SPECIAL SECTION

Errors in the Heat of Battle: Taking a Closer Look at Shared Cognition Breakdowns Through Teamwork

Katherine A. Wilson, Eduardo Salas, and **Heather A. Priest,** University of Central Florida, Orlando, Florida, and **Dee Andrews,** Air Force Research Laboratory, Mesa, Arizona

Objective: We developed a theoretically based taxonomy for classifying shared cognition breakdowns related to teamwork which contribute to fratricide incidents. **Background**: Fratricide on the battlefield is an inescapable cost of war. A number of technological advancements have been made in terms of combat identification systems to reduce the risk of these incidents. However, fratricide continues to occur at alarming rates. **Method**: We take a human-centered approach to understanding errors leading to fratricide incidents by focusing on shared cognition. We turn to the literature and provide the theoretical foundations for an error classification taxonomy to improve understanding of why fratricide incidents occur. **Results**: Based on our review of the literature, we identified a number of problem areas leading to fratricide incidents. However, many of the cited contributing factors were broad terms (e.g., poor coordination) and did little to tell us why the breakdown occurred and where improvements are needed. Therefore, we chose to focus on one specific area – teamwork breakdowns – and discuss in depth how these breakdowns contribute to fratricide. **Conclusion**: In this paper, we take a first step toward proposing a taxonomy that allows for the diagnostic assessment of what causes teamwork breakdowns in fratricide. We understand that a taxonomy is only as good as the data available and encourage richer case studies from which to learn. **Application**: To apply this taxonomy in an operational setting, we provide a set of behavioral markers that can be used to identify teamwork breakdowns on the battlefield.

INTRODUCTION

On April 22, 2004, because of a mission delay following a vehicle breakdown, the "A" Company of the 2nd Battalion of the 75th Ranger Regiment was commanded to split into two groups – Serial 1 and Serial 2 – and proceed with its operation. Because of limited communications in and around a canyon, Serial 2 could not report its change in course to Serial 1. This unfortunate turn of events led to Serials 1 and 2 engaging in a war fight against each other. Spec. Pat Tillman cried out, "Cease fire! Friendlies!" However, the sound of gunfire was too loud for his fellow Rangers to hear. In a desperate attempt to identify his group, Tillman detonated a signal grenade. By the time the error was recognized, it was too late to save Tillman and an Afghan militia soldier working with U.S. troops. The 2 soldiers were killed by friendly fire.

FRATRICIDE: AN INESCAPABLE COST OF WAR?

Fratricide, as defined by the U.S. Army's Training and Doctrine Command (TRADOC) Fratricide Action Plan, is "the employment of friendly weapons and munitions with the intent to kill the enemy or destroy his equipment or facilities, which results in unforeseen and unintentional death or injury to friendly personnel" (U.S. Army, n.d.). Fratricide (or friendly fire) has been a concern since humans first engaged in combat operations, although it gained much emphasis in the Persian Gulf War (Department of Defense, 1992). The

Address correspondence to Katherine Wilson, Institute for Simulation & Training, University of Central Florida, 3100 Technology Pkwy., Orlando, FL 32826; kwilson@ist.ucf.edu. ***HUMAN FACTORS,*** Vol. 49, No. 2, April 2007, pp. xxx–xxx.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
APR 2007	**Journal Article**	**00-01-2006 to 00-03-2007**

4. TITLE AND SUBTITLE
Errors in the Heat of Battle: Taking a Closer Look at Shared Cognition Breakdowns Through Teamwork

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
62202F

6. AUTHOR(S)
Katherine Wilson; Eduardo Salas; Heather Priest; Dee Andrews

5d. PROJECT NUMBER
1123

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory/RHA,Warfighter Readiness Research Division,6030 South Kent Street,Mesa,AZ,85212-6061

8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL; AFRL/RHA

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory/RHA, Warfighter Readiness Research Division, 6030 South Kent Street, Mesa, AZ, 85212-6061

10. SPONSOR/MONITOR'S ACRONYM(S)
AFRL; AFRL/RHA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
AFRL-RH-AZ-JA-2007-0003

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Published as a Special Section in Human Factors, 49(2), 249-256

14. ABSTRACT
We developed a theoretically based taxonomy for classifying shared cognition breakdowns related to teamwork which contribute to fratricide incidents. Background: Fratricide on the battlefield is an inescapable cost of war. A number of technological advancements have been made in terms of combat identification systems to reduce the risk of these incidents. However, fratricide continues to occur at alarming rates. Method: We take a human-centered approach to understanding errors leading to fratricide incidents by focusing on shared cognition. We turn to the literature and provide the theoretical foundations for an error classification taxonomy to improve understanding of why fratricide incidents occur. Based on our review of the literature, we identified a number of problem areas leading to fratricide incidents. However, many of the cited contributing factors were broad terms (e.g., poor coordination) and did little to tell us why the breakdown occurred and where improvements are needed. Therefore, we chose to focus on one specific area - teamwork breakdowns - and discuss in depth how these breakdowns contribute to fratricide. In this paper, we take a first step toward proposing a taxonomy that allows for the diagnostic assessment of what causes teamwork breakdowns in fratricide. We understand that a taxonomy is only as good as the data available and encourage richer case studies from which to learn. Application: To apply this taxonomy in an operational setting, we provide a set of behavioral markers that can be used to identify teamwork breakdowns on the battlefield.

15. SUBJECT TERMS
Heat of battle; Friendly fire; Teamwork; Fratricide; Combat identification systems; Shared cognition; Teamwork breakdowns

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Public Release**	**14**	

percentage of deaths attributed to fratricide has ranged from 17% in the Persian Gulf War (Garamone, 1999) to 21% during World War II (American War Library, 1996). Others argue that these numbers are too high and suggest that fratricide incidents account for only 2% of casualties (see Office of Technology Assessment [OTA], 1993). However, given the difficulty associated with identifying a friendly fire incident and the lack of incident reporting, it is cautioned that these numbers may be deceptively low (OTA, 1993).

Whatever the absolute numbers, friendly fire incidents occur and will continue to occur, injuring or killing U.S. and allied troops. Unfortunately, fratricide has been argued to be one of the inescapable costs of war (Marine Corps University Command and Staff College [CSC], 1995). Such was the case in a well-publicized incident involving the bombing of the "A" Company of the 3rd Battalion of Princess Patricia's Canadian Light Infantry on April 17, 2002 (Morgret, 2002). Four soldiers were killed and 8 were wounded when a U.S. pilot, believing that he was being fired upon, returned fire on friendly forces. In 2003, a number of other incidents occurred – for example, a U.K. jet was shot down by a U.S. missile (2 were killed); a U.K. tank fired on another tank (2 were killed); and a U.S. A-10 antitank aircraft fired after mistaking a British tank for an enemy one (1 killed and at least 3 injured; British Broadcasting Corporation [BBC] News, 2003, 2004b). A more recent event occurred in 2006, when two U.S. A-10 aircraft, under control of the North Atlantic Treaty Organization, mistakenly fired upon Canadian troops (1 killed, 5 seriously wounded; Columbia Broadcasting System News, 2006). Incidents such as these can have detrimental effects on troops. Data collected through the U.S. Army's Center for Army Lessons Learned (CALL) suggest 10 potential effects of friendly fire incidents (CALL, 1992). These include, but are not limited to, disrupted operations, a loss of initiative, and a loss of team cohesion and confidence in the team leader.

Does friendly fire have to be an inescapable cost of war? Unfortunately, yes, but it can be mitigated. As such, the purpose of this paper is threefold. First, we turn to the literature to uncover frequently cited causes of fratricide and what is being done to minimize these incidents. Next, we take a first step toward proposing a taxonomy for categorizing factors contributing to fratricide, namely those related to shared cognition. It does not appear from our review that fratricide incidents have been viewed from this perspective previously. We argue that a failure of shared cognition can result from breakdowns in the individual, team, organization, task, technology and/or environment. For this paper, we concentrate on one aspect of the taxonomy – teamwork breakdowns – and provide behavioral markers for identifying these breakdowns when they occur. Finally, we discuss how this taxonomy can be applied to incidents on the battlefield.

