task knowledge. After test completion a researcher reviewed each item of the test with each participant to further ensure that participants understood what was expected of them. Participants then completed three search missions in which one participant was the team leader and one participant was the forensics officer. Each mission lasted for 10 minutes and after each mission, participants completed a Simulator Sickness Questionnaire (SSQ; see Appendix H) and a teamwork awareness questionnaire (see Appendix I). After completing the questionnaires, teams were given a chance to review their performance in one of three ways – through reviewing the training manual, through a tele-AAR moderated by an administrator, or through a DIVAARS AAR moderated by an administrator. All AARs were conducted according to a pre-defined set of guidelines (see Appendix XYZ) and were completed in approximately 6 minutes. Participants in the training manual review condition were given 6 minutes to review the training manual to maintain consistent participant treatment across experimental conditions. After all three missions were completed participants completed the team cohesion index, were debriefed completely, having all their questions answered, and compensated.

Experimental Results

All analyses were conducted using SPSS 11.5 for Windows. The alpha level was preset to .05. An inter-rater reliability of .90, or greater, as determined by Pearson’s correlation coefficient and was observed for rated metrics in this study, one third of all cases were coded by two independent raters.

Hypothesis 1

For hypothesis 1, including predictions 1.1 and 1.2, a series of univariate tests (ANOVAs) were performed on the dependent variables, which consisted of number of rooms searched, search accuracy, target item score, target item count, target item accuracy, and search technique score, for AAR condition. The means and standard deviations can be seen in Table 6.

Table 6. Means and standard deviations of variables in Hypothesis 1.

Variable	Condition	Mean	Standard Deviation
Number of rooms searched	Book	20.970	9.583
	Teleconference	17.667	7.900
	DIVAARS	23.849	10.465
Search accuracy	Book	0.745	0.208
	Teleconference	0.756	0.171
	DIVAARS	0.729	0.215
Target Item score	Book	8.181	4.792
	Teleconference	7.151	5.019
	DIVAARS	8.546	4.988
Target Item count	Book	2.212	1.219
	Teleconference	1.849	1.372
	DIVAARS	2.273	1.329
Target Item accuracy	Book	0.842	0.292
	Teleconference	0.720	0.432
	DIVAARS	0.845	0.281
Search Technique Score	Book	4.273	4.223
	Teleconference	3.576	3.231
	DIVAARS	5.546	3.850

The ANOVA for number of rooms searched showed that there was a significant difference among AAR condition, $F(2, 63) = 3.591$, $p = .031$. An LSD post-hoc analysis showed that participants in the DIVAARS condition searched significantly more rooms ($M = 23.85$, $SD = 10.46$) than those in the teleconferencing condition ($M = 17.67$, $SD = 7.90$), $p = .009$. However, there were no differences between DIVAARS and the baseline condition ($M = 20.97$, $SD = 9.58$),

p = .197, or between teleconferencing and the baseline, p = .172. The average scores and error scores for the variable rooms searched by AAR condition can be seen in Figure 4.

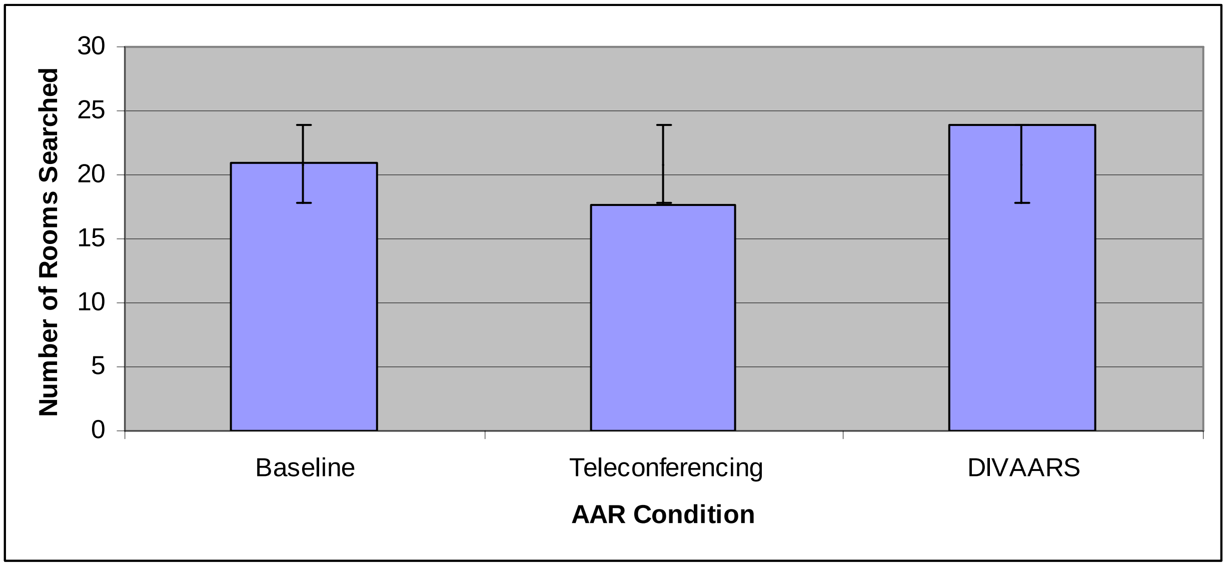


Figure 4. Number of rooms searched by AAR condition.

The ANOVAs for search accuracy, target item score, target item accuracy, target item count, and search technique score showed that there were no significant differences among AAR condition, F (2,63) = 0.584, p = .561, F (2,63) = 0.556, p = .576, F (2,63) = 0.245, p = .783, F (2,63) = 0.814, p = .448, and F (2,63) = 2.523, p = .088, respectively.

Hypothesis 2

For hypothesis 2, including predictions 2.1 and 2.2, a series of univariate ANOVAs were performed on rate of improvement for AAR condition. Rate of improvement was calculated by subtracting the preceding mission score from the following mission score for each dependent variable. All analyses were conducted on the dependent variables, which consisted of number of rooms searched, search accuracy, target item reporting score, target item count, target item accuracy and search technique score. The means and standard deviations of the variables used can be seen in Table 7.

Table 7. Means and standard deviations for variables used in Hypothesis 2.

