U.S. Army Research Institute
for the Behavioral and Social Sciences

Research Report 1865

Performance in Non-Face-to-Face Collaborative Information Environments

**Brooke B. Schaab, J. Douglas Dressel,
and Mark A. Sabol**
U.S. Army Research Institute

Andrea L. Rittman
George Mason University
Consortium Research Fellows Program

January 2007

U.S. Army Research Institute
for the Behavioral and Social Sciences

A Directorate of the Department of the Army
Deputy Chief of Staff, G1

Authorized and approved for distribution:

SCOTT E. GRAHAM	**MICHELLE SAMS**
Acting Technical Director	**Acting Director**

Technical review by

Dan Horn, U.S. Army Research Institute
Gregory A. Ruark, U.S. Army Research Institute

NOTICES

DISTRIBUTION: Primary distribution of this Research Report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, Attn: DAPE-ARI-MS, 2511 Jefferson Davis Highway, Arlington, Virginia 22202-3926

FINAL DISPOSITION: This Research Report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research Institute for the Behavioral and Social Sciences.

NOTE: The findings in this Research Report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy)	2. REPORT TYPE	3. DATES COVERED (from. . . to)
January 2007	Final	June 2006-December 2006

4. TITLE AND SUBTITLE Performance in Non-Face-to-Face Collaborative Information Environments	5a. CONTRACT OR GRANT NUMBER 5b. PROGRAM ELEMENT NUMBER 20262785A
6. AUTHOR(S) Brooke B. Schaab, J. Douglas Dressel, and Mark A. Sabol, US Army Research Institute for the Behavioral and Social Sciences; Andrea L. Rittman, George Mason University Consortium Research Fellows Program.	5c. PROJECT NUMBER A790 5d. TASK NUMBER HO1 5e. WORK UNIT NUMBER 217
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Research Institute for the Behavioral & Social Sciences, ATTN: DAPE-ARI-RK 2511 Jefferson Davis Highway Arlington, VA 22202-3926	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) US Army Research Institute for the Behavioral & Social Sciences 2511 Jefferson Davis Highway Arlington, VA 22202-3926	10. MONITOR ACRONYM ARI 11. MONITOR REPORT NUMBER Research Report 1865

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

Subject Matter POC: Brooke B. Schaab

14. ABSTRACT *(Maximum 200 words)*:

Using technology to obtain and process information requires training not only in human-computer interaction but also in human-human-computer (collaborative) interaction. Warfighters must not only develop their own situational awareness (SA), they must understand each others' SA (Pew, 1995). This common ground is what each collaboration participant assumes about the others to ensure effective interactions (Ross, 2003; Wellons, 1993). Communication is key. Collaborators must coordinate and share information. Collaboration influences military operations at all levels. Technical interoperability is not enough to produce the synchronization required.

15. SUBJECT TERMS

Collaborative, situational awareness, leader development, information environments

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON
16. REPORT	17. ABSTRACT	18. THIS PAGE			
Unclassified	Unclassified	Unclassified	Unlimited	26	Ellen Kinzer Technical Publication Specialist (703)602-8047

Standard Form 298

Research Report 1865

Performance in Non-Face-to-Face Collaborative Information Environments

Brooke B. Schaab, J. Douglas Dressel, and Mark A. Sabol
U. S. Army Research Institute

Andrea L. Rittman
George Mason University
Consortium Research Fellows Program

Leader Development Research Unit
Stanley M. Halpin, Chief

U. S. Army Research Institute for the Behavioral and Social Sciences
2511 Jefferson Davis Highway, Arlington, VA 22202-3926

January 2007

Army Project Number 622785A790

Personnel Performance and Training Technology

PERFORMANCE IN NON-FACE-TO-FACE COLLABORATIVE INFORMATION ENVIRONMENTS

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army is increasingly operating in a network centric environment where Soldiers work together towards a common goal. Although the Soldiers are working together, they may be miles or thousands of miles apart using digital systems to share task information and communications. This collaboration of distal Soldiers each having their own duties and tasks, raises many questions including: how knowledge of other collaborative team members' tasks influences overall team performance; how mode of communication influences performance, and how different types of communication are associated with successful performance. The experimental research reported here attempts to provide answers to these important questions.

Procedure:

Twenty-eight pairs of college students worked together in pairs over a computer network to locate scud missile launchers in the computer-based game SCUDHunt. The students operated from different rooms in a research suite; they were physically isolated from each other. Each partner had a different array of intelligence gathering assets, with different capabilities and reliabilities, to employ to locate the launchers. After completing a demographics questionnaire, each isolated team member was taught the rules of the game and the characteristics of their assets. After the first training module, the team member completed a paper and pencil test on the training material and was given immediate test feedback. Each team member then received a second training module. For half the teams, this was a repeat of the first module in which each team member learned about the assets he/she would manage in the game; the other half of the teams learned about their partner's assets during this second training module. These conditions were called Own and All respectively. Again, each team member was given a test on the training material just presented and given immediate feedback. Teams then practiced the game for one turn. Experimenters answered any questions regarding operation of the game or the assets. Teams then played two 5-turn games of SCUDHunt selecting the three most likely launcher locations at the end of each turn. For one game each team communicated via voice over headphones (Oral) and used text chat (Chat) via the computer for the other game. After each game, partners completed a task load index. The number of launchers located on each turn was recorded (quality score) as well as the number of map grid locations selected in common by each partner (shared situational awareness).

Findings:

Method of communication had no significant ($p>.05$) effect upon either the quality or the shared situational awareness scores. The training condition did influence performance with the All teams locating significantly more launchers in game 2 than Own teams which had a significantly higher level of shared situational awareness. The Own teams also reported a higher workload after game 1. Analysis of the text messages indicated greater success in locating launchers in those teams with the highest frequency of messages in the communication categories regarding: game situation, player status and non-task related/social interactions.

