SPECIAL ISSUE: Exploring Cognitive Readiness in Complex Operational Environments: Advances in Theory and Practice, Part I

A Team Cognitive Readiness Framework for Small-Unit Training

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ABSTRACT: The modern battlefield is characterized by a need to mitigate the effects of creative tactics by insurgent enemies. At the small-unit level, this need requires coordination by team members highly proficient in battle drills and immediate actions. Furthermore, these teams must demonstrate a facility in adaptive decision making and flexible action execution to effectively respond to threats. At issue is whether current training theory can appropriately support this need to enable teams that are not only procedurally ready but also *cognitively ready*. In this article, the authors provide a theoretical framework meant to guide the development of training for *team cognitive readiness* (TCR). Beginning with perceptual processing and cue recognition, elevating to problem solving and decision making, and scaling up to complex coordinative processes, TCR requires a comprehensive theoretical framework capable of addressing the varied processes and performance demands at the small-unit level. In service of this need, the authors provide a framework to improve the understanding of, and to improve adaptive coordination in, teamwork in dynamic environments.

KEYWORDS: adaptation, attention, cognitive processes, collaboration, decision making, mental models, planning, replanning, team performance, team processes, training, team cognition

THE ONGOING THREAT OF IRREGULAR WARFARE HAS CREATED AN OPERATIONAL ENVIRONMENT characterized as a “small unit fight” (Hossenlopp, 2010). This environment requires more sensemaking at the small-unit level, more decentralized and rapid

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decision making, and more complex coordination within and between units. Small units confront a highly adaptive threat, rapidly evolving tactics, and interactions within new cultural networks. Teams must be highly proficient in battle drills to take immediate actions in response to these threats. At the same time, the teams must also be prepared to adapt to unpredictable events while conducting a variety of missions. Examples include missions in which the teams come under attack, while working to improve the security situation for the noncombatant civilian population, or while helping to create a foundation for cooperation and transition with host nation forces.

At issue is whether current training theory can appropriately address the need for adaptive thinking and coordinated flexible action in response to unique and evolving conditions across the full range of military missions. Traditional training solutions and their theoretical underpinnings effectively support the attainment of proficiency in immediate action drills. However, they do not necessarily produce the types of highly skilled teams capable of efficiently adapting in unpredictable, high-stress situations. Furthermore, it is not entirely clear that the theory and training solutions focus on the individual and team cognitive factors required for team-level readiness.

To address this gap, we provide a theoretical framework for *team cognitive readiness* (TCR) to guide both training research and development. Such a framework is required as a lens to understand the rich and complex set of challenges faced when developing and executing coordination expertise within and across teams. We focus on small-unit cognitive readiness, beginning with perceptual processing and cue recognition, elevating to problem solving and decision making, and scaling up to complex coordinative processes. Our overarching goal is to support training adaptive coordination in teams. Toward this end, we briefly describe how emotion and stress alter attention, discuss how cues and patterns of cues are perceived in service of decision making, and describe how these ultimately come together in dynamic environments.

Cognition and Team Readiness

Cognition in the context of military preparedness encompasses both readiness and effectiveness (Morrison & Fletcher, 2002). The concept of *effectiveness* has to do with a summative evaluation measured as mission or task performance. But *readiness* is the potential to perform well in military operations (for a full discussion, see Morrison & Fletcher, 2002). The challenge is that readiness needs to be assessed with hypothetical components of what is believed to contribute to effectiveness in some future operational environment. Essentially, the notion of cognitive readiness was developed out of a need to conceptualize *preparation* for the complex, dynamic, and resource-limited nature of modern warfare (Etter, Foster, & Steele 2000). Morrison and Fletcher (2002) argued that more than mental preparation is required in support of sustained performance in the face of information overload, uncertainty, fatigue, and/or danger. Proficient performance also requires flexible and sometimes creative responses to operational challenges. In this article, we discuss constructs useful in defining small-unit TCR, with the implication being that those same factors can be used to develop training for effectiveness.

Readiness as Adaptability

Current military doctrine emphasizes that warfighters must be ready to adapt to a creative enemy in irregular warfare (Department of the Army, 2007). In this vein, cognitive readiness has been defined as the "mental preparation (including skills, knowledge, abilities, motivations, and personal dispositions) an individual needs to establish and sustain competent performance in the complex and *unpredictable environment* of modern military operations" (Morrison & Fletcher, 2002; p. I-3, emphasis added). This highlights an operational need to adapt quickly to unforeseen challenges and "to expect the unexpected and be ready to deal with it rapidly and successfully" (Morrison & Fletcher, p. I-3). Others have echoed this refrain, noting that cognitive readiness is the ability to "accomplish a mission by making and implementing decisions in a timely, efficient, and effective manner, often with very limited information in a *constantly changing*, complex, and dangerous environment" (Dyer, Centric, & Wampler, 2007, p. 19; emphasis added). Furthermore, as noted by Bolstad, Cuevas, Costello, and Babbitt (2008), cognitive readiness must be recognized as a "complex, dynamic, multidimensional construct" (p. 970).

Given these definitions, we suggest it is important for trainees to acquire the type of knowledge that enables them to transfer their existing capabilities to more complex situations or new ones and to do so in stressful and emotionally taxing conditions. Specifically, it is commonly understood that trainees must be able to demonstrate a degree of adaptive expertise so that they can transfer their skills across dissimilar and often dangerous situations (e.g., Holyoak, 1991; Kozlowski, Gully, Nason, & Smith, 1999). At the same time, it is also clear that much remains to be learned as to how best promote such transfer (cf. Reeves & Weisberg, 1994).