Variable	Condition	Mean	Standard Deviation
Room count, difference between trials 1-2.	Book	5.636	7.877
	Teleconference	2.456	7.448
	DIVAARS	4.454	8.490
Room count, difference between trials 2-3.	Book	3.090	5.718
	Teleconference	4.727	8.380
	DIVAARS	3.363	10.356
Search accuracy, difference between trails 1-2.	Book	.5306	.11601
	Teleconference	.4249	.24678
	DIVAARS	.4660	.22292
Search accuracy, difference between trials 2-3	Book	.0112	.18866
	Teleconference	.1267	.14881
	DIVAARS	.0361	.19170
Target item reporting score, difference between trials 1-2	Book	.9091	4.48229
	Teleconference	2.00	5.05964
	DIVAARS	3.0909	5.06862
Target item reporting score, difference between trials 2-3	Book	2.2727	5.42385
	Teleconference	1.0909	4.48229
	DIVAARS	.0909	5.41211
Target item count, difference between trials 1-2	Book	.2727	1.27208
	Teleconference	.2727	1.3484
	DIVAARS	.8182	1.32802

Variable	Condition	Mean	Standard Deviation
Target item count, difference Between trials 2-3	Book	.6364	1.28629
	Teleconference	.6364	1.43337
	DIVAARS	0	1.41421
Search technique score, difference between trials 1-2.	Book	2.1818	3.21926
	Teleconference	.9091	2.42712
	DIVAARS	2.7273	3.25856
Search technique score, difference between trials 2-3.	Book	.8182	2.71360
	Teleconference	.7273	3.19659
	DIVAARS	1.6364	2.06265

The ANOVA for rate of improvement in rooms searched showed no significant difference in AAR condition from the first mission to the second, or from the second mission to the third, F (2, 32) = 0.556, p = .579, and F (2, 32) = 0.121, p = .887, respectively

The ANOVA for rate of improvement in search accuracy showed no significant differences in AAR condition from the first mission to the second or from the second mission to the third, F (2,32) = 0.755, p = .479, and F (2,32) = 1.291, p = .29, respectively.

The ANOVA for rate of improvement in target item score showed no significant differences in AAR condition from the first mission to the second or from the second mission to the third, F (2,32) = 0.55, p = .583, and F (2,32) = 0.50, p = .612, respectively.

The ANOVA for rate of improvement in target item count showed no significant differences in AAR condition from the first mission to the second or from the second mission to the third, F (2,32) = 0.629, p = .54, and F (2,32) = 0.78, p = .467, respectively.

The ANOVA for rate of improvement in target item accuracy showed no significant differences in AAR condition from the first mission to the second or from the second mission to the third, F (2,32) = 0.755, p = .479, and F (2,32) = 1.291, p = .290, respectively.

The ANOVA for rate of improvement in search technique score showed no significant differences in AAR condition from the first mission to the second or from the second mission to the third, F (2,32) = 1.067, p = .356, and F (2,32) = 0.379, p = .688, respectively.

Hypothesis 3

For hypothesis 3, including predictions 3.1 through 3.4, a series of univariate tests (ANOVAs) was performed on dependent variables team cohesion and mutual awareness of teamwork.

The ANOVA for team cohesion showed that there were no significant differences among AAR conditions, F (2.30) = 0.58, p = .56, with Baseline (M =3.16, SD = 0.56) Teleconference, (M = 3.51, SD = 0.55) and DIVAARS (M =3.24, SD = 0.69).

The ANOVA for mutual awareness of teamwork showed a significant main effect among the AAR conditions, F (2, 96) = 3.117, p = .049. The LSD post-hoc analysis showed that participants in the DIVAARS condition had better mutual awareness of teamwork (M = 0.39, SD = 0.27) than those in the teleconference condition (M = 0.23, SD = 0.23), p = .015. However, there was no significant difference between baseline (M = 0.30, SD = 0.28) and teleconference, p = .348, or between baseline and DIVAARS, p = .129. The average scores and error scores for the variable mutual awareness of teamwork by AAR condition can be seen in Figure 5.

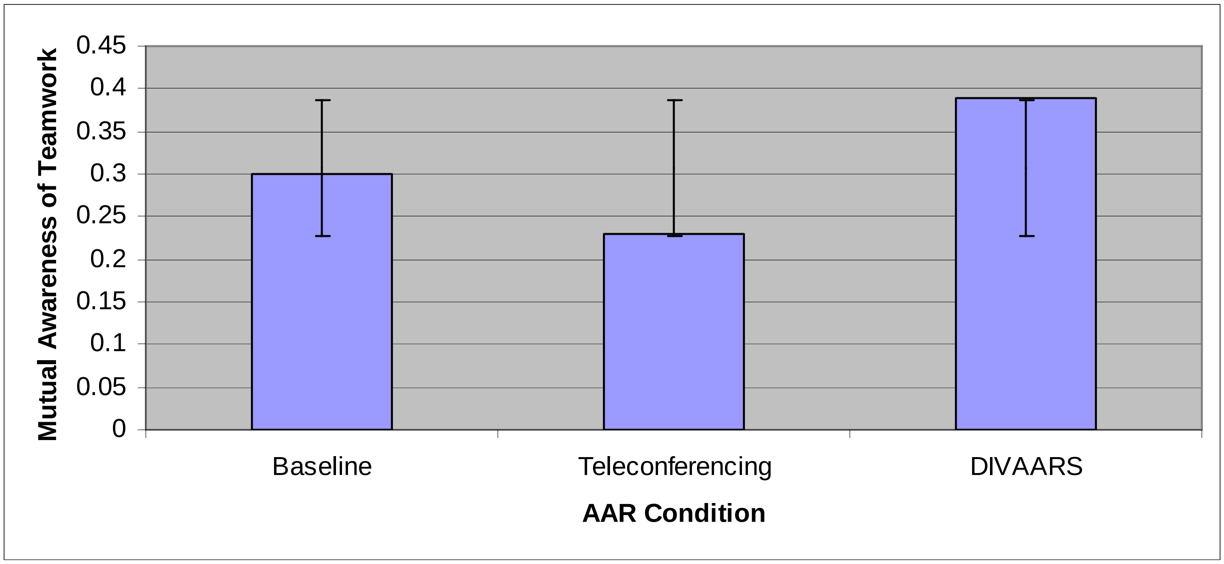


Figure 5. Average mutual awareness of teamwork score by AAR condition.

CHAPTER FOUR: DISCUSSION

Summary

Several of the dependent measures in this study were influenced by the AAR manipulations. Furthermore, two measures out of eight were significantly affected by AAR condition. These results are summarized below by dependent measure.

The dependent measure “number of rooms searched” showed an overall effect by AAR condition, in that participants in the DIVAARS condition were able to search more rooms compared to participants in the teleconference AAR condition. There were no significant differences in number of rooms searched by AAR condition for any given mission number; however, participants increasingly searched more rooms in mission three than mission two. There was no difference in rate of improvement for number of rooms searched by AAR condition. Thus, for number of rooms searched, DIVAARS proved to be a better AAR platform than teleconference, and participants improved as they continued with missions.

The dependent measure “search accuracy” was not affected by AAR condition and there was no significant difference for rate of improvement by AAR condition. Search accuracy improved as participants continued with missions, but no significant differences were observed.