These results indicate that performance on collaborative tasks benefits when collaborating participants are cross-trained to have a broader, system-wide view of the entire situation. Additionally, this cross-training reduces the initial workload for the cross-trained teams. This research also indicated identifiable communication patterns related to higher performance. Understanding the types of communication that develop more accurate situational awareness provides insights into how to train Soldiers to communicate effectively in non-face-to-face environments.

Utilization and Dissemination of Findings:

These findings can be used by Army trainers and training developers when designing or conducting training for collaborative network centric distal operations. Emphasis must be placed on the value of cross-training and effective communication among the collaborative team.

The findings of this research have been briefed and discussed at numerous TRADOC, HEL, and JFCOM meetings and conferences.

PERFORMANCE IN NON-FACE-TO-FACE COLLABORATIVE INFORMATION ENVIRONMENTS

CONTENTS

List of Tables

List of Figures

PERFORMANCE IN NON-FACE-TO-FACE COLLABORATIVE INFORMATION ENVIRONMENTS

Technological innovations play a paradoxical role in military transformation. While they help to resolve existing battlefield challenges on the one hand, they invariably introduce new challenges on the other hand. Network-centric operations (NCO) are just such an innovation.

(LTG W.S. Wallace, June 2005, p.2)

INTRODUCTION

Today's military operates in a network-enabled environment where technological advances exploit gathering and sharing information to building shared-situational awareness. These technologies have transformed the nature of traditional collaborative work (Easley, Devaraj, and Crant, 2003). The research in this report helps us understand what is different in these network-enabled environments.

Sonnenwald & Pierce (1998) observed that using technology to obtain and process information requires training not only in human-computer interaction but also in human-human-computer (collaborative) interaction. Warfighters must not only develop their own situational awareness (SA), they must understand each others' SA (Pew, 1995). This common ground is what each collaboration participant assumes about the others to ensure effective interactions (Ross, 2003; Wellons, 1993). Communication is key. Collaborators must coordinate and share information (Hevel, 2002; Salas, Prince, Baker, and Shrestha, 1995; Sonnenwald & Pierce, 1998). Griffin and Reid caution, *Warfare is not 'network centric'. It is either 'people centric', or it has not centre at all*. (Griffin & Reid, unpublished manuscript).

Collaboration influences military operations at all levels. Technical interoperability is not enough to produce the synchronization required. Major General Gordon C. Nash, Commander, Joint Warfighting Center, Director, Joint Training J7 states:

.Collaboration capabilities can affect all aspects of joint operations.

… These capabilities are important to Department of Defense efforts to transform the way we plan and execute joint operations. To accomplish this transformational task, we must improve collaboration among combatant commands, Services, agencies, and multinational partners. An ***environment of collaboration*** *can enable and integrate such a cooperative effort among these organizations and help the joint force achieve decision superiority.*

Information sharing while working towards a common goal is a key aspect of collaboration (Alberts 2003). To gain insights into issues involving collaboration and training, the U.S. Army Research Institute for the Behavioral and Social Sciences (USARI) conducted observations and interviews of U.S. Army personnel who operated digital systems incorporated into their units (Schaab & Dressel, 2003; Schaab, Dressel, & Hayes, 2005). It soon became clear that classroom training on how to use digital systems was not enough. Soldiers understood that job success requires an understanding of how their system interacts with other systems. Developing both a clear sense of how to collaborate with people operating those other systems and an appreciation of how important collaboration is in achieving and maintaining situational understanding requires experience in multiple training exercises that incorporate a variety of scenarios. In one command center, Soldiers actually place two different systems side-by-side and cross-train each other to promote collaboration. They comprehended the need to understand the interrelationship between their roles. Such opportunities to foster mutual understanding become more difficult, of course, when members are dispersed. Alberts (2003) cautions that, without appropriate training and practice, the network-centric environment might actually increase the fog of war rather than provide superior situational understanding. To insure the latter result and avoid the former, the training side of the military, in particular, needs to understand the dynamics of this new environment, where warfighters increasingly interact with their peers and leaders digitally.

To improve the warfighter’s ability to perform effectively in this information-rich and changing environment, the military needs to train personnel at all levels to do essential coordination with others across horizontal and vertical networks. The current research examines characteristics of network-collaborative environments (e.g., personnel geographically dispersed, different knowledge sets, unacquainted) and how this environment impacts performance. A second phase of this research will examine different techniques to train participants to collaborate.

RESEARCH CONCEPTS

Researchers first selected a game that both allowed performance, using different communication modes and knowledge sets, to be examined and the collection of communication exchanges. Descriptions of the practical features of the game and several relevant underlying research concepts follow.

Research Venue

SCUDHunt, a game developed by Thought link, INC, was selected for this research on collaboration because it provided a simplified model of the interplay of shared awareness and communication, while permitting independent manipulation of variables thought to affect them. SCUDHunt requires participants to (1) collaborate from distributed locations and (2) share unique information from their intelligence assets for optimal game performance. The goal of the game is simple, to locate three SCUD missile launchers on a map. The game requires geographically-dispersed players to collaborate while executing digital tasks in order to achieve a shared goal.

Cognitive Task Analysis

The research included a cognitive task analysis of this game to identify critical points where collaboration would be beneficial (Ross, 2003). In general, players need to communicate planning strategies and to share gathered information in order to perform effectively. The collaboration areas identified were:

Coordinating deployment: Players discuss where best to place their assets on the map grid, with the goals of (1) maximizing coverage of the area remaining to be searched, and (2) using certain assets to verify the results of earlier searches;

Interpreting results: Players discuss the reliability of reports from different intelligence-gathering assets, leading to a determination of the likelihood that a SCUD launcher is at any particular location. This involves interpretation of results from the current turn, as well as integration of findings from previous searches.

Common Knowledge

This situation of networked individuals who have shared goals but unique roles and responsibilities raises a new question for research on collaboration at a distance: To what extent does knowledge about a partner’s role influence an individual’s performance effectiveness? Knowledge about others’ roles, responsibilities, and job requirements has been termed "interpositional knowledge." One effective training strategy for increasing interpositional knowledge among team members is cross-training (Blickensderfer, Cannon-Bowers, & Salas, 1998).