In this context, we distinguish *adaptive* expertise from *routine* expertise (e.g., Hatano & Inagaki, 1986; Holyoak, 1991; Kozlowski, 1998) in that routine expertise refers to the ability to draw from a vast store of knowledge when dealing with standard problem-solving situations, much in the way that a computer uses algorithms to solve problems or a squad engages in an immediate action drill in response to an anticipated threat. Adaptive expertise thus describes the ability not only to draw from that same store of knowledge but also to use it in novel situations or to transfer it to a different domain, as in solving a problem via analogy or when a squad dynamically replans to coordinate actions for an unforeseen event. For more than two decades, differences between routine and adaptive expertise have been discussed in both the cognitive and training sciences (Chen, Thomas, & Wallace, 2005; Entin & Serfaty, 1999; Kozlowski et al., 1999; Waller, 1999). Nonetheless, it still remains a challenging juxtaposition for training pedagogy.

We make the distinction between routine and adaptive expertise because adaptability seems to be a core capability for cognitive readiness. Indeed, following their extensive review, Morrison and Fletcher (2002) highlighted this distinction when describing cognitive readiness as a combination of the ability to (a) recognize patterns in a chaotic situation, (b) flexibly and creatively modify problem solutions, and (c) implement plans on the basis of identified solutions. But cognitive readiness is not just an individual process; it is increasingly a collaborative process. As we noted at the onset, more complex team coordination on the modern battlefield is not only increasingly prevalent; it is a necessity. As such, what is required is explication of TCR. We next describe how team cognition theory can be integrated with extant team training theory to specifically address these three components of cognitive readiness to produce a framework for training TCR.

Defining Teams in the Context of TCR Research

Clearly, the past three decades have seen a tremendous increase in the use of teams (Salas & Fiore, 2004; Salas, Fiore, & Letsky, 2012). Similarly, there has been a concomitant increase in the research on team training and performance. With this increased study of teams, definitions of what is a team have become more focused. Initially, teams were described as "interdependent collections of individuals who share responsibility for specific outcomes for their organizations" (Sundstrom, De Meuse, & Futrell, 1990, p. 120). Later, a more specific definition states that a team is composed of "two or more individuals who must interact and adapt to achieve specified, shared, and valued objectives" (Salas, Dickinson, Converse, & Tannenbaum, 1992, p. 4). Although numerous definitions have been offered, it is generally accepted that for a team to exist, there needs to be an identifiable level of interdependence, coupled with clearly articulated roles and goals (e.g., Swezey, & Salas, 1992). Furthermore, to be effective, team members must possess not only task- and team-relevant knowledge but also a shared understanding of each of these factors (DeChurch & Mesmer-Magnus, 2010; Fiore & Salas, 2004; Smith-Jentsch, Mathieu, & Kraiger, 2005).

We use the military small unit as the illustrative example for our concepts of TCR and specifically address the squad, that is, a small unit of between 8 and 12 soldiers (or marines, airmen, or sailors) and commanded by a noncommissioned officer, such as a sergeant. The military has recognized the increasingly evolving role of the squad and its small-unit leader by emphasizing (a) autonomous decision making at levels that previously were reserved for officers and (b) a requirement for adaptive performance that must include, but go beyond, well-rehearsed battle drills. For example, U.S. Army Field Manual No. 7-8, *Infantry Rifle Platoon and Squad*, states that

> platoon and squad leaders . . . cannot rely on a book to solve tactical problems. They must understand and use initiative in accomplishing the mission. This means that they must know how to analyze the situation quickly and make decisions rapidly. . . . They must be prepared to take independent action if necessary. (Department of the Army, 2003, chap. 1, Section I.1-3)

Although such directives are representative of current manuals, the ways that small-unit leaders can train for, and achieve, these goals are typically not well defined, and we see TCR as a framework to guide these developments.

In several ways, we consider squads to be similar to what in other domains has been named *action teams* (McKinney, Barker, Davis, & Smith, 2005). In particular, action teams contain experienced, often specialized, individuals who have to quickly form to address some need. More specifically, action teams have the following characteristics: (a) experienced or even expert individuals, (b) requirement for rapid performance, and (c) prevalence of risk in the operational context (see McKinney et al., 2005; Wildman, Fiore, Burke, Salas, & Garven, 2011).

The difference between the traditional action team, whereby multiple members have expertise and hierarchies and formal leadership are frequently ill defined, and the squad is that the squad is generally led by one primary experienced individual, the squad leader. This leader is typically 25 years old or younger, and squad members are usually between 18 and 21 years of age. The squad leader selects team leaders for two or three smaller units, called "fire teams" in the U.S. Army, on the basis of experience and/or perceived talent. That talent is judged subjectively as the squad begins predeployment preparation and goes through a number of activities, including physical tests, drill practice, and problem-solving situations in which differing factors (e.g., "friction points") are integrated in the drill.

All members of the squad practice the execution of immediate action drills extensively during training and are generally well prepared for anticipated situations. But small-unit teams still will often face challenges in process and performance because they may have limited preparation time for some training activities attributable to the high operational tempo in today's military and because of the many tasks that must be accomplished during predeployment training. Furthermore, there is no real training for what we described earlier as adaptive response. When deployed, the squad is required to work with more expert leaders to whom they report, coordinate with other units and technical experts who provide specific kinds of support, work in high-risk environments, adapt to missions that may include a variety of tasks within the same day, and execute rapid reactions to threats. In many instances during deployment, the squad is rapidly working at the edge of chaos to gain control in potentially lethal situations.

The focus on the small unit, and especially the military squad, helps to ground our theoretical framework in that it identifies the core factors to be addressed in training TCR. A focus on the small unit encompasses experienced individual leaders and outside experts who work with rapidly prepared teams that may have many inexperienced members and that all must perform in high-risk environments across a variety of tasks.

We contend that that training for TCR is less about training each individual to be proficient in their task. Rather, training for TCR should ensure that individuals who have mastered, to the extent possible, their individual roles are also proficient at coordinating within a relatively new team, across teams, or with external support while performing under stress. Specifically, our argument is that

TCR must emphasize the ability to link the team members' knowledge to environmental cues associated with their impending team deployment and their ability to coordinate this knowledge with their teammates. In short, our emphasis is not on training "knowledge" or skill mastery per se; it is on training the adaptive application of that knowledge in dynamic and time-stressed environments. Foundational to this is team cognition theory, the topic we turn to next.

