The Leadership Quarterly 25 (2014) 972–986

Contents lists available at ScienceDirect

The Leadership Quarterly

journal homepage: www.elsevier.com/locate/leaqua

Mind the gap: The role of leadership in multiteam system collective cognition

Toshio Murase [a], Dorothy R. Carter [a,*], Leslie A. DeChurch [a], Michelle A. Marks [b]

[a] Georgia Institute of Technology, Atlanta, GA, USA
[b] George Mason University, Fairfax, VA, USA

ARTICLE INFO

Article history:
Received 19 July 2013
Received in revised form 24 May 2014
Accepted 18 June 2014
Available online 22 July 2014

Handling Editor: Shelly Dionne

Keywords:
Multiteam systems
Leader strategic communication
Multiteam-interaction mental models

ABSTRACT

The increasing prevalence of team-based organizations places a premium on leadership that will "mind the gap" and enable smooth synchronization of activities across multiple distinct teams. Prior work shows that leaders can be trained to directly facilitate between-team coordination processes. Yet, relatively little is known about the intervening psychological mechanisms that enable between-team coordination. Here, we advance multiteam-interaction mental models—cognitive structures containing knowledge of appropriate between-team activities—as one mechanism that facilitates coordination among multiple teams. We use leader and team cognition data gathered in DeChurch and Marks' (2006) MTS study to test these ideas. Results reveal leaders' multiteam-interaction mental model accuracy "transfers" to teams through strategic communication, and leader strategic communication enables between-team coordination by promoting accuracy in followers' mental models. This study highlights the importance of leadership for developing collective cognition that allows teams to "scale up" from small stand-alone teams to larger and more complex systems.

Introduction

Scholars have long emphasized leadership as a particularly potent force for organizing and coordinating collectives. However, the challenges associated with leading *multiple* teams, groups, or organizations, have not been adequately addressed by traditional leadership research (Hogg, van Kippenberg, & Rast, 2012). Typically, leadership is studied in contexts where leaders and followers all share a common group membership. Yet, in real world contexts, leaders are often responsible for influencing the coordinated activities of multiple groups or teams (Pittinsky & Simon, 2007). For example, as work is increasingly structured into teams, specialized teams are often called upon to work interdependently with *other* specialized teams to tackle complex problems requiring disparate skills and expertise (e.g., DeChurch & Zaccaro, 2010; Lanaj, Hollenbeck, Ilgen, Barnes, & Harmon, 2013). Hybrid organizational forms in which two or more teams work interdependently toward one or more shared goals are termed *multiteam systems* (i.e., MTSs; Mathieu, Marks, & Zaccaro, 2001), and a small, but growing set of findings demonstrate that between-team processes are critical drivers of their success (Davison, Hollenbeck, Barnes, Sleesman, & Ilgen, 2012; DeChurch & Marks, 2006; Marks, DeChurch, Mathieu, Panzer, & Alonso, 2005).

Unfortunately, effective collaboration among multiple teams is not a given. Groups or teams that should be working together may instead compete for scarce resources (Pfeffer & Salancik, 1977) or emphasize individual or team objectives above superordinate goals (Marks et al., 2005). In organizations, these breakdowns can lead to great losses in revenue; at a more macro scale, these breakdowns can be catastrophic—for example, when the FBI and CIA failed to coordinate knowledge sharing prior to September 11, 2001 (Caruso,

* Corresponding author.
E-mail addresses: toshio.murase@gmail.com (T. Murase), dorothyrpc@gmail.com (D.R. Carter), lesliedechurch@gmail.com (L.A. DeChurch), mmarks@gmu.edu (M.A. Marks).

http://dx.doi.org/10.1016/j.leaqua.2014.06.003

Rogers, & Bazerman, 2013). As such, recent theoretical work suggests optimizing the performance of multiple groups or teams requires *leadership* that effectively connects disparate groups, diverting self-interest and inter-group competition, and transforming tendencies toward insularity into intergroup collaboration and coordination (Hogg et al., 2012). Moreover, enabling integration across component teams in MTSs is the essential function of MTS leadership (DeChurch & Marks, 2006; Zaccaro & DeChurch, 2012).

