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Understanding Aspects of Individual and Collaborative Skill Acquisition in Face-to-Face and Distance Training Situations

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New Mexico State University

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UNDERSTANDING ASPECTS OF INDIVIDUAL AND COLLABORATIVE SKILL ACQUISITION IN FACE-TO-FACE AND DISTANCE TRAINING SITUATIONS

EXECUTIVE SUMMARY

Research Requirement:

The military's ability to achieve successful team performance in both co-located and distance situations places a premium on understanding how cognitive, social, and contextual factors interact optimally on high-performing teams. The experimental, basic research completed at New Mexico State University offers important insights into how context affects team performance and trust. Emerging from this work is an applied perspective on the importance of optimal training and trust activities to achieve team objectives.

Procedure:

Two experiments were performed in which teams were trained and tested in the same physical context or they were trained and tested in different physical contexts. All teams consisted of three individuals, with many hours of both training and transfer tasks. Teams were given the same initial declarative training materials. Materials for training and testing differed between experiments. An additional aspect of this research examined team trust: Antecedents to trust (perceived trustworthiness dimensions of ability, competence, integrity, and benevolence), dispositional trust, and trust behaviors were assessed to construct a model that predicted team performance.

Findings:

Our results offer basic and applied tenets: (a) that teams working at a distance on complex tasks perform as well or better than face-to-face teams; (b) that communication should not be hindered by unnecessary complexity (such as pushing buttons to communicate), to decrease cognitive load to allow increased attention toward task demands; and (c) that team members need to perceive that they and others on the team are able and competent at performing their tasks, which suggests that initial task training should be thorough. Further, according to our findings, when teams transfer to different tasks, they will experience a slight decrement in performance, but will "bounce back" and perform well on the new complex task.

Utilization and Dissemination of Findings:

The data collected over several years in this programmatic research have been disseminated at ARI mini-conferences, ARI laboratory visits, ARI briefings, and at national psychology conferences. In addition, manuscripts have been and are being submitted for publication in peer-reviewed psychological journals. The learning and transfer research was presented at the Psychonomic Society annual meeting in Vancouver, Canada, and at the annual meeting of the American Psychological Society in Chicago, IL. The trust research was presented at the American Psychological Society's annual meeting in Toronto, Canada.

UNDERSTANDING ASPECTS OF INDIVIDUAL AND COLLABORATIVE SKILL ACQUISITION IN FACE-TO-FACE AND DISTANCE TRAINING SITUATIONS

CONTENTS

Page

THE CHALLENGE OF TRAINING TEAMS AT A DISTANCE 1
Communication Challenges 1
The Challenge of Team Trust 1
Challenge for the Military 2

RESEARCH OBJECTIVES 2

THEORY OF LEARNING AND TRANSFER 3

SUMMARY OF CONTRACTED RESEARCH 3
Introduction 4
Theory of Transfer Related to Context Change 4
Distance Training 5
Team Training 6
Summary of Experiments 7

EXPERIMENT 1. UNMANNED AIR VEHICLE (UAV) SIMULATION 7
Method 7
Participants 7
Design 7
Materials 8
Software 8
Communication 9
Training Materials 9
Procedure 9
Results 10
Training 10
Transfer 12
Individual Contribution 12

EXPERIMENT 2. PEACEKEEPING SIMULATION 12
Method 13
Participants 13
Design 13
Materials 13
Simulation Software 13
Computer-Based Training Materials 14
Other Questionnaires and Assessments 15

Procedure ... 15
Results and Discussion ... 15
Description of Data ... 15
Push-to-Talk versus No Push-to-Talk ... 15
Training Data ... 17
Transfer Results ... 17
Push-to-Talk Analysis ... 17
Push-to-Talk Training Data ... 17
Push-to-Talk Transfer Data ... 18
No Push-to-Talk Analysis ... 18
No Push-to-Talk Training Data ... 18
No Push-to-Talk Transfer Data ... 19
Individual Contribution. ... 19
General Discussion: Contracted Research ... 20
Overall Team Performance ... 21
Individual Contributions ... 23
Theory of Learning and Transfer ... 23
Implications ... 24
Future Directions ... 25
Conclusion ... 26

SUMMARY OF ADDITIONAL RESEARCH ... 26
Introduction ... 26
Groups and Teams ... 27
Co-Located and Distributed Teams ... 27
Group Trust and Performance ... 27
Trust Defined ... 28
Antecedents to Trust and Trust Behaviors ... 28
Factors That Define Perceived Trustworthiness ... 28
Trust and "Touch" in Distributed and Co-Located Teams ... 29
Perceived vs. Actual Performance ... 30
Trust Differences in Co-Located and Distributed Teams ... 30
Technology for Task and Team Performance ... 30
Team Trust and Context Transfer ... 31

EXPERIMENT 1. PERCEIVED TRUSTWORTHINESS IN A COMPLEX TEAM PEACEKEEPING TASK ... 32
Method ... 32
Participants ... 33
Materials and Stimuli ... 33
Technological Equipment and Software ... 33
Factors Important to Perceived Trustworthiness in a Complex Team Task ... 34
Procedure ... 34

Results and Discussion 35
Perceived Trustworthiness Analysis 35
Perceived Team Trustworthiness in Context 35
Perceived TeamTrustworthiness by Mission 38
Perceived Team Trustworthiness Factor Models Predicting Team Performance 38
Swift Trust in Co-Located and Distributed Teams 39
Team Performance by Context 40

EXPERIMENT 2. ANTECEDENTS TO TRUST, TRUST BEHAVIORS, AND TEAM PERFORMANCE IN CONTEXT 41
Method 41
Participants 42
Technological Equipment and Software 42
Procedure 42
Trust Behavior Coding 42
Results and Discussion 43
Reliability of Propensity to Trust Scale 43
Relationships to Performance 43
SPT Metric 43
Trust Behavior Analysis 44
Longitudinal Perceptions of Shortened Perceived Trustworthiness and Trust Behaviors 45

DISCUSSION OF FINDINGS IN ADDITIONAL RESEARCH 45
CONTRIBUTIONS TO BASIC RESEARCH 46
POTENTIAL ARMY/MILITARY APPLICATIONS 46
FINAL SUMMARY 47
REFERENCES 51

LIST OF TABLES

TABLE 1. DESIGN FOR EXPERIMENTS 8

TABLE 2. NUMBER OF TEAMS COMPLETING UAV EXPERIMENT 1 10

TABLE 3. EXPERIMENT 1 PERFORMANCE OF CO-LOCATED VERSUS DISTANCE TEAMS 11

TABLE 4. EXPERIMENT 2 PUSH-TO-TALK TRAINING WITH CO-LOCATED VERSUS DISTANCE TEAMS 18

TABLE 5. EXPERIMENT 2 NO PUSH-TO-TALK TRAINING WITH CO-LOCATED VERSUS DISTANCE TEAMS 19

TABLE 6. EXPERIMENT 2 PAIRED *T*-TEST RESULTS FOR ROLES ... 20

TABLE 7. EXPERIMENT 2 REGRESSION RESULTS FOR INDIVIDUAL ROLE DATA BY PUSH-TO-TALK AND NO PUSH-TO-TALK ... 20

TABLE 8. ROTATED COMPONENTS MATRIX FOR PERCEIVED TRUSTWORTHINESS RATINGS ... 37

TABLE 9. MEAN PERCENTAGE TEAM COOPERATING AND TEAM MONITORING LANGUAGE BEHAVIORS, AND DIFFERENCE SCORE IN LANGUAGE BEHAVIORS OF TEAMS IN EACH CONTEXT CONDITION ... 44

LIST OF FIGURES

FIGURE 1. EXPERIMENT 1 TEAM PERFORMANCE RESULTS ACROSS MISSIONS ... 11

FIGURE 2. EXPERIMENT 2 PUSH-TO-TALK VERSUS NO PUSH-TO-TALK TEAM PERFORMANCE RESULTS. ... 16

FIGURE 3. EXPERIMENT 2 PUSH-TO-TALK TEAM PERFORMANCE RESULTS ... 16

FIGURE 4. EXPERIMENT 2 NO PUSH-TO-TALK TEAM PERFORMANCE RESULTS ... 17

FIGURE 5. EXPERIMENT 1 CUBIC FIT OF MY ABILITY/COMPETENCE, BENEVOLENCE, THEIR ABILITY/COMPETENCE, AND INTEGRITY PERCEIVED TRUSTWORTHINESS FACTORS ON TEAM PERFORMANCE ... 39

FIGURE 6. EXPERIMENT 1 CONTEXT-BASED MEAN TEAM PERFORMANCE IN MISSIONS 1, 5, 7, AND 8 ... 41

The Challenge of Training Teams at a Distance

Bell and Kozlowski (2002) and Cohen and Gibson (2003) indicate that one defining characteristic of distributed, or virtual, teams is that they are divided by space or are dispersed geographically. Co-located teams work in geographic proximity. Under ideal training situations, multiple individuals can be trained together to form effective teams. However, the constraints of distance and time often play a role in limiting team training. Furthermore, limitations in available personnel and the need to spread these personnel over wide geographic areas also impede the ability to train effective teams. Previous studies have shown that distance training of teams can be a cost effective means of instruction; however, research has demonstrated mixed results on performance (Hahn, 1990). Therefore, continued study of the factors affecting team distance learning is needed and this paper describes research that we performed toward furthering knowledge in this area.

Communication Challenges

Some researchers suggest that there is a productivity advantage for teams that work in co-located environments over distributed task environments even when technological advances have improved communication technology for distributed work teams (Olson, Teasley, Covi, & Olson, 2002). If distributed teams are to be trained effectively, then communication media must at least afford a sense of *co-temporality*, among other attributes, such as *visibility, audibility, simultaneity, and sequentiality* (Driskell, Radtke, & Salas, 2003; Kraut, Fussell, Brennan, & Siegel, 2002) for distributed team members to exhibit adequate performance. To achieve co-temporality, distributed teams working in separate locations should be able to see or hear each others' communication in real time, and should be able to see their own work and work performed by other team members as it is output, in real time.

Communication equipment used in the military often demands that users push buttons (push-to-talk) in order to communicate via audio headsets. Although language is shared co-temporally, without a time delay, the cognitive load involved in pressing buttons and in equipment operations might detract from team performance in distributed task environments. Thus, communication is another important challenge for distributed team training and performance.

The Challenge of Team Trust

Training teams at a distance is challenging; researchers in the past have said that in order to trust others on a team, team members must have some proximal contact. If there is little or no trust at team-level, performance might be affected. One of Charles Handy's (1995) seven trust maxims for contemporary organizations is that "trust needs touch," and, specifically in distributed working relationships, merely seeing a face on a videoconference screen or possessing an e-mail address to work together on distributed tasks is not sufficient for trust to develop. Handy (1995) argues that distributed groups require some face-to-face (co-located) contact because a shared commitment necessitates personal contact to make that commitment real. Similarly, Johansen and O'Hara-Devereaux (1994) assert that face-to-face interaction enhances trust-building and allows greater opportunity to repair trust if it has been broken among group members. Rocco, Finholt, Hofer, and Herbsleb (2001) found lower trust in Computer Mediated Communication (CMC) groups when compared to face-to-face (co-located) groups unless there was a face-to-face meeting in the CMC groups. CMC groups are connected via the Internet, instant-messaging, cellular phone text, decision support systems. CMC is defined as "any human symbolic text-based interaction conducted or facilitated through digitally-based technologies" (Spitzberg, 2006). The Rocco et al. (2001) findings support Handy's argument that "trust needs touch."

In practice, however, it is not always feasible for workgroups from global corporations or military units or governmental institutions to make arrangements for face-to-face meetings in order to build and maintain trust within workgroups. Further, distributed teams that function for a limited duration of time on temporary projects do not always have the opportunity to hold face-to-face meetings merely to build team trust. It is important that new methods for building and maintaining trust in distributed workgroups and teams be identified so that the "touch" in trust can extend to the distributed domain without the need for face-to-face meetings.

Challenge for the Military

In practical terms, military trainers must make decisions within budgetary constraints to train teams in face-to-face contexts or via distance contexts. Inherently, trainers would prefer face-to-face contact for teams being trained to do some task. Yet an increasingly common training scenario involves forming virtual teams, which consist of personnel from different locations or across different branches of the military. Those teams are formed and trained to tackle some problem, formulate tactical plans, or make policy. Often they must do so under time pressure. By virtue of their geographic separation, these groups must now interact electronically. How is this best handled? What potential problems must be forestalled and how can the technologies best be used to optimize communication and information exchange? What if, as is so often the case, these situations involve time pressure, stress, or information overload? Such questions motivated the current endeavor.

Research Objectives

Our approach to the overarching issue of how teams can be trained effectively, both in face-to-face and in distributed contexts, is to apply learning theory to the issue of training and transfer. We also use contemporary trust theories from organizational and psychological literature to try to understand how trust develops and is sustained at team-level. The primary research questions addressed in three waves of research are:

- How do teams learn at a distance?
- How does changing the context between training and test affect performance?
- What kind of training can we provide to improve transfer between contexts?
- What is the effect of communication equipment and technology on team performance?
- Can trust be built in distributed teams?
- What aspects of trust are important to teams working on complex tasks?

Theory of Learning and Transfer

Guiding our approach to the overarching issue of how teams can be trained effectively, both in face-to-face and in distributed contexts, is the theory of learning and transfer advanced by Anderson (1982, 1983). His theory predicts that transfer will occur when overlapping productions between two situations exist (Anderson, 1982, 1983, 1993). A production rule takes the form of (IF condition THEN action). For example, you might say, "If rain, then take umbrella." One can imagine that this particular production would be true whether you are in Arizona or Oregon. However, note that this might be different if a production were specifically tied to a certain context. For example, after an individual learns how to drive a car with an automatic transmission, the same productions should fire whenever an individual is driving a car with that kind of transmission. If, however, a person learns how to drive a car with an automatic transmission but is then asked to drive a manual (stick shift) car, then the productions do not overlap exactly and some transfer will not occur. Thus, when the context (driving a car) is held constant but the task is changed slightly (automatic transmission to manual transmission), a decrement in performance is usually measured (Singley & Anderson, 1989).

One can imagine that if the context is vastly different, then the condition portion of the productions would not overlap and performance could be greatly disrupted. Indeed in studies of memory or state dependent learning, one can find up to 47% better recall of items when recall is in the same context as learning (Godden & Baddeley, 1980). In addition, similar results have been found for contexts as obvious as drug induced states (Davies & Thompson, 1988; Eich, 1980, 1989) or as subtle as mood effects (Bower, 1983, Leight & Ellis, 1981; Teasdale, 1983). However, these results have not always been replicated (Davies & Thompson, 1988; Fernandez & Glenberg, 1985; McDaniel, Anderson, Einstein & O'Halloran, 1989; Saufley, Otaka, & Bavaresco, 1985; Smith, 1994) or contradictory results have been found (Bjork & Richardson-Klavehn, 1987; Smith, 1988). Thus, although a constant context may be better in general, salient cues may overcome contextual effects. Context may not be solely defined by a change in physical location or an internal change based on chemical ingestion, and, possibly defining what the most relevant aspects of the situation might be the more important focus for a researcher or instructor (Wickens, 1987).

Summary of Contracted Research

This research focuses on applying learning and transfer theory to team training. Even though groups and teams are used extensively within industry and the military, and schools have been moving toward including teams in classroom learning, previous learning research based upon theory has focused on the individual. Thus, the goal of these studies is to examine the acquisition of knowledge for complex military tasks by individuals within teams and teams themselves. We tested transfer across contexts, where training occurs either face-to-face (co-located) or at a distance (distributed) and testing occurs in the opposite context. Results of Experiment 1 indicated that distance training was better than co-located training and all teams had a performance decrement at transfer/test. In Experiment 2, results for the push-to-talk condition were similar to the results obtained for Experiment 1; however, results for no push-to-talk conditions indicated that physical context effects played a role at transfer. Improvements in both training and learning theory are suggested by identifying the factors that affect team training and performance.

Introduction

In most real world situations, students learn in one context (school) and then are expected to apply their knowledge in another very different context (job). Although transfer of learning has been studied extensively (for reviews see Lee, 1998; Singley & Anderson, 1989), the focus has been on individuals. However, most students are expected to learn in groups and, if not, they are often expected to perform in groups or teams in industry at a later time. Even though group learning has been studied at a social level, team training and cognition has only recently been a focus for researchers (Cooke, Salas, Cannon-Bowers & Stout, 2000). In addition, distance learning has been available with more modest media such as videotape and correspondence courses, but the rise of the Internet and other new technologies has made distance training of individuals and teams more readily available. Previous studies have shown that distance training of teams can be a cost effective means of instruction; however, research has demonstrated mixed results on performance (Hahn, 1990). Thus, by combining distance learning and team training ideas and studying team learning and transfer in face-to-face (co-located) or distance contexts, a greater understanding can be had of what an individual learns within collaborative learning situations and the role that context plays in that learning.

In this research we studied teams training together in the same room (co-located) or distributed at a distance across rooms or floors in a building (distributed). Then we asked the team members to either perform a task in the same context (co-located to co-located, distributed to distributed) or in different contexts (co-located to distributed, distributed to co-located). By treating teams as entities, the results from team training and transfer should be explained by applying theories and ideas from previous individual training and transfer research.

Theory of Transfer Related to Context Change

Individual training and transfer has been studied extensively (Lee, 1998; Singley & Anderson, 1989) but not necessarily for teams with context change. For this experiment, teams first were trained and then were tested. The test was a different task than the training materials but doable based on training. For transfer, for some teams, we changed the context from distance to co-located or vice versa. A slight decrement in performance would be expected for those staying in the same physical context but performing the test (a slightly different task). However a large decrement in performance is expected for those experiencing differing physical contexts. These results should be tempered by the contradictory research discussed above because the change in physical context that we are imposing may not be the context of importance or relevance to the team (or individuals within the team). If the important context is not the physical context but some other context (for example, the computer simulation) and this other context does not change, then only the decrement for change of task (test) should occur.