Team Cognition Theory for TCR

A long line of research on team cognition has shown how teams are able to use environmental resources to distribute workload across other individuals in teams or collaborative groups (Fiore et al., 2010; Fiore, Salas, Cuevas, & Bowers, 2003; Hollan, Hutchins, & Kirsh, 2000; Salas & Fiore, 2004). Substantial progress has been made in identifying the factors for effective teamwork, and researchers are viewing team cognition as a binding mechanism that produces coordinated behavior within experienced teams. In particular, team cognition is said to encompass an embodied awareness that binds the actions of the team as well as the communication (both implicit and explicit) to scaffold coordinated behaviors (Fiore & Salas, 2004). Team cognition theory suggests that this awareness is possible through the development and use of shared mental models for operational environments (Cannon-Bowers, Salas & Converse, 1993; Klimoski & Mohammed, 1994; Rouse, Cannon-Bowers, & Salas, 1992).

In team cognition theory, shared mental models and related forms of overlapping knowledge are used to support the execution of previously learned task procedures in familiar environments (e.g., Cannon-Bowers et al., 1993; Salas & Fiore, 2004). These procedures are described in terms of the *component* knowledge held by a team as well as the dynamic processes team members use when acting on this stored knowledge. Expert teams, then, maintain a compatible understanding of roles and responsibilities as well as an understanding of the team task at a level sufficient to coordinate their actions (e.g., Marks, Zaccaro, & Mathieu, 2000; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005; Rentsch & Davenport, 2006; Smith-Jentsch et al., 2005; Smith-Jentsch, Campbell, Milanovich, & Reynolds, 2001).

This notion of shared knowledge forms an important foundation to our theory for training TCR in that it helps us to understand how teams anticipate, coordinate, and adapt to task demands. Specifically, in light of adaptability and TCR, team cognition theory shows that high-performing teams are able to coordinate their actions because they possess commonly held knowledge structures with respect to teammate roles (i.e., knowledge pertaining to their individual responsibilities and required actions), their team tasks, and the types of situations they may encounter. The combination of these components allows a team to dynamically respond to environmental stimuli and demands in a highly coordinated fashion.

As coordination within the team is foundational to TCR, we need to better define what is meant by *team coordination*. At the theoretical level, Marks et al. (2001) defined team coordination as "orchestrating the sequence and timing of interdependent actions" (p. 363). But following the call by Fiore and Salas (2006) for a deeper understanding of coordination (see also Elias & Fiore, 2012), we expand on this definition to provide more clarity to this foundational issue and illustrate how coordination is at the core of TCR.

Researchers have elaborated on what is meant by *coordination* by explicating the varied forms of interdependencies that exist in teams. Saavedra, Earley, and Van Dyne (1993) provided a theoretical taxonomy describing the various classes of interdependencies within teams by evoking the construct of complex interdependence, which combined Thompson's (1967) construct of task interdependence with the constructs of goal and feedback interdependence, forming a three-dimensional construct space. Within this construct, task interdependence can be understood as the degree to which individual team members need to interact to perform the team's task(s). Thompson had outlined four levels: pooled, sequential, reciprocal, and team interdependence. First, in *pooled interdependence*, each person performs his or her own task, and the sum of each member's output is the team's output. Second, *sequential interdependence* requires one team member's output for another member's input. Third, with *reciprocal interdependence*, one team member's output becomes another's input and vice versa. Finally, in *team interdependence*, team members jointly diagnose situations to anticipate needed actions and coordinate to make decisions and adapt to complete a task.

Although small units may sometimes use all forms of interdependence, the level of team task interdependence as defined by Thompson (1967) more closely aligns with our approach for training TCR. We next use a squad's combat patrol mission as an illustrative example. Coordination for the mission is divided into three phases: preparation for combat, execution, and postmission debrief. Although we describe each of these phases, we note that our primary emphasis for TCR is on the execution phase.

First, after receipt of a mission, the squad leader performs an initial analysis of the mission in terms of the commander's intent and then analyzes the threats and potential events the squad may face as well as the assets available (Department of the Army, 2003, chap. 2, Section I.2-1). Having completed this analysis, the squad leader gives a brief order to the squad with instructions to his or her team leaders on how to prepare on the basis of the squad leader's intent for the squad's mission (such as what weapons and communications equipment to prepare, both within their own resources and outside the squad assets). Meanwhile, the squad leader coordinates with a variety of resources outside the squad on the basis of his or her analysis of what could happen during the mission and the contingencies he or she has envisioned to deal with these situations. The squad leader's goal is to gain more information and prepare for potential support he or she may need from experts and resources outside the squad. For example, he or she coordinates with the intelligence unit to ensure that his or her understanding is current about the threat potential in the environment, with fire support, with other squads that have worked in the same environment recently, and with the air officer to coordinate potential air support. The squad leader creates notes and a more complete order, devises his or her preferred route, and then prepares the squad members, who will react to situations on the basis of their roles and mission rehearsal.

Second, during execution, if the squad encounters a situation requiring the execution of a contingency plan, such as an ambush, or even something totally unexpected, the squad leader depends heavily on the ability of the squad to perform drills, on the ability of team leaders to direct on the basis of the understanding they gained in preparing for the mission, and on his or her own ability to coordinate with external assets for support. The primary resource support for a U.S. Marines squad leader, for example, is the combat operations center (COC) and the operations chief there to manage the external resources he or she requests to respond to the emergent situation. The operations chief is there to assist the squad leader as the commander on the ground. The squad leader must adequately describe the scene on the ground amid a confusing set of events that the leader is assessing on the spot, so the COC can facilitate the provision of external assets and expertise previously coordinated (such as a fire plan whereby assets have previously been set aside for the combat patrol during the preparation phase) or suggest alternatives or augmentation on the basis of the evolution of the situation and/or what is actually available at the time. The squad leader wants to provide the COC with enough information to create common mental models of the situation to facilitate option generation and the coordination of those options. The ability to adapt in these situations comes from experience in making difficult decisions under pressure through training, assessment skills, understanding of roles and tasks, and understanding of and ability to coordinate external resources.