Initial empirical work suggests that MTS leaders can be trained to engage in certain functional leadership behaviors that directly facilitate between-team coordination (DeChurch & Marks, 2006). However, the psychological mechanisms through which leadership shapes between-team coordination processes are not yet clear, leaving a gap in our understanding of and ability to develop effective leadership for multiple teams. The current paper begins to address this gap by identifying one mechanism that MTS leaders can capitalize upon in order to optimize between-team coordination—*collective cognition*. Over two decades of research on stand-alone teams reveals the extent to which teams build effective collective cognition predicts their coordinated performance (Cannon-Bowers, Salas, & Converse, 1993; Marks, Zaccaro, & Mathieu, 2000; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Mohammed, Ferzandi, & Hamilton, 2010). We argue that, as is the case with single teams, the cognitive underpinnings of MTSs play a central role in enabling distinct teams to coordinate.

Much prior research on collective cognition in teams has focused on members' *mental models*—the manner in which knowledge important to team functioning is organized and represented mentally, and distributed among members (e.g., Cannon-Bowers et al., 1993; Klimoski & Mohammed, 1994). Teams can have many different mental models, covering topics such as the team task, environment, team members, and members' interactions (Mohammed et al., 2010). Of particular relevance to team coordination are *team-interaction* mental models, which encompass information about the structure of interaction patterns, roles and responsibilities, and role interdependence among members (Cannon-Bowers et al., 1993). These knowledge structures enable members to form accurate conceptualizations of their task and team members, and, in turn, enable direct coordination (Marks, Sabella, Burke, & Zaccaro, 2002). In the multiteam context, between-team coordination processes are vital (Davison et al., 2012; Marks et al., 2005). Thus, in MTSs, *multiteam-interaction* mental models are needed consisting of accurate knowledge of appropriate between-team activities. We advance the multiteam-interaction mental model construct as one mechanism by which leaders facilitate coordination among multiple teams. Such coordination is essential for the "scale up" from single teams to larger and more complex systems of teams.

Theory development and hypotheses

Formally defined, MTSs are "two or more teams that interface directly and interdependently in response to environmental contingencies toward the accomplishment of collective goals" (Mathieu et al., 2001, p. 290). As such, MTSs are often comprised of multiple component teams that each possess unique specialized skills and expertise and are linked together through interdependent processes. These fundamental attributes of MTSs make these structures especially well suited for adaptively tackling problems in today's complex and turbulent organizational environments (Davison et al., 2012; Mathieu et al., 2001).

In a single team, collective processes serve to combine the efforts of individual team members. In an MTS, processes must harmonize both the efforts of individuals within each team as well as the efforts that span team boundaries (Marks et al., 2005). Because of the interdependencies connecting component teams in an MTS, rhythms of activities within each team are entrained to those at the MTS level (Ancona & Caldwell, 1992; Ancona & Chong, 1996; Standifer & Bluedorn, 2006). A component team whose actions are out of sync with other teams may not only fail to achieve its own objectives, but may also jeopardize the entire system by failing to deliver information or inputs needed by other teams. Thus, depending on the degree of interdependence required by the task, MTS performance depends on the successful coordination of efforts across teams (Marks et al., 2005).

However, achieving between-team coordination is innately problematic. Because of the often-observed characteristics of MTSs—diverse expertise, geographic dispersion, and different organizational memberships—social divides are likely at the boundaries between component teams. Social identity theory suggests that different memberships are sufficient to create ingroup–outgroup attitude structures (Turner, 1984) whereby people favor ingroup members over those in the outgroup (Tajfel & Turner, 1979). Negative attitudes toward outgroup members can be exacerbated when outgroup members have different backgrounds or values, are from different geographic locations, or when opportunities for socialization are limited (Lau & Murnighan, 1998; Li & Hambrick, 2005). Moreover, typical MTS structures can create a situation in which members most strongly identify and communicate with other members of their own component team, thereby limiting opportunities for successful coordination across teams. To facilitate MTS success involves enabling seamless coordination across distinct teams by identifying and capitalizing upon mechanisms that encourage teams to overcome naturally occurring divides.

Multiteam-interaction mental models

Numerous empirical studies have established the robust impact of team mental models on team processes and performance (Edwards, Day, Arthur, & Bell, 2006; Marks et al., 2000; Mathieu et al., 2000; Randall, Resick, & DeChurch, 2011; Smith-Jentsch, Cannon-Bowers, Tannenbaum, & Salas, 2008; Smith-Jentsch, Mathieu, & Kraiger, 2005). In particular, the *team-interaction* mental model construct is useful for understanding how teams coordinate their actions in complex dynamically changing environments. Here, we extend this construct to the MTS environment as a mechanism for integration across teams.