Distance Training

In ideal training situations, multiple individuals can be trained together to form effective teams. However, the constraints of distance and time often play a role in limiting team training. Furthermore, limitations in available personnel and the need to spread these personnel over wide geographic areas also impede the ability to train effective teams. One promising solution to these problems is distance learning.

Distance learning in one form or another has been of interest to educators; and, with the increased use of the Internet, interest in providing distance training has increased (Kerka, 1996). The Internet provides many advantages including the ability to transfer video and audio in real time, as well as access to repositories of public information that may be difficult to visit in person (Butler, 2000). Some researchers have indicated a benefit for distance learning over traditional face-to-face instruction (Chute, Balthazar, & Poston, 1989). They reason that students must take more personal responsibility and be more active in their learning and this added responsibility results in a benefit for distance learning.

In a review of the literature on distance learning in the military, Barry and Ryan (1995) argued that not only has distance learning provided substantial cost savings but that distance learning outcomes can be comparable for distance and resident learners. For example, for the U.S. Navy, from Fiscal Year 1989 through Fiscal Year 1994, the cost savings for travel and per diem was $7,154,000 and for the U.S. Air Force "travel time savings totaled thirty man-years and student throughput increased from 300 to 3,000" for 1992-1993 (Westfall, Christopher, & Cramer, 1994; as cited in Barry & Ryan, 1995, p. 37).

Studies performed in military settings tend to show no difference in achievement between distance learners and resident learners. In the three studies that compared distance and resident learners reported by Barry and Ryan using Army participants: (a) Hahn (1990), using Air Combat Command (ACC), found no differences between distance and resident trainees, (b) Phelps, Wells, Ashworth, and Hahn (1991), using a Computer-Mediated Communication (CMC) system, also found no differences, and (c) Keene and Cary (1992) showed a benefit for distance learners over resident learners in using interactive video teleconferencing training. A fourth study by Bramble and Martin (1995) found that community colleges could provide adequate training for the military when using the U.S. Army's two-way audio/video Teletraining Network. Thus, distance learning can be both a cost effective and an efficient way to provide training.

On the other hand, distance learning may have a different meaning in the context of group (collaborative) or team training. Few studies have examined collaborative, distance learning and even fewer studies have examined team distance training (Frost & Fukami, 1997; Kerka, 1996). Computer internet/Web contexts have tended to be built for the individual (Calvani, Sorzio, & Varisco, 1997); however, groupware and CMC have allowed for the possibility of the delivery of team distance learning. Results from studies comparing CMC to face-to-face have found mixed results. For example, studies have suggested that CMC can reduce social norms (Sproull & Kiesler, 1986), can be a hindrance to the creation of meaning (Mantovani, 1996), and can lead to lengthy decision making (Hedlund, Ilgen, & Hollenbeck, 1998) in comparison to face-to-face communication. These studies are limited because they tend to focus on organizational and social factors rather than team process, cognition, and performance.

One benefit of distance instruction is that individuals can learn at their own pace, in their own time (on-demand, real-time training). However, if the members of the team train without any knowledge of the other individuals or the individuals' part in the total task, then how can they develop team knowledge and teamwork skills? Thus, we would predict that distance team training should be worse than face-to-face team training. Recent technology such as the development of chat rooms and shared virtual spaces may provide one solution, but the effectiveness of those technologies for complex tasks is not well understood.

Team Training

Teams play an increasingly larger role in many aspects of military work. In particular, the growing complexity of tasks frequently surpasses the cognitive capabilities of individuals and thus, necessitates a team approach (Cooke, Salas, et al., 2000; Salas, Cannon-Bowers, Church-Payne, & Smith-Jentsch, 1998). However, most individuals have little formal training in how to work within a group, much less how to learn within one. Moreover, the move toward distributed mission training for many military training programs creates new challenges for collaborative learning by teams. Trainers are faced with the problem of training both the skills directly needed for the job and the interpersonal skills needed for successful team performance. In addition, trainers and trainees must adapt to distributed training programs. At the heart of both individual and team training, however, is the ability to accurately and reliably assess learning and measure the knowledge that results from training.

Theories of learning often focus on delineating how a person's knowledge representation of the information changes over time (e.g., ACT/ACT-R, Anderson, 1983, 1993; Van Lehn, 1996). These theories have been used to improve individual learning through intelligent tutoring systems (Anderson, Corbett, Koedinger, & Pelletier, 1995). Even though these theories could be applicable to group (collaborative) and team learning, they have not been fully applied to these areas. In order to apply these theories, changes would need to reflect the differences between individual and group/team knowledge acquisition. Team knowledge acquisition differs from individual knowledge acquisition because both task and team knowledge must be gained. Moreover, team knowledge is multifaceted and comprised of each individual's mental model as well as collective knowledge in the form of team mental models and, more specifically, team situation models.

Although progress has been made on knowledge measurement at the individual level, the measurement of team knowledge, and team cognition in general, is still in its infancy (Cooke, Salas, et al., 2000). In addition, extensive research has been performed on individuals' cognitive skill acquisition; however, team learning and computer supported cooperative learning have only recently become the focus of attention, especially for groups larger than two individuals. A greater understanding of what an individual learns within collaborative learning situations and, as opposed to or in conjunction with, what the team learns is needed in order to provide information for trainers.

Extensive research has been performed in education on group collaborative learning (Johnson, 1981; Johnson, Johnson, & Holubec, 1990; Slavin, 1996); however, team learning may differ considerably. A team can be defined as "a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission, who have each been assigned specific roles or functions to perform, and who have a limited life span of membership" (Salas, Dickinson, Converse & Tannenbaum, 1992, pp. 126-127). This differs from the definition of "group" in that teams have differentiated responsibilities and roles (Cannon-Bowers, Salas, & Converse, 1993). This division of physical and cognitive labor enables teams to tackle tasks too complex for any individual (Cooke, Salas, et al., 2000); however, it also introduces a level of complexity to training that does not exist for a simple group. That is, not only must a training system allow for each individual team member to learn his/her role to criterion, but the team as a whole must subsequently also learn its tasks to criterion.

Summary of Experiments

In this research the main goal was to examine team training and transfer across differing physical contexts. We tested individual learning and transfer theory in more realistic team training environments to see whether the same results would hold. The two experiments described in this paper were performed using two different complex simulations: Unmanned Air Vehicle and Peacekeeping. Each simulation mimics real life parameters while still allowing for experimenter control. In both experiments, teams of three individuals were asked to learn a complex task individually and then perform missions together. After a certain number of missions, the teams either stayed in the same context or they changed contexts. Teams that stayed in the same context were expected to maintain performance or sustain only small amounts of interference due to task change, while teams that changed contexts were expected to experience more interference due to task change and to context change. Distance training was expected to be detrimental but would not necessarily affect transfer when the context remained the same (distance to distance).

Experiment 1: Unmanned Air Vehicle (UAV) Simulation

Method

Participants

Participants were 27 teams of 3 students, all with no military experience, attending New Mexico State University. Participation was voluntary and participants received $6 per hour compensation.

Design

Participants were assigned to one of four conditions: (a) Train co-located and test co-located, (b) train co-located and test distance, (c) train distance and test co-located and (d) train distance and test distance (See Table 1). All participants were trained in either co-located (face-to-face) training or distance training for five missions. Then for three transfer missions, they either stayed in the same context or changed to a different context.

The number of teams per condition was unequal because Dr. Cooke left for Arizona and took her equipment with her. We were unable to use the lab several months prior to her leaving and were unable to obtain enough teams to complete the cells.

Table 1
Design for Experiments

	Transfer	
Train	Co-located (C)	Distance (D)
Co-located (C)	CC	CD
Distance (D)	DC	DD

Materials

This experiment used the CERTT (Cognitive Engineering Research on Team Tasks) Lab: a state-of-the-art Department of Defense (DOD) funded laboratory for studying team cognition (Cooke & Shope, 1998, 2004). The hardware consists of four participant consoles and an experimenter control workstation that can be arranged to simulate distributed or co-located team contexts.

Software

The synthetic task context (STE; see Martin, Lyon, & Schreiber, 1998 for a generic description) that was used in these studies is an abstraction of the Predator UAV operations (Cooke, Rivera, Shope & Caukwell, 1999; Cooke, Shope, & Rivera, 2000). The UAV-STE was abstracted from results of a cognitive task analysis (Gugerty, DeBoom, Walker, & Burns, 1999) of the Predator operational context, with the goal of providing an experimenter-friendly test-bed for the study of team cognition. The goal of the task is for the team to safely fly the UAV to targets and to orient the vehicle so that good photographs of targets can be taken.

The three team members had different roles and the mission can only be accomplished by interaction and information sharing among the three roles. The three roles were the Air Vehicle Operator (AVO), the Payload Operator (PO), and the DEMPC (Data Exploitation, Mission Planning and Communication Operator). The AVO controls airspeed, heading, altitude, and monitors UAV systems. The PO adjusts camera settings, takes photos, and monitors the camera equipment. The DEMPC oversees the mission and determines flight paths under varying constraints. To complete the mission, team members needed to share information with one another and coordinate their planning and actions. Each team member was trained on unique material and had access to two unique displays of information. In addition, each operator used a unique screen to monitor in order to avoid system alarm states.

The task scenarios used for training and testing materials included a number of waypoints selected from a database of waypoints created for the UAV simulation. (For details on the simulation and calculation of performance information, see Cooke, Kiekel, & Helm, 2001; Cooke & Shope, 1998; Cooke et al., 2000). Each waypoint in the database was associated with coordinates, type information, restrictions on altitude and airspeed, and camera requirements. Routes and waypoints differed between training and test (transfer).

Communication

Participants communicated over aviation-quality headsets and an advanced intercom system allowed detailed recording of communication content, duration, and speaker and listener identities. Participants were also required to push a button and hold it down when they wished to communicate with either other team members or the experimenter (push-to-talk).

Training Materials

Because each team member was trained on unique material and had access to two unique displays of information, training material was different for each participant/team member. The training program included a PowerPoint tutorial and 30 minutes of individual hands-on skill training. Success of teams depended upon the individual learning of team members before a group can achieve optimal performance (Denning & Smith, 1997; Randall, 1999) and therefore assessment of individual learning was performed, as well as the team assessment. A set of multiple choice questions was used for this assessment (e.g., whether the individual had learned what roles were present, and how well an individual had learned the declarative knowledge associated with his/her individual role).

Procedure

Team members were randomly assigned to each of three different roles (AVO, PO, or DEMPC) at the beginning of each investigation. They retained these positions within the same team for the remainder of the effort. After assignment, each person trained individually on a computer for his/her specific role. Individual training was not considered complete until each individual had achieved some level of proficiency in his or her portion of the training sessions as measured by the assessment test. When all participants reached criterion, the team was asked to perform five training missions with feedback provided. Experimenters checked off skills as they mastered them (e.g., the AVO needed to change altitude and airspeed, the PO needed to take a good photo of a target) until all skills were mastered. An experimenter or experimenters assisted in cases of difficulty. Performance scores at the team and individual levels, based on a complex metric, were provided at the conclusion of each mission.

For the co-located condition, three consoles with monitors and other equipment were placed in a horseshoe shape in the laboratory room. Each participant sat at an individual console and participants could physically interact with each other by turning to the side. For the distance learning, one participant used a console in another location with a separate experimenter assigned to interact and monitor that participant. The other two participants were in the laboratory with the two consoles separated by a moveable partition (not a wall). Team members who were in this lab setup were led into the room at different times and took their breaks in separate rooms. However, it might still be possible to know that another individual was just beyond the partition. For both co-located and distance conditions, participants pushed buttons to talk (push-to-talk) and used headsets to communicate.

The research was conducted over two days with a one day's separation between each experimental day. Teams completed team training – eight total missions that lasted 40 minutes—with three practice missions on the first day, two practice missions the second day, and three test missions. Testing consisted of three missions without feedback.

Results

A dedicated computer automatically collected measures of individual and team performance. The number of teams completing each condition is shown in Table 2. The performance data are shown in Figure 1.

Training

Although unequal numbers of teams completed per cell, the number of teams that received co-located training and the number that received distance training were very close (14 teams for co-located and 14 teams for distance). Since teams were not told what would happen during transfer (test), training data should be the same for all teams within one of the training (co-located or distance) conditions.

Table 2
Number of Teams Completing UAV Experiment 1

	Transfer	
Train	Co-located (C)	Distance (D)
Co-located (C)	9 (CC)	5 (CD)
Distance (D)	5 (DC)	9 (DD)

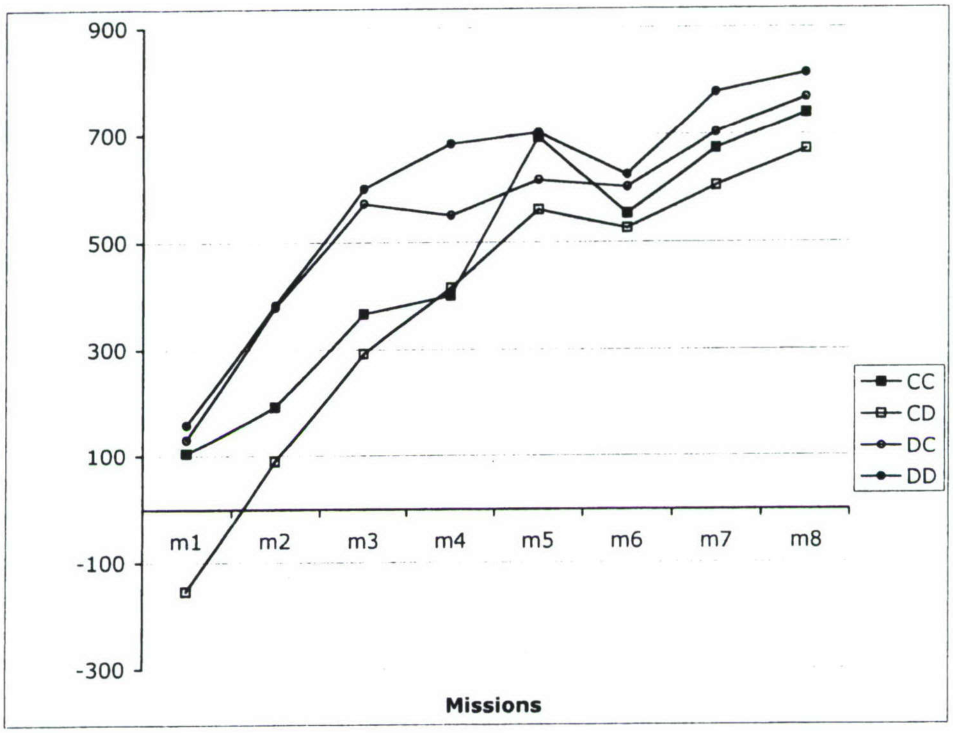

Figure 1. Experiment 1 team performance results across missions.

Note. CC= co-located; CD = co-located to distributed; DC = distributed to co-located; DD= distributed.

A repeated measures analysis of variance (ANOVA) was performed with co-located versus distributed (training context) as the independent variable and performance on training missions as the dependent variable. Even though all teams received the same declarative training, the distance teams performed better on the training missions than the co-located teams, $F(1, 25) = 7.0, p < .01$. The means of both co-located and distributed teams are shown in Table 3. Performance improved over missions, $F(4, 100) = 45.9, p < .01$, but there was no interaction between missions and training context.

Table 3
Experiment 1 Performance of Co-located Versus Distance Teams

	Missions				
	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5
Co-located	5.3 (57.2)	153.2 (47.2)	337.9 (55.3)	406.2 (87.1)	643.7 (50.8)
Distance	141.7 (42.2)	380.6 (58.9)	581.4 (51)	597.4 (67.5)	646.9 (67.9)

Note. The standard deviation is shown in parentheses.

Transfer

A repeated measures ANOVA was performed using the performance on the first transfer test (Mission 6) as the dependent variable and the performance on the training missions (Mission 1 through 5), a variable for training context (co-located, distance), and a variable for transfer context (same, different context) as the independent variables. All teams suffered a decrement in performance at transfer, $F(1, 127) = 14.9, p < .01$; mean Mission 5 = 645.4, SE = 42; mean Mission 6 = 577.6, SE = 42.3). Thus, even though a context difference might be predicted, instead the main result was a decrement in performance due to the test. This is consistent with the results of Singley and Anderson (1989) for interference changes between tasks.

Again, consistent with Singley and Anderson (1989), even though performance declined at the initial test mission, all teams improved from Mission 6 to Mission 8 (repeated measures ANOVA, $F(2, 46) = 11.7, p < .01$; mean Mission 6 = 577.6, SE = 42.3; mean Mission 7 = 690.8, SE = 40.8; mean Mission 8 = 753.0, SE = 33.5).

Individual Contribution

Each team had three members and each member performed a distinct role. Using paired comparisons of overall means for each role, no differences were found between roles. A regression was performed to see what contribution each of the individual team members (roles) had on overall team performance (three participants with roles DEMPC, PO, and AVO and eight missions, compared to an overall team score over eight missions). Results indicate that all roles contributed to the team performance with the PO contributing the most, the AVO next and the DEMPC the least (PO coefficient = .42, $t(212) = 8.9, p < .01$; AVO coefficient .36, $t(212) = 6.9$, $p < .01$; DEMPC coefficient = .33, $t(212) = 8.5, p < .01$). The difference in contribution based upon coefficient is small, however.

One question that often arises in group learning is whether the group's overall performance ever exceeds the best person in the group, and in most cases, this is not the case (Hill, 1982). In order to examine this question for teams, the mean for each role and the team's performance were computed. Then the best score and the worst score for each team was compared to the team's score. The best performer did better than the team, $t(26) = 6.5$, $p < .01$; mean of the team = 497.9, SE = 321.8; mean of the best team = 665.7, $p < .01$, SE = 32.1, and the team did better than the worst performer, $t(26) = 3.0, p < .01$; mean of the worst performer = 440.2, SE=36.2. Thus, working in a team does not necessarily benefit the best performer but it does help the worst performer.