Third, during the debrief phase after the mission, the squad leader arranges a meeting with the squad and with experts, such as a representative of the intelligence section, and selected external assets to discuss what actually happened during the execution. Here, they review how well various assets were coordinated and to what effect and what was learned. This phase, then, serves to enhance preparation for later missions by specifically identifying how to leverage effective coordination as well as how to improve on ineffective coordination processes.

As this example illustrates, preparation for contingencies, and executing unplanned behaviors while coordinating with others, is key to the success of the small unit. In this example, the salient features for TCR training involve dealing with unexpected situations. First, TCR involves preparation for what could happen and contingencies to deal with these situations. Second, TCR involves a team leader's ability to assess any such situations and to direct the squad to perform the appropriate drills while coordinating with external assets to deal with newly emerging task demands. Note that both the squad leader and the team members must be able to perform under pressure and in chaotic situations. We next describe how we link such factors with team cognition via a framework for guiding training in TCR. We suggest not only that TCR encompasses attentional and perceptual processes but that these processes are regulated by emotion, given the dangerous and sometimes chaotic situations faced by small units (cf. Morrison & Fletcher, 2002). Furthermore, these processes are linked to pattern recognition and long-term memory structures in service of dynamic decision making. These processes form the foundation of adaptability in teams whereby shared knowledge and assessment processes drive a common interpretation of task, team, and environmental cues in service of coordinated responses (cf. Salas, Cannon-Bowers, Fiore, & Stout, 2001).

A Framework for Training TCR

Our framework represents an integration of research in the cognitive and training sciences and is meant to provide a generalizable relationship between adaptive teamwork and TCR (refer to Figure 1). Because adaptability has consistently been identified across discussions of readiness in irregular warfare, and given the challenges associated with this construct, we have chosen adaptability to be the core teamwork component associated with TCR. Thus, we differentiate our approach from other theories of adaptive teams (Burke, Stagl, Salas, Pierce, & Kendall, 2006) in that our goal is to introduce a set of constructs and their interrelations so as to guide training for TCR. Within this context, we think it is important to more specifically clarify what we mean by team adaptability, as this definition helps make the training needs more tractable.

Adaptability can be construed as a behavioral sequence that is initiated on the basis of recognition of a single cue or a cue pattern in the team environment that suggests that a change in the team's work should occur. Drawing from our earlier illustration on small-unit coordination for combat patrol missions, we build on this description to move these issues to the theoretical level. We note that adaptive coordination can pertain to the following three situations: (a) realization by the team of an error in execution (e.g., it has done something wrong when dealing with a situation) such that a revision to the execution needs to be made, (b) realization of an error in planning (i.e., it has anticipated the situation incorrectly) such that it needs to modify the current response, or (c) the realization that it is facing a situation for which it has not necessarily prepared and an appreciation of the fact that it must now dynamically plan how to address the situation.

We next describe research on cognition and on the development of expertise. The latter forms an important foundation for our framework. As illustrated in Figure 1, we have two primary individual cognitive processes that serve as both precursors to and consequences of adaptation by the team. At the individual level, attention and perception interact with emotions to influence processing of environmental cues. These components, in turn, interact with pattern recognition and long-term memory structures to understand these cues. Finally, these factors are interpreted in light of the task requirements, the mission objectives, and the team's roles. This interpretation supports planning and execution behaviors for the team, which feed back into the aforementioned individual processes.

Theoretical Foundation

Research in the learning sciences suggests that what is required for expertise is the ability to identify and comprehend sometimes subtle critical features, cues, and patterns in a particular task context (Bransford, Franks, Vye, & Sherwood,

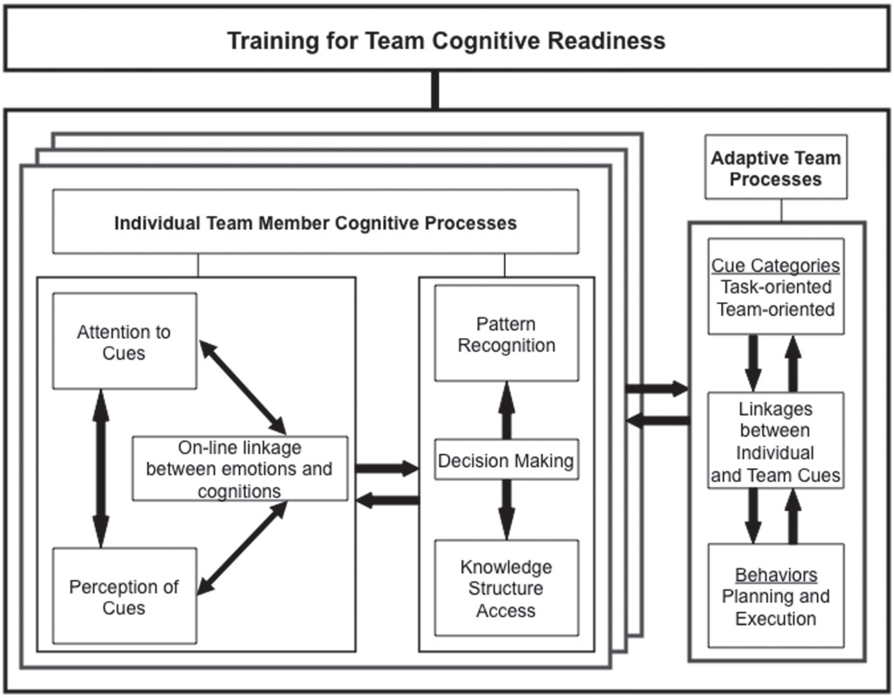

Figure 1. Theoretical framework for training team cognitive readiness.