FRATRICIDE: CAUSES AND TECHNOLOGICAL SOLUTIONS

U.S. and allied forces in the air, at sea, and on land are all at risk of fratricide. TRADOC and others have suggested a number of reasons as to why fratricide continues to occur, many related to human error. For example, the U.S. Army analyzed ground fratricide incidents during U.S. conflicts prior to the Persian Gulf War and suggested that 45% of incidents were caused by poor coordination, 29% by target misidentification, and 19% by inexperienced troops (see OTA, 1993). Other factors cited as contributing to fratricide include inadequate training and experience, poor leadership, inappropriate procedures, language barriers, lack of appreciation of own platform position and heading, an inability to communicate changing plans or situations, and disorientation, confusion, and carelessness of aircraft crews (BBC News, 2004a, 2004b; CSC, 1995; Penny, 2002). It has been argued that many fratricide incidents that occurred during the Persian Gulf War were preventable in that a target was engaged too quickly, although the shooter was not in imminent danger and more deliberate steps could have been taken in identifying the target (OTA, 1993). It has also been suggested that fratricide is more likely at certain locations – namely, boundaries between military units, boundaries with allies/coalition forces, and environmental or service boundaries (i.e., air to surface and surface to air; Penny, 2002).

The most common approach to reducing fratricide is the development of combat identification (i.e., combat ID) systems or Blue Force Tracker technologies. The technological advancements of combat ID systems made within the last decade have been substantial (e.g., more reliable, more cost effective, smaller), and millions of dollars are being spent to develop the best systems for U.S. and allied forces.

It is no surprise that military forces are turning to technology to reduce the risk of fratricide. After all, human error is inevitable, and human capabilities are limited. However, the ultimate decision to fire a weapon remains in the hands of its operator. This is even more of a concern for tactical forces conducting operations on foot without the aid of these new technologies (Brenner & Sherman, 1998). Other human factors issues such as sleep deprivation and fatigue can affect decision making (O'Rourke, 2003). Findings indicated that although war fighters could accurately hit targets when sleep deprived, they had difficulties identifying them. Finally, research examining the impact of automated systems (similar to combat ID systems) has indicated that people underutilize or overutilize automation (e.g., Dzindolet, Pierce, Beck, Dawe, & Anderson, 2001; Parasuraman & Riley, 1997). Furthermore, although technology has improved, it is not infallible; technology will fail or will simply not be available. When this occurs, war fighters must be trained on how to recognize a failure, how to accurately detect friend or foe, and how to make decisions under stress (see Cannon-Bowers & Salas, 1998).

Because human error will always play a role in fratricide, the next section describes the first steps toward a taxonomy for digging deeper into shared cognition and its role in fratricide. The goal here is to begin to understand more thoroughly why these incidents occur and how such events can be mitigated. This taxonomy is based on theoretical and empirical foundations (e.g., schema theory, teamwork) of shared cognition that were found in the literature.

TOWARD A TAXONOMY: A CLOSER LOOK AT SHARED COGNITION

The steps being taken to reduce fratricide with technology are commendable. However, taking a closer look at cognition on the battlefield may be one (equally important) way to address why fratricide incidents occur and propose ways to mitigate them. Troops on the battlefield perform cognitive tasks every day. They detect and recognize cues in the environment, acquire knowledge, remember relevant information, plan, and make decisions to engage a target (Cooke, Salas, Kiekel, & Bell, 2004). These cognitive processes require a collective effort. To accomplish these tasks, troops rely on shared cognition. Shared cognition is a multidimensional construct that "enables team members to have more accurate expectations and a compatible approach for task performance" (Salas & Cannon-Bowers, 2001, p. 87). Shared cognition is important on the battlefield for several reasons. First, it helps to explain how effective teams are able to coordinate without explicit communication (Cannon-Bowers, Salas, & Converse, 1993). This is possible, for example, through shared knowledge that enables team members to interpret cues similarly, make decisions that are compatible, and take correct actions (see Cooke, Salas, Cannon-Bowers, & Stout, 2000; Klimoski & Mohammed, 1994; Mohammed & Dumville, 2001). In addition, shared cognition allows one to understand the multiple elements of effective teamwork (e.g., team knowledge, closed-loop communication and mutual trust), which can then be used to diagnose deficiencies. Based on these findings and others, it is legitimate to conclude that when shared cognition "fails," the incidence of fratricide increases.

We would also argue that a number of factors influence shared cognition beyond the team – individual-, task-, organization-, technology-, and environment-based factors (see Figure 1). These factors become obvious when one examines the battlefield environment in which war fighters engage in cognitive tasks. It has been stated that "battlefield realities dictate that commanders will always make decisions under conditions of uncertainty and ambiguity" (Dubik, 2003, p. 36). The battlefield can be characterized as an environment that has high stakes; is dynamic, ambiguous, and time stressed; and in which goals are ill defined or competing (Zsambok & Klein, 1997). The battlefield's intense nature, also referred to as the "fog of war," places unimaginable pressures on war fighters that most people will never face. War fighters receive extensive training on what to expect, have strict rules of engagement, and must pursue the commander's intent, but nothing can prepare them quite like the real thing, where they must make life-or-death decisions quickly. Therefore, the battlefield is one of the most difficult operational environments within which to perform cognitive tasks; therefore, breakdowns in shared cognition are inevitable.

Taking what is known about shared cognition and the battlefield environment, one can begin to hypothesize how to investigate and categorize errors that occur. A number of frameworks for classifying human error contributing to accidents

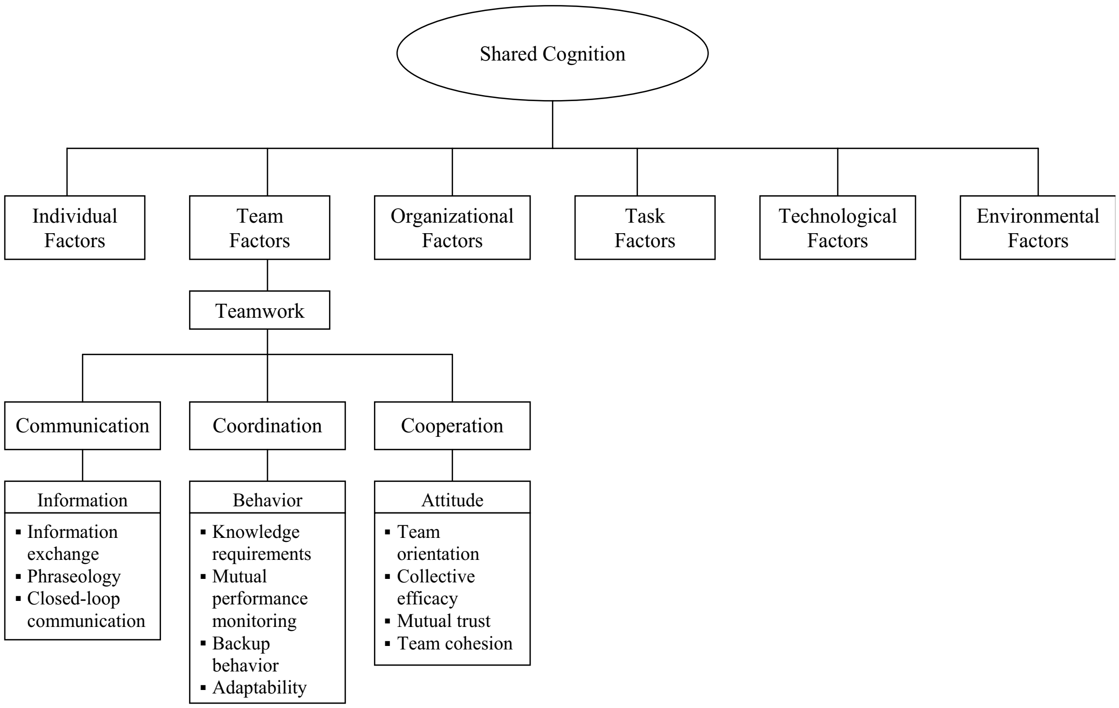

Figure 1. Toward a framework for classifying teamwork breakdowns.

and incidents have been developed (e.g., Swiss cheese model: Reason, 1990; Human Factors Analysis and Classification System [HFACS]: Wiegmann & Shappell, 2001). It is often easiest to place the label "human error" as the root cause of an accident, but this term is broad and leaves much to one's imagination as to what really occurred. Research suggests that when determining the cause of an accident or incident, investigators must look deeper into human error, beyond that of even the human operator, and we agree. Wiegmann and Shappell (2001) and others (OTA, 1993; Reason, 1990) have argued that an accident or incident can be affected by a number of factors (e.g., organizational factors, teamwork deficiencies) that may have led to the error caused by the human. Building from these frameworks, we have developed a taxonomy that seeks to further parse out what contributed to an incident. For example, it is not enough to say that a failure of teamwork caused the incident. It leaves one asking, "What part of teamwork failed?" We feel that this is something that is lacking from other frameworks.