Volpe, Cannon-Bowers, Salas, and Spector (1996) defined cross-training as a strategy where “each team member is trained on the tasks, duties, and responsibilities of his or her fellow team members” (p. 87). This involves having team members understand and sometimes practice each other’s skills. The Volpe et al. (1996) initial research on cross-training, as well as an extension (Cannon-Bowers, Salas, & Blickensderfer, 1998), showed that those team members who received cross-training were better able to anticipate each other’s needs, shared more information, and were more successful in task performance. Additional research has found that cross-training and a common understanding of roles contributes to shared mental model development, effective communication, and improved coordination (McCann, Baranski, Thompson, & Pigeau, 2000; Marks, Sabella, Burke, & Zaccaro, 2002).

Similarly, U.S. Army trainers found that Soldiers needed an understanding of how their digital system interacted and complemented other Army systems (Schaab & Dressel, 2003; Schaab, Dressel & Hayes, 2005). Computer systems training has been modified to include an introductory module on the unique contributions of each system and how they work together to achieve optimal situational understanding.

To investigate such issues, cross-training (called the **All** condition) versus intensive training in one role (called the **Own** condition) was included as a variable in this research. Players received either a double dose of training on the tasks they would perform (deployment and interpretation of their **own** assets) or a single dose of training on both their tasks and on the tasks of their partner; this is referred to as the **All** training condition.

Communication Patterns and Mode

Recent research has shown that communication content (Urban, Weaver, Bowers, & Rhodenizer, 1996) can influence team coordination and performance. To investigate these relationships, researchers explored how the type of communication during a collaboration effort was associated with success. A two tier communication categorization was used to analyze text chat communication between players (see Appendix A). The first tier consisted of 7 types of communication actions while the second tier considered the game related object of the first tier action. For example, a message could be categorized as a request for information (action) regarding asset capability (object of action). More specifically, consider the communication, “How reliable is your satellite in detecting a SCUD?” First tier (action) is a request for information and the second tier (object of the action) is asset capability.

In addition, communication mode was manipulated. All pairs wore headsets that allowed oral communication during one of the two games they played; during the other game, participants communicated by sending typed messages via an on-screen "chat" box. For a random half of the pairs, the "chat" game came first. The data analyzed included measures of the types and frequency of communication between participants in the "chat" game and game performance.

METHOD

Participants

Fifty-six undergraduate students, 31 females and 25 males, received course credit for three hours of participation. Participants ranged in age from 18 to 35 years, with the overwhelming majority between 18 to 25 years. Five participants had military experience. Participants were paired for the research. Forty-two individuals forming 21 pairs had never met. The remaining participants were acquaintances or friends.

Instruments

Questionnaire: At the beginning of the session, participants completed a questionnaire that requested demographic information (e.g., gender, age, and military experience) and computer experience.
Workload: The NASA Task Load Index (TLX) (Hart & Staveland, 1988) is a multi-dimensional rating tool that provides workload scores based on six subscales: Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, and

Frustration. A definition of each subscale is provided in Appendix B. The NASA TLX was administered to each participant after completing the first and second game of SCUDHunt.

<u>Game Description:</u> The SCUDHunt game presents players with the mission of determining where – on a five-by-five grid board representing the map of a hostile country – the launchers for SCUD missiles are located. Participants are told that there are three SCUD launchers, each in a different fixed location among the 25 squares on the board. On each of five turns, participants deploy intelligence-gathering assets (for example, a reconnaissance satellite or a team of Navy Seals), receive reports from those assets, and create a “strike plan” (to be sent to their fictional commander) indicating their independent best guesses based on all the information received both from that turn and previous turns as to the SCUD launcher locations. They are told that the final strike plans – after the fifth turn – will be used by their commander to direct an attack on the SCUD launchers, and they are given the results of this final strike plan in terms of which bombed location held a now-destroyed launcher. Participants control either air or ground assets (see Figure 1) with each asset having unique capabilities and returning intelligence reports of different reliabilities. For example, eyes on target reports from Human Intelligence assets would be more reliable than reports generated from satellites where sensors must interpret images from great distances. This game then is a representation of a situation in which Soldiers would use digital systems to execute tasks requiring collaboration for successful performance.

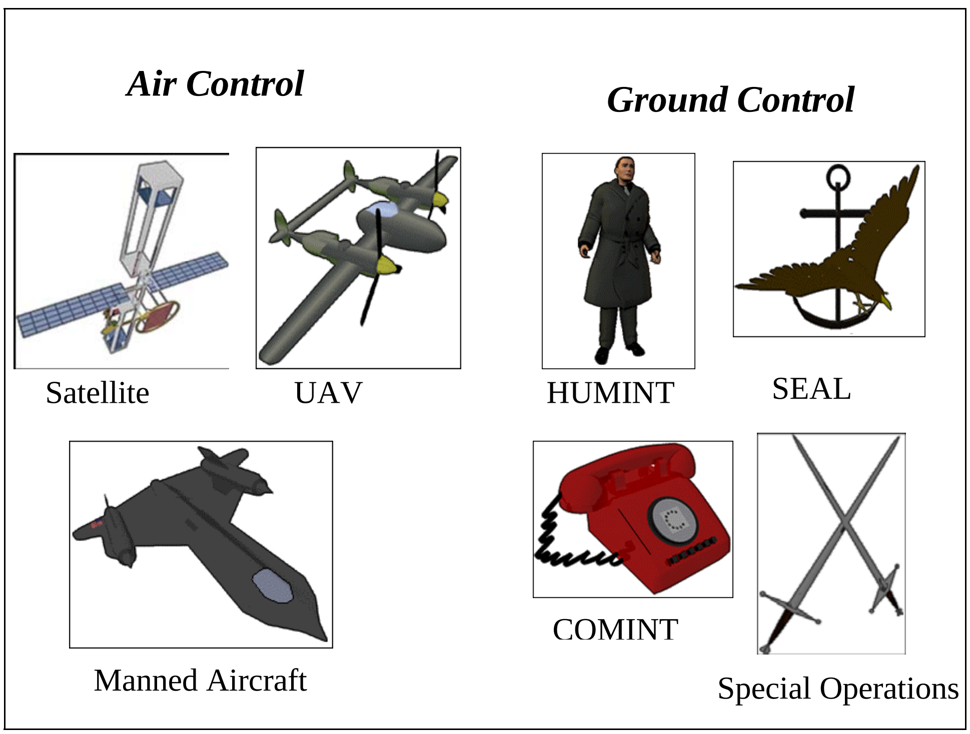


Figure1. Symbols for air and ground assets controlled by participants.