Also, the dependent measure “target item identification score” was not affected by AAR condition, nor was the rate of improvement for target item identification score. The related dependent measure “target item accuracy” was not affected by AAR condition, nor was the rate of improvement for target item accuracy. Additionally, the dependent measure “target item count” was not affected by AAR condition, nor was the rate of improvement for target item count.

The dependent measure “search technique score” showed no overall effect by AAR condition and no difference in rate of improvement by AAR condition were observed.

The dependent measure “team cohesion” showed no overall effect by AAR condition. Finally, the dependent measure “mutual awareness of teamwork” showed a significant difference across AAR condition. In a pairwise comparison, participants in the DIVAARS condition did prove to be better than the teleconference AAR condition at establishing mutual awareness among team members. However, no significant differences in mutual awareness of teamwork were observed between the training manual review condition and the teleconference AAR condition, or between the training manual review condition and the DIVAARS AAR condition. Thus, teammates in the DIVAARS condition demonstrated better shared cognition only when compared to teleconference AAR condition.

As the results show, where there was a difference between DIVAARS and the teleconference condition, the DIVAARS condition resulted in better team performance overall compared to the teleconference condition. However, while better team performance scores were observed for DIVAARS compared to the training manual review condition, no statistically significant differences were observed. Moreover, no statistically significant differences were observed between the training manual review condition and the teleconference AAR condition. These results suggest that media platform used during post-action review affects team training outcomes for distributed teams. These results and the differences seen likely reflect differences in cognitive load associated with each AAR platform. Specifically, better outcomes observed in the DIVAARS condition might be a result of reduced cognitive load because DIVAARS leverages human capabilities associated with information processing. These relationships will be discussed in detail in the following sections.

General Discussion

The current study demonstrated that team training effectiveness for distributed teams is affected by media platform used during post-action review. In this study, post-action feedback was presented in review sessions across three platforms, namely training manual review, teleconference AAR, and DIVAARS - teleconference AAR with a computer generated playback, and the results suggest that media platform is an important factor in providing team feedback for distributed teams.

Team training effectiveness as measured by performance (i.e. number of rooms searched) and subjective rating (i.e. mutual awareness of teamwork) metrics was significantly affected by the media platform used during post-action review sessions. Contrary to research predictions, platforms that allowed teammate interaction during post-action review sessions were not shown to be universally more effective for training distributed teams than non-interactive media. Moreover, no differences were observed for team cohesiveness across AAR conditions. For instance, teams that were allowed to discuss the mission via headsets during teleconference AARs did not outperform teams, or demonstrate greater team cohesion, than teams that had no communication during post-action review sessions. The most common results were for teams with a visual aide as the primary media platform to outperform teams with an audio support aide. In fact, the only significant differences observed were between the teleconference AAR and the DIVAARS AAR conditions, which respectively represent the lowest visual aide support platform and the most comprehensive visual aide support platform. However, these findings do not mean that media platforms that provide visual aides as the primary support are better across the board than media platforms that provide auditory aides as the primary support. Results showed no significant differences on any metric between participants in the training manual review condition (i.e. a visual aide media platform) or the teleconference AAR condition (i.e. an auditory media platform).

The role of media platform during team feedback for distributed team training is not necessarily simple or straightforward. In cases where visual aide media platforms (i.e. training manual review and DIVAARS) were used during post-action review sessions, no significant differences were observed on any metric; however, teams in these conditions did not demonstrate equitable outcomes across all metrics. In considering these results, there appears to be a continuum of team training effectiveness for this study in which team training effectiveness was good, better, and best, represented by teleconference AAR, training manual review, and DIVAARS AAR, respectively. Given these findings, the optimal media platform for providing team feedback appears to be a media that provides both visual and audio aides during post-action review.

These findings supported the primary research hypothesis, and teams that received feedback via audio and visual playback performed better, or as well as other teams. However, these were not the only interesting findings in this study. Also of importance are results concerning learning and team training, as outlined below.

The results indicating improved team performance over training trials in this study are consistent with previous work in learning and team training domains. In both the learning and team training literature, intentional efforts to improve performance with systematic procedures have been observed as effective for improving performance in individuals and teams. For instance, the progressive improvement in team performance across training trials is likely a result of deliberate practice. Deliberate practice is a widely accepted technique for achieving high levels of performance, and even experts can improve task performance through deliberate practice. The effects of deliberate practice are well documented and have a long history in the learning literature (Ericsson, Krampe, & Tesch-Romer 1993). As teams progressed through this study, they were able to practice specific team tasks together, and they gained experience with experiment apparatuses (e.g., system inputs). The impact of this practice is likely responsible for some of the improvements observed from mission to mission. Moreover, improvements observed in teamwork for this study are at least partially accounted for by the systematic team training protocol developed for this study. Previous work in the team training field has revealed that team training does improve teamwork (Morgan, Coates, Kirby, & Alluisi, 1984). While deliberate practice and systematic team training are likely responsible for a portion of the improvements observed in team performance and teamwork for all teams over training trials in this study, the differences observed across AAR conditions illuminate the importance of the media platform used during team feedback for distributed teams, and one of the foremost differences among AAR conditions was cognitive load.

During team feedback sessions, participants in the teleconference AAR training condition experienced greater cognitive load than the two other conditions. Participants in this condition were required to simultaneously perform mental tasks in a more inefficient manner compared to the other training conditions. Specifically, the teleconference AAR condition imposed greater demands on working memory (Baddeley & Hitch, 1974) by increasing the amount of mental resources devoted to mental tasks, such as information retrieval and encoding. For instance, participants in the teleconference-supported review condition were not able to easily reference visual aides, so they had to rely on recall and visual imagery while discussing mission tasks, whereas participants in the DIVAARS-supported review condition had less mental resources devoted to such tasks because a visual playback provided by DIVAARS provided memory support. Thus, participants in the DIVAARS condition had more mental resources available for information processing than those in the teleconference condition, and improved team training outcomes resulted.

Furthermore, the DIVAARS condition had information processing advantages because information was presented over two sensory modes, maximizing processing efficiency (Paivio, 1986). In the DIVAARS training condition, relevant training information was integrated across visual and audio displays, and information presented across two sensory modes has been shown to benefit learning (Tindall-Ford, Chandler, & Sweller, 1997). Moreover, the visual and audio information was integrated into a single presentation, which reduced the negative effects for learning associated with split attention (Mayer & Moreno, 2003).