In the next section of this paper, we focus on one factor of the taxonomy so as to parse out what aspects contribute to fratricide. Specifically, we focus on unpacking the team's influence on shared cognition and ultimately fratricide. As the complex nature of the battlefield requires a team effort to engage the enemy, we argue that it is through a series of team processes (i.e., communication, coordination, and cooperation) that an individual war fighter engages in the "shoot-don't shoot" action. Furthermore, the expanse of research that has been conducted on teams in multifaceted environments provides lessons learned from which teamwork breakdowns (e.g., training strategies) can be addressed. The development of combat identification systems, though necessary and useful, seems to address the "what" of the problem without really focusing on "why" fratricide occurs – failures of the team. We acknowledge that these are complicated issues, not quick or simple to address, but we hope that this will begin a dialogue and provide a starting place for future empirical work. With that said, we will begin to lay out the teamwork variables included within the taxonomy and discuss their relationship to human error and fratricide.

TEAM FACTORS

Effective teamwork is extremely important when coordinated, interdependent behavior is required, particularly in highly chaotic or ambiguous situations such as the battlefield. Teamwork is a multidimensional, dynamic construct that refers to a set of interrelated cognitions, behaviors, and attitudes that occur as team members perform a task that results in a coordinated and synchronized collective action (Salas, Stagl, & Burke, 2004). Team competencies are cyclic in nature, acting as processes, outcomes, and processes again. What serves as an outcome of one variable may serve as an input to another. These processes together help form the shared cognition of the team. By exchanging information through communication, for example, team members develop shared cognition and are better able to coordinate (Stout, Cannon-Bowers, & Salas, 1996). As a result, effective team performance ensues. When team members lack a shared understanding of the task and surrounding environment, teamwork will suffer and the likelihood of friendly fire incidents will increase.

To address the challenges faced by teams on the battlefield, the U.S. military conducts joint exercises among military branches to improve communication, coordination, and cooperation (Crawley, 2003). However, these are "blanket" terms that encompass an array of teamwork competencies (i.e., knowledge, skills, and attitudes, or KSAs). Therefore, to better understand why teams on the battlefield derail and how improvements can be made, the military must dig deeper and examine what facets constitute these team competencies.

In the next section we present a number of theoretically and empirically derived KSAs that constitute team communication, coordination, and cooperation and which can also be used to identify when team breakdowns occur (see Table 1). We then use this information as a basis for developing a comprehensive yet practical tool (i.e., behavioral markers checklist) that outlines a number of questions to ask when examining teamwork-related errors that lead to fratricide (see Table 1). The focus of this paper is on fratricide, but we submit that these KSAs may be useful in other complex team settings as well. The KSAs are broken down by the team factors that the research suggests most significantly contribute to shared cognition. We understand that some of the factors may be difficult to observe directly (e.g., shared knowledge, collective efficacy); however, all manifest themselves through observable behaviors (i.e., behavioral markers). We hope that this will serve as a first step in helping researchers to better understand why fratricide incidents occur.

Communication

Communication in its simplest form can be thought of as the transferring of information between two individuals: a sender and a receiver (McIntyre & Salas, 1995). Communication breakdowns are thus incidents in which there is a delay of or lack of the right information being transferred to the right person at the right time. *Communication* is often used as a blanket term to cover all types of communication, but several, more precise, terms can be used to better understand how team members communicate and how communication affects fratricide incidents. Three distinct types of communication are discussed here – namely, information exchange, phraseology, and closed-loop communication – which, when not applied appropriately, can lead to communication breakdowns, which will ultimately impact shared cognition (MacMillan, Entin, & Serfaty, 2004; Salas & Fiore, 2004).

Smith-Jentsch, Zeisig, Acton, and McPherson (1998) distinguished between different types of communication. *Information exchange* refers to what information is passed between the sender and receiver and includes use of all available information sources, passing the appropriate information to the appropriate person without being asked, and providing situation updates periodically so as to summarize the big picture. Information passed along may include situation (e.g., task, environmental) updates, performance feedback, or mission changes, to name a few, and can come in verbal or nonverbal forms. When information exchange is effective, teams are better able to develop and maintain shared cognition by having an accurate and congruent picture of the situation at hand.

Phraseology refers to how information is delivered between the sender and receiver. Components of effective phraseology include use of proper terminology, providing complete standard reports, being brief and avoiding excess chatter, and transmitting information clearly without inaudible communications.

Once the information is exchanged and communicated to team members, it is important to ensure that the information was received and interpreted correctly (Bandow, 2001). Employing closed-loop communication techniques is critical to ensure that information is clearly and concisely transmitted, received, and correctly understood, and it has been shown to distinguish effective

TABLE 1: Behavioral Markers of Teamwork Breakdowns

Communication

Information exchange
- Did team members seek information from all available resources?
- Did team members pass information within a timely manner before being asked?
- Did team members provide "big picture" situation updates?

Phraseology
- Did team members use proper terminology and communication procedures?
- Did team members communicate concisely?
- Did team members pass complete information?
- Did team members communicate audibly and ungarbled?

Closed-loop communication
- Did team members acknowledge requests from others?
- Did team members acknowledge receipt of information?
- Did team members verify that information sent was interpreted as intended?

Coordination

Knowledge requirements
- Did team members have a common understanding of the mission, task, team, and resources available to them?
- Did team members share common expectations of the task and team member roles and responsibilities?
- Did team members share a clear and common purpose?
- Did team members implicitly coordinate in an effective manner?

Mutual performance monitoring
- Did team members observe the behaviors and actions of other team members?
- Did team members recognize mistakes made by others?
- Were team members aware of their own and others' surroundings?

Backup behavior
- Did team members correct other team member errors?
- Did team members provide and request assistance when needed?
- Did team members recognize when one performed exceptionally well?

Adaptability
- Did team members reallocate workload dynamically?
- Did team members compensate for others?
- Did team members adjust strategies to situation demands?

Cooperation

Team orientation
- Did team members put group goals ahead of individual goals?
- Were team members collectively motivated, and did they show an ability to coordinate?
- Did team members evaluate each other and use inputs from other team members?
- Did team members exhibit "give-and-take" behaviors?

Collective efficacy
- Did team members exhibit confidence in fellow team members?
- Did team members exhibit trust in others and themselves to accomplish their goals?
- Did team members follow team objectives without opting for independence?
- Did team members show more and quicker adjustment of strategies across the team when under stress, based on their belief in their collective abilities?

Mutual trust
- Did team members confront each other in an effective manner?
- Did team members depend on others to complete their own tasks without "checking up" on them?
- Did team members exchange information freely across team members?

Team cohesion
- Did team members remain united in pursuit of mission goals?
- Did team members exhibit strong bonds and desires to remain a part of the team?
- Did team members resolve conflict effectively?
- Did team members exhibit less stress when performing tasks as a team rather than as individuals?

teams from ineffective ones (Bowers, Jentsch, Salas, & Braun, 1998; McIntyre & Salas, 1995). *Closed-loop communication* involves three steps: (a) a sender transmits a message, (b) a receiver accepts the message and acknowledges receipt of that message, and (c) the sender verifies that the message was received and interpreted as expected.