Team-interaction mental models provide an organized knowledge base for team members to draw upon to predict one another's behaviors and anticipate their needs (Cannon-Bowers et al., 1993). Team-interaction mental models allow members to stay in sync without the need for extensive direct mutual adjustment. For example, members of a military team enacting a mission in a war zone may not have time to engage in costly explicit communication with one another. Because time and resources are limited, these teams need to rely on an accurate implicit understanding of the environment, and the needs and actions of other members.

Accurate interaction mental models permit teams to focus their efforts on coordinating actions and adapting behavior to changing environments, thereby enabling team coordination and performance (Cannon-Bowers et al., 1993; Mathieu et al., 2005). As such, a series of studies on team cognition demonstrates that coordination processes mediate the team cognition–performance relationship (Marks et al., 2000, 2002; Mathieu et al., 2000; Randall et al., 2011).

Prior research suggests that collective cognition serves a similar functionality in larger and more complex collectives as it does in single teams (Iaquinto & Fredrickson, 1997; Schneider, Ehrhart, Mayer, Saltz, & Niles-Jolly, 2005). The positive effect of collective cognition on group outcomes is essentially homologous across the team, department, and organization levels (e.g., DeChurch & Mesmer-Magnus, 2010; Iaquinto & Fredrickson, 1997; Schneider et al., 2005). However, as the level of analysis moves from single teams to MTSs, the number of components in the social system increases, and the patterns of interactions among members become much more complex. In MTSs, the significant knowledge content that should enable between-team coordination centers on how component teams should work together. In other words, although each team in an MTS is distinct in terms of expertise and proximal goals and may naturally see the system through their own unique lens, in order to achieve superordinate MTS goals, members need an awareness of the appropriate sequencing of actions among the teams.

An accurate understanding of appropriate interaction patterns may be especially necessary to MTS success as compared to teams working in isolation. Component teams in an MTS are often embedded in different contexts and face disparate pressures, constraints, and opportunities. These separations between teams create friction points where teams can dislocate from the larger system. Due to between-team differences with regard to geographic location, organizational membership, or temporal norms for behavior, a component team may not otherwise be able to accurately predict the behaviors of other component teams. Especially when teams operate in complex and dynamically changing environments, an accurate understanding of between-team action sequencing can assist teams in overcoming coordination challenges by enabling implicit, as opposed to explicit between-team action processes. Thus, we argue that accurate multiteam-interaction mental models will enable MTS performance by enhancing teams' ability to coordinate their interactions. Accordingly, we posit:

Hypothesis 1. *Component team multiteam-interaction mental model accuracy positively predicts between-team coordination (H1a), which subsequently positively predicts MTS performance (H1b); between-team coordination fully mediates the effect of component team multiteam-interaction mental model accuracy on MTS performance (H1c).*

The role of leaders in shaping multiteam cognition

Leadership scholars have long recognized that a key role of leadership is to shape followers' understanding of their task and provide strategies for achieving desired objectives (e.g., Fiedler, 1967; House, 1971; Murase, Resick, Jiménez, Sanz, & DeChurch, 2011). Substantial evidence supports the relevance of collective cognition for group outcomes, and theoretical work argues that a major responsibility of team leaders is to facilitate an accurate cognition understanding of the team operating environment (Zaccaro, Rittman, & Marks, 2001), Yet, very little empirical research has investigated the impact of leadership on collective cognition (van Ginkel & van Knippenberg, 2012).

Like team cognition, multiteam cognition can emerge in MTSs both bottom-up and top-down. For example, MTS members can construct their own multiteam-interaction mental models through bottom-up processes by communicating and interacting with one another over time (Pearsall, Ellis, & Bell, 2010). In addition, mental models can develop top-down, as leaders actively intervene and alter members' existing mental models through their actions and communications with team members (Marks et al., 2000). MTS leaders are particularly potent in building an understanding of the system as a whole, because they occupy legitimate positions of influence (French & Raven, 1959) and can stay abreast of the resources, needs, and constraints facing each of the teams. Whereas component team members are often well aware of how members fit together within their own team, MTS leaders are in a better position to see how different teams fit together throughout the system. Moreover, MTS leaders serve a boundary-spanning role in systems with multiple groups or teams (Ernst & Chrobot-Mason, 2011; Mathieu et al., 2001), ideally positioning them to mold and shape component teams' understanding of how they should interact.