Experiment 2: Peacekeeping Simulation

In Experiment 1, the distance condition performed better than the co-located condition in training and all conditions suffered a decrement (with no one condition suffering a greater decrement) in performance in the first transfer test mission. These results should be viewed with some caution, though, because the co-located conditions did not fully allow participants to look at each other or communicate easily with each other physically. In addition, the computer simulation was so difficult that it demanded quite a bit of the participants' attention. This may have created a context and actually allowed the distance condition, with its greater isolation from the physical distraction of other teammates, to interfere with the task itself. As Smith and Vela (2001) indicate in a meta-analysis of context effects, greater task processing might lessen encoding of physical context, thereby lessening transfer interference. Thus, context may not just be the physical location (in the same room versus in different rooms) but may also include the context of the computer simulation. If the simulation stays the same and task demand is high, then differences in physical context may not make as much of a difference.

In Experiment 2, we used another complex simulation but increased the physical differences between co-located and distance conditions. The co-located condition used smaller computer setups with participants facing each other and the distance condition used three computers in three different rooms. (These rooms also were physically separated.)

Method

Participants

Participants were 60 teams of 3 students, all non-military, at New Mexico State University (NMSU). One team of three students who were all enrolled at NMSU's ROTC program participated but their data were not included in the analyses. Participation was voluntary and participants received $6 per hour compensation.

Design

The same design as Experiment 1 was used. For 40 of the teams, team members did not have to use push-to-talk technology; whereas, for 20 of the teams, team members were required to push-to-talk.

Materials

Simulation Software. This experiment used software developed by Aptima Corporation to train individuals and teams in peacekeeping, or Support and Stability Operations (SASO). Aptima's Dynamic Distributed Decision-making (DDD) software was developed for the Army and is used by Soldiers (see Aptima Corporation, 2005; see also Hollenbeck & Ilgen, 2000; Ilgen & Hollenbeck, 1999, 2000; Kleinman, Young, & Higgins, 1996). The software allows for three team members to interact through standard PCs and the Internet. The Internet connection allows members to immediately see other team members' actions on their screens and to communicate via e-mail. In this case, we disabled the e-mail facility to force participants to speak with each other over the headsets. The no push-to-talk participants spoke freely into their headsets without the need to push buttons to communicate and their language was digitally recorded. The participants in the push-to-talk condition were required to push a button and keep it depressed in order to talk (push-to-talk). Recording occurred only when the button was depressed.

In the task, teams were expected to use their role-specific resources to respond to problems that would arise within their peacekeeping operations in Bosnia. For example, if there was a problem in the refugee camp, dismounted troops could be sent in to respond to the problem. As in Experiment 1, training and transfer missions differed in two respects: Participants received feedback during training missions and different problems arose during the mission.

Each team member had a specific role. One role is the G2 (Army intelligence officer/general staff). In this role, a person would send in a variety of resources to gather information from many sources. A second role is the G3 (Army operations officer/general staff). In this role, a person would send in a third party to intervene in problems, and would gather information from infantry and police activity. The third role is the S3 (Army operations officer/unit staff). In this role, a person has control over patrol resources that either gather information or carry out security operations. In this case, the resources sent may include troops that could directly interact with local populations and may incur some risk.

In addition to these three team roles, the software had five different events that could occur in four geographic event areas: crowd, election, memorial, and refugees. Icons appeared on a map of Bosnia to indicate the four event areas where problems had arisen. A participant could click on these locations to find out more information about the problem in order to better determine what resources to send in, or to ask a team member to send in. After an event had occurred and resources were sent in, feedback appeared in the form of an e-mail message from the software. Each team member could see his/her own performance score and the overall team score in a continuous fashion over the course of each peacekeeping mission. Events were timed and if no resource or few resources are sent in, the possibility of escalation in a later event at the same location could occur. For training we used 1-3 of the events for each location and for testing/transfer, we used 4-5 of the events.

Computer-Based Training Materials. Because most participants would have little knowledge of either the software or the situation in Bosnia, a self-paced computer-based tutor was developed that provided information on both topics. The basic material on Bosnia included a history, maps of the conflict, and the current state of affairs. The basic material on the software simulation included a description of the individuals' specific role and responsibilities, as well as what the other participants' roles were, what the icons on the map meant, and where and how to find information as the simulation was progressing (scores, icons for events, etc.).

Team communication may not come naturally to people, especially when they first meet their teammates. In order to improve the training provided (over what was provided in Experiment 1) and to promote both discussion and camaraderie, two separate communication training events were included in the software. After a few pages introducing Bosnia and peacekeeping, the computer presented several examples of sample dialogues with the correct communication protocol. For example, participants were shown dialogue, such as "S3, this is the G3. What is your favorite color?" Participants were then asked to request the information from each other using this communication format and they were not allowed to proceed in training until the experimenter provided a code. They were given three practice communication trials. At the end of the first training session, participants again were asked to use the communication protocol and practice for another six practice communication trials. A videotape showing a team communicating with each other was provided at the end of training. The communication training served two purposes. First, the questions helped to create familiarity among team members before the practice missions began and, second, the team could practice using the correct communication protocol.

The computer-based tutor also provided each participant with unique knowledge so that a sense of responsibility over the knowledge needed to perform the task would be created. Each participant was also informed about the special knowledge of the other participants. Presumably this would promote sharing of knowledge during the missions and further distinguish each participant's role.

Each participant completed the computer-based training materials individually, aside from the practice communication trials, as described above. Periodically during training, the computer presented knowledge-based assessment questions and the participant had to correctly answer these questions before being allowed to continue with the material.

Other Questionnaires and Assessments. Several computer based questionnaires and assessments were provided to collect demographic information. In addition, during missions the experimenter would stop the simulation and ask specific knowledge questions of each participant (situation awareness questions). These questions were designed to measure the person's knowledge state or whether the person was paying attention during the missions.

Procedure

The same procedure as Experiment 1 was used with some exceptions. This experiment also was a 2-day effort, with 1 day's rest between sessions, but teams performed six training missions and two transfer missions in the peacekeeping simulation.

Results and Discussion

Description of Data

The computer automatically collected measures of individual and team performance. One team in the push-to-talk condition was missing performance data for one mission due to a computer problem. Thus, analyses did not include this team's data. Experimenters recorded the situation awareness answers as the information was gathered. Two independent raters scored this data. The analyses discussed below were performed on these scores.

Push-to-Talk Versus No Push-to-Talk

Figure 2 shows a graph of the mean performance for push-to-talk and no push-to-talk for the six training missions. A repeated measures ANOVA was performed with push-to-talk versus no push-to-talk as the between subjects variable and training Missions 1 through 6 as the within subjects variable. Teams in the no push-to-talk condition out-performed the push-to-talk condition, $F(1, 57) = 3.9, p < .05$. Since the results for the training were different, these two groups are treated differently in the description of team performance analysis to follow.

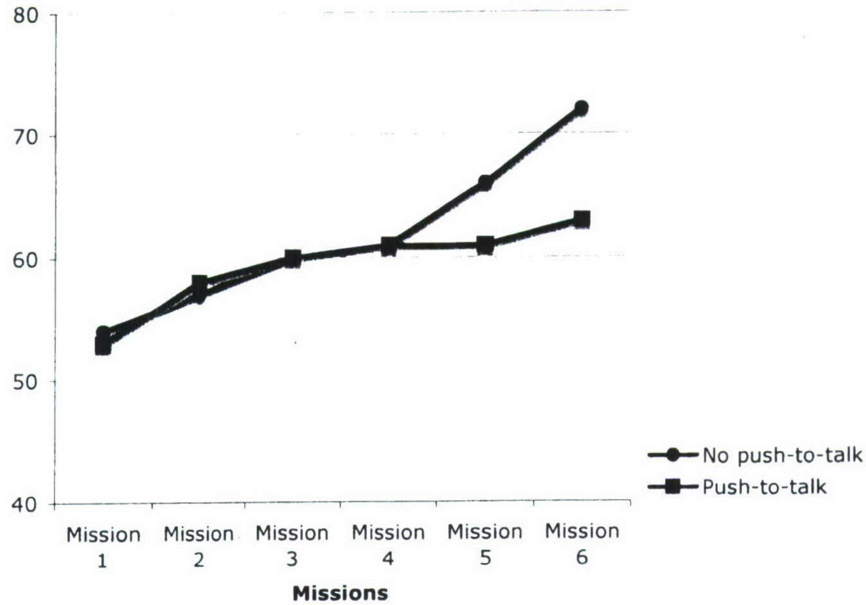

Figure 2. Experiment 2 push-to-talk versus no-push-to-talk team performance results

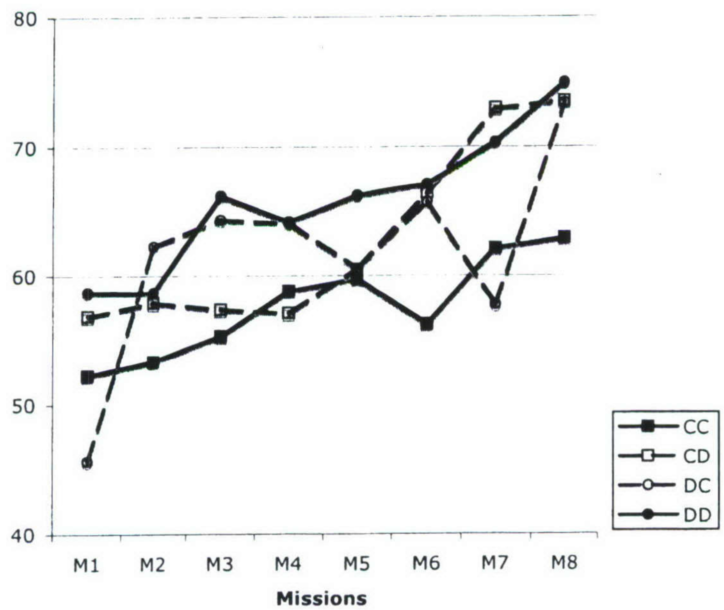

Figure 3. Experiment 2 push-to-talk team performance results.

Note. CC= co-located; CD = co-located to distributed; DC = distributed to co-located; DD= distributed.

Training Data

The overall performance data for no-push-to-talk is shown in Figure 3 and the overall performance data for push-to-talk is shown in Figure 4. During training (Missions 1-6), teams trained either in a co-located or distance condition.

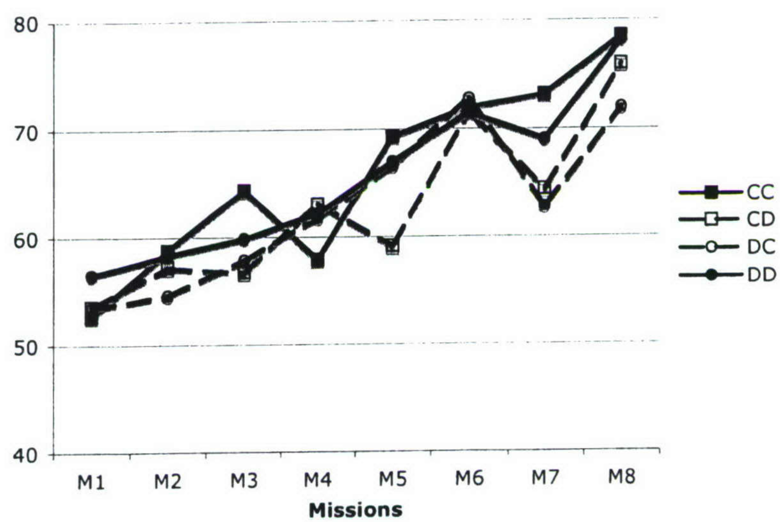

Figure 4. Experiment 2 no push-to-talk team performance results.

Note. CC= co-located; CD = co-located to distributed; DC = distributed to co-located; DD= distributed.

Transfer Results

Teams were trained in one of two conditions, co-located or distance. However, after Mission 6, teams either stayed in the same condition, co-located to co-located or distance to distance (CC, DD) or transferred to the opposite condition, co-located to distance or distance to co-located (CD, DC). (See Table 1.) In addition, teams were asked to do a different task after transfer than they had performed during training.

Push-to-Talk Analysis

Push-to-Talk, Training Data. Eleven co-located and eight distance teams participated. (Although Figure 3 shows overall performance, means for training missions are shown in Table 4). A repeated measures ANOVA was performed using Missions 1-6 as a within subjects variable and co-located versus distance as the between subjects variable. All teams improved from the first to the last mission, $F(5, 285) = 24.1, p < .01$. Even though all teams received the same initial declarative training, distance teams performed better on training missions than co-located teams, $F(1, 17) = 6.1, p < .05$.

Table 4

Experiment 2 Push-to-Talk Training With Co-located Versus Distance Teams

	Missions					
	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5	Mission 6
Co-located	54 (2.7)	55 (1.8)	56 (1.5)	58 (2.3)	60 (1.3)	51 (2.4)
Distance	52 (3.3)	61 (1.5)	65 (2.2)	64 (1.2)	63 (3.3)	67 (1.6)

Note. The standard error is in parentheses.

Push-to-Talk Transfer Data. Five teams participated in the CD condition; six teams performed in the CC condition; four teams participated in the DD condition, and five teams participated in the DD condition. A repeated measures ANOVA was performed with training missions as the repeated measure and Mission 7 performance score as the dependent variable and training context (co-located versus distance) and transfer context (same context versus different context) as the independent variables. Teams in the co-located training increased performance at transfer as compared to the distance training, $F(1, 118) = 5.8, p < .01$. However, the interaction between train and transfer contexts was significant also, $F(1, 118) = 55.4, p < .01$. In examining the graph, the reader can see that rather than decreasing in performance, as in Experiment 1, just about all conditions increased, except for the condition where teams trained at a distance and then transferred to co-located. These results not only contradict the findings from Experiment 1 but also the research performed by Singley and Anderson (1989).

A repeated measures ANOVA was conducted with Mission 7 and Mission 8 as the within subjects variable and co-located versus distance and same versus different context as the between subjects variable. Teams generally improved from Mission 7 to Mission 8, $F(1, 16) = 5.9, p < .05$ (mean Mission 7 = 65.8, SE = 2.4; mean Mission 8 = 70.5, SE = 2.1); however, this might be due entirely to the decreased performance of the teams that trained in the distance context and tested in the co-located context. (The interaction was significant, $F(3, 16) = 3.6, p < .05$; nonsignificant increases were found in all conditions except DC, where mean DC Mission 7 = 57.8, SE = 3.0; mean DC Mission 8 = 73.4, SE = 2.6). Note that both the CD and DD teams had increased performance between Mission 6 and Mission 7 and may have reached asymptote, and the CC condition did not improve from Mission 7 to Mission 8. Essentially the CC condition stayed at a very low level of performance throughout the experiment. In this case, the distance trained teams that changed context experienced diminished performance, while the co-located trained teams benefited from a context change.

No Push-to-Talk Analysis

No Push-to-Talk Training Data. Twenty distance and co-located teams participated in the no push-to-talk condition. Means are displayed in Table 5. A repeated measures ANOVA using Missions 1-6 as the within variable and co-located versus distance as the between variable was performed. All teams improved from the first mission to the last, $F(5, 190) = 29, p < .01$. No difference was found between the conditions in training, $F(1, 38) = 0.2, p = .67$.

Table 5

Experiment 2 No Push-to-Talk Training With Co-located Versus Distance Teams

	Missions					
	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5	Mission 6
Co-located	53 (1.8)	58 (1.3)	61 (1.6)	60 (1.4)	64 (1.8)	72 (2.2)
Distance	55 (2.3)	56 (1.4)	59 (1.3)	62 (1.4)	67 (1.5)	72 (2.4)

Note. The standard error is in parentheses.

No Push-to-Talk Transfer Data. Ten teams participated in each of the four conditions. An ANCOVA was performed with training missions as the repeated variable, first transfer mission (transfer Mission 7) performance as the dependent variable, and co-located versus distance and same context versus different context as the independent variables. Although Figure 4 indicates that all teams suffered a decrement in performance from training to test, the main effects of co-located versus distance training and different versus the same context overwhelm the results, $F(1, 239)=10.4, p < .01$ and $F(1, 239)=67.0, p < .01$ respectively. Teams that trained at a distance experienced a greater decrement in performance than teams that trained in a co-located fashion, and teams that changed contexts experienced a greater decrement in performance than teams that remained in the same context.

A repeated measures ANOVA was performed with Mission 7 and Mission 8 as the within subjects variable and co-located training versus distance training and different versus same context as the between subjects variables. Similar to Experiment 1, all teams improved between Mission 7 and Mission 8, $F(1, 36) = 22.9, p < .01$. A main effect for different contexts was found, where teams that transferred to the different context had a greater increase between Mission 7 and Mission 8, $F(1, 36) = 5.7, p < .05$ (mean difference for different contexts = 10.3, SE = 2.9; mean difference for same contexts = 7.2, SE = 2.1). Taken with the transfer results above, when no push-to-talk is employed, a change of context causes a greater change in performance than other factors.

Individual Contribution

For this experiment, each team consisted of three people who performed distinctly different roles. Paired *t*-tests indicate that all the roles differed from each other and that generally the best performer was the S3, and the worst performer was the G3. (Table 6 summarizes this analysis.) A regression was performed to discover the level of contribution that each individual had on the overall team performance score (three participants with roles G2, G3, and S3 and eight missions, compared to an overall team score over eight missions). For both push-to-talk and no push-to-talk, all three roles contributed to the overall performance score. (Table 7 summarizes the analysis.)