Without a doubt, the complexity and dynamic nature of the battlefield environment requires efficient and effective communication (in the broader sense) between team members. Added challenges are faced by war fighters when communicating with allied forces if language barriers (e.g., accents, different communication styles) and other linguistic difficulties must be overcome. From our review of fratricide incidents, it appears that a variety of incidents have occurred between different U.S. services, and between coalition allies, because the closed-loop communication was not well executed. In addition to human errors (e.g., sender shares the wrong information, the sender has the correct information but does not share it or shares only part of it, or the sender shares the correct information but the receiver misunderstands it), there are technological and environmental challenges as well. For example, communication devices may be faulty (e.g., radio battery is dead) or not in sync (e.g., teams operating on different radio frequencies), or there may be environmental interference (e.g., terrain interrupting signals, excessive noise). Regardless of the reason for the breakdown, its impact can be significant on the team and shared cognition, and it ultimately jeopardizes the safety of war fighters.

Coordination

Teamwork does not just happen. Rather, teams must coordinate their activities to successfully reach their goals and complete their tasks (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995), and research suggests that team coordination is important to effective team performance (e.g., Guzzo & Shea, 1992; Swezey & Salas, 1992). Like that of communication, coordination among team members is not simple. Rather, coordination is contingent on correct and timely actions and contributions by all team members (Kozlowski & Bell, 2003). Through appropriate coordinating mechanisms, team members are able to sequence, synchronize, integrate, and complete tasks without wasting valuable resources (e.g., time, personnel; Cannon-Bowers et al., 1995; V. Rousseau, Aubé, & Savoie, 2006; Spreitzer, Cohen, & Ledford, 1999). Therefore, coordination is the behavioral mechanism team members use to orchestrate their performance requirements. When coordination breakdowns occur, this can lead to errors, missed steps or procedures, and lost time (to name a few). For example, if one team member makes an error, this will likely translate to another team member error if it is not caught and corrected. Furthermore, a lack of coordination or contribution by a team member may hinder another team member from being able to accomplish his or her part of the task. On the battlefield, these “process losses” (Steiner, 1972) may eventually lead to fratricide incidents, as team members may not share a common understanding of the situation.

As mentioned, poor team coordination has been cited in numerous fratricide incidents (OTA, 1993). This is useful in the broad sense to help one to recognize teamwork deficiencies, but it does little to explain how coordination broke down or to identify where it needs to improve. In this section we discuss several critical team coordination mechanisms that foster shared cognition and may contribute to fratricide on the battlefield when breakdowns occur. Specifically, to reduce the risk of errors and maintain performance (i.e., through coordination), team members must (a) share knowledge of the team, task and environment; (b) ask for assistance or assist others when overloaded; (c) monitor each others’ performance to identify deficiencies and provide assistance; and (d) maintain vigilance so as to adapt as the situation deems necessary. Several team competencies are critical to accomplishing this, and without them teams will derail: knowledge of the task, knowledge of teammates, mutual performance monitoring, backup behavior, and adaptability (Salas, Sims, & Burke, 2005; Xiao & Moss, 2001). Although other team coordination skills are arguably important to teamwork, we feel that these are the most critical to fostering shared cognition (e.g., McIntyre & Salas, 1995; Porter et al., 2003; Rentsch & Hall, 1994).

Knowledge requirements. Important to the development and maintenance of shared cognition is the shared knowledge among the team. In general, there are three types of team-related knowledge that enable teams to develop shared cognition: (a) task-specific knowledge (i.e., knowledge pertaining to a specific task); (b) task-related knowledge (i.e., knowledge pertaining to a variety of tasks’ processes); and (c) knowledge of teammates (i.e., understanding team members' preferences, strengths, weaknesses, and tendencies). Task-specific knowledge allows team members to share expectations of what should happen regarding task performance and to take action in a coordinated manner without explicit communications (Cannon-Bowers et al., 1993). Task-related knowledge, such as a shared understanding of teamwork, contributes to a team's ability to successfully complete a task because team members know the strategies by which to coordinate (e.g., Rentsch & Hall, 1994). Finally, knowledge of teammates allows members to compensate for others, predict the actions they will take, provide information without being asked, and allocate resources according to team members' expertise.

Research suggests that members of successful teams possess this knowledge, resulting in more effective communication, improved teamwork, greater willingness to work with team members in the future, and better performance (Griepentrog & Fleming, 2003; Mohammed, Klimoski, & Rentsch, 2000; Rentsch & Klimoski, 2001; Stout, Cannon-Bowers, Salas, & Milanovich, 1999). Some have argued that deficient shared knowledge may lead to miscommunication and uncooperative behavior because of a failure to recognize and integrate contingencies of a task (Jones & George, 1998). Shared knowledge is especially critical during periods of extreme stress (e.g., those experienced on the battlefield). Teams that hold shared knowledge are able to coordinate implicitly rather than explicitly because they are able to anticipate and predict the needs and actions of team members (Entin & Serfaty, 1999; Kleinman & Serfaty, 1989; Orasanu & Salas, 1993; Salas, Cannon-Bowers, & Johnston, 1997). For example, a team member will not need to ask for information from another member. Rather, each team member will know what information is expected from him or her, when it is expected to be transmitted, and to do so without explicitly being prompted for it. By coordinating implicitly, cognitive resources are thus made available to handle the stress and the task. It is during periods of low stress that successful teams update and ensure that all team members share a common understanding (Orasanu, 1990). Unfortunately, on the battlefield there may be no periods of "low stress," leading to shared cognition breakdowns and errors.

Mutual performance monitoring. When team members understand the tasks performed by the team and their teammates' roles and responsibilities, they develop expectancies of how team members should be performing (McIntyre & Salas, 1995). Formally defined as the ability to "keep track of fellow team members' work while carrying out their own…to ensure that everything is running as expected and…to ensure that they are following procedures correctly" (McIntyre & Salas, 1995, p. 23), mutual performance monitoring increases the team's chance of success by catching errors (e.g., locking on a friendly target) before they become irreversible (e.g., a friendly soldier gets killed). Critical to mutual performance monitoring is the development of mutual trust within the team (discussed later). When team members are able to trust one another, they can more readily monitor one another's performance for deficiencies (e.g., mistakes or lapses), as well as exceptional performance, and provide and accept feedback (both positive and negative) in order to facilitate team self-correction without fear of criticism (Smith-Jentsch et al., 1998). Mutual trust also enables team members to seek feedback from others while feeling safe from judgment. Likewise, mutual performance monitoring behavior is highly reliant on agreement within the team that assistance and feedback are important and valued, as well as on support and rewards from the team leader. Mutual performance monitoring in combination with constructive feedback allows team members to improve the team's collective awareness of the situation (and ultimately shared cognition), helping them remain up to date on their progress and the progress of teammates (Paris, Salas, & Cannon-Bowers, 1999; Salas, Burke, & Cannon-Bowers, 2000).

Backup behavior. Another antecedent to shared cognition is knowing how and when to back up other team members. In addition to knowledge of team members' roles and responsibilities and the ability to monitor performance, team members need to know who should step up, when to step up, or how (Salas et al., 2005). Some have argued that backup behavior makes a team a team (McIntyre & Salas, 1995), and empirical research has shown that it does improve performance (Porter et al., 2003) and minimize error (Johnston & Briggs, 1968). Especially critical under periods of high workload, members of successful teams monitor each other's performance and identify deficiencies (e.g., workload has surpassed one's capabilities) so as to provide backup behavior in the form of

(a) feedback or coaching or (b) assistance to ensure team goals are achieved (Marks, Mathieu, & Zaccaro, 2000; McIntyre & Salas, 1995; Porter et al., 2003). Assistance may involve offloading a subset of the task, completely relieving a team member of a task and assigning a portion or portions of it to others, or ensuring that an error is corrected (Marks et al., 2000). However, the ability of a team to demonstrate backup behavior is not a one-way street. In other words, backup behavior is more than just team members offering assistance to others. Members of successful teams are also able to monitor their own performance and ask for assistance when performance or team goals are at risk. For example, a team member may ask for more information from others before making the decision to verify the target is correct. This capability to shift one's roles and responsibilities to assist and reduce stress on others (e.g., by shifting workload) requires flexibility and adaptability (as discussed next). Taken together, teams are thus able to improve team coordination and cooperation (e.g., backup behavior builds team cohesion) and, ultimately, shared cognition.