1989; Chi, Glaser, & Farr, 1988; Klein & Hoffman, 1993). As expertise develops, one may come to rely on "straightforward condition-action rules in which a specific pattern (the condition) will trigger a stereotypic" response (Chi et al., 1988, p. xvii). Environmental cues trigger recognition processes and allow an expert to activate his or her vast store of knowledge used in support of problem solving and decision making (e.g., Carlson, 1997; Klein, 1997).

In addition to studying recognition processes, researchers on expertise have also focused on the differing forms of knowledge that develop with learning (Crandall, Klein, & Hoffman, 2006; Melcher & Schooler, 2004). At a general level, experts differentially rely on perceptual and conceptual knowledge in the context of their tasks. For example, perceptual knowledge enables one to recognize critical cues in the environment, whereas conceptual knowledge supports the ability to interpret the relevance and meaning of such cues (e.g., Melcher & Schooler, 1996, 2004). Importantly, research has shown that these can develop at different rates. Lesgold et al. (1988), for example, found that task novices develop perceptual expertise more rapidly than conceptual expertise but that the latter also increases over time. And research in aviation has shown not only that perceptual and conceptual knowledge develop at different rates but that these forms of knowledge should be trained in different manners (see Fiore, Jentsch, Oser, & Cannon-Bowers, 2000).

Research differentiating the forms of knowledge that develop as expertise is acquired provides an important grounding for identifying varied targets for training (e.g., Fiore, Fowlkes, Martin-Milham, & Oser, 2000; Shobe & Fiore, 2003). And research in complex task environments has specifically argued that training needs to focus on

> critical information-seeking and information processing behaviors. . . . This may be accomplished by systematically exposing the trainee to a variety of scenarios where, through guided practice and feedback, he or she may develop the knowledge structures necessary for rapid and accurate situation assessment. (Salas, Prince, Baker, & Shrestha, 1995, p. 133)

Finally, these types of processes have been trained at the individual level (Fadde, 2009) but have yet to be integrated with training at the team cognitive level.

Building on these and related theories, our framework for TCR focuses on the differing forms of knowledge that individuals and teams must develop in support of TCR. Specifically, across this theorizing, and critical to the distinctions of team adaptability outlined earlier, is the need to recognize cues in the environment that are indicative of errors in execution or planning or are anomalous enough to warrant creative responses. As such, cue perception and recognition form the precursor processes for our framework of TCR. But these processes are integrated with higher-level cognitive and collaborative processes to show the cross-level connection to adaptive teamwork. The training framework we describe complements well more recent forms of training focusing on process issues rather than content issues. For example, Gorman, Cooke, and Amazeen (2010) examined how “perturbation training” might improve coordination. By introducing disruptions into the training, such that team interactions are constrained, Gorman et al. found that teams are better able to deal with varied coordination requirements that will arise in operational contexts.

Next, we first describe the components of our framework relating to cognitive processes at the individual level. These components represent the operationalization of what we see as a key subset of the components of cognitive readiness as described in the literature (Fletcher, 2004; Morrison & Fletcher, 2002). Second, we describe team adaptability and how it is related to the individual-level factors. We also illustrate how simulation-based training can be used to train TCR.

Individual Team Member Cognitive Processes

Attention, Perception, and Emotion TCR

The negative impact of stress on performance has long been studied in the military and sports sciences (e.g., Tenenbaum, Edmonds, & Eccles, 2008), yet the stress–performance relationship and its linkage to cognitive readiness have not been fully explicated. In their original report on cognitive readiness, Morrison and Fletcher (2002) noted that “emotion must be channeled and controlled if military personnel are to perform complex tasks under the stress and confusion that accompany modern military operations" (p. E-3). We build on this idea and suggest that the key to making this linkage is to articulate how attention and perception are attenuated by emotional factors, thus potentially affecting cognitive readiness (Niedenthal & Kitayama, 1994). This line of research examines how stress influences attention in dynamic contexts and has focused on how emotional states, such as anxiety, can alter the physiological mechanisms responsible for regulating visual attention. As noted by Janelle and Hatfield (2008), "the most critical factor for high-level performance is attention to the right things at the right time . . . [and one] cannot perform well without continuous attention to appropriate cues" (p. 41). As an example, stress may lead to a form of attention narrowing as one attempts to adapt the emotional state, both in individuals (S. Cohen, 1978, 1980) and in teams (Driskell, Salas, & Johnston, 1999). This attention narrowing will, thus, influence perceptual processes and attenuate cognitive readiness. In particular, the challenge is that attentional narrowing prevents one from even having the possibility of perceiving a cue. But even if one is able to attend to a cue, the stress may also prevent one's ability to perceive that cue.

Given the potential impact of stress on attention and perception, the first component of our training framework involves the types of strategies that have been shown to help ameliorate the negative effects of stress. Research suggests that experienced personnel can engage in self-regulatory processes that can mitigate the impact of stress (Tenenbaum et al., 2008). Strategies such as self-talk, emotional control, imagery, relaxation, and attentional control, for example, are used by experienced athletes to cope with the impact of stress (A. Cohen, Tenenbaum, & English, 2006). This finding suggests that psychological and emotional self-regulation strategies can lead to optimal affective states and superior performance. Similarly, Hardy, Hall, and Hardy (2004) surveyed athletes and found that preconceived and structured self-talk was used more frequently among the more skilled than the less skilled athletes (see also Hardy, Gammage, & Hall, 2001). In controlled studies, self-talk has been shown either to exasperate responses to stress-inducing conditions if it is negative (Vera, Vila, & Godoy, 1994) or to improve performance if it is more positive in nature (e.g., Hatzigeorgiadis, Theodorakis, & Zourbanos, 2004; Van Raalte et al., 1995). Importantly, self-talk can reduce the occurrence of negative thoughts that could interfere with performance (for a discussion, see Tenenbaum et al., 2008). The relevance of these factors and the ability to influence them has been recognized by the military as important for performance enhancement, as is evidenced by current investments in programs to enhance attentional control and self-regulation (e.g., Stanley, Schaldach, Kiyonaga, & Jha, in press).