Measures generated as the game is played are 1) the number of SCUD launcher locations identified, called **quality score**, 2) the degree to which the two participants on a team chose the same grid squares or location in their independent strike plans, called **shared-situational awareness**, 3) the number of text chat communications taking place, 4) the categorized content of the text chat, 5) measures of subjective workload reported on the NASA TLX, and 6) responses to questionnaire items on demographics and computer experiences.

Design. Three primary independent variables for this experiment were training condition, mode of communication and communication patterns. **All** versus **Own** training conditions involved training on the characteristic of the information-gathering assets used in the SCUDHunt game. Every participant received, as their first training module, an explanation of the characteristics of the assets they would be controlling. Half of the pairs (the **Own** condition) received a second exposure to the same asset training; the other half (the **All** condition) received training in which each participant learned the characteristics of the assets to be controlled by that participant's partner.

Mode of communication (**Oral** or **Chat)** was analyzed to determine if communication mode influenced game performance.

Communication patterns, as described in Appendix A, were also evaluated to determine if the frequency of certain types of communication were associated with higher quality scores and increased shared-situational understanding.

Procedure. Upon arrival at the laboratory, individual participants were ushered into separate rooms where they read and signed a standard consent form describing the experiment and their rights as participants. This was followed by each participant completing a questionnaire on demographics and their experience with computers and computer games. Researchers then explained that the experiment involved participants playing a computer game with a partner who was located in another room.

Several computer-based training modules were then presented on 1) the overall aspects of playing the SCUDHunt game and 2) the characteristics of the information-gathering assets used in playing the game. Following each training module, participants took paper and pencil quizzes on the material just presented and were given immediate corrective feedback, if necessary, to ensure that they understood how to play the game and the capabilities of their assets. After this training, the pair played a one-turn practice game, to ensure that the mechanics of playing the game were understood. After the experimenters answered any question the participants might have, the pair played two complete five-turn games of SCUDHunt. During these games, data were automatically collected on 1) the messages participants sent to each other, 2) the degree to which grid squares chosen as targets in the "strike plans" (submitted at the end of each turn) were identical for the two members of the pair, and 3) the number of those chosen target squares that actually contained missile launchers.

RESULTS and DISCUSSION

Performance by Mode of Communication

All participants played the game in each of the two communication modes (**Oral** or **Chat**) with the order of presentation balanced across pairs. Analyses of variance revealed no significant effect (p>.05) of mode of communication upon either the number of Scud launcher identified (the quality score) or the concordance of best guesses of the partners (shared situational awareness).

Performance by Training Condition

Participants were trained either on both their tasks and their partner's tasks (**All** condition) or they were trained twice on their own tasks (**Own** condition).

During the first of the two games played, no differences in performance were seen between those trained in the **All** or the **Own** conditions in either quality score or shared-situational awareness. In the second game, participants in the **All** condition located significantly more SCUD launchers than did those in the **Own** condition (see Figure 2), but those in the **Own** condition had significantly higher levels of shared-situational awareness (see Figure 3). This means that participants who were cross-trained in both their role and in their partner's role were more successful in locating SCUD launchers. Participants trained solely in their role achieved higher levels of agreement with their partner on where they thought the SCUD launchers were located, but were wrong more frequently than those who were cross-trained.

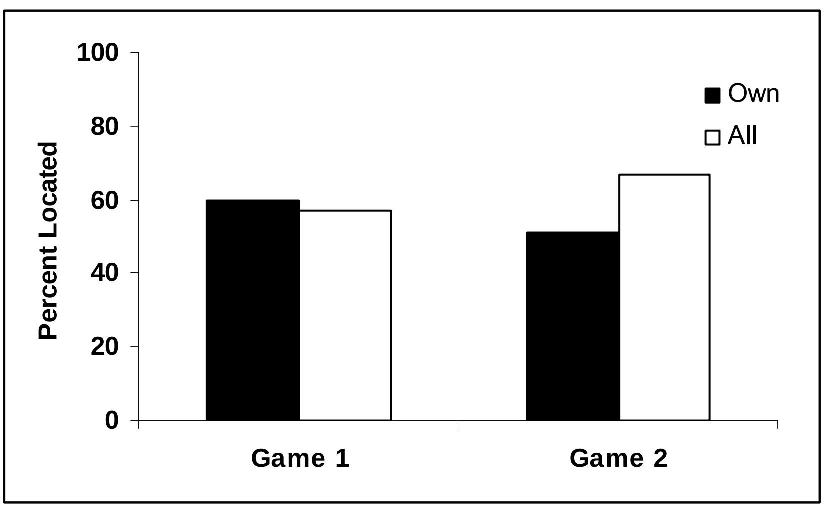


Figure 2. Quality score for participants trained in the **All** versus the **Own** condition**.** Participants in the **All** condition located significantly more SCUD launchers in Game 2 than those in the **Own** condition (F (1, 54) = 4.435, p<.05).