Adaptability. The ability of team members to create a shared understanding and their willingness to use this information to monitor and assist the performance of teammates requires that team members be flexible and adaptive. Similar to backup behavior, the relation between adaptability and shared awareness is reciprocal. Shared awareness allows the team to adapt to changing situations on the battlefield. By adapting to new situations, team strategies for adaptation are refined and shared awareness builds.

To be adaptable, team members must have a global perspective of the team task, understand how changes may alter a team member's role in relation to that task, and be able to recognize changes in other team members, the task, or the environment as they occur (Salas et al., 2005). In other words, vigilant team members are able to recognize changing cues and adjust their strategies accordingly (through flexibility, compensatory behavior, and the dynamic reallocation of resources) to maintain a focus and progress toward its objectives (Cannon-Bowers et al., 1995; Burke, Stagl, Salas, Pierce, & Kendall, 2006). The need for adaptability within a team is based on the premise that things do not always go as planned, especially on the battlefield. Although war fighters can try to predict and plan for a number of contingencies, it is likely that new plans will need to be made on the fly.

Cooperation

Finally, shared attitudes and beliefs allow team members to have compatible perceptions of the task and/or environment, which will lead to better shared cognition, more effective decisions, and enhanced team performance. Furthermore, the team members' attitudes and motivation influence their ability to communicate and coordinate. *Cooperation breakdowns* can be defined as incidents in which team members lack the desire and motivation to coordinate. As such, team members do not interact and anticipate each others' needs, which are required to promote and maintain shared cognition. Whereas cooperation is often measured based on observable behavioral markers (e.g., timing activities to fit the needs of the team, offering help only to those team members who need it, or behaving in an unambiguous manner so that actions are not misinterpreted), we argue that in order to understand why communication and coordination fail, one must look at the attitudes (i.e., cooperation) of team members. Therefore, we discuss several attitudinal components of the team that we believe impact team performance through shared cognition and can lead to fratricide when not present.

However, before going into detail, we must acknowledge the difficulty in including cooperation in an error classification system. Namely, the difficulty lies in the practicality. For example, how do you realistically measure or classify attitudinal variables such as team orientation following an accident? The easiest way is to interview witnesses and survivors. This is not always possible, so in some instances the attitudinal variables underlying observable teamwork and shared cognitive variables will remain unknown. However, we argue that this does not justify the exclusion of these variables from the current discussion. The discussion of cooperation and its underlying factors is an integral part of the identification of breakdowns and the understanding of shared cognition. Therefore, although such an important building block to shared cognition is not easily classifiable or observable, ignoring it would not do this framework justice.

Team orientation. Team orientation is an attitudinal component of cooperation that extends beyond a team member's preference for working with others. Specifically, team orientation is more than an individual's preference to put group goals ahead of individual goals (i.e., collective orientation; Hofstede, 1984; Wagner, 1995) or an individual's attraction to and desire to work with a particular team (i.e., team cohesion; Goodman, Ravlin, & Schminke, 1987). Team orientation has been identified as having malleable properties (Eby & Dobbins, 1997) in that it is based on a team member's past experience in teams (Loher, Vancouver, & Czajka, 1994), how team members perceive their ability to complete a given task (e.g., Bandura, 1991; Loher et al., 1994; Vancouver & Ilgen, 1989), and what positive outcomes may be expected from completing the task (Eby & Dobbins, 1997).

Ultimately, team orientation results in the enhancement of team performance through the coordination, evaluation, and utilization of task inputs from other team members in an interdependent manner while performing a team task (Driskell & Salas, 1992). Research has found that when individual members are high in team orientation or collectively motivated, the desire and ability to coordinate increases, resulting in team synergy or what Allport (1962) called "reciprocal give-and-take behaviors," identified as the "essence that constitutes a functioning group" (Driskell & Salas, 1992, p. 278). Whereas team orientation means team members are more likely to coordinate and cooperate (Eby & Dobbins, 1997), resulting in higher quality decisions and improved error detection (Driskell & Salas, 1992), Eby and Dobbins (1997) suggested that the relationship between team orientation and performance is mediated by factors such as past experiences and individual differences (e.g., self-efficacy), which explains a lack of evidence for a direct relationship between team orientation and performance. However, we argue that despite the mediating factors, team orientation is the foundation of cooperation in that it is necessary but not sufficient for shared cognition. For example, if individuals have a team orientation, then they are more likely to cooperate. Unfortunately, negative past experiences working in teams may lessen their team orientation and lead to a lack of cooperation in team settings.

That being said, team orientation is important within complex environments because individual team members will likely have different roles and expertise. They will also have different yet vital information that may offer a unique perspective on how to approach a situation that must be shared and integrated to meet team objectives. Therefore, team orientation will result in members being more willing to accept feedback and assistance from others (i.e., performance monitoring and backup behavior). Furthermore, it has also been found that a lack of team orientation can be detrimental to performance. For example, a number of studies show that teams exhibit poor performance when composed of individuals who prefer to work independently, (i.e., egocentric orientation; e.g., Driskell & Salas, 1992; Thomas, 1957). As has been illustrated in some of the aforementioned fratricide examples, working independently within a team setting, when stressors and ambiguity are present, may lead to a lack of communication or coordination. This can lead to a reduction in a shared cognition among team members and a misidentification of friendlies as enemies when not closely communicating and coordinating.

Collective efficacy. Collective efficacy is essential for coordinated and cooperative interactions. *Self-efficacy* is defined as an individual's belief in his or her ability to accomplish a certain task (Bandura, 1977). Individual team members have expectations of their own and others' efficacy, which determine how much effort people will expend and how long they will persist. Similar to outcome expectancy, which refers to an estimate of the extent to which a given behavior will lead to certain outcomes, an efficacy expectation is the conviction that one can successfully execute the behaviors required to produce those outcomes. These expectations also extend to others, resulting in collective efficacy. *Collective efficacy* goes beyond the aggregation of individual team member efficacy and can be defined as the belief a team has in its collective ability to perform a given task (Bandura, 2000; Gully, Incalcaterra, Joshi, & Beaubien, 2002; Smith-Jentsch, Kraiger, Cannon-Bowers, & Salas, 2006).

Although the contribution of collective efficacy to team performance needs more empirical examination (Guzzo, Campbell & Shea, 1993; Smith-Jentsch, Blickensderfer, Salas, & Cannon-Bowers, 2000), the benefit of collective efficacy in the theater of war is obvious. For example, high-performing teams develop a sense of collective efficacy and "teamness" based on their experience and their belief in their fellow team members. This allows the team members to more quickly develop a shared understanding of the environment and a more commonly held awareness (i.e., shared cognition). These teams are effective because they recognize their interdependence and believe in the ability of the team to solve complex problems (Salas & Cannon-Bowers, 2000). Collective efficacy results in feelings and attitudes toward an individual's team that promotes team effectiveness and reduces errors by allowing team members to optimize their resources. Teams with collective efficacy promote adaptation of strategies under high stress based on their belief in their collective ability to perform, decreasing the chance that individuals will stray from team roles and try to take on problems independently of their team.

Mutual trust. Mutual trust is critical for team member coordination, as it influences how team members will interpret and respond to the behavior of others (Simons & Peterson, 2000). *Mutual trust* can be defined as "the shared perception… that individuals in the team will perform particular actions important to its members and…will recognize and protect the rights and interests of all the team members engaged in their joint endeavor" (Webber, 2002, p. 205). Furthermore, trust has been envisioned as an individual's "confidence in the character, integrity, strength and abilities of another person" (Earley & Gibson, 2002, p. 106). If a team does not have mutual trust, behaviors and actions (e.g., mutual performance monitoring and backup behavior) may be misinterpreted, leading to a downward spiral of dysfunctional team processes (Creed & Miles, 1996).