Table 6
Experiment 2 Paired t-Test Results for Roles

	Mean Difference	*t*-value
G2 vs. G3	4.0	$t(319) = 2.5$, $p = .01$
G2 vs. S3	-8.1	$t(319) = -5.1$, $p < .01$
G3 vs. S3	-12.1	$t(319) = -11.9$, $p < .01$

Table 7
Experiment 2 Regression Results for Individual Role Data by Push-to-Talk and No Push-to-Talk

	Coefficient	*t*-value
Push-to-talk		
G2 performance	0.19	11.2
G3 performance	0.31	12.9
S3 performance	0.31	12.5
No push-to-talk		
G2 performance	0.08	6.3
G3 performance	0.31	14.3
S3 performance	0.40	16.8

Note. All results are significant at $p < .01$ level.

To examine whether team overall performance exceeds the highest performing person in the group, the mean for each role and the team's performance was computed. Then the best score and the worst score for each team was compared to the team's score. The best performer scored more highly than the team, $t(39) = 6.3$, $p < .01$; mean of the team = 64.1, SE = 0.6; mean of the best team = 72.1, $p < .01$, SE = 1.3, and the worst performer did more poorly than the team, $t(39) = 7.6$, $p < .01$; mean of the worst performer = 58.0, SE = 0.8. These results are interesting because while working in a team may not necessarily benefit the best performer, it certainly improves the performance of the worst performer.

General Discussion: Contracted Research

This research examined the effects on teams when they train in the same location (co-located) or different locations (distance) and when the test/transfer occurs in the same context or situation (co-located to co-located or distance to distance) or in different contexts (co-located to distance or distance to co-located). Previous research with individuals has shown extensive context effects when participants change contexts (Singley & Anderson, 1989). Two experiments using two different simulations with essentially the same design were performed. The next two sections discussed will be: overall team performance and individual contribution. These will be followed by a discussion on theory, implications, and conclusions.

Overall Team Performance

For these experiments, we were primarily interested in whether changes in physical context affect performance for teams in the same way they tend to affect performance for individuals. Teams performed missions for which computer simulations captured performance data for individuals and for teams. In Experiment 1, distance teams performed better than co-located teams in the training but at test, no change of context effects (where change of context would result in poorer performance) were found. All teams performed worse on the transfer mission than on the previous training mission and then all teams increased in performance for the last two missions.

In Experiment 2, a difference was found between push-to-talk teams and no push-to-talk teams. Distance push-to-talk teams performed better than co-located teams in training; but at test, the co-located teams performed better than distance teams. All teams increased performance for the last test mission. On the other hand, no differences were found between distance and co-located no push-to-talk teams during training. In addition, at transfer, teams who changed context (co-located to distance or distance to co-located) performed worse than those teams who stayed in the same context. Although all teams again improved between the two test missions, the teams that changed context increased their performance at a significantly greater rate (i.e., they bounced back).

Generally, one would expect differences in the results across experiments because a number of variables were changed. The critical variables are: (a) hardware change from large consoles to regular computer desks and low profile headphones, (b) changes in the physical space from physically in the same room but not being able to establish eye-to-eye contact during use of simulation to computers facing each other and eye-to-eye contact easily attained, (c) UAV simulation to peacekeeping simulation, and d) push-to-talk and no push-to-talk conditions available. Nonetheless, there were consistencies in the results across the two experiments.

In this case, the training results for Experiment 1 were similar to those for the push-to-talk condition in Experiment 2. Essentially, the distance teams performed better on training trials than the co-located teams. One explanation is that the software environment was difficult to learn and therefore distance teams performed better than co-located teams because they did not have the distraction of interacting with the physical presence of others and could focus on the materials at hand. However, in Experiment 2, with no push-to-talk, no differences in conditions were found. Therefore, even if the difficulty level of the software did play a role in distance versus co-located training, some other factor may be more important and more general across experiments.

Another explanation is that push-to-talk affects performance. The distance teams may have found it more awkward to have to use push-to-talk in the counter-intuitive situation of sitting face-to-face with other people. The greater the isolation (distance training) the easier it is to focus on the training missions. Further, most undergraduates do not have any training in push-to-talk before the experiment. Therefore, the process itself is both untrained and unnatural. Some individuals and teams may find it easier to overcome this problem. For the no push-to-talk teams, this problem did not exist and therefore the measurement of team training did not include this possibly relevant variable.

For transfer, the results differ between experiments and between Experiment 1 and the push-to-talk condition of Experiment 2. The most logical explanation for Experiment 1 is that interference from the test played the largest role in determining transfer performance. However, this is not the same for the Experiment 2 push-to-talk conditions. If we assume that the test situation was either at the same difficulty or lower difficulty than the training missions, then the transfer missions become additional learning trials and increased performance is expected. The only condition which did not increase performance was with the distance to co-located condition. This group was likely hurt by the push-to-talk technology for the same reason that the co-located conditions were hurt during training. For the no push-to-talk condition, assuming the same level of difficulty of test as the push-to-talk, the same increase of performance is expected but was only obtained for the co-located to co-located teams. The other conditions decreased in performance with the largest decrease for those teams changing context. Thus, for no push-to-talk, transfer (physical context change) played the most important role in the decrement of performance with test playing a lesser role.

In summary, interference (decrement in performance) was measured in Experiment 2 and in the distance to co-located team for push-to-talk but not for other conditions. This supports the idea that physical context change (context effects) can be found in certain situations. However, when a task is difficult to learn, such as when push-to-talk is added to an already demanding simulation task, then attention must be focused in order to accomplish the task, and a dual task, such as pressing a button while talking, may be difficult. The dual task may become even more difficult when it is considered unnatural (such as when one is sitting across from someone else). Thus, task difficulty may affect whether context effects are measured.

These problem solving results are consistent with the literature on context and memory. In Smith and Vela (2001), context effects are reliable but may be affected by other variables. Greater task processing is one of the variables and this would be consistent with the results found for push-to-talk (in both Experiment 1 and the push-to-talk condition of Experiment 2).

So, along with interference caused by the test found in Experiment 1, the actions participants (team members) must perform and task difficulty may be variables to consider. These explanations reflect the complexity of transfer and of defining what context is critical for transfer of training to occur. Thus, whatever is most salient to the participant or the team (or causing the most difficulty in the learning context) may indicate what the critical context is.

Individual Contributions

The literature on group learning is often focused as to whether more learning occurs in a group than if the individual had learned by themselves (Hill, 1982). In most cases, a group does not usually perform better than the best individual in that group (which implies that for the best individual, the group situation might not be beneficial). Team studies differ from group studies because each member of the team has a distinct role and/or distinct knowledge. Thus, we sought to examine what contribution each individual in the team had to the overall performance.

Both experiments consisted of teams of three members with distinct roles. The results indicated that regardless of experiment, each of the roles contributed to overall team performance. (There were no roles that did not provide some input to team performance.) In addition, specific roles may outperform other roles (within a team).

In returning to the first question, we examined whether the best and worst performers outperformed the overall team performance score. In general, the best performer did outperform the team and the overall team's performance was better than the worst performer. These results are consistent with the literature (Hill, 1982) but again may indicate some problems for team training. In some situations, individual team performance may need to be monitored more closely and immediate feedback/remediation provided in order to prevent the team performance from sliding due to the worst performer.

Theory of Learning and Transfer

During learning, people form productions based upon the skills and tasks to which they are exposed (Anderson 1982, 1983). These productions become stronger over time and performance improves along a learning curve similar to those found in this research (Pirolli & Anderson, 1985). In the push-to-talk conditions for both experiments, the distance conditions performed better than the co-located conditions. These results could be due to interference with the desire to speak to someone directly when in a face-to-face situation. Speaking directly without pushing a button is a more automatic response and in order to perform in the push-to-talk conditions, participants must inhibit this automatic response (see Hull, 1952).

Anderson's theory of transfer posits that overlapping productions result in transfer (Singley & Anderson, 1989). The theory predicts a slight decline in performance at test but that performance will improve on the next trials. Focusing solely on the conditions where the physical context did not change, results from Experiment 1 are consistent with these ideas, but the results from Experiment 2 are not uniformly supportive of this idea, unless the test missions were considered to be easier than the training. Because the experiments include change of context conditions, some other mechanism to handle the change in physical context must be included.

One can imagine that the physical environment could be encoded into the condition side of the production rule and prevent or deter transfer from occurring. For the no push-to-talk condition, there was a strong context effect indicating interference. However, in Experiment 1, the change in context conditions actually decreased less and for push-to-talk one change in context condition performed better at test.

If a situation is not exactly the same, transfer can still occur. As Lee (1998) has argued, transfer may be a more active process than is suggested by overlapping productions. It may be a matter of noticing the critical similarities and ignoring the superficial aspects (which is, however, difficult for novices to do). Other aspects of a situation also may be important and the relevance of various parameters may be what matters. For example, if a teacher instructs in English in a certain classroom and then at testing changes classrooms and gives the test in French, poor performance could be due to either the change in classroom, the language of the test, or both. Some individuals may find that the change in classroom matters because they know French, but those who do not know French may find that to be the critical variable. Without push-to-talk and controlling for test difficulty, the physical context became important; however, with push-to-talk, the physical context became less important for some and more important for others. (That is, for Experiment 2 push-to-talk, the distance to co-located condition performed worse on the test. This was probably due to push-to-talk in a more rigorous environment—an interaction between hardware and environment.) Thus, treating the condition side of a production rule as a series of variables with different relevance ratings may reflect transfer more accurately in complex situations.

Implications

In these experiments, teams' performance at transfer was similar to individual's performance at transfer. The critical point is that transfer can be hindered under a range of potential circumstances; there's really no one uniform rule that can be applied. Although the researcher should examine all possible factors that could play a role in performance to determine which ones are the most critical to the learner, a good place to start would be the task itself. For example, if the task itself creates an especially compelling context, other factors (such as physical context) may play a smaller role. In addition, the task may include the hardware to execute the task (in this case, push-to-talk). Finally, even though team research adds the social interaction among team members as a factor, if the team remains intact from training through transfer, social interaction will not be a factor.

These results also indicate that findings for individuals may apply to teams, even though teams may appear to be a different entity. In some ways, in order to perform well as a team, the individuals within a team must be thinking and acting in a coordinated fashion, and therefore their performance would look like an individual.

Finally, in previous research in transfer and interference, Singley and Anderson (1989) found that a decrement in performance occurs at the point of interference but that the individuals recover and go on to better performance. The results across both experiments support this finding for teams. This implies that if team members train at a distance and then are brought together to perform a task, an initial decrement in performance may be found but recovery may take place. For example, military personnel could be trained at specific training sites across the country and be brought together for a peacekeeping activity in another country. However, we do not know how much of a decrement of performance will be incurred or how quickly a recovery will occur.

If the decrement in performance is very bad, it may significantly impair the ability of team members to improve back to their original level of performance. In the case of this research, the decrement was not severe and performance quickly regained and surpassed its original level; however, further research would have to be performed to examine the parameters involved in determining the extent of decrement to performance that greater context changes could have.

Future Directions

This research indicated additional future directions. First, because the team's performance overall often was better than the worst individual, software could be developed that focuses on identifying that worst individual quickly, monitoring his or her performance closely, and providing immediate feedback. Second, although we found that push-to-talk may be a critical factor in these studies, the difficulty level of the software still may provide a context for the team that may determine transfer. (Push-to-talk was originally used to make the hardware simulation close to the hardware used in the military. Further testing with push-to-talk would not necessarily provide information about basic processes, unless extensive practice with push-to-talk is provided before actual missions are performed.) Third, in the second experiment, we provided both extensive training on the scenario and the software. In addition, we provided training on communication because we wanted the first mission to be focused on getting to know the software without the added pressure of getting to know one's teammates or how to use the communication protocol. This proved to be very successful. Identifying this place where improvement could be provided by training was determined by examining videotapes of the teams. Right now, the protocols for the studies are being transcribed. These could be analyzed for other places to provide additional training and future studies could examine this improved training.

Another direction that is much more challenging is the issue of the provision of more adequate feedback and examining more configurations for both communication and physical environment. For feedback, the peacekeeping software currently provides an e-mail summary for the teams. Because communication is via headsets, all oral communications are captured. Recent developments in automatic analysis of text could be applied to automatic analysis of oral communication as the team is performing a task, if the communication could somehow be automatically transcribed as teams are speaking to each other (and to the experimenter) (Foltz & Martin, 2004). Note that this is dependent on the current form of oral communication.

Several other configurations of both communication and physical environment are possible. In the military, many communications are moving toward an e-mail only format. This may actually make it easier to analyze the communication using automatic methods.

In addition, some physical contexts are not as pure as those we tested in Experiment 2[a]. Instead four team members may be in a van with two next to each other, one in the front seat

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[a] A "pure" distance condition would be one in which individuals could not merely not see each other but also have no physical awareness of other individuals. That is, they are not in the same room separated by dividers but are in separate rooms, possibly separate floors, and maybe even separate buildings or separate cities. For example, training facilities could be located on the East Coast and West Coast and if

with equipment and the other driving. Distance may include being able to visually see the other individuals although the individuals are separated by continents. Thus, the number of possible communications and physical environments could be varied extensively and may uncover other issues in training in both co-located and distance formats.

Conclusion

The goal of these studies was to examine distance versus co-located training and transfer to similar or different environments. Distance training was not always detrimental. In addition, change of context is not always detrimental but can be when other factors do not play a large role in either training or ability to perform the task. For example, hardware factors, such as push-to-talk, can play a huge role in what transfers. The results of these studies were consistent with previous literature on individuals but extend those results by indicating places where the theories are incomplete. In conclusion, examining teams as they perform missions in different contexts can inform and extend theories of training and transfer.

Summary of Additional Research

The goal of this research was to assess team trust and performance in distributed and co-located (face-to-face) contexts. Antecedents to trust (propensity to trust, perceived trustworthiness) and trust behaviors were examined in relation to team performance in a complex peacekeeping simulation where teams participated in same, different, and transfer context conditions. In Experiment 1, a "my" ability/competence factor accounted for most of the variance in perceived trustworthiness. In Experiment 2, propensity to trust held no relationship with performance but ability-based perceived trustworthiness predicted greater distributed and co-located team performance. This research has many implications for research in the areas of education, military training, and memory.

Introduction

Teams play an increasingly larger role in many aspects of work performed by business organizations, government institutions, and the military. The growing complexity of work frequently surpasses the cognitive capabilities of individuals and thus, necessitates a team approach (Cooke, Salas, Cannon-Bowers, & Stout, 2000; Salas, Cannon-Bowers, Church-Payne, & Smith-Jentsch, 1998). Research that compares distributed and face-to-face (co-located) collaborative behaviors, including training, learning, trust, performance, and other aspects, has been conducted with dyads or groups, but not many studies exist that have investigated those behaviors at a team level (Cooke, Salas et al., 2000). The relationship between team trust and performance, which is the focus of this research, necessitates that a clear distinction be made between *groups* and *teams*, and also that a distinction be made between teams that are *distributed* and *co-located*.

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one team member trained on the East Coast and one on the West Coast, this would be a pure distance condition. In a university lab, it is difficult to create such pure conditions.

Groups and Teams

One definition of "group" is proposed by Levine and Moreland (1998); defined as "several people who interact on a regular basis, have affective ties with one another, share a common frame of reference, and are behaviorally interdependent" (p. 415). A "team" is "a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission, who have each been assigned specific roles or functions to perform, and who have a limited life span of membership" (Salas, Dickinson, Converse & Tannenbaum, 1992, pp. 126-127). Guzzo and Dickson (1996) also indicate that work teams are composed of individuals who are mutually accountable and work interdependently. These definitions of "team" differ from "group" in that teams have differentiated responsibilities and roles (Cannon-Bowers, Salas, & Converse, 1993), they are accountable on their task performance and to each other, and they work dynamically in their limited partnership to complete the task at hand.

Co-Located and Distributed Teams

Bell and Kozlowski (2002), and Cohen and Gibson (2003), indicate that one defining characteristic of distributed or virtual teams is that they are divided by space or are dispersed geographically. Co-located teams work in geographic proximity. However, Kirkman and Mathieu (2005) have recently challenged those definitions, suggesting that level of team virtuality in both distributed and co-located teams is the more important contextual construct. Those authors argue that purely virtual and co-located teams interface, either wholly or partially, through virtual means.

In our research, co-located teams operate in physical proximity, but virtually they share the same technological equipment (headsets for communications, computers for participating in military simulations) as distributed teams, who work in geographically-dispersed locations. We will adhere to the geographical definition of co-located and distributed teams, yet we also will take into account the level of virtuality shared by all teams when discussing similarities and differences we find in antecedents to trust, trust behaviors, propensity to trust, and performance in the differing physical contexts.

Group Trust and Performance

Most researchers who have examined trust and antecedents to trust (explained below) have studied co-located and/or distributed groups rather than teams, based on the definitions presented above. For example, no relationship was found between trust and performance in one group experiment where business students worked to complete a research paper and report together (Aubert & Kelsey, 2003). The business students in that study held no specific differentiated roles in completing the group task and they knew their task was a joint project. The researchers measured antecedents to trust and trust before and after groups from two universities worked together. Results in the Aubert and Kelsey (2003) research showed that antecedents to trust and trust were higher in subgroup members who had the opportunity to meet co-located (same university affiliation) and lower for distributed subgroup members (different university). Since Aubert and Kelsey (2003) studied group work, their results might not replicate in this research of team trust and performance. Team members in the current effort have differentiated roles and responsibilities and work dynamically and interdependently on a complex task together, and should trust one another in order to perform their role-specific functions for optimal team performance in either distributed or co-located contexts. If there is lower team trust in either physical context, then performance should suffer.