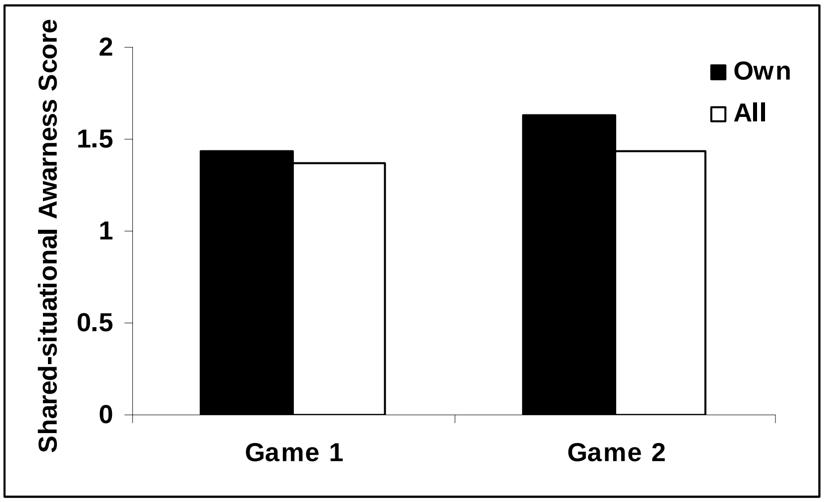


Figure 3. Shared-situational awareness for participants trained in the O**wn** versus the **All** condition. Participants in the **Own** reported more SCUD launcher location in common in Game 2 than did those in the **All** condition (F (1, 54) = 4.49, p<.05). No locations in common =0; All 3 locations in common=2

Workload.

Participants completed the NASA TLX after game 1 and game 2. During game 1, those in the **Own** condition reported higher levels of time demand (F (1, 53) = 11.162, p < .05) and frustration (F (1, 53) = 6.275, p <.05) than those in the **All** condition (see Figure 4). No differences in workload were reported during Game 2. This suggests that participants in the **Own** condition initially experienced higher levels of workload than those trained in the **All** condition.

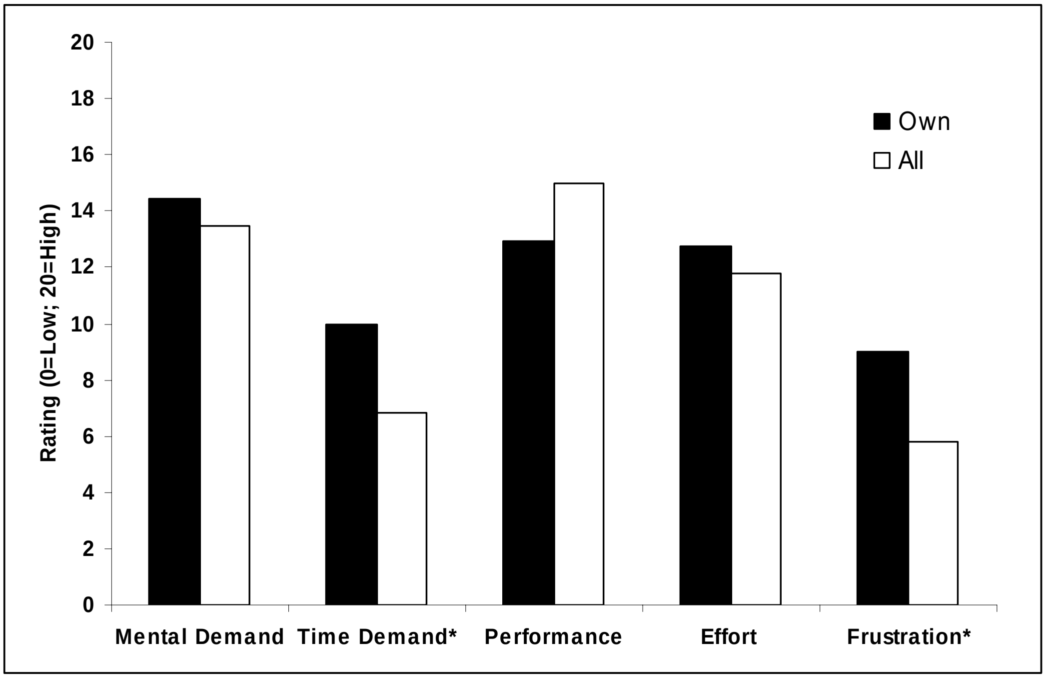


Figure 4. Comparison of workload in the **Own** and **All** conditions. After Game 1, participants in the **Own** condition reported significant higher levels of Time Demand and Frustration than those in the **All** condition.

Age, Computer Experience, and Gender Differences

Fifty-one of the 56 participants (91 percent) were 25 years old or younger with none of the participants over age 25 reporting "a lot" of experience with either computer/video games or web-based gaming. Although differences in gaming experience were reported, no significant differences in performance between "older" and younger players were found. Comparisons between older and younger participants are tenuous because these groups are dissimilar in size and the "older" group was between 26-35 years of age.

Relationships between computer experience in gaming and gender further our understanding of how these variables interact. Most participants used computers for email, searching the internet and instant messaging (see Figure 5). Thirteen of 56 participants (23 percent) reported "a lot" of experience with computer/video games, while only 6 of the 56 (11 percent) had "a lot" of experience with web-based gaming. A significant correlation was found (r= **-**.264, p<.05) between experience with web-based gaming and the number of SCUD launchers located in the first game played. Participants with more web-based gaming experience actually performed worse during the first game. This difference was not seen in the second game. It is possible that prior gaming experience initially resulted in negative transfer to the new game. Additional research would be needed to understand this relationship more fully. No other significant correlations were found between any of the types of computer experience reported and performance.