This means that the hypothesized benefits of the teleconference AAR were outweighed by the extraneous cognitive load associated with the feedback media platform for that condition. The poorer performance measured by fewer rooms searched in the teleconference AAR condition is likely a result of an inferior instructional design and a demanding learning environment. When mental processes are under high cognitive load, there are fewer resources available for learning, and poorer performance may result (Sweller, 1994). Furthermore, the cognitive load associated with the teleconference AAR condition also explains why teammates were not able to establish the same level of mutual awareness for teamwork as compared to teammates in the DIVAARS condition. Establishing mutual awareness of teamwork means that teammates share a common schema, or mental structure, for their environment, and there is a common set of expectations for future work (Gick & Holyoak, 1983). Given the detrimental effects of high cognitive load on learning, it is understandable that teammates in the teleconference AAR condition would not be as effective in schema acquisition when compared to the DIVAARS training condition.

The three types of cognitive load previously discussed should be discussed with regard to the results of the current research. Regarding intrinsic cognitive load, the DIVAARS condition likely had the least amount of intrinsic cognitive load because it supported cognitive processing by providing a visual memory aide that can be used to break feedback down into integrated manageable segments, whereas the teleconference condition had a greater intrinsic cognitive load because it is difficult to compartmentalize feedback without a visual aide. Likely this explains why no statistically significant difference was observed between the training manual review condition and the DIVAARS review condition. Participants in the training manual review condition had the most amount of intrinsic cognitive load during the review process, so they more effectively managed their time. Participants in this condition could self-select a review topic and reduce the intrinsic cognitive load during the review process.

Regarding extraneous cognitive load, the training manual and DIVAARS conditions provided visual aides as the primary reference, and they typically performed better than the teleconference condition. Consistent with Cognitive Load Theory (Sweller and Paas, 1998), access to instructional materials likely reduced the cognitive load, compared to the teleconference condition, on the learner and resulted in better scores on team performance metrics. Having access to instructional material was better suited for learning these tasks than not having it, which is why performance in these conditions was better than the teleconference condition. Thus, for these types of tasks, the teleconference feedback sessions proved to be less suitable for training distributed teams than the training manual (baseline) independent review sessions and the DIVAARS feedback sessions.

Regarding germane cognitive load, the search task trained in this experiment required participants to coordinate as a team and perform tasks that required synchronized movements, but the participants in this study were novices in the domain, so they did not have well defined schemas for search tasks. However, it was likely easier for participants in the training manual and DIVAARS conditions to adjust their search schemas, as they had visual aides and were able to easily focus their attention on areas in which they had questions. However, participants in the teleconference condition had no visual aide, so they might have been attempting to change their schema in an area different than the AAR, thus causing a conflict and more cognitive load.

While cognitive load and its subtypes are vitally important to understand the results of differing media platforms in this experiment, there is another equally important area to be reviewed, which is the media platform themselves.

In this study, participants in the DIVAARS condition were exposed to the most comprehensive form of team feedback. The DIVAARS media platform presented mission review materials through both visual and auditory displays. Participants were able to watch their actions as rendered by a computer-generated playback, listen to mission communications, and discuss the mission with teammates during the AAR. This comprehensive feedback platform appears to benefit team training for distributed teams in variety of ways.

The DIVAARS media platform improves both task performance and shared cognition for distributed team members. Teams in the DIVAARS condition searched more rooms than teams in any other condition, and teammates in the DIVAARS condition demonstrated a greater amount of shared cognition than teammates in other conditions. While no significant differences were observed among AAR conditions for other team tasks, it is important to note that the primary team task (i.e. number of rooms searched) was affected by media platform used during post-action review sessions. Additionally, the improved ability of teammates to establish a greater mutual awareness of teamwork in the DIVAARS condition is significant.

Finally, the importance of shared mental models in teamwork is well researched and has been identified as a significant factor in team performance (Salas & Fiore, 2004). Many researchers agree that shared, or team, mental models are required for effective team performance (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Converse, Cannon-Bowers, & Salas, 1991). Results in this study indicate better shared cognition for teams that received post-action review through a media platform that displays feedback over visual and auditory displays. These findings represent an important step in establishing an instructional framework for distributed team training. Interface development for team feedback should include visual and auditory displays when attempting to establish shared cognition for distributed teams.

Implications for Training Design

This study compared different media platforms for team feedback during distributed team training, and many implications for the design of distributed team training can be gleaned from it. These implications should be strongly considered when developing any type of team training, particularly distributed team training in the military. The implications derived from the results of the study are summarized below.

First, this study showed that instructional designers should integrate visual and audio instructional media when possible. The findings in this study showed improved team performance and shared cognition for teams that used an integrated media platform during team feedback.

Second, this study showed that VE simulation-based training can be used to improve team cognition and team performance. Deliberate practice is well regarded as a mechanism for achieving expert performance (Ericsson, Krampe, & Tesch-Romer, 1993). This study showed that practice in VE could improve team outcomes for distributed team members. The improved shared cognition observed in this study is significant because shared cognition is critical to team performance and because shared cognition is likely to transfer in real world settings.

Lastly, this study showed that mutual awareness of teamwork is important to successful search missions. Given the distributed and ad-hoc teams that are currently present in the military, it is often hard to establish a feeling of “team” among members. This study showed that an effective post-action review can increase mutual awareness of teamwork. Thus, a post-action review session should be included in training protocols for teams with novice team members.

If these recommendations are followed when designing distributed team training programs, team performance should improve. While these recommendations can be generalized to many domains, including law enforcement and aviation, they would especially benefit the military.

Future Work

Future work in distributed team training should build on what was demonstrated in this current research. While all results from this study were interesting and useful, there is one area that needs further investigation, namely shared mental models for distributed teammates. This current study showed that mutual awareness of teamwork can be improved for teams comprised of novice teammates, the next step is to investigate teams comprised of expert teammates.

Participants in this current study were unfamiliar with the team tasks being trained and had ill-defined mental models for these tasks. In contrast, many teams (e.g., military teams) are comprised of teammates that have substantial domain knowledge and/or have received significant training in that domain. Research dedicated to training expert teams, like teams found in the military, would move distributed team training research into new directions and lead to the development of improved team training protocols. Future team training protocols could be tailored for teams with varying levels of domain knowledge.

Additionally, the high degree of intrinsic cognitive load associated with learning a new domain in this current study may have minimized the impact of the experimental manipulation, and this would likely not be true of teams of experts. While experts certainly have intrinsic cognitive load, they typically experience fewer cognitive demands from intrinsic cognitive load, thus, another reason researchers should investigate teams of experts.

Future research with well established teams should explore the affects media platform may have during team feedback. More established teams may require different levels of media support for distributed training. Expert teams will likely show different patterns of results compared to the teams in this study, and understanding these differences will benefit research in this area.