Although not always directly observable, the decline or absence of mutual trust can be the catalyst for deficient teamwork behaviors and, therefore, can be used as a starting point to address why an accident occurred. Although we acknowledge the difficulty in coding these incidents as mutual trust breakdowns, the importance of this variable to backup behaviors and similar observable teamwork behaviors begs for its inclusion, at least in the discussion of such incidents. For example, team members may view performance monitoring and backup behavior as "spying" rather than trusting that team members are just looking out for one another and the greater good of the team. In addition, trust among team members leads to greater dissemination of information and teamwork (i.e., communication and coordination), leading to more effective shared cognition (Jones & George, 1998) because team members feel that the information they provide is valued and will be used appropriately (Bandow, 2001).

D. M. Rousseau, Sitkin, Burt, and Camerer (1998) determined that there are two unifying characteristics of trust: willingness to be vulnerable and confident expectation. In other words, mutual trust is not only about creating a safe yet vulnerable environment in which information is exchanged freely. Also important is the confidence that team members will perform the actions required of them to achieve the team's goals (Salas et al., 2005). This involves the willingness to accept a degree of risk that team members will meet deadlines, contribute to the task, and communicate and coordinate without being prompted.

On the battlefield, mutual trust is even more critical because not completing a task or not sharing vital information could lead to catastrophic consequences (such as friendly fire). As war fighters put their lives in the hands of others to operate effectively (e.g., provide fire cover, remain vigilant, complete tasks), it is critical that team members trust each other to do the job they were assigned to do. Joint and coalition training exercises between military branches are one way to help build this trust by providing the opportunity for units that may be working together to begin the team-building process prior to meeting on the battlefield.

Team cohesion. Team cohesion is "a dynamic process that is reflected in the tendency of a group to stick together and remain united in its pursuit of its instrumental objectives and/or for the satisfaction of member affective needs" (Carron, Brawley, & Widmeyer, 1988, p. 213) and is undeniably a critical issue to effective teamwork (Seashore, 1955; Stogdill, 1972; Swezey, Meltzer, & Salas, 1994; Wech, Mossholder, Steel, & Bennett, 1998). For example, Barrick, Stewart, Neubert, and Mount (1998) positively linked team cohesion and team performance, calling team cohesion a "general indicator of synergistic group interaction – or processes" (p. 382). This is particularly true when teams interact more and demonstrate higher levels of performance than do less cohesive collectives (Mullen & Cooper, 1994). Another factor that may influence the development and maintenance of team cohesion is the degree to which the team has member similarity, external challenges, shared goals, and member interaction. Team size and team success are other factors (McShane & Von Glinow, 2000). Some of the benefits of team cohesion in team performance that have been identified are that members tend to want to remain a part of the team, have strong interpersonal bonds, are more willing to share information, tend to have more enjoyment and less stress, and resolve conflict effectively.

The importance of cohesion in teams on the battlefield has significance to incidents of fratricide. For example, remaining part of the team, both in body and mind, leads to less confusion about who's who in the fog of war. Furthermore, willingness to share information can serve only to decrease the chance that mistakes in identification will be made.

APPLYING THE TAXONOMY

The variables discussed in this paper were used to compose a preliminary taxonomy (presented in Table 1) of the factors and their associated behaviors (i.e., behavioral markers) that can affect shared cognition in teams. We propose that this taxonomy be used to investigate the human factors that contribute to fratricide incidents. To date, the literature suggests that fratricide incidents have not been investigated in this way. Rather, general teamwork failures have been cited as contributing to these incidents (e.g., poor coordination, failure to communicate), and these are not diagnostic of what truly contributed to the event.

Critical to identifying teamwork breakdowns is access to a rich source of data from which one can dig deep into the root cause of the incident. NASA's Aviation Safety Reporting System is one such database that has been useful in understanding near misses in general and commercial aviation. From trends found in this database, recommendations have been made to minimize risk in aviation. Similar data are needed regarding fratricide near misses and incidents. From there, one can begin to offer solutions for improving teamwork (e.g., training strategies, policies and procedures) and minimizing the risk of fratricide. The taxonomy presented in Table 1 has the potential to be a useful tool in diagnosing the contribution of teamwork breakdowns in fratricide. However, such tools are necessary but not sufficient. A repository of cases to study is also needed, and the taxonomy presented in Table 1 must be tested, refined, and validated.

CONCLUSION

Fratricide incidents are one of the unfortunate costs of war; however, much can be done to minimize their frequency. By understanding why these incidents occur, one can begin to correct them. Only then can appropriate tools and interventions be developed to reduce the numbers. A significant amount of research has been conducted to develop combat identification systems. However, the human solutions cannot be ignored, such as better teamwork, superior command and control, more efficient allocation of resources, changing the rules of engagement, and training to improve communication, coordination, and cooperation (within and across U.S. services and allies). Each of these leads to improved shared cognition. In this paper, we have presented our first thoughts on developing a theoretically based framework to classify how poor shared cognition results through teamwork breakdowns, which yields fratricide incidents. We recognize that more thinking is needed, and we hope that the taxonomy presented in Table 1 stimulates future research.

ACKNOWLEDGEMENTS

We would like to thank David Baker, Kelley Krokos, and three anonymous reviewers for their thoughtful comments and insights on earlier drafts of this paper. This research was supported by the U.S. Air Force Research Laboratory, Mesa, Arizona. All opinions expressed in this paper are those of the authors and do not necessarily reflect the official opinion or position of the University of Central Florida, the U.S. Air Force Research Laboratory, or the Department of Defense.

REFERENCES

Allport, G. W. (1962). The general and the unique in psychological science. *Journal of Personality, 30,* 405–422.

American War Library. (1996). *The Michael Eugene Mullen American friendly fire notebook.* Available from http://members.aol.com/veterans/

Bandow, D. (2001). Time to create sound teamwork. *Journal for Quality and Participation, 24,* 41–47.

Bandura, A. (1977). *Social learning theory.* New York: General Learning Press.

Bandura, A. (1991). Self-regulation of motivation through anticipatory and self-reactive mechanisms. In R. Dienstbier (Ed.), *Nebraska Symposium on Motivation 1990* (Vol. 38, pp. 69–164). Lincoln: University of Nebraska Press.

Bandura, A. (2000). Cultivate self-efficacy for personal and organizational effectiveness. In E. A. Locke (Ed.), *The Blackwell handbook of principles of organizational behavior* (pp. 120–136). Oxford, UK: Blackwell.

Barrick, M. R., Stewart, G. L., Neubert, M. J., & Mount, M. K. (1998). Relating member ability and personality to work-team processes and team effectiveness. *Journal of Applied Psychology, 83,* 377–391.

Bowers, C. A., Jentsch, F., Salas, E., & Braun, C. (1998). Analyzing communication sequences for team training needs assessment. *Human Factors, 40,* 672–679.

Brenner, C., & Sherman, K. (1998). Three combat ID systems for the dismounted soldier. In P. R. Snow, Jr., & D. A. Randall (Eds.), *SPIE Proceedings* (Vol. 3394, pp. 28–38). Bellingham, WA: SPIE – The International Society for Optical Engineering.

British Broadcasting Corporation News. (2003). *"Friendly fire" hits Kurdish convoy.* Retrieved December 27, 2006, from http://news.bbc.co.uk/2/hi/middle_east/2921743.stm

British Broadcasting Corporation News. (2004a). *Marine killed in "friendly fire."* Retrieved December 27, 2006, from http://news.bbc.co.uk/2/hi/uk_news/3507514.stm

British Broadcasting Corporation News. (2004b). *"System error" link to RAF deaths.* Retrieved December 27, 2006, from http://news.bbc.co.uk/2/low/uk_news/england/norfolk/3714251.stm

Burke, C. S., Stagl, K. C., Salas, E., Pierce, L., & Kendall, D. L. (2006). Understanding team adaptation: A conceptual analysis and model. *Journal of Applied Psychology, 91,* 1189–1207.