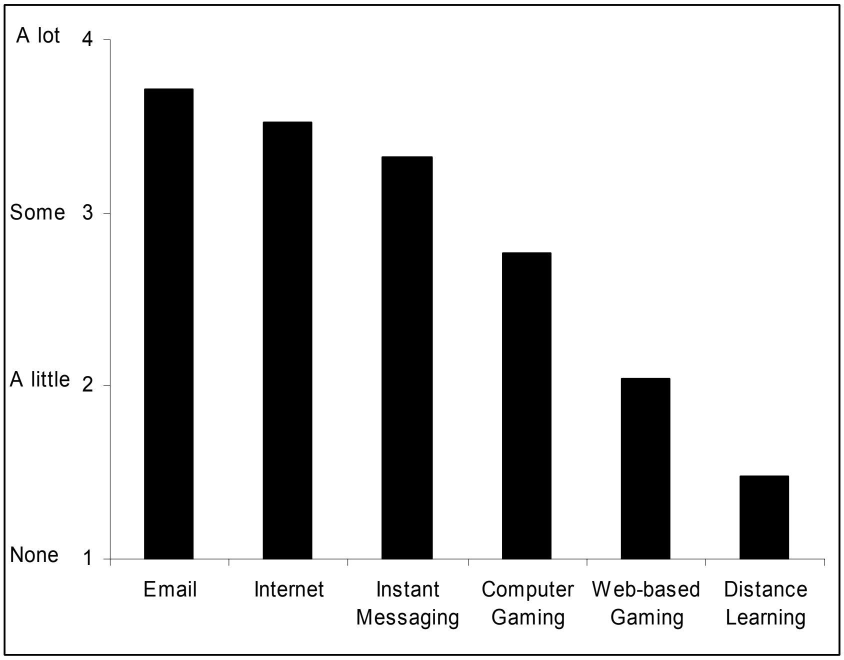


Figure 5. Survey results describing participants' computer experience.

Significant gender differences were found, with males reporting more experience in the categories of web-based gaming ($\chi^2_{.1,\,3}$= 6.47) and computer/video games ($\chi^2_{.05,\,3}$= 15.37) than did females (see Tables 1 and 2) Despite these significant differences in gaming experience, no difference in performance, either in level of shared-situational awareness or number of SCUD launchers located, was found between males and females. Although males engage in more computer gaming activities than females, these experiences did not lead to better performance on this game.

Additionally, when looking at males only, no differences in game performances were found as a function of relative gaming experience. These findings imply that regardless of prior gaming experience, people can benefit from training that incorporates serious gaming activities.

Table 1. Experience with Web-based Gaming

	Males (Percentage)	**Females** (Percentage)
None	20	45
A little	44	36
Some	16	16
A lot	20	3

Table 2. Experience with Computer/Video Games

	Males (Percentage)	**Females** (Percentage)
None	0	13
A little	16	45
Some	40	36
A lot	44	6

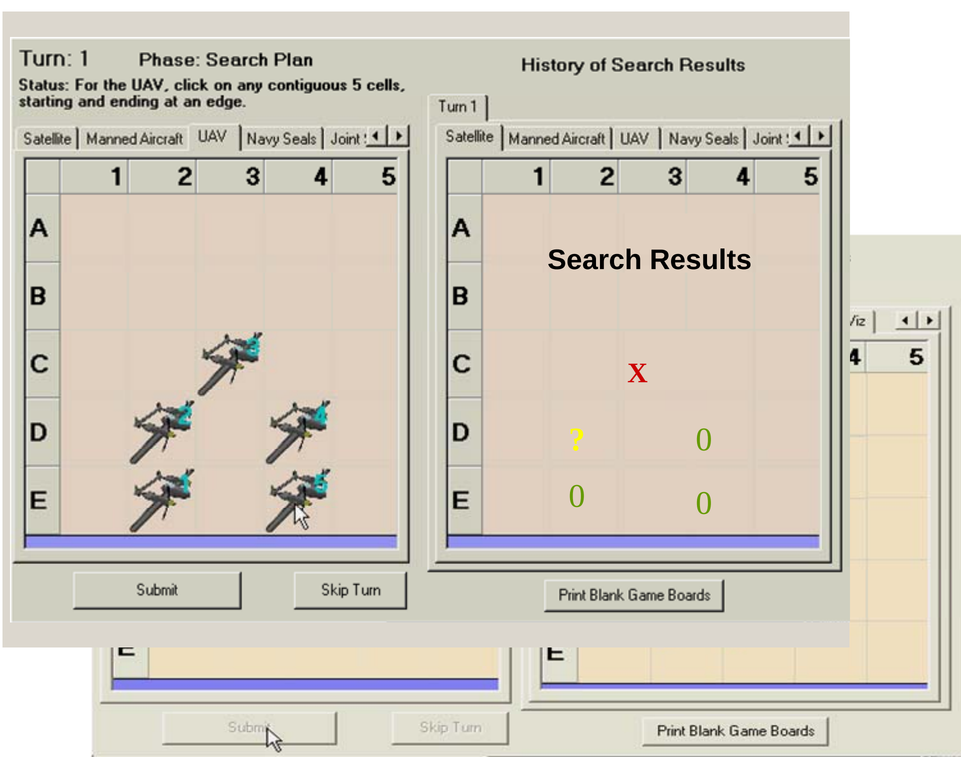
Also, no significant differences were found in quality scores or shared-situational awareness based on computer experience, military background, or acquaintance with partner.

Communication Patterns

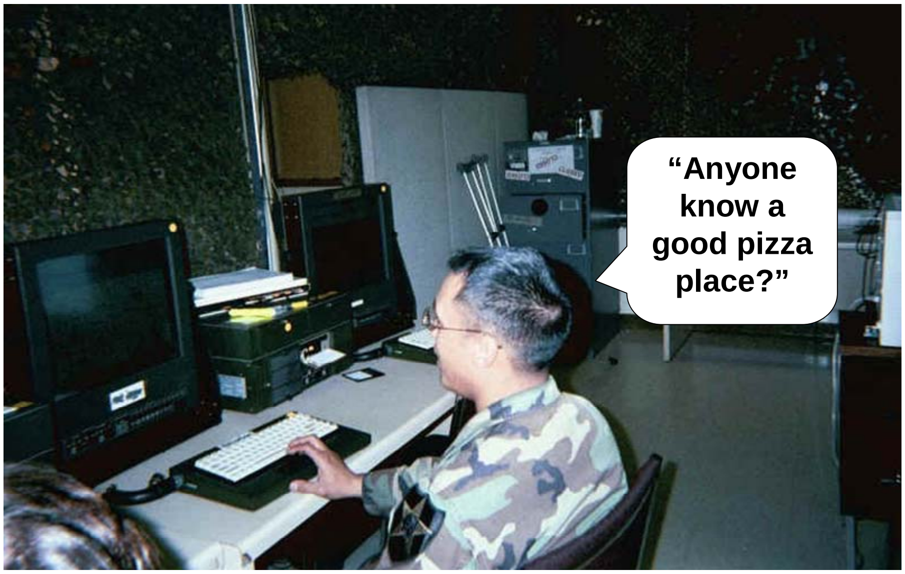
Players with a higher frequency of communications in the categories of game situation, player status, and non-task related/social, identified a significantly greater number of SCUD launchers (Game Situation F (3, 51) = 4.78, p<.05; Player Status (F (3, 51) = 6.43, p<.05; Non-task Related/Social F (3, 51) = 8.166, p<.05). Examples of these types of communication patterns follow.