Pattern Recognition and Long-Term Memory in TCR

Traditionally, decision making in dynamic environments requires one to deal with multiple cues and informational inputs in a dynamic environment. It also requires one to manage time constraints while dealing with continually changing factors (Gonzalez, 2005). We suggest that foundational to decision making in dynamic environments is the linkage between pattern recognition processes and knowledge structures. In particular, TCR requires a blend of lower-level perceptual processes with higher-level cognitive ones, such as pattern recognition and decision making. For example, research on perceptual expertise in naturalistic environments has shown that experts are able to see something seemingly invisible to the task novice and that they rapidly go from pattern recognition to decision making (Klein, 1997, 1998; Klein & Hoffman, 1993). Radiologists, for instance, are able to quickly examine X-ray images to make a diagnosis, and firefighters are able to decide a course of action using cues such as color and flame movement and the form of the smoke (Hoffman & Fiore, 2007). Perhaps most challenging, these patterns must often be perceived through multiple forms of "noise" in the environments.

In collaborative environments, teams must be able to perceive complex patterns not simply defined by the presence or absence of individual cues but must also be able to assess how such cues relate to teammates' roles and responsibilities. Because of this critical connection between pattern recognition and long-term memory in support of rapid decision making in teams, the next component of our framework involves training for this linkage. We propose that the critical need is training that supports the development of shared knowledge structures integrating these various forms of cognition. As noted by Glaser (1989), in discussions of learning and knowledge structures, "structuredness, coherence, and accessibility to interrelated chunks of knowledge become . . . objectives for instruction" (p. 272). In the context of training for TCR, what is required is the development not only of stored knowledge but also of knowledge that is rapidly accessible in varied contexts when pattern recognition has identified critical cues (cf. Bjork, 1994; Cuevas, Fiore, Bowers, & Salas, 2004). From the standpoint of training and linking pattern recognition processes to long-term memory structures, research in expertise suggests that well-trained performers are able to quickly grasp and solve problems within their domains, often with remarkably little search through a problem space (e.g., Charness, Reingold, Pomplun, & Stampe, 2001; Salas & Klein, 2001). This ability is attributable to superior pattern recognition processes that allow experts to rapidly develop a problem representation (see Charness, 1991). Importantly, from a training standpoint, it is well-learned knowledge that enables one to bypass what are typically lengthy search processes.

The key for TCR, then, is linking this pattern recognition to team-relevant knowledge structures. Specifically, training research in TCR must identify the nature of the knowledge structures associated with team adaptability, that is, structures triggered by cue recognition and that facilitate transferring across team task situations (cf. Fiore, Fowlkes, et al., 2000). The rationale is based partially on the argument that if a "particular type of knowledge is associated with successful performance then training that incorporates instruction in this type of knowledge may result in performance improvements" (Rowe, Cooke, Hall, & Halgren, 1996, p. 44). We next describe how this linkage between cues and pattern recognition can be incorporated into notions of team adaptability.

Adaptive Team Processes

As we have discussed, foundational to TCR is the rapid apperception of cues and cue patterns in the environment (Salas et al., 2001). Environmental cues have been described as “situation observables” that get factored together with general knowledge (Noble, 1993), and they are said to be responsible for triggering rapid pattern recognition processes that lead to initial problem solutions (Klein, 1997). Thus, “critical cues” form the basis one uses to match the features in the environment with stored knowledge. From the team coordination standpoint, only when an operational situation has been accurately assessed can a team engage the appropriate behaviors necessary to act. When a team or team member recognizes that either the team has inaccurately assessed a situation or a new cue suggests the team is on the wrong solution path, then the team must rapidly coordinate an adaptive response (i.e., change its behaviors). Thus, we posit that team adaptability has more to do with how teams effectively deal with altered and/or unplanned events (Martin-Milham & Fiore, 2004). In particular, adaptability corresponds to the degree to which a team is able to modify behavior and/or plans dependent on situational demands (Burke, Fiore, & Salas, 2003; Prince & Salas, 1993; Zalesny, Salas, & Prince, 1995).

Within this context, we next detail how to link cue recognition strategies to behavioral responses in support of adaptive team performance. Key to effective training for small units is the authenticity of the cognitive processes practiced in the training environment as well as the realism of the information available to trainees as they practice the tasks in the training context. By *cognitive authenticity*, we mean that the cognitive processes stimulated must be like those of proficient or expert practitioners (Ross, Halterman, Pierce, & Ross, 1998; Ross, & Pierce, 2000). Cognitive authenticity thus draws on the real, lived experiences from the performer’s point of view. Cognitively authentic stimulation of the desired cognitive processes is thus dependent on the inclusion of the features that experts would (a) perceive in a specified domain and (b) use to build perceptual skills that allow them to recognize critical cues and factors in the problem-solving and decision-making processes (Klein & Hoffman, 1993). In this context, we distinguish cognitive authenticity from what is sometimes termed *cognitive fidelity*, as the achievement of authenticity is not dependent on an exact representation of all dynamic features in the natural environment. In short, perceptual attunement and recognitional decision making are part of expertise in any area with substantial cognitive requirements, and understanding these processes for any particular domain is necessary for creating authentic tasks in a training experience and for instructor facilitation of the desired cognitive processes.

Additionally, because decision-making skills are at the forefront of the training requirement for effective full-spectrum operations, it is imperative that cognitively authentic requirements are appropriately and systematically represented in the training. In service of supporting the development of cognitively authentic training for TCR, we suggest that training must include (a) the types of decisions and judgments that are trained; (b) the context in which the training takes place, including not only aspects of the physical environment determined to affect decision making but also the uncertainty, competing demands, lack of resources, and other stressors that are typical of the operational environment; (c) the perceptual cues and indicators that are presented to the trainee when he or she is required to conduct the cognitive task; and (d) the background factors available to the trainee and relevant to cognitive task performance. Members of teams not only must have these skills, but they must hold a shared understanding of how to execute them and who is responsible for particular responses to task elements.