APPENDIX A: EXPERIMENTAL OVERVIEW

Experiment Overview

This experiment will be conducted using a PC-based simulation. You and another participant will be trained to conduct a missing persons search according to specific rules. This experiment will last approximately 120 minutes and will follow the following outline:

- Initial gathering of participant data
    - You will complete a demographics questionnaire, evaluation of PC-based game playing ability, and other surveys.
- Participant training
    - Game controller familiarization. Here you will practice using the controllers (keyboard and mouse) for this simulation.
    - Training manual read-through (with a follow-up quiz) which describes how to conduct a proper missing persons search for a two-person team.
    - Three training missions conducted in a virtual environment. You will participate in a team search task with another trainee (participant) This participant will only interact with you via PC media. The other participant will receive the same training as you.
    - Following each VE training mission you will complete a couple self-report surveys and then participate in a mission review session.
    - Post mission review session. Following the first two missions you will review relevant search task materials.
    - Following the third and final mission you will complete a few self report measures.

Mission Overview

You will serve as a member of a two-person team that searches for clues left behind by a missing person. A team consists of a Team Leader (radio call sign “Green 1”) and a Forensics Officer (radio call “Green 2”). Your team reports to an off-site Incident Commander (radio call sign

“Sierra” pronounced SEE -AIR-AH). The Team Leader will be responsible for reporting to Sierra during missions.

Before the mission starts you will be given a map of the area you are to search and told what clues to look for. A mission starts near a truck that has transported you to the general area to be searched. The Team Leader will use the “right turn rule” guideline described in the training manual to determine which building to search first. Use the “right turn rule” and “leap frog” guidelines to determine the order in which to search the rooms within a building, and which team member searches which room. The Forensics Officer will have access to a time display and will watch the mission elapsed time. Use your judgment as to when to head back to the truck so that Green 1 can radio Sierra that the team is back before or right at the 10 minute mark.

Good Luck!

APPENDIX B: MISSION DESCRIPTIONS

Mission

An Alzheimer's patient (see photo below) has gone missing in Myer Town. He is an elderly man and was last seen carrying a briefcase (see photo below). The briefcase is considered a "target" item for this search.

Reference the map pinned up to the right of you. Your assigned area of responsibility for this search is sector 1 which includes buildings; 11, 12, 41, 42, and 43. Your team's start location is denoted on the map with the letter “A”. Green 1, you will be responsible for choosing which buildings to search first and you will lead your team through this search sector. Green 2, a digital clock display is positioned to the right of your monitor. Green 2, you are responsible for keeping track of elapsed time. The elapsed time will automatically begin at the start of the mission. Green team, you have exactly 10 minutes to search as many buildings as possible and be back at location “A” from the time Sierra says, “Green team, begin mission”.

Good Luck!

APPENDIX C : TEAM TRAINING MANUAL

BUDDY SYSTEM RULES

- *Rationale*: Good teamwork is imperative when conducting a search. Search areas are potentially dangerous and searching alone is not permitted. Each team member is responsible for maintaining a safe team distance, a safe distance is defined by the following rules.

- *Rules*:

  - Team members will not exceed 20 feet of separation during outside movements.

  - Team members will never search any building alone.

  - Teammates will always be in rooms, or common areas, that are adjacent to each other.

BUILDING TAG RULES

- *Rationale*: Multiple teams might (accidentally) be searching the same area at the same time, and this presents opportunities for several types of mistakes. Primarily it becomes difficult to know if a building has already been searched, or if a building is currently being searched. To overcome this issue, buildings will be systematically "tagged". Teams will "tag" buildings according to these rules.

- *Rules:*

- All buildings will be entered and exited through the same doorway.

- Before entering a building the Team Leader will mark an exterior wall near the building's doorway with a red spray tag.

- After exiting each building (even a partially searched building), the Forensics Officer will mark an exterior wall near the doorway with a green spray tag.

- When the team exits a building, the Team Leader will report to Sierra. This report should include building number and the status of the building

  EXAMPLE: Team Leader, "Sierra, building 99 is cleared"

  If the building exited has not been searched completely, the Team Leader should report that the building was partially searched.

  EXAMPLE: Team Leader, "Sierra, building 99 has been partially searched"

BUILDING/ROOM SEARCH RULES

- *Rationale:* Coordination and cooperation during a missing persons search is important. Making the wrong choice can have costly consequences, such as, wasted time, rooms getting searched more than once, and/or some un-searched rooms. Here we outline rules for conducting a proper search within a building by a two-person team.

- *Rules:*

  - The RIGHT TURN RULE:

        - The Right Turn Rule is a common rule of thumb used during searches. According to the right turn rule, whenever there is a choice of direction, the searcher will always choose to turn right. This helps organize a search, so that fewer mistakes are made.

    - Application of the Right Turn Rule:

        - Once the team enters a building, the Team Leader will lead the team, in single file, through the building using the Right Turn Rule.

            - EXCEPTION to the Right Turn Rule: Do not use a staircase until the entire floor has been searched.

        - Every room within a building should be searched.

        - Each room will be searched using the Right Turn Rule by either the Team Leader, or the Forensics Officer.

    - The LEAP FROG RULE:

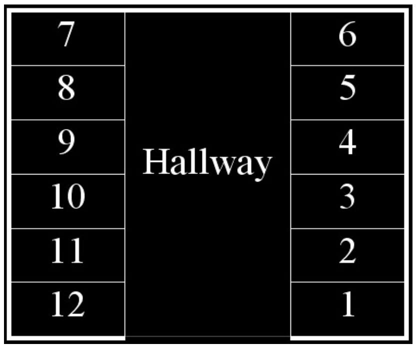
        - Rooms within a building will be searched using a search pattern, which is comparable to the children's game "Leap Frog". Similar to the game, a team member can "jump" past another team member to search the next un-searched room. Team members can only "jump" to the next un-searched room if another team member is searching a room next to that un-searched room.

    - Application of the Leap Frog Rule:

        - The first room will be searched by the Team Leader, and then the Team Leader searches every other room from that point forward.

        - The Forensics Officer will search the second room, and then every other room from that point forward. See example in Figure 1:

Figure 1: Sample floor plan



According to the above search rules, this floor plan would be searched as follows. The TL would search rooms 1, 3, 5, 7, 9, and 11, while the FO searched rooms 2, 4, 6, 8, 10, and 12.

- After a room search has been completed, teammates should inform each other that the room is clear.

- Remember to adhere to the Buddy System Rules. Teammates should maintain a safe team distances while searching. (example, reference Figure 1):

    - If the Team Leader is in room 5, the Forensics Officer could be in room 4, or room 6, but no further separation is allowed.

    - Additionally, teammates should not be separated by common areas (e.g. hallways, foyers, patios, etc…). While the Forensics Officer searches room 6, the Team Leader should not proceed to room 7 until the Forensic Officer's search is complete.