Game Situation: The specific game context the players have created by their play of the current game.

“Not much going on in E2.” or
“Grid square C3 looks like a possible target.”



Non-task Related Social: Social remarks not game related.



Interestingly, the second highest number of communications in each of these three categories occurred when only one Scud launcher was located. This difference was significant only for the Game Situation category (see Figure 6)

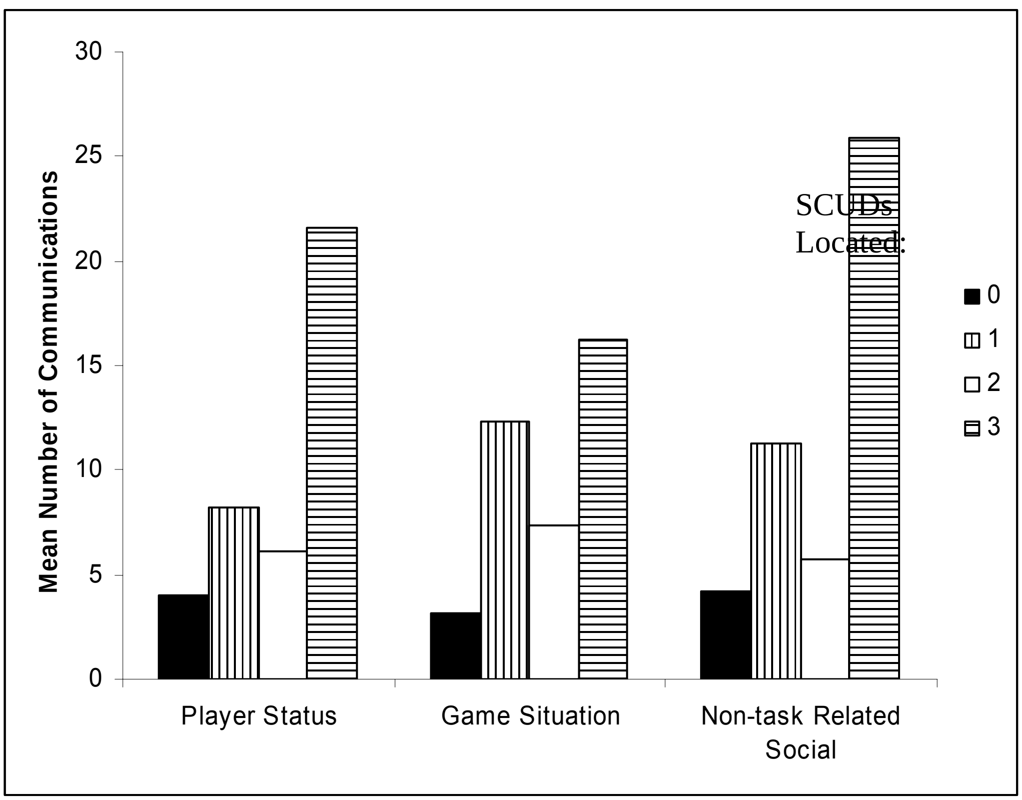


Figure 6. Number of communications exchanged compared to number of SCUDs located. Significantly more communications took place when all three SCUD launchers were located.

CONCLUSIONS

These results demonstrate that collaborative tasks benefit when collaborating participants are cross trained to have a broader, system-wide view of the entire situation. Participants trained on both their role and their partner's role (**All** condition) were more successful in locating SCUD launcher locations and, in Game 1, did so with lower levels of Time Demand and Frustration than found in those trained solely on their role (**Own** condition). In addition, while those in the **Own** condition identified more suspected SCUD launcher locations in common (shared- situational awareness) than those in the **All** condition, these concurrences were more likely to be incorrect locations.

Training Soldiers of the 21st century to effectively communicate non-face-to-face in order to develop accurate shared-situational awareness is essential in our transforming military. This research implies that Soldiers achieve higher levels of accurate situational awareness when they understand each other's role. Without this shared understanding, Soldiers may agree on what is taking place, but this agreement is more likely to be incorrect.

Participants with high levels of gaming experience performed similarly to those with little or no experience. Males and females performed equally well despite males reporting significantly more experience with gaming than did females. When looking at males only, those with high levels of gaming experience did not perform any differently than those with little or no experience.

Gaming, which was used in this research, is being investigated as a training tool because it may motivate trainees to train more frequently and for longer periods. Although additional research is needed to understand how to maximize the training benefits of gaming, the current research suggests that learning benefits of serious gaming may apply to both gamers and non-gamers.

Identifiable communication patterns are related to performance. Better performers communicated more often. Communication categories related to higher performance include player status, game situation, and non-game related social.

Understanding the types of communication that develop more accurate situational awareness provides insights into how to train Soldiers to communicate effectively in non-face-to-face environments. Good performers keep their partner informed of their status and the current situation. Interestingly, better performers engaged in higher level of non-game related social interaction. Perhaps these social communications aid in building understanding and trust.

References

Alberts, D. S. (2003). *Information age transformation: Getting to a 21st century military.* Washington, DC: DoD Command and Control Research Program.