Trust Defined

What is trust? Trust is a difficult construct to define (Gambetta, 1988; Yamagishi & Yamagishi, 1994). However, two key facets in a definition of trust are (a) *positive expectations* and (b) a *willingness to become vulnerable* (Costa, Roe, & Taillieu, 2001). First, a person must have optimistic expectations (Elangovan & Shapiro, 1998) or positive expectations about others (Lewicki & Bunker, 1996), in order to trust. Also, one will willingly become vulnerable to others when those others' actions are not under one's control (Mayer, Davis, & Schoorman, 1995; Zand, 1972). As defined in this investigation and stated in Costa et al. (2001), trust is defined as follows. "Trust is a psychological state that manifests itself in the behaviors toward others, based on the expectations made upon behaviors of these others, and on the perceived motives and intentions in situations entailing risk for the relationship with these others" (Costa et al., 2001, p. 228). Expectations and perceptions of others' behaviors form the basis for an individual's trust (or lack of trust), and the perceptions of risk associated with the relationships address the issue of willingness (or unwillingness) to become vulnerable. When more than two people work together on a temporary project, the trust relationship becomes complex, where positive expectations are variable within and between members, as is the willingness to become vulnerable at a team level.

Antecedents to Trust and Trust Behaviors

Trust includes antecedents to trust formation (*propensity to trust*, and dimensions of *perceived trustworthiness*), and actual *trust behaviors* (Costa et al., 2001). Propensity to trust is relatively dispositional (Rotter, 1967), and is thought to remain stable (Aubert & Kelsey, 2003). Perceived trustworthiness is derived from observations and interpretations of team members' behavior over time and can vary over tasks, situations, and people (Costa et al., 2001; Zand, 1972). Trust behaviors are behavioral reactions to perceptions of trustworthiness, and include cooperative behaviors (if trusting), or monitoring behaviors (if not trusting; Leifer & Mills, 1996).

Factors That Define Perceived Trustworthiness

Mayer, Davis, and Schoorman (1995) propose three factors that define trustworthiness: *benevolence, ability,* and *integrity*. Benevolence represents an affective bond between people that involves providing mutual support (Aubert & Kelsey, 2003) and a mutual desire to do well (Mayer et al., 1995). Ability is a set of skills and characteristics exhibited within a domain (Mayer & Davis, 1999). Integrity is composed of honesty and morality, defined as the trustor's perception that a trustee's actions adhere to an acceptable set of principles (Mayer & Davis, 1999). McAllister (1995) also suggests that evaluations of *competence* are made by a trustor in a judgment of trustworthiness. Mayer and colleagues (1995) include competence in their ability dimension, but one might possess ability in a domain, yet not show competence in demonstrating those sets of skills over a given task.

Perceived trustworthiness is measured in this research using a metric administered several times over the course of a complex task that yields reciprocal ratings of how each team member perceives themselves (self-perceived trustworthiness) and every other team member's (other-perceived trustworthiness) benevolence, ability, integrity, and competence. Mayer and Davis (1999) suggest that the dimensions of perceived trustworthiness (benevolence, integrity, ability, and also included in this research is a competence dimension) may be more or less important to the situation and task. If a situation is technically difficult and ambiguous, for example, a trustee's ability and/or competence may be more important to perceived trustworthiness than the other factors. If a situation is less-cognitively demanding but depends more on mutual honesty or morality, then integrity might be a more important dimension in perceived trustworthiness (Mayer & Davis, 1999).

Trust and "Touch" in Distributed and Co-Located Teams

One of Charles Handy's (1995) seven trust maxims for contemporary organizations is that "trust needs touch," and specifically in distributed working relationships, merely seeing a face on a videoconference screen, or possessing an e-mail address to work together on distributed tasks is not sufficient for trust to develop. Handy (1995) argues that distributed groups require some face-to-face (co-located) contact because a shared commitment necessitates personal contact to make that commitment real. Similarly, Johansen and O'Hara-Devereaux (1994) assert that face-to-face interaction enhances trust-building and allows greater opportunity to repair trust if it has been broken among group members. Rocco, Finholt, Hofer, and Herbsleb (2001) found lower trust in Computer Mediated Communication (CMC) groups when compared to face-to-face (co-located) groups unless there was a face-to-face meeting in the CMC groups. CMC groups are connected via the Internet, instant-messaging, cellular phone text, decision support systems, etc., and CMC is defined as "any human symbolic text-based interaction conducted or facilitated through digitally-based technologies." (Spitzberg, 2006). The Rocco et al. (2001) findings support Handy's argument that "trust needs touch." In practice, however, it is not always feasible for workgroups from global corporations or military units or governmental institutions to make arrangements for face-to-face meetings in order to build and maintain trust within workgroups. Further, distributed teams that function only for a limited duration of time on temporary projects do not always have the opportunity to hold face-to-face meetings merely to build team trust. It is important that new methods for building and maintaining trust in distributed workgroups and teams be identified so that the "touch" in trust can extend to the distributed domain without the need for face-to-face meetings.

One preliminary study reported by Zheng, Veinott, Bos, Olson, and Olson (2002) analyzed dyads engaged in a Prisoner's Dilemma task. Although using CMC dyads, the important implication of this research is that it demonstrated initial trust can be built by the mere exchange of some social/personal information before working on a task together (e.g., favorite color, food). Thus, one sub-goal of this research is to discover whether distributed teams will "touch" and thus, build trust, by having a short initial exchange of social/personal information before beginning the complex team task.

Perceived vs. Actual Performance

Psychologists and management scientists have conducted tests of trust predicting team performance, primarily using surveys (e. g., Costa, 2003; Costa, Roe, & Taillieu, 2001; Politis, 2003) or questionnaires (e. g., Spector & Jones, 2004). In most of those studies, the performance metric was *perceived* performance reported by individuals on the team, rather than measured performance in a complex task. Although these types of studies have been conducted with participants who work in naturalistic settings, which are preferable to studies conducted in artificial laboratory settings, it is important to conduct a controlled investigation that assesses the complex trust-performance relationship with *actual*, and not perceived, performance metrics as is done in this research.

Trust Differences in Co-Located and Distributed Teams

In the past, researchers have used social dilemma games such as the Prisoner's Dilemma to assess trust between people, by assessing how well people cooperate and the level of collective pay-off (refer to review in Riegelsberger, Sasse, & McCarthy, 2003). Recently, some researchers have criticized the use of the Prisoners' Dilemma game in the context of computer-mediated communication such that the game does not model real-world situations (Riegelsberger et al., 2003). One criticism is that experimental settings do not create serious risks for participants because of ethical reasons. Instead, participants are well aware "of the gravity and nature of risks associated with their decisions" (Riegelsberger et al., 2003, p. 768). Thus, this sort of social dilemma game may not be appropriate in assessing the relationship between trust and performance and perceived trustworthiness dimensions such as ability or benevolence (Riegelsberger et al., 2003). In addition, social bargaining games involve two persons each of whom chooses the best payoff; while the current effort uses three persons assigned to specific roles/duties that constitute a team, and their performance can affect everyone as a whole.

In this research, team members trained in a complex peacekeeping simulation, and carried out missions together, communicating by headsets as they worked in co-located and/or distributed contexts. This design allowed us to assess propensity to trust before the team formed. It also allowed us to assess perceived trustworthiness several times over the course of team missions. In addition, since team members communicated verbally over headsets during the missions, we evaluated cooperating and monitoring trust behaviors derived from team communication. The computerized simulation measured actual performance on the individual and team level automatically for each peacekeeping mission.

Technology for Task and Team Performance

Some researchers suggest that there is a productivity advantage for teams that work in co-located environments over distributed task environments even when technological advances have improved communication technology for distributed work teams (Olson, Teasley, Covi, & Olson, 2002). If distributed teams are to improve productivity, and if it is the case that co-located teams show greater productivity, then communication media must at least afford a sense of *co-temporality*, among other attributes (such as *visibility, audibility, simultaneity, sequentiality*; Driskell, Radtke, & Salas, 2003; Kraut, Fussell, Brennan, & Siegel, 2002), for distributed team members to exhibit adequate performance. To achieve co-temporality, distributed teams working in separate locations should be able to see or hear each others' communication in real time, and should be able to see their own work and work performed by other team members as it is output, in real time. The sense of co-temporality is fostered by open verbal communication and through the visibility of other team members' actions as seen on a computer screen in this investigation.

McAllister (1995) and others (e. g., Gruenfeld, Mannix, Williams, & Neale, 1996; Zand, 1972) suggest that there is a relationship between the strength of team members' trust for each other and the quality or effectiveness of a team's performance over a given task in co-located environments. In a study of CMC groups, Bos, Olson, Gergle, Olson, and Wright (2002) examined trust emergence under four communication modes (text, audio, video, and face-to-face). Face-to-face, video, and audio mode groups established higher trust than text mode groups. Video and audio groups performed almost as well as face-to-face groups, but showed evidence of delayed trust. Meyerson, Weick, and Kramer (1996) indicate that the establishment of "swift trust," a form of trust in temporary teams with a finite task, is important to performance, and so delayed trust in a geographically distributed team might predict lower overall team performance, even under enhanced communication conditions (audio in this research).

In higher-trusting distributed teams, Jarvenpaa and Leidner (1999) also reported that initially those teams formed a kind of trust that was swift, depersonalized, and action-based. Although performance was not a central measure in their study, the higher trusting teams seemed to overcome task and technological uncertainty and relied on each other's ability, while lower trusting teams blamed the virtual environment for task problems. Thus, the Jarvenpaa and Leidner (1999) research indirectly suggests that trust behaviors and an ability and/or competence dimension of perceived trustworthiness might impact distributed team performance, and that higher initial ability- and/or competence-based perceived trustworthiness might predict greater task performance.

Team Trust and Context Transfer

The current effort implements a balanced context-based trust-performance manipulation. Some teams trained and tested (conduct missions) in a face-to-face (co-located) context (CC; train co-located, test co-located), and others trained and tested in a distributed (virtual) context (DD; train distributed, test distributed). However, another group of teams trained in co-located context and transferred to test in a distributed context (CD), and other teams trained in a distributed context and transferred to test in a co-located context (DC). It is predicted that perceived trustworthiness will diminish when teams train in one context and transfer to another context, since performance is predicted to suffer in the first peacekeeping mission after transfer for those groups, and perceived trustworthiness should be predictive of team performance. Thus, the contextual manipulation should show that team performance should vary as a function of perceived trustworthiness. The research is divided into two large experiments. In Experiment 1, we examined the attributes of perceived trustworthiness, and the effects of the dimensions of perceived trustworthiness on team performance over time in the four context conditions. In Experiment 2, we tested whether propensity to trust, perceived trustworthiness, and trust behaviors are related to performance in the context conditions.

Experiment 1: Perceived Trustworthiness in a Complex Team Peacekeeping Task

Experiment 1 was designed to identify the most important dimensions of reciprocal perceived trustworthiness. In this investigation of teams working on a complex peacekeeping task, it was predicted that ability and competence are the most important dimensions of Perceived Trust to team members, because of the complex nature of the task (Mayer & Davis, 1999). The first experiment includes a 48-item post-mission Perceived Trust questionnaire administered after four of eight missions in the 8-mission team peacekeeping simulation. All the factors, ability, competence, integrity, and benevolence dimensions of Perceived Trust, were assessed to determine which of the dimensions are important in contributing to team performance; a shorter metric can be designed for Experiment 2 which addresses these dimensions of Perceived Trust. Thus, Experiment 1 investigated factors that are most important to Perceived Trust in a complex team peacekeeping simulation, and assessed the dimensions of Perceived Trust as they relate to team performance in context-based conditions.

Method

Teams of three undergraduates participated as peacekeepers in a simulation developed by Aptima®. Aptima's Dynamic Distributed Decision-making (DDD) software was developed for the Army and is used by Soldiers (see Aptima Corporation, 2005; also see Hollenbeck & Ilgen, 2000; Ilgen & Hollenbeck, 1999, 2000; Kleinman, Young, & Higgins, 1996). The software allows teams to interact through standard PCs and the Internet. The Internet connection allows members to immediately see other team members' actions on their screens.

Roles for each team were S3, G3, and G2, and the three team members were randomly assigned to each role. S3 (Army operations officer/unit staff) controlled patrol resources that gathered information or carried out security operations. S3 resources might include troops that could directly interact with local populations and might incur some risk. G3 (Army operations officer/general staff) could send in a third party to intervene in problem situations, and could gather information from infantry and police activity. The G2 (Army intelligence officer/general staff) could send in a variety of intelligence resources to gather information.

In addition to these team roles, the software allowed for five different events that could occur in each of four geographic event areas: crowd, election, memorial, and refugees. Icons appeared on a map of Bosnia to indicate the four event areas where problems had arisen. A participant could click on these locations to extract more information about the problem and current situation in order to determine what resources to send in, or to ask some other team member to send in. After an event had occurred and resources were sent, feedback appeared in the form of a report during the simulation. Each team member could monitor his/her own performance score and the overall team score continuously in each mission. Events were timed and if no resource or few resources were sent in, escalation in a later event at the same location could occur. For training (Missions 1-6), participants received the same three events for each location and for testing/transfer, participants received three different events.

After extensive training, teams conducted eight missions in the simulation. There were four randomly assigned context-based experimental conditions: CC, CD, DC and DD. Training, practice Missions 1-2, and Missions 3-6 were accomplished in the first context (all pre-transfer missions), and after transfer, Missions 7 and 8 were conducted. After Missions 1, 5, 7, and 8, teams answered the 48-item Perceived Trust questionnaire that asked questions about each team member's ability, competence, integrity, and benevolence.

Participants

Fifty-one teams comprised of three persons each participated. Participants were undergraduates, ages 18-30, from many academic disciplines with no military or ROTC experience. English was their first learned language, and ethnicities were primarily Caucasian and Hispanic. The research was conducted on one day for approximately 6 hours, with breaks. Participants were paid $6 per hour for their participation.

Materials and Stimuli

A training system was developed and was divided into two sets: (a) one that gave a team-level introduction to peacekeeping, an individual-level introduction to expertise-specific Bosnian history, and a short social/personal exchange of information via team communication; and (b) a second set that gave a team-level overview of all role-specific resources and videos of examples of team communications. For example, expertise-specific history included historical information about: (a) the Memorial in Bosnia, which was dedicated to thousands of Muslim males killed in Bosnia; (b) the Elections area, which would be the site of the first free and fair elections in Bosnia since the United Nations had begun peacekeeping operations there; and (c) the Refugees area, where thousands of displaced people were returning to Bosnia from other areas. Each of the team members (S3, G2, G3) were randomly assigned one area in the expertise-specific history training (Memorial, Elections, Refugees), and all were trained in a fourth area, the Crowd event area. Role-specific resources were also taught specifically to S3 (Dismounted Patrol, Presence, and THT resources); to G2 (CIMIC, OSINT, and C-12 imaging aircraft resources); and to G3 (Presence, BILAT, and IPTF resources). During training, teams saw videos depicting other teams communicating either in a co-located context or in a distributed context, specific to the experimental training condition.

Technological Equipment and Software

A laboratory was arranged where movable workstations could be placed in distributed rooms or in a central room, depending upon randomly-assigned experimental conditions. Dell computers, audio communication equipment, and Sennheiser headsets were installed on the workstations. Audio was connected to a centralized dedicated Dell server in a control room, and participant computers were connected to a second Dell server where an experimenter controlled team training and simulations. Cameras were installed high on the walls of each of the remote and central laboratory rooms, and were connected to a dedicated Dell video server used for continuous video recording. Audio was recorded on multiple tracks using CoolPro® software. The simulation data were saved automatically. Microsoft XP® was used for the presentation and recording of the training, and Linux RedHat® was used for the presentation and recording of the post-mission trust questionnaires.

Factors Important to Perceived Trustworthiness in a Complex Team Task

To construct the Perceived Trust questionnaire, 16 English-language dictionaries were randomly chosen to extract three constructs mentioned most frequently in the definitions of each of four Perceived Trust dimensions (ability, competence, benevolence, and integrity). Those constructs were used in the questions presented to team members. Ability questions involved skill, ability, and capability. Competence questions regarded qualification, knowledge, and capacity. Kindness, goodwill, and generosity were used to assess benevolence. Honesty, morality, and ethical behaviors characterized integrity.

After Missions 1, 5, 7, and 8, the Perceived Trust questionnaire was administered. Since this questionnaire was administered to a three-member team, questions were comprised of "my" (self) and "their" (other) ability, competence, integrity, and benevolence. One question designed to measure "my" ability, for example, asked the team member, "On a seven-point scale, how would your teammates rate your skill in doing your job?" The team member was asked the same type of question about the other two team members ("their" ability). A rating of one would represent "not skilled at all" and a seven rating would represent "exceptionally skilled."

Procedure

Participants arrived on different floors and areas of the building so they did not see each other unless they were in co-located conditions. Experimenters brought each team member individually into the laboratory, through separate entrances and into separate rooms if distributed, or through a single entrance into a central laboratory room if co-located. Co-located participants' workstations were set up so that all three team members faced each other in a triangular arrangement, and they could clearly interact together and see each other without visual obstructions. Participants in distributed rooms did not see each other, but could verbally communicate with each other, although they were not aware of the physical locations of either of their other teammates. Participants wore headsets in all context conditions, which allowed verbal communication exchange and digital recording of their language.

Participants signed video and audio recording consent forms and a general consent to participate, and then trained for approximately 1 ½ hours. They were given a fifteen minute break, and if they were in distributed conditions, they did not see each other during the break. Upon return, teams participated in one of two practice missions on the actual simulation, and experimenters gave individual help regarding how to send in resources to event areas, and answered any questions team members had about the simulation or their objectives. Standard prompts were read verbally to participants over their headsets, to call attention to individual and team scores, to read simulation feedback and to use the feedback to make better choices about sending resources to event areas. After the first mission, team members responded to post-mission questionnaires. The team participated in a second practice mission during which no help was given by the experimenters, and if questions were asked, team members were directed to communicate together to solve the problem. After the sixth mission (Missions 1-6 are pre-transfer missions), depending upon whether the team was randomly assigned to transfer or stay in same-context conditions, experimenters either moved the portable workstations to distributed rooms or to the co-located central room, or the workstations remained distributed or co-located for the final two missions (post-transfer missions). The Perceived Trust questionnaire was administered after Missions 1, 5, 7, and 8. After the final mission, experimenters debriefed the team members about the experiment's objectives and paid team members for their participation.