- Search Tips
    - Remember to search all possible areas. Often items or people are found in unusual places (e.g. behind furniture, under furniture, on top of furniture, etc…).
    - Request help when needed. Some areas within a room are not easy to search by one person. If an area is complicated you can ask a team member for assistance.

KEY ITEM RULES

- *Rationale:* During a search the primary goal is to find the missing person. In achieving this goal it is important to also be looking for key items that might be helpful. Sierra will provide descriptions of key items for each search. If a key item is found the item should be reported to Sierra.
- *Rules:*
    - Only report key items that are specified by Sierra.
    - When one team member locates a target item (for example the missing person's briefcase), call the other team member to that location to confirm the key item.
    - While both team members have eyes on the item, the Team Leader (Green 1) will radio the Incident Commander (Sierra) to report the building number where the item has just been found. When a key item is found both teammates should stand-by for instructions from Sierra.

This training manual outlines the necessary procedures for conducting a proper missing persons search. The rules and strategies outlined here should be followed as closely as possible. Among other things, time is a key element during a missing persons search. Please move as quickly as possible during this search.

APPENDIX D : DEMOGRAPHIC QUESTIONNAIRE

Demographics Questionnaire

Participant # _______ Date ___________

Age _________ Major ____________________________________ Gender : M / F

1. What is the highest level of education you have had?

Less than 4 yrs of college ____ Completed 4 yrs of college ____ Other ____

2. When did you use computers in your education? (*Circle all that apply*)

Grade School Jr. High High School

Technical School College Did Not Use

3. Where do you currently use a computer? (*Circle all that apply*)

Home Work Library Other________ Do Not Use

4. Which of the following best describes your expertise with computer? (*Check only one*)

_____ Novice

_____ Good with one type of software package (such as word processing or slides)

_____ Good with several software packages

_____ Can program in one language and use several software packages

_____ Can program in several languages and use several software packages

5. Are you in your usual state of health physically? YES NO

If NO, please explain: ____

____

____

____

6. How many hours of sleep did you get last night? ______ hours

7. Do you have normal color vision? YES NO

8. Do you have any hearing loss, visual impairment (other than color blindness), or motor difficulty that may affect this experiment? Y / N

If YES, please explain: ____

____

____

____

APPENDIX E: VIDEO GAME EXPERIENCE

Video Game Experience Measure

1. What is your level of confidence with video games in general?

1	2	3	4	5
Low		Average		High

2. How many hours per week do you currently play video games? ______ hours per week

3. What is the maximum number of hours per week you've ever played? ____ hours per week.

4. About how many times have you read a video game magazine or website to find out tips to improve your gaming skill? _______ times

5. How often do you play:

Adventure - Graphical (Myst, Fable)	Daily – Weekly – Monthly – Rarely - Never
Adventure - Text-based (ZORK)	Daily – Weekly – Monthly – Rarely - Never
Puzzle (Minesweeper, Tetris)	Daily – Weekly – Monthly – Rarely - Never
Racing (Need for Speed, Test Drive)	Daily – Weekly – Monthly – Rarely - Never
Role-playing (Final Fantasy)	Daily – Weekly – Monthly – Rarely - Never
Simulation (Flight Simulator, Trains)	Daily – Weekly – Monthly – Rarely - Never
Sports (Madden Football, FIFA Soccer)	Daily – Weekly – Monthly – Rarely - Never
Strategy Real-time (Age of Empires)	Daily – Weekly – Monthly – Rarely - Never

Strategy - iTurn (X-Com: Apocalypse)	Daily – Weekly – Monthly – Rarely - Never
First Person Shooter (FPS)	Daily – Weekly – Monthly – Rarely - Never
Multiplayer (World of Warcraft)	Daily – Weekly – Monthly – Rarely - Never
Online	Daily – Weekly – Monthly – Rarely - Never

6. List your recent favorite 5 game titles in the blanks and then indicate your experience with each game:

(circle one) None Very little Average High Expert	(circle one) None Very little Average High Expert	(circle one) None Very little Average High Expert	(circle one) None Very little Average High Expert	(circle one) None Very little Average High Expert

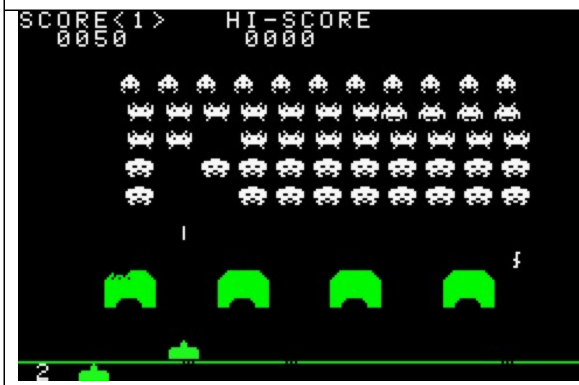
7. Indicate your experience with the following types of game controllers:

a. 	b. 	c. 	d. 	e. 	f. 
(circle one) None Very little Average	(circle one) None Very little Average	(circle one) None Very little Average	(circle one) None Very little Average	(circle one) None Very little Average	(circle one) None Very little Average

High	High	High	High	High	High
Expert	Expert	Expert	Expert	Expert	Expert

8. Look at the following screenshots of video games and answer the questions for each:

	A. Which controller from question 7 above would you most likely use with this game? _______ B. If you were controlling the character on the right, what controller actions would you perform to defeat the enemy (button press, joystick movement, etc.)?______________________________ C. Would your enemy most likely be controlled by the computer or another person? ___________________ D.
	E. Which controller from question 7 above would you most likely use with this game? _______ F. If you were controlling the character facing you, what controller actions would you perform to defeat the enemies (button press, joystick movement, etc.)?______________________________ G. Would your enemy most likely be controlled by the computer or another person? ___________________ H. Which enemy are you currently attacking, the one on the left of the screen or the right?

	I. Which controller from question 7 above would you most likely use with this game? _______ J. If you were controlling the character on the left, what controller actions would you perform to defeat the enemies (button press, joystick movement, etc.)?______________________________ K. Would your enemy most likely be controlled by the computer or another person? ___________________ L. Which enemy are you currently attacking, the one on the left of the screen or the right?
	M. Which controller from question 7 above would you most likely use with this game? _______ N. The missile on the left side of the screen is about to hit which character (circle the character)? ________________________ O. Would your enemy most likely be controlled by the computer or another person? ___________________
	P. Which controller from question 7 above would you most likely use with this game? _______ Q. How would you throw a pass to receiver Holt? (button press, joystick movement etc.)? ____________________________________ _ R. Would your enemy most likely be controlled by the computer or another person? ___________________ S.