Cannon-Bowers, J. A., & Salas, E. (Eds.). (1998). *Making decisions under stress: Implications for individual and team training*. Washington, DC: American Psychological Association.

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

Cannon-Bowers, J. A., Tannenbaum, S. I., Salas, E., & Volpe, C. E. (1995). Defining competencies and establishing team training requirements. In R. A. Guzzo & E. Salas (Eds.), *Team effectiveness and decision making in organizations* (pp. 333–381). San Francisco: Jossey-Bass.

Carron, A. V., Brawley, L. R., & Widmeyer, W. N., (1998). Measurement of cohesion in sport and exercise. In J. L. Duda (Ed.), *Advances in sport and exercise psychology measurement* (pp. 213–226). Morgantown, WV: Fitness Information Technology.

Center for Army Lessons Learned. (1992). *Fratricide risk assessment for company leadership* (CALL Handbook No. 92-3). Fort Leavenworth, KS: Author.

Columbia Broadcasting System News. (2006). *Friendly fire that killed Canadian was "freak accident": Major.* Retrieved September 20, 2006, from http://www.cbc.ca/story/world/national/2006/09/04/afghanfriendly.html

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

Cooke, N. J., Salas, E., Kiekel, P. A., & Bell, B. (2004). Advances in measuring team cognition. In E. Salas & S. M. Fiore (Eds.) *Team cognition: Understanding the factors that drive process and performance* (pp. 83–106). Washington, DC: American Psychological Association.

Crawley, V. (2003). Joint exercise aimed at preventing friendly-fire incidents. *Air Force Times, 64*(5), 31–34.

Creed, W. E. D., & Miles, R. E. (1996). Trust in organizations: A conceptual framework linking organizational forms, managerial philosophies, and the opportunity costs of controls. In R. M. Kramer & T. R. Tyler (Eds.) *Trust in organizations: Frontiers of theory and research* (pp. 16–39). Thousand Oaks, CA: Sage.

Department of Defense. (1992). *Conduct of the Persian Gulf War: Final report to Congress* (Public Law 102-25). Washington, DC: Author.

Driskell, J. E., & Salas, E. (1992). Collective behavior and team performance. *Human Factors, 34,* 277–288.

Dubik, J., (2003). Effects-based decisions and actions. *Military Review, 8*(1), 33–36.

Dzindolet, M. T., Pierce, L. G., Beck, H. P., Dawe, L. A., & Anderson, B. W. (2001). Predicting misuse and disuse of combat identification systems. *Military Psychology, 13*, 147–164.

Earley, P. C., & Gibson, C. B. (2002). *Multinational teams: A new perspective*. Mahwah, NJ: Erlbaum.

Eby, L. T., & Dobbins, G. H. (1997). Collectivistic orientation in teams: An individual and group-level analysis. *Journal of Organizational Behavior, 18,* 275–295.

Entin, E. E., & Serfaty, D. (1999). Adaptive team coordination. *Human Factors, 41,* 321–325.

Garamone, J. (1999). *Fixes touted to combat friendly fire casualties.* Retrieved August 28, 2004, from American Forces Information Service Web site, http://www.defenselink.mil/news/Feb1999/n02021999_9902027.html

Goodman, P. S., Ravlin, E., & Schminke, M. (1987). Understanding groups in organizations. *Research in Organizational Behavior, 9,* 121–175.

Griepentrog, B. K., & Fleming, P. J. (2003, April). *Shared mental models and team performance: Are you thinking what we're thinking?* Paper presented at the 18th Annual Conference of the Society of Industrial Organizational Psychology, Orlando, Florida.

Gully, S. M., Incalcaterra, K. A., Joshi, A., & Beaubien, J. M. (2002). A meta-analysis of team efficacy, potency, and performance: Interdependence and level of analysis as moderators of observed relationships. *Journal of Applied Psychology, 87,* 819–832.

Guzzo, R. A., Campbell, R. J., & Shea, G. P. (1993). Potency in groups: Articulating a construct. *British Journal of Social Psychology, 31,* 87–106.

Guzzo, R. A., & Shea, G. P. (1992). Group performance and intergroup relations in organizations. In M. D. Dunnette & L. M. Hough (Eds.), *Handbook of industrial and organizational psychology* (Vol. 3, 2nd ed., pp. 269–313). Palo Alto, CA: Consulting Psychologists Press.

Hofstede, G. (1984). The cultural relativity of the quality of life concept. *Academy of Management Review, 9,* 389–398.

Johnston, W. A., & Briggs, G. E. (1968). Team performance as a function of team arrangement and workload. *Journal of Applied Psychology, 52,* 89–94.

Jones, G., & George, J. (1998). The experience and evolution of trust: Implications for cooperation and teamwork. *Academy of Management Review, 23,* 531–546.

Kleinman, D. L., & Serfaty, D. (1989). Team performance assessment in distributed decision making. In R. Gilson, J. P. Kincaid, & B. Goldiez (Eds.), *Proceedings of the Interservice Networked Simulation for Training Conference* (pp. 22–27). Orlando: University of Central Florida.

Klimoski, R., & Mohammed, S. (1994). Team mental model: Construct or metaphor? *Journal of Management, 20,* 403–437.

Kozlowski, S. W. J., & Bell, B. S. (2003). Work groups and teams in organizations. In W. C. Borman, D. R. Ilgen, & R. J. Klimoski (Eds.), *Handbook of psychology: Industrial and organizational psychology* (Vol. 12, pp. 333–375). London: Wiley.

Loher, B. T., Vancouver, J. B., & Czajka, J. (1994, April). *Preferences and reactions to teams.* Paper presented at the Ninth Annual Conference of the Society for Industrial and Organizational Psychology, Nashville, TN.

MacMillan, J., Entin, E. E., & Serfaty, D. (2004). Communication overhead: The hidden cost of team cognition. In E. Salas & S. M. Fiore (Eds.), Team cognition: Process and performance at the inter- and intra-individual level (pp. 61–82). Washington, DC: American Psychological Association.

Marine Corps University Command and Staff College (CSC). (1995). *Fratricide: Avoiding the silver bullet*. Unpublished student paper. Retrieved January 8, 2007, from http://12.1.239.226/isysquery/irl34aa/1/doc, available from http://www.mcu.usmc.mil/MCRCweb/Archive/ResearchCollection.htm

Marks, M. A., Mathieu, J. E., & Zaccaro, S. J. (2000). A temporally based framework and taxonomy of team processes. *Academy of Management Review, 26,* 356–376.

McIntyre, R. M., & Salas, E. (1995). Measuring and managing for team performance: Emerging principles from complex environments. In R. A. Guzzo & E. Salas (Eds.), *Team effectiveness and decision making in organizations* (pp. 9–45). San Francisco: Jossey-Bass.

McShane, S., & Von Glinow, M. A. (2000). *Organizational behavior.* Burr Ridge, IL: McGraw-Hill.

Mohammed, S., & Dumville, B. C. (2001). Team mental models in a team knowledge framework: Expanding theory and measurement across disciplinary boundaries. *Journal of Organizational Behavior, 22,* 89–106.

Mohammed, S., Klimoski, R., & Rentsch, J. R. (2000). The measurement of team mental models: We have no shared schema. *Organizational Research Methods, 3,* 123–165.

Morgret, F. (2002). Friendly fire kills allies and support. *Proceedings of the United States Naval Institute, 128*(8), 86.

Mullen, B., & Cooper, C. (1994). The relation between group cohesiveness and performance: An integration. *Psychological Bulletin, 115,* 210–227.

Office of Technology Assessment. (1993). *Who goes there: Friend or foe?* (OTA-ISC-537). Washington, DC: U.S. Government Printing Office.