To represent the multitude of factors that must be integrated to support training for TCR, we argue that simulation-based training is the most appropriate method. Indeed, as noted by Morrison and Fletcher (2002), "deeply engaging, sensory immersing simulations provide promise for training warfighters to retain critical pieces of information and to perform under highly stressful conditions" (p. E-3). Simulations have been used in sports psychology to study and train perceptual processes involving anticipation and decision making. For example, film-based simulations record specific tasks and use them to assess interpretation skills for a receiving player (see Helsen & Starkes, 1999; Williams & Davids, 1998; Williams, Ward, Knowles, & Smeeton, 2002). Such research often digitally enhances or dampens the recordings to vary the amount of information provided and uses them as scaffolds for training how to interpret challenging situations (e.g., the intention of an opponent) or how to move appropriately in response to what is being shown (e.g., see Ward, Williams, Ward, & Smeeton, 2004). In the context of TCR, simulation-based training allows one to mimic the complex and stressful situations often experienced in operational tasks, thus providing for a range of contexts that duplicate the kinds of situations that may be found in operational environments.

We further suggest that simulations supporting the core component of TCR need to be designed such that the simulations' cues trigger required team-related actions that facilitate adaptive coordination. That is, in addition to providing information, the cues need to be linked to team roles and mission objectives. In this way, team skills requiring members to recognize cues and execute the appropriate teamwork behaviors (e.g., provide backup or pass information) can be executed. Specifically, to train these behaviors, simulations must enable the learning of cue patterns (i.e., cue pattern recognition training) and behaviors in response to those cue patterns (i.e., team skills training). For each cue pattern presented, optimal team behaviors can be trained. In this way, simulations for TCR facilitate learning adaptive choice of behaviors in response to cue patterns.

In support of this goal, our framework guides the development of training scenarios that illustrate the subcomponents of shared mental models necessary for effective coordination. This training includes manifestation of the task, the roles, and teammates within a given scenario to train shared understanding of how they are linked to the perceptual components of the task environment (Fiore, Hoffman, & Salas, 2008). As noted by Martin-Milham and Fiore (2004), timely detection of abnormalities in the environment is the necessary precursor to team adaptability. We build on the team adaptability training method outlined by Martin-Milham and Fiore, as it represents an important foundation for training TCR. At the highest level, this method involves developing two complementary components of training: critical cue recognition and adaptive responses. We suggest that by linking these perceptual and conceptual factors with behaviors, training for TCR becomes more tractable. The cue component of the training involves identification and inclusion of task and team cues. Task cues provide information regarding the status of a mission and any environmental factors that need attending, whereas team cues provide information about the status and performance of teammates. Adaptive behaviors are those that must be executed when particular mission-relevant cues have been identified (e.g., a freshly dug section of the road) and/or when teammate cues warrant action on the part of a teammate (e.g., a teammate appears to be under high workload). We next describe these in more detail.

Determining Content of Cue Categories

Prior to developing simulations for the training targeting TCR, researchers must identify critical cues to be used within the simulation scenarios. If the task context is relatively established, the cues can come from the training literature or operational manuals. If the task is relatively new, however, cues will likely have to be identified from domain or cognitive task analyses (see Neville, Fowlkes, Milham, Bergondy, & Glucroft, 2002). Nonetheless, what is critical is that the relations between particular cue patterns and team coordination are identified. As noted by Martin-Milham and Fiore (2004), such patterns are indicative of meaningful changes in the environment requiring a coordinated response by the team. In team coordination theory, the cue patterns fall along the lines of timeline cues, situational cues, and team member cues (see Table 1). For example, timeline cues provide information for events whereby the team is monitoring and using the timeline as a way to coordinate the performance of the team. Team member cues provide information about workload and the awareness of other team members as to their current task execution requirements (e.g., they did not respond appropriately to particular need). As is illustrated in Table 1, each of these cue types supports adaptation by the team through a shared understanding of the task, the situation, and teammates' response to the situation.

Planning and Execution Behaviors

Critical to training TCR are simulations that not only instantiate meaningful cues for training cue recognition at the individual and team levels but also require varied responses by different team members. More specifically, varied contexts are used to help trainees experience cue patterns unfolding (cf. Greeno, 1998). Furthermore, within this context, what must be trained are two broad categories of knowledge (see Marshall, 1995) that we suggest form the foundation for adaptive team behaviors in TCR. Specifically, Martin-Milham and Fiore (2004) argued that both planning knowledge and execution knowledge are the keys to team adaptability. As they described, *planning knowledge* is used to create expectations. When assessing one's environment, one uses one's knowledge to develop expectations of what might occur or what should occur next. For example, if an unknown vehicle is seen up ahead, a planning goal might be to inform teammates of the anomaly and to engage in cautionary approach in preparation for a more

TABLE 1. Coordination Cues for Team Cognitive Readiness

Cue Type	Cue Definition	Example
Timeline	Timeline cues are used by the team to monitor critical events that correspond to a complementary response by team members.	The team on patrol reaches a checkpoint requiring changeover in vehicle order.
Situational	Situational cues can be anomalies in the environment, unusual behavior of civilians, or suspicious objects that warrant further attention.	If an unknown vehicle is within 150 feet of a gate, it is a high priority.
Team member	Team member cues provide input about workload or stress of teammates and include lack of attention or task focus.	During patrol, a team member fails to engage in an adequate environmental scan in an area with a number of high priority threats.

Source. Adapted from Martin-Milham and Fiore (2004).

careful search. In contrast, with *execution knowledge*, team members carry out a plan drawing from a behavioral repertoire of appropriate responses. For example, this response might involve engagement of specific information exchange with teammates to provide input regarding the unknown vehicle.

Linking Individual and Team Cues

For simulations that support TCR training to be effective, the aforementioned individual and team factors must be linked; that is, the knowledge must be integrated with the behaviors across the individuals and the team. In this way, trainees learn how to use their team skills adaptively. In Table 2, we illustrate these at behaviors the individual and team levels. First, cue patterns must be attended to and interpreted in light of the teammate roles and responsibilities. Second, these patterns must be understood in light of the task and the goals of a mission. Finally, these goals must drive the selection of appropriate responses by different team members that support teammates while addressing a situational anomaly and meeting mission objectives.