	T. Which controller from question 7 above would you most likely use with this game? _______ U. If you were controlling the character closest to you, what controller actions would you perform to defeat the enemies (button press, joystick movement, etc.)?______________________________ V. Would your enemy most likely be controlled by the computer or another person? ___________________ W.

APPENDIX F : KNOWLEGE TEST OF SOPS

Training Manual Knowledge Test

Circle "T" for each item that is true and "F" for each item that is false.

1. T/F Any item that might have been left behind by a missing person should be reported to Sierra.

2. T/F When searching a building the Team Leader should search the rooms on the right side of a hallway and the Forensics Officer should search the rooms on the left side of a hallway.

3. T/F Each room will be searched by both team members.

4. T/F Target items must be verified by both team members.

5. T/F In a two story building the second floor would be searched first.

APPENDIX G: TEAM COHESION INDEX

Team Cohesion Index

This questionnaire is designed to assess your perceptions of your team. Please answer based on the single team you indicated in the previous questions. There are no right or wrong answers so please give your open and honest response. Some of the questions may seem repetitive but please answer ALL questions. Your candid responses are very important to us. Your responses will be kept in strict confidence. Neither your teammates nor anyone other than the researcher will see your responses. The following questions are designed to assess your feelings about YOUR PERSONAL INVOLVEMENT with this team. Select a number between 1 and 9 to indicate your level of agreement with each of the statements. Please consider the entire scale from 1 (strongly agree) to 9 (strongly disagree) when answering each statement.

I am not happy with the amount of playing or performance time I get.

1 2 3 4 5 6 7 8 9

Our team is united in trying to reach its goals for performance.

1 2 3 4 5 6 7 8 9

We all take responsibility for any loss or poor performance by our team.

1 2 3 4 5 6 7 8 9

In my team the members really care about what happens to each other.

1 2 3 4 5 6 7 8 9

Members of my team can trust one another.

1 2 3 4 5 6 7 8 9

Members of my team feel very close to each other.

1 2 3 4 5 6 7 8 9

Members of my team like being on the team.

1 2 3 4 5 6 7 8 9

Members of my team really respect one another.

1 2 3 4 5 6 7 8 9

Members of my team like one another.

1 2 3 4 5 6 7 8 9

Members of my team make each other feel like doing a good job.

1 2 3 4 5 6 7 8 9

Members of my team work well together.

1 2 3 4 5 6 7 8 9

Members of my team help each other to get the job done.

1 2 3 4 5 6 7 8 9

Members of my team encourage each other to succeed at team tasks or competitions.

1 2 3 4 5 6 7 8 9

Members of my team work hard to get things done.

1 2 3 4 5 6 7 8 9

Members of my team pull together and share the load for team tasks or competitions.

1 2 3 4 5 6 7 8 9

Members of my team are very committed to the tasks and activities of the team.

1 2 3 4 5 6 7 8 9

Members of my team like one another and have positive relationships.

1 2 3 4 5 6 7 8 9

Members of my team are very united or cohesive.

1 2 3 4 5 6 7 8 9

The members of my team get along very well with one another.

1 2 3 4 5 6 7 8 9

There is a very high degree of teamwork and cooperation among members of my team.

1 2 3 4 5 6 7 8 9

I am unhappy with my team’s level of desire to achieve.

1 2 3 4 5 6 7 8 9

This team does not give me enough opportunities to improve my personal performance.

1 2 3 4 5 6 7 8 9

I do not like the style of play or performance on this team.

1 2 3 4 5 6 7 8 9

Our team members have conflicting aspirations for the team’s performance.

1 2 3 4 5 6 7 8 9

Members of our team do not communicate freely about each team member’s responsibilities during competition, practice, or activity.

1 2 3 4 5 6 7 8 9

APPENDIX H : SIMULATOR SICKNESS QUESTIONNAIRE

Note, adapted from Kennedy, Lane, Berbaum, & Lilienthal (1993)

ID Date

Instructions: Please indicate how you feel right now in the following areas, by circling the word that applies.

1.	General Discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Headache	None	Slight	Moderate	Severe
4.	Eye Strain	None	Slight	Moderate	Severe
5.	Difficulty Focusing	None	Slight	Moderate	Severe
6.	Increased Salivation	None	Slight	Moderate	Severe
7.	Sweating	None	Slight	Moderate	Severe
8.	Nausea	None	Slight	Moderate	Severe
9.	Difficulty Concentrating	None	Slight	Moderate	Severe
10.	Fullness of Head	None	Slight	Moderate	Severe
11.	Blurred vision	None	Slight	Moderate	Severe
12.	Dizzy (Eyes Open)	None	Slight	Moderate	Severe
13.	Dizzy (Eyes Closed)	None	Slight	Moderate	Severe
14.	Vertigo*	None	Slight	Moderate	Severe
15.	Stomach Awareness**	None	Slight	Moderate	Severe
16.	Burping	None	Slight	Moderate	Severe

** Vertigo is a disordered state in which the person or his/her surroundings seem to whirl dizzily: giddiness Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

APPENDIX I: TEAMWORK AWARENESS QUESTIONNAIRE

Team Mutual Awareness Measure

Please rate your team on each of the six dimensions below using the 7-point scale.

1. To what extent did team members provide relevant information to another team member? a pro-active way, without that team member having to ask for it?

    (7) = Team members always provided important information to others without being asked.

    (1) = Team members never provided information to others unless specifically asked.

1 2 3 4 5 6 7

2. Did the team members adjust individual task responsibilities to prevent overload?

    (7) = Team members were consistently aware of each other's workload buildup and reacted quickly to adjust division of task responsibilities to redistribute workload.

    (1) = Team members were generally unaware of each other's workload buildup; little or no attempt was made to adjust the distribution of task responsibilities before significant compromises to mission safety or mission effectiveness occurred.

1 2 3 4 5 6 7

3. To what extent was the team's behavior coordinated?

    (7) = Good coordination behavior occurs when team members consistently pass critical

information to the other members, thereby enabling them to accomplish their tasks. Team members appear very familiar with the relevant parts of one another's jobs and carry out individual tasks in a synchronized manner.

(1) = Poor coordination behavior occurs when team members consistently carry out their tasks ineffectively, leading to other team members' failing at their tasks; members carry out their tasks unpredictably, leading to delays in execution of critical tasks; members neglect to pass on critical pieces of information to one another, leading to breakdowns in team performance

1 2 3 4 5 6 7

4. How congruent/similar were the commander's and the other team members' understanding of the mission?

(7) = The commander and other team members were completely in agreement.

congruent) on goals, tasks, and concepts involving the mission.

(1) = The commander and other team members were rarely in agreement (i.e., congruent) on goals, tasks, and concepts involving the mission.