Orasanu, J. (1990). *Shared mental models and crew performance* (Cognitive Science Laboratory Tech. Rep. 26). Princeton, NJ: Princeton University Press.

Orasanu, J., & Salas, E. (1993). Team decision making in complex environment. In G. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok

(Eds.), *Decision making in action: Models and methods* (pp. 327–345). Norwood, NJ: Ablex.

O'Rourke, M. (2003). Combating fatigue risks. *Risk Management, 50*(11), 9–10.

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human Factors, 39,* 230–253.

Paris, C. R., Salas, E., & Cannon-Bowers, J. A. (1999). Human performance in multi-operator systems. In P. A. Hancock (Ed.), *Human performance and ergonomics* (pp. 329–386). San Diego, CA: Academic Press.

Penny, P. H. G. (2002). Combat identification: Aspirations and reality. *Military Technology, 26*(5), 50–54.

Porter, C. O. L. H., Hollenbeck, J. R., Ilgen, D. R., Ellis, A. P. J., West, B. J., & Moon, H. (2003). Backup behaviors in teams: The role of personality and legitimacy of need. *Journal of Applied Psychology, 88,* 391–403.

Reason, J. (1990). *Human error.* New York: Cambridge University Press.

Rentsch, J. R., & Hall, R. J. (1994). Members of great teams think alike: A model of the effectiveness and schema similarity among team members. *Advances in Interdisciplinary Studies of Work Teams, 1,* 223–261.

Rentsch, J. R., & Klimoski, R. J. (2001). Why do "great minds" think alike? Antecedents of team member schema agreement. *Journal of Organizational Behavior, 22,* 107–120.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academy of Management Review, 23,* 393–404.

Rousseau, V., Aubé, C., & Savoie, A. (2006). Teamwork behaviors: A review and an integration of frameworks. *Small Group Research, 37,* 540–570.

Salas, E., Burke, C. S., & Cannon-Bowers, J. A. (2000). Teamwork: emerging principles. *International Journal of Management Reviews, 2,* 339–356.

Salas, E., & Cannon-Bowers, J. A. (2000). The anatomy of team training. In S. Tobias & J. D. Fletcher (Eds.), *Training and retraining: A handbook for business, industry, government, and the military* (pp. 312–335). New York: Macmillan Reference.

Salas, E., & Cannon-Bowers, J. A. (2001). Special issue preface. *Journal of Organizational Behavior, 22,* 87–88.

Salas, E., Cannon-Bowers, J. A., & Johnston, J. H. (1997). How can you turn a team of experts into an expert team? In C. E. Zsambok & G. Klein (Eds.), *Naturalistic decision making* (pp. 359–370). Hillsdale, NJ: Erlbaum.

Salas, E., & Fiore, S. M. (2004). Why team cognition? An overview. In E. Salas & S. M. Fiore (Eds.), *Team cognition* (pp. 3–8). Washington, DC: American Psychological Association.

Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there "big five" in teamwork? *Small Group Research, 36,* 555–599.

Salas, E., Stagl, K., & Burke, C. S. (2004). 25 Years of team effectiveness in organizations: Research themes and emerging needs. In C. L. Cooper & I. T. Robertson (Eds.), *International review of industrial and organizational psychology* (Vol. 19, pp. 47–91). New York: Wiley.

Seashore, S. E. (1955). *Group cohesiveness in the industrial work group.* Ann Arbor, MI: Survey Research Institute for Social Research.

Simons, T. L., & Peterson, R. S. (2000). Task conflict and relationship conflict in top management teams: The pivotal role of intragroup trust. *Journal of Applied Psychology, 85,* 102–111.

Smith-Jentsch, K. A., Blickensderfer, E., Salas, E., & Cannon-Bowers, J. A. (2000). Helping team members help themselves: Propositions for facilitating guided team self-correction. In M. M. Beyerlein, D. A. Johnson, & S. T. Beyerlein (Eds.) *Advances in interdisciplinary studies of work teams* (Vol. 6, pp. 55–72). Greenwich, CT: JAI Press.

Smith-Jentsch, K. A., Kraiger, K., Cannon-Bowers, J. A., & Salas, E. (2006, August). *Can familiarity breed backup? Interactive effects of team efficacy and shared teammate knowledge.* Paper presented at the Annual Meeting of the Academy of Management, Atlanta, GA.

Smith-Jentsch, K. A., Zeisig, R. L., Acton, B., & McPherson, J. A. (1998). Team dimensional training: A strategy for guided team self-correction. In J. A. Cannon-Bowers & E. Salas (Eds.), *Making decisions under stress: Implications for individual and team training* (pp. 271–297). Washington, DC: American Psychological Association.

Spreitzer, G. M., Cohen, S. G., & Ledford, G. (1999). Developing effective self-managing work teams in service organizations. *Group and Organizational Management, 24,* 340–366.

Steiner, I. D. (1972). *Group process and productivity.* New York: Academic Press.

Stogdill, R. M. (1972). Group productivity, drive, and cohesiveness. *Organizational Behavior and Human Performance, 8,* 26–43.

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

Stout, R. J., Cannon-Bowers, J. A., Salas, E., & Milanovich, D. M. (1999). Planning, shared mental models, and coordinated performance: An empirical link is established. *Human Factors, 41,* 61–71.

Swezey, R. W., Meltzer, A. L., & Salas, E. (1994). Some issues involved in motivating teams. In H. F. O'Neil, Jr., & M. Drillings (Eds.), *Motivation: Theory and research* (pp. 141–169). Hillsdale, NJ: Erlbaum.

Swezey, R. W., & Salas, E. (1992). Guidelines for use in team-training development. In R. W. Swezey & E. Salas (Eds.), *Teams: Their training and performance* (pp. 219–245). Norwood, NJ: Ablex.

Thomas, E. J. (1957). Effects of facilitative role interdependence on group functioning. *Human Relations, 10,* 347–366.

U.S. Army. (n.d.). *Chapter 6: Crew warfighting*. Retrieved October 10, 2004, from http://www.usarmyaviation.com/pubs/new%201-140/Ch6Ab.htm

Vancouver, J. B., & Ilgen, D. R. (1989). Effects of interpersonal orientation and the sex-type of the task on choosing to work alone or in groups. *Journal of Applied Psychology, 74,* 927–934.

Wagner, J. A. (1995). Studies of individualism-collectivism: Effects on cooperation in groups. *Academy of Management Journal, 38,* 152–172.

Webber, S. S. (2002). Leadership and trust facilitating cross-functional team success. *Journal of Management Development, 21,* 201–214.

Wech, B. A., Mossholder, K., Steel, R. P., & Bennett, N. (1998). Does work group cohesiveness affect individuals' performance and organizational commitment? A cross-level examination. *Small Group Research, 29,* 472–494.

Wiegmann, D. A., & Shappell, S. A. (2001). Human error analysis of commercial aviation accidents: Application of the Human Factors Analysis and Classification System (HFACS). *Aviation, Space, and Environmental Medicine, 72,* 1006–1016.

Xiao, Y., & Moss, J. (2001). Practices of high reliability teams: Observations in trauma resuscitation. In *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting* (pp. 395–399). Santa Monica, CA: Human Factors and Ergonomics Society.

Zsambok, C. E., & Klein, G. (Eds.). (1997). *Naturalistic decision making.* Mahwah, NJ: Erlbaum.

Katherine A. Wilson is a research assistant at the Institute for Simulation & Training, Orlando, Florida. She received an M.S. in modeling and simulation from the University of Central Florida in 2002.

Eduardo Salas is a professor of psychology and trustee chair at the University of Central Florida. He received a Ph.D. in industrial/organizational psychology from Old Dominion University in 1984.

Heather A. Priest is a research assistant at the Institute for Simulation & Training, Orlando, Florida. She received an M.S. in psychology from Mississippi State University in 2001.

Dee Andrews is a senior scientist in the Human Effectiveness Directorate at the Air Force Research Laboratory in Mesa, Arizona. He received a Ph.D. in instructional systems from Florida State University in 1980.

Date received: September 12, 2005
Date accepted: November 6, 2006