Results and Discussion

Perceived Trustworthiness Analysis

The analyses of the Perceived Trust questionnaire consisted of a principal components factor analysis with varimax rotation (refer to Table 8)[b]. Factors were named "My Ability/Competence," "Benevolence," "Their Ability/Competence," and "Integrity," since those factors clearly represented perceptions of trustworthiness in this experiment. Each of the concepts predicted to load on the four Perceived Trust factors loaded at > .40; however, honesty, which was predicted to be an attribute of integrity, loaded more highly on the benevolence factor (my honesty = 0.60; their honesty = 0.63) than on the integrity factor (my honesty = 0.44; their honesty = 0.40). In partial support of the Perceived Trust prediction, where ability and/or competence was predicted to be most important to the teams performing a complex peacekeeping task, the "My" Ability/Competence Factor explained 53.2% of the variance in Perceived Trust, with Benevolence (9.9%), "Their" Ability/Competence (6.6%), and Integrity (5.4%), explaining 75.1% of the variance in Perceived Trust.

Thus, the Mayer et al. (1995) research, which included competence in their ability dimension, replicated in this experiment, with the caveat that on a team level there is a clear difference between the perception of "My" Ability/Competence, and "Their" Ability/Competence in a complex team task. The peacekeeping task was technically difficult and ambiguous (Mayer & Davis, 1999), and "My" perceived ability/competence was more important to Perceived Trust than factors that might be important to less-cognitively demanding tasks.

Perceived Team Trustworthiness in Context

In order to investigate differences between teams in co-located, distributed, or context transfer conditions, each of the four factors of Perceived Trust was examined as dependent measures with Context Group (CC, CD, DC, DD) as the independent variable. An analysis of variance (ANOVA) revealed no significant differences on My Ability/Competence between Context Group, $F(3, 608) = 0.75$, *ns*. Benevolence, however, was different between Context Group, $F(3, 608) = 5.80$, $p < .01$, $R^2 = .03$; indicating that kindness, goodwill, and generosity perceptions in perceived trustworthiness were influenced as a function of context. Follow-up mean comparisons revealed that the CC Benevolence mean ($M = 0.30$, $SE = 0.09$) was significantly higher than DD ($M = -0.10$, $SE = 0.08$), and CD ($M = -0.15$, $SE = 0.08$) scores at $p < .05$.

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[b] The Factor analysis was based on an aggregation across the 4 missions. (N = 588, where 588 = 3 Roles X 4 Missions X 49 Teams).

Their Ability/Competence was also different between Context Group, $F(3, 608) = 3.20$, $p < .05$, $R^2 = .02$, where follow-up comparisons revealed that CC ($M = 0.20$, $SE = 0.09$) was significantly greater than DC ($M = -0.15$, $SE = 0.08$) at $p < .05$. Integrity was also different between Context Group, $F(3, 608) = 4.42$, $p < .01$, $R^2 = .02$. The DD condition ($M = -0.15$, $SE = 0.08$) teams showed lower ratings regarding the integrity of their teammates than teams in either the DC condition ($M = 0.14$, $SE = 0.08$) or the CC condition ($M = 0.17$, $SE = 0.09$) at $p < .05$.

The initial factors by context analyses generally show that co-located teams perceived their teammates to show greater benevolence, ability/competence, and integrity than teams in distributed conditions. CD teams were not significantly different from co-located teams on the Perceived Trust (PT) factors, possibly because they trained in co-located conditions. Only on the important My Ability/Competence factor were all teams equal, advancing the notion that one dimension of Perceived Trust that transcends any continuum of virtualness (Kirkman & Mathieu, 2005) is that at team-level, Perceived Trust is mainly about "my ability/competence." Results partially support Handy's (1995) suggestion that virtual teams need to have some co-located "touch" in order to build most of the other dimensions of Perceived Trust (benevolence, their ability/competence, and integrity) to a higher level, at least when teams are working on a complex task together.

Table 8

Rotated Components Matrix for Perceived Trustworthiness Ratings

Perceptions	F1 (My Ability/ Competence)	F2 (Benevolence)	F3 (Their Ability/ Competence)	F4 (Integrity)
	Loadings			
My Ability	**0.836**	0.235	0.225	0.198
My Skill	**0.836**	0.235	0.225	0.198
My Capability	**0.761**	0.233	0.260	0.206
My Qualification	**0.742**	0.205	0.359	0.145
My Knowledge	**0.722**	0.189	0.384	0.139
My Capacity	**0.703**	0.215	0.342	0.210
Their Kindness	0.059	**0.807**	0.253	0.225
Their Generosity	0.141	**0.789**	0.299	0.150
My Kindness	0.264	**0.789**	0.123	0.201
My Generosity	0.338	**0.776**	0.172	0.198
Their Goodwill	0.200	**0.765**	0.239	0.185
My Goodwill	0.336	**0.732**	0.161	0.170
Their Honesty	0.088	**0.625**[a]	0.286	0.402
My Honesty	0.229	**0.600**[a]	0.143	0.437
Their Qualification	0.306	0.187	**0.793**	0.103
Their Knowledge	0.300	0.172	**0.775**	0.146
Their Skill	0.266	0.191	**0.773**	0.160
Their Capability	0.230	0.282	**0.757**	0.146
Their Capacity	0.232	0.295	**0.729**	0.241
Their Ability	0.254	0.299	**0.699**	0.265
Their Morality	0.150	0.343	0.305	**0.774**
Their Ethics	0.127	0.273	0.372	**0.758**
My Ethics	0.392	0.262	0.137	**0.754**
My Morality	0.340	0.355	0.092	**0.751**
Variance accounted for by each factor	53.2%	9.9%	6.6%	5.4%

[a] Loadings for My/Their Honesty were higher on the Benevolence factor than on the Integrity factor, although loadings on Integrity were >.40.

Note. Significant loadings for each of the four factors are indicated in **bold**.

Perceived Team Trustworthiness by Mission

To investigate longitudinal dimensions of Perceived Trust over the complex peacekeeping task for collapsed Context Groups, separate analyses of variance were conducted with Mission (1, 5, 7, and 8) as the independent variable, and the four Perceived Trust factor scores as the dependent variables. The My Ability/Competence factor did show differences between the four missions, $F(3, 608) = 36.95$, $p < .01$, $R^2 = .15$, where follow-up mean comparisons revealed that My Ability/Competence in Mission 1 ($M = -0.64$, $SE = 0.07$) was significantly lower than Missions 5 ($M = 0.01$, $SE = 0.07$), 7 ($M = 0.29$, $SE = 0.07$), and 8 ($M = 0.34$, $SE = 0.08$), at $p < .05$. Comparisons also showed that Mission 5 was significantly lower than Missions 7 and 8; however, Missions 7 and 8 were not significantly different from one another on ratings of My Ability/Competence. Thus, perceptions that others on the team trusted one's ability/competence to perform one's complex task strengthened across the simulation.

The test of mission on the Benevolence Factor revealed no differences between ratings over the course of the experiment. Their Ability/Competence factor showed $F(3, 608) = 14.70$, $p < .01$, $R^2 = .07$, where follow-up mean comparisons revealed differences on ratings of Their Ability/Competence Factor only when Mission 1 ($M = -0.43$, $SE = 0.08$) was compared with Missions 5 ($M = 0.02$, $SE = 0.08$), 7 ($M = 0.18$, $SE = 0.08$), and 8 ($M = 0.23$, $SE = 0.08$), at $p < .05$. Comparisons did not show differences on ratings of Their Ability/Competence factor between Missions 5, 7, or 8. The Integrity Factor ANOVA showed $F(3, 608) = 2.67$, $p < .05$, $R^2 = .01$, where the minimal effect was driven by a difference of team Integrity ratings between Mission 1 ($M = -0.15$, $SE = 0.08$), and Mission 8 ($M = 0.17$, $SE = 0.08$).

The results show a significantly steady increase of ratings of My Ability/Competence over the course of the complex peacekeeping task. This result, also taking into consideration the finding that Context Group was not important when looking at My Ability/Competence, lends stronger support to the notion that Perceived Trust at team-level is driven by the idea that "it is all about My Ability/Competence" on the team, and this factor increases over time in a complex team task.

Perceived Team Trustworthiness Factor Models Predicting Team Performance

Figure 5 depicts the fit of My Ability/Competence, Benevolence, Their Ability/Competence, and Integrity models on team performance. In each relationship, the cubic function of each dimension of PT best fits the data in terms of variance explained by each factor. Benevolence was not significant ($p = .17$) in the model with Team Performance, however all other Perceived Trust factors were predictors of Team Performance at $p < .01$ (refer to *Figure 1* Notes for values). It should be noted that My Ability/Competence explained only 6% of the variance in performance, matched by Their Ability/Competence (6%), and followed by Integrity (2%), and Benevolence (1%); in total explaining less than 15% of Team Performance.

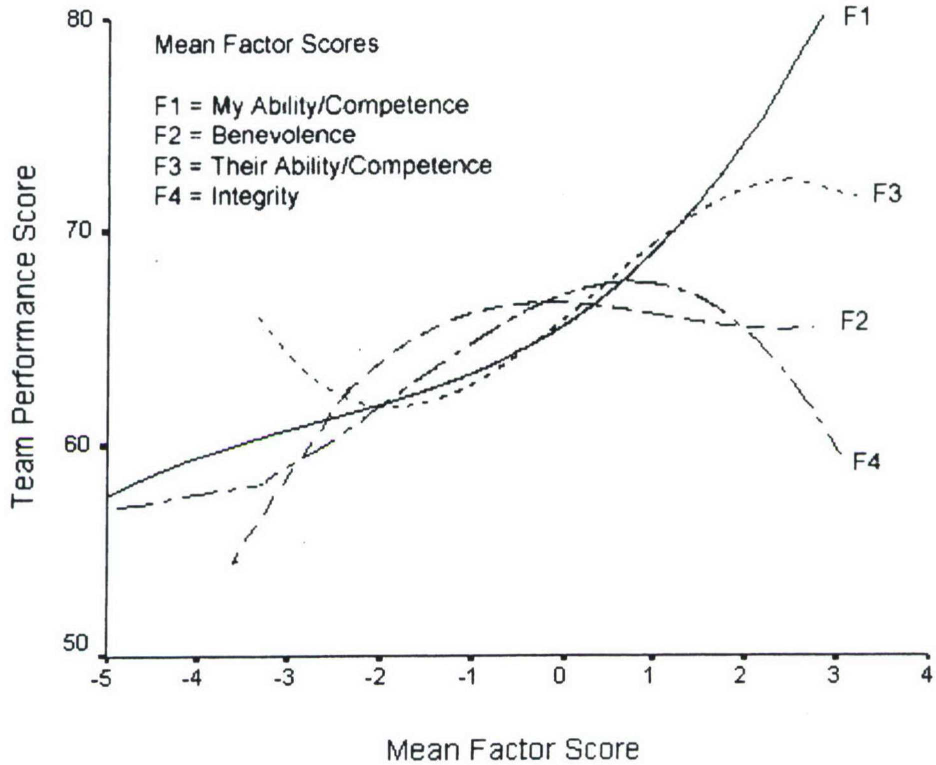

Figure 5. Experiment 1 cubic fit of my ability/competence, benevolence, their ability/ competence, and integrity perceived trustworthiness factors on team performance.

Notes. F1 (My Ability/Competence) $F(3, 608) = 13.07, p < .01$; F2 (Benevolence) $F(3, 608) = 1.69$, *ns*; F3 (Their Ability/Competence) $F(3, 608) = 13.96, p < .01$; F4 (Integrity) $F(3, 608) = 4.43, p < .01$.

Swift Trust in Co-Located and Distributed Teams

The Jarvenpaa and Leidner (1999) research suggested that higher initial ability- and/or competence-based PT might predict greater task performance. In order to test this prediction, team ratings on each of the My Ability and Their Ability PT factors at Mission 1 were averaged, and reliability for the two factors was calculated. Context and Mission showed acceptable reliability, $\alpha = .95$. A composite score was created from the two factors by summing the averaged scores. In addition, a median split was performed on the composite where averaged team ratings higher than the median on each PT factor at Mission 1 were assigned a "1" for high initial PT, and averaged team ratings lower than the median were assigned a "0" for low initial PT. Team Performance in Missions 1, 5, 7, and 8 constituted the dependent repeated measures in the two ANOVA tests (composite score). It is also possible that high initial PT teams on the ability/competence composite show greater Team Performance. The results revealed a main effect for Team Performance $F(3, 147) = 36.69, p < .0001$. Follow-up mean comparisons revealed better performance for Mission 5 ($M = 67.94$, $SE = 1.21$) than Mission 1 ($M = 56.69$, $SE = 1.23$). Also, Mission 7 ($M = 68.43$, $SE = 1.39$) was greater than Mission 1, and Mission 8 ($M = 71.45$, $SE = 1.56$) was higher than Mission 1. There was also better performance for Mission 8 than 5 and Mission 8 than 7. However, there were no effects for the High/Low composite score suggesting that self-perceptions of ability and/or competence were not important to increased performance.

We assessed averaged team performance with initial perceived trustworthiness as the independent variable. There were no effects for averaged team performance and the composite score, $F(1, 49) = 0.25$, *ns*.

The Jarvenpaa and Leidner (1999) research indirectly suggested that an ability and/or competence dimension of PT might influence virtual team performance, but that did not occur in the My Ability/Competence Factor in the current effort. Several factors do not support findings for a "swift" trust in this research. First, unlike Jarvenpaa and Leidner's (1999) research, the current effort did not make the peacekeeping task a class assignment such that lack of participation could result in a loss of 20% of a course grade. Participation was strictly voluntary. Second, the nature of the task in the current investigation was probably more cognitively complex than the Jarvenpaa and Leidner (1999) study. Participants in the current effort had to learn a new software tool, maintain their resources, maintain team performance, maintain situation awareness, and maintain verbal communication simultaneously in timed missions and in a timeframe of one day. Participants in the Jarvenpaa and Leidner (1999) study communicated via email to each other as necessary over a six-week timeframe. Finally, the nature of the task also could have influenced the lack of a "swift" trust; recall that the task simulated decision-making for peacekeeping missions, which Soldiers use in the Army. Given that, the "repercussions" of bad decision-making could have affected self- and other-perceptions of ability and competence.

Team Performance by Context

An ANOVA was conducted with Context Group (CC, CD, DC, and DD) as the independent variable, and Team Performance as the dependent variable, in order to discover the contribution of context on performance. The results were $F(3, 608) = 3.46$, $p < .01$, $\eta^2 = .02$, which was a small effect. The DC condition showed significantly greater team performance (M = 68.17, SE = 0.9) than the CD (M = 65.04, SE = 0.9) and DD (M = 64.68, SE = 0.9) conditions. Figure 6 depicts the context-based mean team performance values averaged over Missions 1, 5, 7, and 8.

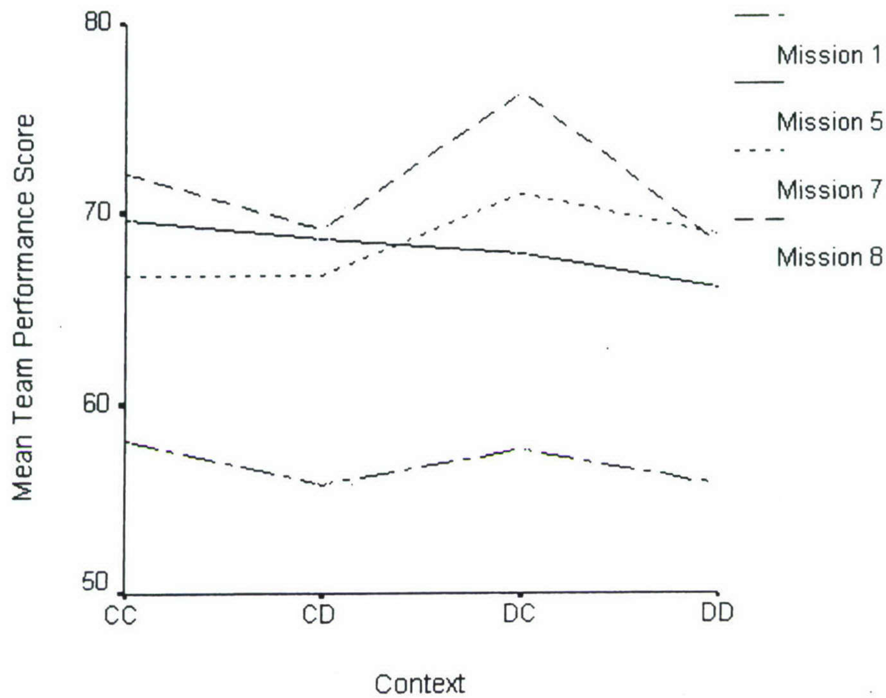

Figure 6. Experiment 1 context-based mean team performance in Missions 1, 5, 7, and 8.

Experiment 2: Antecedents to Trust, Trust Behaviors, and Team Performance in Context

The ability, competence, integrity, and benevolence dimensions of perceived trustworthiness were investigated in Experiment 1 to determine which factor(s) were most important in team-level Perceived Trust in highly-complex team task environments. Results indicated that the "My" Ability/Competence combined factor was most important. Therefore, in Experiment 2 the Perceived Trust scale was shortened: after each mission, team members individually rated how well they felt each of the other team members trusted them to do their own job ("My" Ability/Competence), and how well they trusted each of the other members on the team to do their jobs ("Their" Ability/Competence). These variables comprised a shortened metric of the important factors measuring Perceived Trust in a complex team task. Experiment 2 was designed to assess the relationships between perceived trustworthiness (Shortened Perceived Trust or SPT), propensity to trust, and trust behaviors as predictors of team performance.