1 2 3 4 5 6 7

APPENDIX J: INFORMED CONSENT

Informed Consent Statement

Please read this consent document carefully before you decide to participate in this study. You must be 18 years of age or older to participate.

Project title: DISTRIBUTED TEAM TRAINING: A VIRTUAL ENVIRONMENT SEARCH TASK

Purpose of the research study: The purpose of this study is to examine the effects of feedback for team training effectiveness via a distributed virtual environment.

What you will be asked to do in the study: You will be asked to complete several questionnaires: demographic, simulator sickness, team cohesion, and team performance. You will interact with a desktop virtual environment (similar to PC-based video game). You will be trained how to use the controllers, then you will be given instructions on how to conduct team search tasks. After a brief familiarization session with the system, you will conduct a search task with another teammate in the virtual environment.

Time required: Approximately 2 hrs.

Risks: The anticipated risks in this study are similar to PC-based video games and are therefore deemed minimal risks.

Some individuals may experience symptoms related to simulator sickness, such as, nausea, sweating, disorientation, etc… If this occurs please remain seated and notify the experimenter.

Benefits/Compensation: The compensation for participation is extra-credit for undergraduate UCF courses (as allowed by the course instructor). Credit will be assigned via Sona Systems at the rate of one extra-credit point for every half hour of participation. Any additional portion of a half hour will be rounded up as per UCF/Sona Systems guidelines. Alternatively, volunteers may choose to participate in this experiment for $10.00 per hour, with a $20.00 maximum. Participants can choose only one type of compensation.

Confidentiality: Your identity will be kept confidential. Your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file. When the study is completed and the data have been analyzed, the list will be destroyed. Your name will not be used in any report.

Voluntary participation: Your participation in this study is voluntary. There is no penalty for not participating. You have the right to withdraw from the study at any time without penalty.

Whom to contact if you have questions about the study: You may contact Kevin Oden, (Graduate Student, Psychology Department, College of Sciences, 4000 Central Florida Blvd, Orlando, FL), or by e-mail at Koden1126@gmail.com. You may also contact Dr. Mustapha Mouloua, Faculty Supervisor, Psychology Department at (407) 823-3433 or by email at mouloua@mail.ucf.edu.

Whom to contact about your rights in the study: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (IRB). For information about participants' rights please contact: Institutional Review Board Office, University of

Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246. The telephone numbers are (407) 882-2276 and (407) 823-2901. The office is open from 8:00 am to 5:00 pm Monday through Friday except on UCF official holidays.

___ I have read the procedure described above.

___ I voluntarily agree to participate in the procedure.

____

Print Participant Name

____

Participant Signature   Date

____

Principle Investigator Signature   Date

APPENDIX K: TRAINING CHECKLIST

Train-up Checklist

Place an “X” next to each statement that describes your level of comfort with the game controller functions. If you do not feel comfortable with each of these items please notify the experimenter.

	I feel comfortable using the mouse controller to change point of view and direction.
	I feel comfortable using the “W”, “A”, “S”, and “D” keys to move in the environment.
	I feel comfortable using the “T” key to talk.
	I feel comfortable using the “E” key to open doors.
	I feel comfortable using the “L” key to place a spray tag on a building.
	I feel comfortable using the “F” key to use the flashlight.

APPENDIX L: CONTROLLER FUNCTIONS

Train-up Instructions:

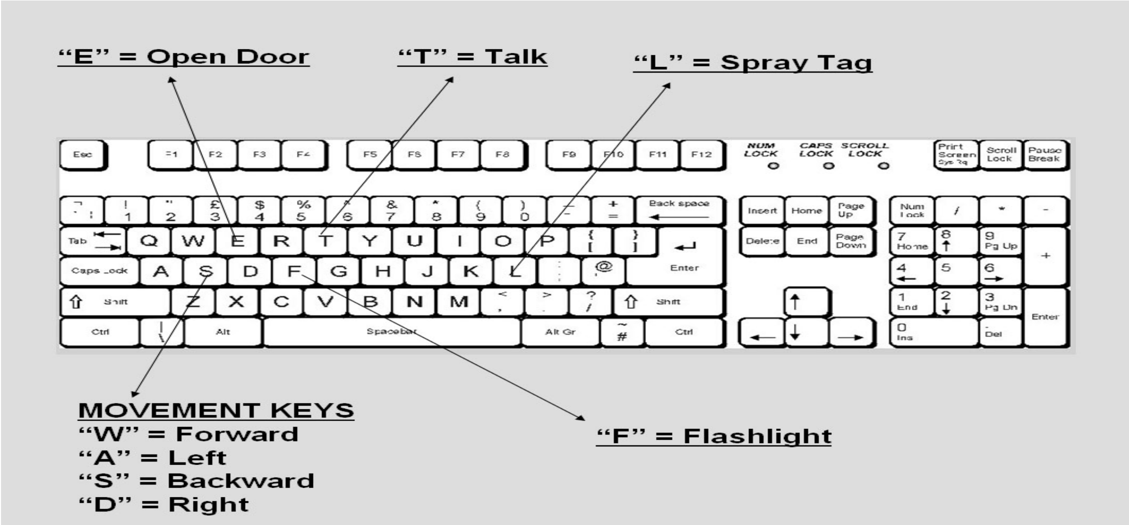
Position yourself comfortably at the computer station you were assigned. Put the headphones on and position the microphone directly in front of your mouth.

Before beginning the search missions you will need to familiarize yourself with the PC controllers. Below you will find a functionality table. This table provides a list of functions with corresponding keyboard and mouse input commands. Please take the next few minutes and familiarize yourself with these functions. Also, reference the keyboard map at the bottom of this page, see Figure 1.

FUNCTIONALITY TABLE	
DIRECTION	*Use the mouse to change direction; moving the mouse to the left will rotate point of view to the left and moving the mouse to the right will rotate point of view to the right.*
MOVEMENT KEYS	*Walk FORWARD………………………………………….....……. press "W"*
	Strafe LEFT………………………………………………….……. press "A"
	Walk BACKWARD………………………………………....……… press "S"
	Strafe RIGHT …………………………………………….....……. press "D"
OPEN DOOR	*Press the "E" key to open a door; you need to be next to the door you are trying to open.*
FLASHLIGHT	*Press the "F" key to turn flashlight on/off.*
SPRAY TAG	*Press the "L" key to spray a tag. You need to be within 5 feet of the targeted area in order for the spray tag to work.*

COMMUNICATION	*Press and HOLD the "T" key to talk. Communications are similar to common radio communications (e.g. Walkie Talkies, CB radio, or Two-Way). Be sure to hold the key down while talking.*

Figure 1: Controller Functions Map



APPENDIX M: UCF IRB APPROVAL LETTER

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