Conclusions

In this article, we have shown how linkages between individual cognition and team cognition can be used to guide training for TCR. Team cognition research encompasses a variety of theories to integrate individual-level information processing, such as attention and memory, with dynamic team processes (Hinsz, Tindale, & Vollrath, 1997; Salas et al., 2012; Salas & Fiore, 2004). It is a phenomenon crossing many levels and comprising interactions and dependencies between intraindividual level processes and interindividual level processes

TABLE 2. Linking Individual and Team Cues to Adaptive Behaviors

Behavior	Individual	Team	Example
Recognize cue patterns	Ability to recognize environmental cue patterns	Ability to learn how to recognize team member cues	Team member assesses whether a teammate has noticed suspicious behavior at a checkpoint.
Understand cue patterns	Knowledge of what cue patterns mean in particular contexts	Knowledge of why team member may be exhibiting particular cues	Team member interprets that a cue was missed by a teammate because he or she is exhibiting high levels of workload.
Relate to goals	Understanding of what goals should be to deal with cues	Understanding of how to address team member need	Team member recognizes the need to immediately secure checkpoint for further review.
Choose response	Choosing of the appropriate skill necessary to respond to cues	Determination of the appropriate team skill in support of teammate need	Team member engages backup behaviors to assist in analyzing suspicious behavior until teammate workload diminishes.

(Cuevas, Fiore, Caldwell, & Strater, 2007; Fiore & Salas, 2004, 2006; Woolley, Gerbasi, Chabris, Kosslyn, & Hackman, 2008). As such, we argue it fits well with theory describing how TCR is to be trained. In Table 3, we provide a set of training guidelines that capture the components of our framework and that are meant to help shape training research in TCR.

In sum, for TCR, teams must be trained in observation and execution strategies and team adaptability to effectively deal with both routine and unplanned events. We have argued that training that combines shared mental model theory with cue assessment (cf. Martin-Milham & Fiore, 2004; Salas et al., 2001) can facilitate the development of TCR. Compatible mental models associated with cue assessment can produce a shared understanding of "cue/action sequences (i.e., which cues should trigger which responses), cue patterns and their significance (i.e., which cue patterns are associated with particular task strategies), team resources and capabilities (i.e., what resources/expertise are available in the team in order to solve a problem), and appropriate task strategies" (Stout, Cannon-Bowers, & Salas, 1996, p. 91). Our TCR framework links together these varied theoretical approaches to facilitate understanding of how to train cue and pattern recognition using simulations that jointly engage team members. Team cognition research can help one understand how to train for situations such as a small unit encountering a problem and how its members interact to diagnose the

TABLE 3. Guidelines for Developing Training for Team Cognitive Readiness (TCR)

Attention and Perception in TCR	
Guideline 1	Training for TCR must incorporate requirements for dynamic attentional and perceptual processes in complex and stressful environments.
Guideline 1.1	Training for TCR must provide scenarios devised to challenge attentional processes (e.g., environmental distracters, increased workload to produce attentional narrowing).
Guideline 1.2	Training for TCR must provide scenarios devised to test perceptual processes in noisy environments (e.g., anomalous cues; cues presented at low visibility).
Pattern Recognition and Knowledge Structures in TCR	
Guideline 2	Training for TCR must account for situations in which complex pattern recognition processes require one to draw from long-term memory structures.
Guideline 2.1	Training for TCR must provide scenarios in which task-related cues and cue patterns are distributed temporally and in environments varying in the amount of interference (e.g., environmental stressors, such as noise or smoke; task stressors, such as time pressure).
Guideline 2.2	Training for TCR must provide scenarios in which task-related cues and cue patterns are distributed spatially and in environments varying in the amount of interference (e.g., environmental stressors, such as noise or smoke; task stressors, such as time pressure).
Teamwork in TCR	
Guideline 3.	Training for TCR must account for situations requiring coordinated teamwork that draws from shared knowledge about teammates and their tasks.
Guideline 3.1	Training for TCR must provide scenarios in which team members have the opportunity to coordinate responses to compensate for the effects of stress.
Guideline 3.2	Training for TCR should examine how training strategies for self-regulation can ameliorate the effects of stress on individual and team performance.
Adaptive Teamwork in TCR	
Guideline 4	Training for TCR must account for situations requiring individuals and teams to adapt to changes in their environment.
Guideline 4.1	Training for TCR must provide scenarios in which team members have to alter their responses on the basis of new task- and team-relevant cues (e.g., cues that illustrate that they have made an initial error in execution).
Guideline 4.2	Training for TCR must provide scenarios in which team members have to innovate in their responses to deal with unanticipated situations (e.g., situations for which they have not prepared and that they must dynamically plan to address).

situation and generate a course of action. In support of cognitive readiness for small units, this research will help to train them for selecting and executing a set of possible procedures or rules to dynamically deal with unplanned situations.

Implications for Theory and Practical Application

Although preliminary, we have laid out an approach that can contribute to research and development in TCR training. The implications for theory development include, first, testing the relationships between the individual and team cognitive processes to understand the best leverage points for improving performance and, second, testing the interactions during training to understand optimal sequencing of tasks and variations of levels of stress during training that best prepare the small unit.

In the context of applications, we have taken the first steps in translating our theoretical descriptions of what team cognition means for the practicing unit into practical descriptions and in further developing our understanding of the concepts supporting teamwork. Researchers must now test and refine these ideas to benefit those small-unit teams that must employ team cognition. Such refinement will support operational effectiveness because the time allotted for training must fit in among a range of competing priorities for the squad leader. Findings that empirically support hypotheses about the most efficient methods for gaining the maximum adaptability, in concert with learning immediate reaction drills, will be of the greatest benefit for improving TCR.

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