Method

Before team members began training or communicating, they completed the Rotter Interpersonal Trust scale (Rotter, 1967). After Missions 1, 5, 7, and 8, teams completed the SPT. As in Experiment 1, teams in Experiment 2 participated in groups of three persons, randomly assigned as S3, G2, or G3. The procedure for Experiment 2 was the same as in Experiment 1 for all other tasks. The simulation output recorded individual and team performance scores based on actual resources used given optimal resources used within mission time constraints. After each experiment, lab assistants transcribed the team communications for coding trust behaviors as described in the Procedure below.

Participants

Fifty-nine teams, each comprised of three NMSU undergraduates, participated ($N = 177$; young adults ranging in age from 18-30). Participants were paid $6 per hour for their participation.

Technological Equipment and Software

Experiment 2 utilized the same laboratory, equipment, and software used in Experiment 1. However, we added the Rotter Interpersonal Trust scale (Rotter, 1967). Team performance was assessed using the metric available in the Aptima® peacekeeping simulation software, where best-possible actions are assigned highest values in the simulation, and a percentage score is derived from actions performed by the team.

Procedure

The procedures used in Experiment 2 were the same as in Experiment 1, except participants completed the Rotter scale before the experiment began and completed the SPT metric after four of eight missions.

Trust Behavior Coding

In order to code team language for trust behaviors (cooperative or monitoring), 24 transcriptions of the 59 total teams were randomly chosen using a random number list, from lists of teams evenly distributed across context conditions, in order to make the coding workload manageable for the two coders (in the 24 transcriptions, there were a total of 9,532 utterances). After verifying the transcriptions, three of the teams contained incomplete data because team audio was unavailable for transcription. Thus, the final number of teams analyzed for coding was 21. Each utterance from each team member from Missions 1, 5, 7, and 8 was placed on a separate line in four Microsoft Excel© spreadsheets. In order to code the utterances, two graduate student coders worked through one team transcript together and defined utterances which constituted cooperative language and monitoring language. Cooperative utterances were defined as answers to another team member's statements where agreement or consensus was reached. For example, statements such as, "I agree with you, G2," or, "S3, that sounds like a plan," or, "yes, I will send the OSINT in to the Refugees area right away," were coded as one cooperative utterance. Monitoring utterances, on the other hand, were questions to other team members, where some suspicion, checking, or monitoring behavior was present in the question. Examples of monitoring utterances were statements such as "are you sure you waited to send BILAT until after I sent the Dismounted patrol?," or, "did you send the THT patrol to the Elections area yet?", or, "did you check with G3 before you sent the CIMIC to the Refugees area?" The coding of cooperating or monitoring utterances was the percentage of each team member's total utterances in a mission (individual trust behaviors) and were coded as a proportion of all utterances in a mission by all team members (team trust behaviors). Inter-coder reliability on cooperating utterances for individual trust behaviors was $r = .95$ and team trust behaviors was $r = .96$. Inter-coder reliability on monitoring utterances for individual trust behaviors was $r = .97$ and team trust behaviors was $r = .93$.

Results and Discussion

Reliability of Propensity to Trust Scale

Reliability of the 25-item Rotter Interpersonal Trust scale showed $\alpha = .41$, *ns*. Twelve items were removed for a scale alpha of .70, which was acceptable. The scale loaded on three factors (Exploitation, Sincerity, and Institutional Trust) in a principal components analysis[c].

No differences in propensity to trust were found between team members in the four context conditions (CC, CD, DC, DD), $F(3, 232) = 0.92$, *ns*, and no differences were found between roles (S3, G2, G3) on propensity to trust, $F(2, 705) = 0.0$, *ns*.

Relationships to Performance

In order to assess the relationships between propensity to trust, SPT, and trust behaviors as predictors of performance, a multiple regression model examined what factors predicted performance without regard to mission or context. For team performance, predictor variables included team propensity to trust, team trust, team monitoring behavior, and team cooperative behavior. Individual propensity to trust was summed for each team. Team scores were automatically calculated by the simulation. The summed value of the SPT items of each team's ratings of how they trusted their teammates and how they thought their teammates trusted them after Missions 1, 5, 7, and 8, constituted the team SPT score. Team monitoring and team cooperative behaviors were percentages of team utterances.

The overall regression model showed that adjusted R^2 accounted for 12.9% of the total variance for predicting team performance while controlling for collinearity, $F(4, 79) = 4.06$, $p = .005$. Team SPT significantly predicted team performance ($B = .714$, $t = 3.32$, $p = .001$). However, team propensity to trust, monitoring behaviors, and cooperative behaviors did not predict team performance in the model (team propensity to trust $B = .0267$, $t = 0.47$, *ns;* team monitoring behavior $B = 40.58$, $t = 1.33$, *ns*; team cooperative behavior $B = -19.86$, $t = -1.28$, *ns*).

SPT Metric

The regression model showed that SPT was a significant predictor of team performance. More specifically, SPT was a significant predictor of performance at Mission 5, but not for the other missions. This finding suggests that SPT may not necessarily be "swift" and actually takes time to establish in a complex task ($B = .483$, $t = -1.69$, *Adj.* $R^2 = -.02$, $p = .02$). Further, SPT predicted team performance under all context conditions, CC ($B = 1.02$, $t = 3.16$, *Adj.* $R^2 = .12$, p

[c] These three factors have been found in several studies that factor-analyzed the Rotter scale (e. g., Couch, Jeffrey, & Jones, 1996; Sacchi, 2004).

= .003); CD ($B = 1.09$, $t = 4.41$, *Adj.* $R^2 = .25$, $p < .0001$); DC ($B = 1.12$, $t = 3.87$, *Adj.* $R^2 = .20$, $p = .0003$); and DD ($B = .68$, $t = 2.38$, *Adj.* $R^2 = .08$, $p = .02$).

These results suggest that the shortened metric of ability/competence-based perceived trustworthiness comprised of reciprocal ratings of ability and competence is a useful metric in understanding the relationship between the most important perceived trustworthiness dimensions and performance in a complex team task.

Trust Behavior Analysis

The mean percentage of cooperative and monitoring language behaviors of teams in each context condition (CC, CD, DC, and DD) appear in Table 9. Independent *t*-tests revealed significant differences between team cooperative and team monitoring behaviors within each context condition: CC, $t(23) = -7.32$, $p < .0001$; CD, $t(27) = -6.52$, $p < .0001$; DC, $t(15) = -8.38$, $p < .0001$; and DD, $t(15) = -4.25$, $p < .0003$).

Mean difference scores between team cooperative and team monitoring behaviors were computed and labeled "overall trust behavior" (mean cooperative – mean monitoring = overall trust behavior). An ANOVA revealed differences in overall Trust Behaviors in Team Context, $F(3, 80) = 4.22$, $p = .008$. Follow-up comparisons revealed that CC ($M = 0.131$, $SE = 0.015$) was significantly greater than CD ($M = 0.082$, $SE = 0.014$) and DD ($M = 0.067$, $SE = 0.018$); CD was greater than DC ($M = 0.135$, $SE = 0.018$) and; DD was greater than DC. The overall trust behavior scores in each context condition did not significantly predict team performance, however: CC ($B = 16.73$, $t = 1.01$, *Adj.* $R^2 = .0007$, $p = ns$); CD ($B = -42.32$, $t = -1.25$, *Adj.* $R^2 = .02$, *ns*; DC ($B = 9.39$, $t = 0.26$, *Adj.* $R^2 = -.07$, *ns*); and DD ($B = -45.03$, $t = -1.01$, *Adj.* $R^2 = .001$, *ns*). These results suggest that verbal cooperative and monitoring communication behaviors among team members was not important to team performance.

Table 9
Mean Percentage Team Cooperating and Team Monitoring Language Behaviors, and Difference Score in Language Behaviors of Teams in Each Context Condition

Context Condition	Team Cooperation %	Team Monitoring %	Difference Score
CC	17.45 (7.68)	4.33 (3.14)	0.131 (0.0087)
CD	12.78 (4.66)	4.57 (3.59)	0.082 (0.0067)
DC	17.14 (8.03)	3.69 (4.28)	0.135 (0.0067)
DD	10.61 (7.19)	3.84 (3.48)	0.067 (0.0077)

Note: Standard deviations shown in parentheses.

Longitudinal Perceptions of Shortened Perceived Trustworthiness and Trust Behaviors

Correlations between SPT and Team trust behaviors were examined for Missions 1, 5, 7, and 8, to determine whether perceptions of ability became less important to team trust over the course of the complex task (refer to Jarvenpaa, Knoll, & Leidner, 1998). The results revealed no significant correlations between the variables in any context.

Discussion of Findings in Additional Research

The most important antecedents to trust on a team engaged in a complex task are beliefs about others' perceptions of one's own ability and competence, and longitudinally, this belief about others' perceptions of one's ability and competence strengthens over the course of work performed by the team. If one feels able and competent at his or her job, one will believe that others recognize that ability and competence, and reciprocal trust will increase if those beliefs are in place. Individual trust behaviors show that individuals high in "My Ability/Competence" beliefs will trust their teammates and will cooperate more than those who are low on "My Ability/Competence" beliefs. Further, strongly correlated "My Ability/Competence" beliefs and trust behaviors at a team level predict stronger team performance, with several caveats.

Jarvenpaa et al. (1998) indicate that as a team's task progresses, trust appears to be less related to assessments of ability. This was evident in Experiment 2 in that correlations between ability/competence and trust behaviors declined over the course of the several missions in the peacekeeping simulations. Thus, there are other cognitive or behavioral aspects that take over that strengthen team trust after antecedents to trust have reached their zenith and dwindled. A second caveat is that trust tells us only a small portion of the story in describing why some teams perform at a greater level than lower-performing teams. For example, verbal communication, confidence, and personality may affect team performance. Teams that focus on the task and discuss ways or ideas to improve individual and team scores may shed light on the differences in performance among the teams. Future research with the verbal protocol data should examine whether or not communication among teams predicts performance.

Confidence of individuals and teams also may also distinguish between high- and low-performing teams. Using subjective reports, understanding of the complex simulation task and verbal protocol data can measure aspects of confidence. While only observational, the verbal protocol data of some teams suggests that some individuals are more assertive in taking leadership roles than others (e.g., S3 requesting teammates to send resources to event areas). In addition, some teams appear to "connect" more than others do and try to work together as observed in the verbal protocol data.

Finally, team and individual personality also can shed light on differences in performances among the teams. For example, if all the teammates were shy, then we would expect low confidence and fewer dialogues, and thus, lower performance scores. However, if members of a team were outgoing, then we would expect the opposite. Observations of our verbal protocol data suggest that there are an array of personalities among the individuals and teams. However, empirical research needs to verify and validate these observations.

Does trust need touch? In this research, participants in the co-located context held higher perceived trustworthiness and higher trust behaviors, and out-performed teams in the distributed context. In past studies, the effects of trusting relationships within distributed teams appear to be similar to those evidenced in co-located teams (Driscoll, 1978). However, even when some social/personal information was exchanged between team members at the onset of the complex team peacekeeping task, and when all teams were given the opportunity to work together via an information-rich mode (audio) of communication, co-located teams still showed greater trust and greater performance over virtual teams.

Contributions to Basic Research

In recent years, the advancement of military technology has resulted in highly complex skills that need to be acquired and maintained to use that technology (Barry & Runyan, 1995). Consequently, the demand for ongoing innovations, including distance training, has increased. Distance training has been shown to be extremely cost effective and has produced similar learning outcomes. Although extensive research on distance learning exists, few studies have focused on group (collaborative) distance training delivered by Internet/Web-based technologies.

A parallel development has occurred in the area of team training. Even though group (collaborative) learning has been the focus of many studies (Slavin, 1996) and progress has been made on knowledge measurement at the individual level, the measurement of team knowledge, and team cognition in general, is still in its infancy (Cooke, Salas, Cannon-Bowers & Stout, 2000). Thus, research on how to improve team distance learning can contribute significantly to the field in several areas including distance education and across-context team transfer.

Interest in distance education has increased due to a concerted effort on the part of public educational institutions to reach new populations of students who otherwise might not be able to attend. With advancements in technology, this has been possible (particularly in the use of Web-based training). On the other hand, few controlled studies exist to determine what is truly beneficial.

Controlled studies for team distance training also could contribute to the transfer literature generally. Research has been performed on individual transfer (Singley & Anderson). Although specifications for transfer are delineated, research on context effects has not been as conclusive (see McDaniel, Anderson, Einstein & O'Halloran, 1989 or Wickens, 1987). The current research project is focused upon describing the effects of a particular physical context change on team performance (with a focus on cognitive skills but also some measurement of social skills).

Potential Army/Military Applications

The applications to the military were in principles for distance training and transfer (changing from one situation to another) situations. These studies were designed to determine what conditions promoted distance training and transfer and what training was needed to improve team and distance transfer. In addition, within the studies, various assessment measures were used that focused on individual and team cognitive and social (social-cultural) skill development.

Final Summary

Our research program of laboratory experiments sought to provide more definitive answers to the reasons why context (physical, communication) affects training and learning at team level in complex tasks. We also sought to identify how communication mode (push-to-talk, no push-to-talk) helps or hinders team performance on those tasks. Our third objective was to determine specific elements of trust that can be built and maintained on teams, especially in distributed contexts, to increase performance.

Two experiments were performed in a university setting using three member teams (as opposed to pairs) and represent extensive hours of training over several days of training and testing. A brief review of findings is discussed next:

- For Experiment 1, results indicated that even though all teams received the same initial declarative knowledge training, distance teams outperformed co-located teams throughout the initial hands-on training sessions and after transfer. After transfer, all teams experienced a decrement in performance but the distance teams (i.e., those who trained at a distance and either stayed in the same distance condition or transferred to a co-located condition) showed a greater improvement for the two missions after transfer. Staying in the same physical context is better than changing contexts.

- For Experiment 2, results indicated that teams in push-to-talk communication conditions showed lower performance scores than teams in no push-to-talk communication conditions, suggesting that the action of push-to-talk adds cognitive load, adversely affects team communication, and lessens team performance overall. Staying in the same context is better than changing context, which replicates the results in the first wave of research.

- In analysis of trust measures, results indicated that ability and competence were the most important dimensions of perceived trustworthiness to team members (rather than integrity and benevolence dimensions), due to the complex nature of the peacekeeping task. Ability and competence perceptions were predictive of team performance: Disposition to trust and trust behaviors were not good predictors of performance. Findings indicate that without regard to context, trustworthiness perceptions of ability and competence develop slowly over the course of team work, and teams that show greater trustworthiness perceptions of each other and themselves perform at a higher level.

Given these basic findings, the following implications can be indicated:

- Experiment 1 indicated the importance of communication training and reducing the complexity of the hardware/software that individuals need to use (i.e., better interface design and less complex systems). Teams composed of people who do not know each other (from different parts of the country) may need to become comfortable in communicating with each other before a team task can be performed. Unfortunately, people are often expected to learn how to communicate through learn by doing or by exposure. In Experiment 2, we directly examined the use of push-to-talk versus no push-to-talk headsets. The latter hardware was less imposing (more familiar and easier to learn). The results, after separating push-to-talk from no push-to-talk, results resembled what one would expect—a change of physical context and software context would result in more difficulties than staying in the same context.

- Teams working at a distance performed better than face-to-face teams; but, the results in both experiments were slightly different. This may simply be due to hardware and software differences. Also, Experiment 1 had far fewer teams. Even though numerous other differences between these experiments may have impacted the results, these studies together indicate how many different types of context might exist for the individual or team. There's the physical context (same room/different room/different floors), the hardware context (large imposing/unfamiliar or familiar) and the software context (SASO's country map and stories, UAV maps and buildings). If the context (simulation or hardware) is particularly compelling, then the physical context (room, building, chairs, etc.) may not play as large a role. However, identifying what the critical context is for the team or individual may be the harder task.

- Team performance can resemble individual performance. For interference, a decrement would be expected at transfer to a different context, but after a little more training, the performance will jump back to the original performance before transfer. For most teams, this result was found. Thus, in most cases, a team that performed peacekeeping in one country could be brought together in another country with a temporary loss of performance. We do not know how much of a decrement would occur or how long it would take to bounce back but at least we do know that the training is not lost permanently.

- In addition to performance measures, trust measures were included. Results indicated that if a team member feels able and competent at doing his or her job, that team member will believe that others recognize his/her ability and competence, and reciprocal trust will increase if those beliefs are in place. The peacekeeping simulations were complex and sometimes difficult, and so benevolence or integrity dimensions of trust were not as important to team members' perceptions of trustworthiness as ability/competence perceptions. The interesting finding here is that it does not matter if a team is collocated or at a distance when training and testing—trust will have some impact on team performance if team-level ability/competence perceptions are strong.

How are these results informative for military applications? First, when teams are to be trained to perform complex tasks together, they should receive thorough training, but training can occur at dispersed geographic locations without decrement, as long as communication technologies are simplified (e. g., audio or telephone equipment that is "open"). It is critical that communication technologies be simple to afford desired team aims and outcomes, and that superiors select appropriate technologies to offset any downside risks of using a given technology.

Second, if a team transfers operations to a different situation or location with different task demands, they will need a warm-up period to bounce back to full performance in the new situation. Depending upon the surface and deep-structure similarities between the original task situation and the new task situation, the bounce-back period may vary until the team resumes operation at optimal levels.

Third, contrary to some past organizational research findings, teams can build and maintain trust for one another from a distance. The important elements of trust that must be built are based on perceptions of ability and competence at doing a particular task. Further, the task must be complex. If the team task is less cognitively challenging or is based primarily on perceptions of integrity or honesty between team members, then ability and competence dimensions of the trusting relationships are not as important as perceptions of teammates' integrity or benevolence.

References

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review*, *89*, 369-406.

Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.

Anderson, J. R. (1993). *Rules of the mind*. Hillsdale, NJ: Erlbaum.