Blickensderfer, E., Cannon-Bowers, J. A., & Salas, E. (1998). Cross-training and team performance. In J. A. Cannon-Bowers & E. Salas (Eds*.), Decision making under stress Implications for training and simulation (pp. 299-312)*. Washington, DC: American Psychological Association.

Cannon-Bowers, J. A., Salas, E., & Blickensderfer, E. (1998). The impact of cross-training and workload on team functioning: A replication and extension of initial findings. *Human Factors, 40,* 92-101.

Easley, R. F., Devaraj, S., & Crant, M. J. (2003). Relating collaborative technology use to teamwork quality and performance: An empirical investigation. *Journal of Management Information Systems*, 19, 247-268.

Griffin, R. E. (Lieutenant Colonel, CA AF) & Reid, D. J. (Australian MoD). *A woven wed of guesses, canto one. Network centric warfare and the myth of the new economy* (p. 21). Unpublished manuscript. Cite in: Wallace, W. S. (May-June 2005). Network-enabled battle command. (pp. 2-5) *Military Review*.

Hart, S. G., & Staveland, L. E. (1988). Development of a multi-dimensional workload rating scale: Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), *Human Mental Workload.* Amsterdam, The Netherlands: Elsevier.

Hevel, J. R. (2002). *The Objective Force Battle Staff?* Monograph, School of Advanced Military Studies, U. S. Army Command and General Staff College, Fort Leavenworth, Kansas.

Marks, M. A., Sabella, M. J., Burke, C. S., & Zaccaro, S. J. (2002). The impact of cross-training on team effectiveness. *Journal of Applied Psychology, 87*, 3-13.

McCann, C., Baranski, J. V., Thompson, M. M., & Pigeau, R. A. (2000). On the utility of experiential cross-training for team decision-making under time stress*. Ergonomics, 43,* 1095-1110.

Nash, G. C. (2005). Operational Implications of the Collaborative Information Environment. JWFC Doctrine Pam 5.

Pew, R. W. (1995). The state of situational awareness measurement: Circa 1995. In D.J. Garland & M. R. Endsley (Eds.), *Experimental analysis and measurement of situational awareness* (pp. 7-15). Daytona Beach, FL: Embry-Riddle Aeronautical University Press.

Ross, K.G. (September, 2003). Perspectives on Studying Collaboration in Distributed Networks, Contractor Report prepared for the U. S. Army Research Institute for the Behavioral and Social Sciences by Klein Associates Inc., Fairborn, Ohio, under Contract PO DASW01-02-P-0526.

Salas, E., Prince, C., Baker, D. P., & Shrestha, L. (1995). Situational awareness in team performance: Implications for measurement and training. *Human Factors*, 37, 123-126.

Schaab, B.B., & Dressel, J.D. (2003). Training the troops: What today's Soldiers tell us about training for information age digital competency. (Research Report 1805). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Schaab, B.B., & Dressel, J.D. (2005). Digital Skills Training for Collaborative Environments. Arlington, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Sonnenwald, D. H., & Pierce L. G. (1998). Optimizing collaboration in battalion staff elements. (Contract Report ARL-CR-435). Chapel Hill, NC: University of North Carolina at Chapel Hill.

Thoughtlink at www.thoughtlink.com

Urban, J.M., Weaver, J.L., Bowers, C.A., & Rhodenizer, L.A. (1996). Naturalistic team decision making: Effects of structure and workload on team process and performance. *Human Factors, 38,* 300-310.

Volpe, C. E., Cannon-Bowers, J. A., Salas, E., & Spector, P. E. (1996). The impact of cross-training on team functioning: An empirical investigation. *Human Factors, 38,* 87-100.

Wallace, W. S. (Lieutenant General , U.S. Army) (May-June 2005). Network-enabled battle command. (pp. 2-5) *Military Review*.

Wellons, A. R. (1993). Group situational awareness and distributed decision making: From military to civilian applications. In N.J. Castellan (Ed.), *Individual and group decision making: Current issues* (pp. 267-291). Mahwah, NJ: Lawrence Erlbaum.

Appendix A

Communications Category Definitions

1st Tier (Action)

Request information: To ask game-related questions.

Response to information request: To answer game-related questions.

Share information - unsolicited: To provide game-related information without being asked.

Direct actions: To dictate the action of the partner.

WILCO: To comply with the directed action recommended.

Non-task related (social): Social remarks directed either toward the play of the game (game related) or something other than the game (non-game related).

Equipment and Technical Problems: Refers to the operation of the experimental apparatus rather than the play of the game.

2nd Tier (Object)

Asset capability refers to how the asset can be moved (deployed) and the reliability of its findings (search results).

-Can your assets be placed individually?
-Manned aircraft, they are excellent at detecting?

Player status refers to the condition of the player: is the player ready, has the player deployed assets, has the search plan been submitted.

-Already submitted.
-There, I submitted my strike plan.
-My SpecOps is very accurate.

Game situation refers to the specific game context the players have created by their play of the current game.

-D1 looks like a target
-That's a place where there's not much going on

Search strategy refers to the plan of how assets can be deployed; i.e., placed on the grid, to the best advantage for target detection.

-I covered 2 sides of the square
-Where are you searching?
-For next turn, which cells do you want to take?

Strike plan refers to the plan of selecting which grid squares are most likely to contain targets as a function of previous searches.

-I will strike C1.

-Where are you thinking about striking?

Game rules/operation refer to the general rules which govern the play of the game

-This next turn is our last.

-It's only the last strike that matters.

Note: A communication may contain several components each of which needs to be coded; however, each component will have only <u>one</u> code.

Appendix B

RATING SCALE DEFINITIONS		
Title	Endpoints	Descriptions
MENTAL DEMAND	*Low/High*	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	*Low/High*	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	*Low/High*	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
EFFORT	*Low/High*	How hard did you have to work (mentally and physically) to accomplish your level of performance?
PERFORMANCE	*Good/Poor*	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
FRUSTRATION LEVEL	*Low/High*	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?