Anderson, J. R., Corbett, A. T., Koedinger, K., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. *The Journal of Learning Sciences, 4*, 167-207.

Aptima Corporation. (2005). Software product: Distributed decision-making: The DDD Team simulation. http://www.aptima.com/.

Aubert, B. A., & Kelsey, B. A. (2003). Further understanding trust and performance in virtual teams. *Small Group Research*, *34*, 575-618.

Barry, M., & Runyan, G.B. (1995). A review of distance-learning studies in the U.S. Military. *The American Journal of Distance Education*, *9*, 37-45.

Bell, B. S., & Kozlowski, S. W. (2002). A typology of virtual teams: Implications for effective leadership. *Group & Organization Management, 27,* 14-49.

Bjork, R. A., & Richardson-Klavehn, A. (1987). On the puzzling relationship between environmental context and human memory. In C. Izawa (Ed.), *Current issues in cognitive processes* (pp. 313-344). Hillsdale, NJ: LEA.

Bos, N., Olson, J., Gergle, D., Olson, G., & Wright, Z. (2002). Effects of four computer-mediated communications channels on trust development. *Conference on Human Factors in Computing Systems,* 135-140.

Bower, G. H. (1983). Affect and cognition. Philosophical Transactions of the Royal Society of London, *B302*, 387-402.

Bramble, W., & Martin, B. (1995). The Florida Teletraining Project: Military training via two-way compressed video. *The American Journal of Distance Education*, *9*, 6-26.

Butler, B. S. (2000). Using the World Wide Web to support classroom-based education: Opportunities and challenges for IS educators. *Web-based Instruction*, 417-423.

Calvani, A., Sorzio, P., & Varisco, B. (1997). Inter-university cooperative learning: An exploratory study. *Journal of Computer Assisted Learning*, *13*, 271-280.

Cannon-Bowers, J. A., Salas, E., & Converse, S. (1993). Shared mental models in expert team decision making. In J. Castellan, Jr. (Ed.*), Current issues in individual and group decision making* (pp. 221-246). Hillsdale, NJ: Erlbaum.

Chute, A., Balthazar, L., & Poston, C. (1989). Learning from teletraining. In M. Moore (Ed.), *Readings in distance learning and instruction*. University Park: Pennsylvania State University.

Cohen, S. G., & Gibson, C. B. (2003). In the beginning: Introduction and framework. In C. B. Gibson & S. G. Cohen (Eds.), *Virtual teams that work: Creating conditions for virtual team effectiveness*, pp. 1-13. San Francisco: Jossey-Bass.

Cooke, N. J., Kiekel, P. A., & Helm E. (2001). Measuring team knowledge during skill acquisition of a complex task. *International Journal of Cognitive Ergonomics: Special Section on Knowledge Acquisition*, *5*, 297-315.

Cooke, N. J., Rivera, K., Shope, S. M., & Caukwell, S. (1999). A synthetic task environment for team cognition research. *Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting* (pp. 303-307). Santa Monica, CA: HFES.

Cooke, N. J., Salas, E., Cannon-Bowers, J. A., & Stout, R. (2000). Measuring team knowledge. *Human Factors, 42*, 151-173.

Cooke, N. J., & Shope, S. M. (1998). Facility for Cognitive Engineering Research on Team Tasks. Report for Grant No. F49620-97-1-0149, submitted to AFOSR, Bolling AFB, Washington, DC.

Cooke, N. J., & Shope, S. M. (2004), Designing a synthetic task environment. In S. G. Schiflett, L. R. Elliott, E. Salas, & M. D. Coovert (Eds.), *Scaled Worlds: Development, Validation, and Application* (pp. 263-278). Surrey, England: Ashgate.

Cooke, N. J., Shope, S. M., & Rivera, K. (2000). Control of an uninhabited air vehicle: A synthetic task environment for teams. *Proceedings of the Human Factors and Ergonomics Society 44th Annual Meeting*. San Diego, CA: HFES.

Costa, A. C. (2003). Work team trust and effectiveness. *Personnel Review, 32*, 605-622.

Costa, A. C., Roe, R. A., & Taillieu, T. (2001). Trust within teams: The relation with performance effectiveness. *European Journal of Work and Organizational Psychology, 10*, 225-244.

Couch, L. L., Jeffrey, A. M., & Jones, W. H. (1996). Measuring level of trust. *Journal of Personality Assessment, 67*, 305-323.

Davies, G., & Thompson, D. (1988). *Memory in context: Context in memory*. NY: Wiley.

Denning, R., & Smith, P. J. (1997). Cooperative learning and technology. *The Journal of Computers in Mathematics and Science Teaching, 16*, 177-200.

Driscoll, J. W. (1978). Trust and participation in organizational decision making as predictors of satisfaction. *Academy of Management Journal, 21*(1), 44-56.

Driskell, J .E., Radtke, P.H., & Salas, E. (2003). Virtual teams: Effects of technological mediation on team performance. *Group Dynamics: Theory, Research, and Practice, 7*(4), 297-323.

Eich, J. E. (1980). The cue-dependent nature of state-dependent retrieval. *Memory and Cognition, 8*, 157-173.

Eich, J. E. (1989). Theoretical issues in state-dependent memory. In H.L. Roediger & F.I.M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honor of Endel Tulving*. (pp. 331-354). Hillsdale, NJ: LEA.

Elangovan, A. R., & Shapiro, D. (1998). Betrayal of trusts in organizations, *Academy of Management Review, 23*(3), 547-566.

Fernandez, A., & Glenberg, A. M. (1985). Changing environmental context does not reliably affect memory. *Memory & Cognition, 13*, 333-345.

Foltz, P. W., & Martin, M. A. (2004). Automated team discourse annotation and performance prediction using LSA. In *Proceedings of the Human Language Technology conference / North American chapter of the Association for Computational Linguistics annual meeting HLT/NAACL 2004*. (pp. 97-100). Stroudsburg, PA: ACL Publications.

Frost, P. J., & Fukami, C. V. (1997). Teaching effectiveness in the organizational sciences: Recognizing and enhancing the scholarship of teaching. *Academy of Management Journal, 40*, 1271-1281.

Gambetta, D. (1988). Can we trust trust? In Gambetta, D. (Ed.), *Trust: Making and breaking cooperative relations*, pp. 213-237. New York: Blackwell.

Godden, D., & Baddeley, A. D. (1980). When does context influence recognition memory? *British Journal of Psychology, 71*, 99-104.

Gruenfeld, D. H., Mannix, E. A., Williams, K. Y., & Neale, M. A. (1996). Group composition and decision making: How member familiarity and information distribution affect process and performance. *Organizational Behavior and Human Decision Process, 67*, 1-15.

Gugerty, L., DeBoom, D., Walker, R., & Burns, J. (1999). Developing a simulated uninhabited aerial vehicle (UAV) task based on cognitive task analysis: Task analysis results and preliminary simulator data. *Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting* (pp. 86-90). Santa Monica, CA: HFES.

Guzzo, R. A. & Dickson, M. W. (1996). Teams in organizations: Recent research on performance and effectiveness. *Annual Review of Psychology,* 47:307-338.

Hahn, H. (1990). Distributed training for the reserve component: Remote delivery using asynchronous computer conferencing. Report No. 2Q263743A794. Boise, ID: Army Research Institute.

Handy, C. (1995). Trust and the virtual organization. *Harvard Business Review*, *73,* 40-50.

Hedlund, J., Ilgen, D. R., & Hollenbeck, J. R. (1998). Decision accuracy in computer-mediated versus face-to-face decision making teams. *Organizational and Behavior and Human Decision Processes*, *76*, 30-47.

Hill, M. (1982). Group versus individual performance: Are N+1 heads better than one? *Psychological Bulletin*, *91*, 512–539.

Hollenbeck, J. R., & Ilgen, D. R. (2000). A look at team performance on modifications of the DDD. Paper presented at the *Annual Meeting of the Society of Industrial and Organizational Psychology*, New Orleans, LA.

Hull, C. L. (1952). *A behavior system: An introduction to behavior theory concerning the individual organism*. New Haven, CT: Yale University Press.

Ilgen, D. R., & Hollenbeck, J. R. (1999). Simulations for the study of teams: A symposium. Paper presented at the *Annual Meeting of the Society of Organizational Behavior*, Atlanta, GA.

Ilgen, D. R., & Hollenbeck, J. R. (2000). Symposium: Simulations for the study of teams. Paper presented at the *Annual Meeting of the Society of Industrial and Organizational Psychology*, New Orleans, LA.

Jarvenpaa, S.L., Knoll, K., & Leidner, D.E. (1998). Is anybody out there? Antecedents of trust in global virtual teams. *Journal of Information Management Systems, 14*(4), 29-65.

Jarvenpaa, S. L., & Leidner, D. E. (1999). Communication and trust in global virtual teams. *Organization Science, 10*(6), 791-815.

Johansen, R., & O'Hara-Devereaux, M. (1994). *Globalwork: Bridging distance, culture, & time.* San Francisco, CA: Jossey-Bass.

Johnson, D.W. (1981). Student-student interaction: The neglected variable in education. *Educational Researcher*, 5-10.

Johnson, D.W., Johnson, R., & Holubec, E. (1990). *Circles of learning: Cooperation in the classroom.* Edina, MN: Interaction Book Co.

Keene, D., & Cary, J. (1992). Effectiveness of distance education approach to U.S. Army reserve component training. In M.G. Moore (Ed.), *Distance Education for Corporate and Military Training*, ACSDE Research Monograph No 3. (pp. 97-103). University Park, PA: The Pennsylvania State University, American Center for the Study of Distance Education.

Kerka, S. (1996). Distance learning, the Internet, and the World Wide Web. ERIC Digest no. 168. ED 395 214. Columbus: ERIC Clearinghouse on Adult, Career, and Vocational Education, the Ohio State University.

Kirkman, B. L., & Mathieu, J. E. (2005). The dimensions and antecedents of team virtuality. *Journal of Management, 31,* 700-718.

Kleinman, D. L., Young, P.W., & Higgins, H. (1996). The DDD-III: A Tool for Empirical Research in Adaptive Organizations. In *Proceedings of the 1996 Command and Control Research and Technology Symposium.* Monterey, CA: NPS.

Kraut, R. E., Fussell, S. R., Brennan, S. E., & Siegel, J. (2002). Understanding effects of proximity on collaboration: Implications for technologies to support remote collaborative work. In P. Hinds & S. Kiesler (Eds.), *Distributed work,* pp. 137-162. Cambridge, MA: MIT Press.

Lee, A. Y. (1998). Transfer as a measure of intellectual functioning. In S. Soraci & B. McIlvane (Eds.), *Perspectives on fundamental processes in intellectual functioning* (pp. 351-366). Stamford, CT: Ablex.

Leifer, R., & Mills, P. K. (1996). An information processing approach for deciding upon control strategies and reducing control loss in emerging organizations. *Journal of Management, 22*(1), 113-137.

Leight, K.A., & Ellis, H.C. (1981). Emotional mood states, strategies, and state-dependency in memory. *Journal of Verbal Learning and Verbal Behavior, 20*, 251-266.

Levine, J. M., & Moreland, R. L. (1998). Small groups. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology* (pp. 415-469). New York: McGraw-Hill.

Lewicki, R. J., & Bunker, B. B. (1996). Developing and maintaining trust in work relationships. In R.M. Kramer & T.R. Taylor (Eds.). *Trust in organizations: Frontiers of theory and research,* pp. 114-139. Thousand Oaks, CA: Sage.

Mantovani, G. (1996). *New communication environments from everyday to virtual.* Bristol, PA: Taylor & Francis.

Martin, E., Lyon, D. R., & Schreiber, B. T. (1998). Designing synthetic tasks for human factors research: An application to uninhabited air vehicles. *Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting* (pp. 123-127). Santa Monica, CA: HFES.

Mayer, R. C., & Davis, J .H. (1999). The effect of the performance appraisal system on trust for management: A field quasi-experiment. *Journal of Applied Psychology, 84,* 123-136.

Mayer, R. C., Davis, J.H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review, 20,* 709-734.

McAllister, D. J. (1995). Affect- and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of Management Journal, 38,* 24-59.

McDaniel, M. A., Anderson, D.C., Einstein, G. O., & O'Halloran, C. M. (1989). Modulation of environmental reinstatement effects through encoding strategies. *American Journal of Psychology*, *102*, 523-548.

Meyerson, D., Weick, K. E., & Kramer, R. M. (1996). Swift trust and temporary groups. In. R. M. Kramer & T .R. Tyler (Eds.). *Trust in organizations: Frontiers of theory and research* (pp. 166-195). Thousand Oaks, CA: Sage Publications.

Olson, J. S., Teasley, S., Covi, L., & Olson, G. (2002). The (currently) unique advantages of co-located work. In P. Hinds & S. Kiesler (Eds.), *Distributed work,* pp. 113-135. Cambridge, MA: MIT Press.

Phelps, R., Wells, R., Ashworth, R., & Hahn, H. (1991). Effectiveness and costs of distance education using computer-mediated communication. *The American Journal of Distance Education*, *5*, 7-19.

Pirolli, P. L., & Anderson, J. R. (1985). The role of practice in fact retrieval. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *11*, 136-153.

Politis, J. D. (2003). The connection between trust and knowledge management: What are its implications for team performance? *Journal of Knowledge Management, 7*, 55-66.

Randall, V. (1999). Cooperative learning: Abused and overused? *The Education Digest*, *65*, 29-32.

Riegelsberger, J., Sasse, M. A., & McCarthy, J. D. (2003). The researcher's dilemma: Evaluating trust in computer-mediated communication. *International Journal of Human-Computer Studies, 58*, 759-781.

Rocco, E., Finholt, T. A., Hofer, E. C., & Herbsleb, J. D. (2001). *Out of sight, short of trust.* Presentation at the Founding Conference of the European Academy of Management. Barcelona, Spain.

Rotter, J. B. (1967). A new scale for the measurement of interpersonal trust. *Journal of Personality, 35,* 651-665.

Sacchi, C. (2004). Interpersonal trust in different ages. *Interdisciplinaria, Numero Especial,* 87-107.

Salas, E., Cannon-Bowers, J. A., Church-Payne, S., & Smith-Jentsch, K. A. (1998). Teams and teamwork in the military. In C. Cronin (Ed.), *Military Psychology: An Introduction* (pp.71-87). Needham Heights, MA: Simon & Schuster.

Salas, E., Dickinson, T. L., Converse, S. A., & Tannenbaum, S. I. (1992). Toward an understanding of team performance and training. In R.W. Swezey and E. Salas (Eds.), *Teams: Their training and performance* (pp. 3-29). Norwood, NJ: Ablex.

Saufley, W. H., Otaka, S. R., & Bavaresco, J. L. (1985). Context effects: Classroom tests and context independence. *Memory & Cognition*, *14*, 347-354.

Singley, M. K., & Anderson, J. R. (1989). *The transfer of cognitive skill.* Cambridge, MA: Harvard University Press.

Slavin, R. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology*, *21*, 43-69.

Smith, S. M. (1985). Effects of number of study environments and learning instructions on free recall clustering and accuracy. *Bulletin of the Psychonomic Society*, *23*, 440-442.

Smith, S. M. (1988). Environmental context-dependent memory. In G.M. Davies & D. M. Thomoson (Eds.), *Memory in context: Context in memory.* (pp. 13-33). NY: Wiley.

Smith, S. M. (1994). Theoretical principles of context-dependent memory. In P. E. Morris & M. Gruneberg (Eds.), *Theoretical aspects of memory.* 2nd Ed. (pp. 168-195). London: Routledge.

Smith, S. M., Glenberg, A. M., & Bjork, R. A. (1978). Environmental contest and human memory. *Memory and Cognition*, *6*, 342-353.

Smith, S. M., Heath, F. R., & Vela, E. (1990). Environmental context-dependent homophone spelling. *American Journal of Psychology*, *103*, 229-242.

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin and Review*, *8*, 203-220.

Spector, M. D., & Jones, G. E. (2004). Trust in the workplace: Factors affecting trust formation between team members. *Journal of Social Psychology, 144*, 311-321.

Spitzberg, B. H. (2006). Preliminary development of a model and measure of computer-mediated communication competence. *Journal of Computer-Mediated Communication, 11*, 629-666.

Sproull, L., & Keisler, S. (1986). Reducing social context cues: Electronic mail in organizational communication. *Management Science, 32*, 1492-1513.

Stout, R., Cannon-Bowers, J. A., & Salas, E. (1996). The role of shared mental models in developing team situation awareness: Implications for training. *Training Research Journal, 2*, 85-116.

Stout, R. J., Salas, E., & Carson, R. (1994). Individual task proficiency and team process: What's important for team functioning? *Military Psychology, 6*, 177-192.

Teasdale, J. D. (1983). Affect and accessibility. *Philosophical Transactions of the Royal Society of London, B302*, 403-412.

Van Lehn, K. (1996). Cognitive skill acquisition. *Annual Review of Psychology, 47*, 513-535.

Westfall, T., Christopher, G., & Cramer, W. (1994). ATN brings to Department of Defense a new capability in satellite distance education (brochure). Dayton, OH: Wright Patterson Air Force Base, AFIT Center for Distance Education.

Wickens, D. D. (1987). The dual meanings of context: Implications for research, theory, and applications. In D. S. Gorfein & R. R. Hoffman (Eds.), *Memory and learning: The Ebbinghaus centennial conference* (pp. 135-152). Hillsdale, NJ: LEA.

Yamagishi, T., & Yamagishi, M. (1994). Trust and commitment in the United States and Japan. *Motivation and Emotion, 18*, 129-166.

Zand, D. E. (1972). Trust and managerial problem solving. *Administrative Science Quarterly, 17*, 229-239.

Zheng, J., Veinott, E., Bos, N., Olson, J. S., & Olson, G. M. (2002). Trust without touch: Jumpstarting long-distance trust with initial social activities. *Conference on Human Factors in Computing Systems,* 141-146.