In fact, development of MTS cognition may benefit substantially from top-down intervention. Because MTSs are composed of specialized teams that are interdependent both within and between teams, there is a high degree of information processing complexity inherent in MTS work (Davison et al., 2012). Formal mechanisms, such as leadership, are often needed to manage between-team processes and reduce the burden on component teams. In MTSs, leaders or leader teams are best suited to handle those "aspects of coordination that are beyond the scope of the component teams" (Davison et al., 2012, pp. 7; Thompson, 1967). Recent work suggests that coordination may come about differently in MTSs than it does in teams. Whereas team coordination benefits from having multiple members all engaged in the coordinative processes simultaneously, research on MTSs suggests that differentiation is beneficial (Davison et al., 2012; Lanaj et al., 2013). Differentiated structures—where some members (e.g., leaders) are more involved than other members in actions such as developing MTS plans—benefit MTS alignment and efficient operation (Davison et al., 2012; Kazanjian, Drazin, & Glynn, 2000; Lanaj et al., 2013). Similarly, although members of small stand-alone teams might be able to develop collective cognition through repeated interactions with one another, developing a system-wide understanding of the needed interactions among teams may be an aspect of MTS coordination best handled by formalized leadership.

Developing collective cognition top-down is an active process involving direct communication and close interaction (Kozlowski & Doherty, 1989; Zaccaro & DeChurch, 2012). In general, *communication* is a key mechanism of influence for leaders (Seyranian, 2014). To shape follower cognitions, in particular, effective leaders engage in various *strategic* communications such as debriefing, planning, and sensegiving (Levesque, Wilson, & Wholey, 2001; Waller, Gupta, & Giambatista, 2004). For example, Schneider et al. (2005) found that leader communication emphasizing the importance of customer service promotes followers' understanding of service importance. Marks et al. (2000) showed that leaders' debriefing communication predicts team mental model accuracy. Furthermore, Randall et al. (2011) found a positive relationship between leader sense-giving communication and mental model similarity and accuracy. Moreover, through strategic communications, leaders encourage members to narrow their focus toward a limited set of environmental features and information, perceive their actions and plans as meaningful, and adapt their cognitive schemas to their performance environment (Kozlowski & Doherty, 1989; Salancik & Pfeffer, 1978).

The MTS environment can be ambiguous with regard to MTS and team objectives, responsibilities and expectations, and the appropriate timing of between-team coordination. To reduce members' uncertainty, leaders must highlight specific features of the MTS performance environment and frame mission plans and actions in a manner that helps members organize information. The crucial function of leaders of multiple teams is not only to direct followers but also to alter the state of followers' existent or developing mental models in a way that supports between-team coordination. In summary, MTS leaders can intervene in the development of multiteam-interaction mental models through their strategic communications about appropriate sequencing of interactions among teams.

Lastly, empirical evidence in small groups suggests that the top-down process of shaping collective cognition in a way that benefits the group performance begins with the leader's own cognitions. For example, past research demonstrates that groups tasked with making decisions that integrate members' distinct knowledge sets perform substantially better when the members understand that the task requires information exchange, discussion, and integration (i.e., information elaboration; van Ginkel & van Knippenberg, 2008, 2009; van Knippenberg, De Dreu, & Homan, 2004). van Ginkel and van Knippenberg (2012) showed that the degree to which a leader in a decision-making group holds a representation of the group task that emphasizes information elaboration influences the group's engagement in elaboration of decision-relevant information. Specifically, these researchers found that leaders' understanding of the task requirements influences group decision-making performance through sequential meditational processes of a) leader behaviors (e.g., advocating for information elaboration); b) followers' cognitions about the task requirements; and c) the degree to which the group engages in information elaboration (van Ginkel & van Knippenberg, 2012). In other words leaders' cognitions have the potential to shape subsequent leader communications and follower cognitions.

We expect a similar sequential process to exist in the multiteam environment with leader mental models impacting leaders' strategic communications, and in turn, component team mental models. However, given the complexity of these systems, in MTS or inter-group collaboration contexts, leadership is often handled by multiple leaders who must coordinate their activities (Carter & DeChurch, 2014; Hogg et al., 2012; Zaccaro & DeChurch, 2012). Prior research suggests that groups with multiple leaders function most effectively when the leader *team* holds an accurate mental model (McIntyre & Foti, 2013). Thus, we argue that accuracy of the mental models held by MTS leader teams enable these leaders to communicate system-wide strategic plans to their followers that explicate how component teams should interact with one another. In turn, these strategic communications help build a cognitive platform that enables MTS members to make sense of their task environment, coordinate across teams, and effectively accomplish superordinate objectives. These relationships are summarized in Fig. 1. Stated formally, we hypothesize:

Hypothesis 2. *Leader team multiteam-interaction mental model accuracy positively predicts leader team strategic communication (H2a); which subsequently positively predicts component team multiteam-interaction mental model accuracy (H2b). Leader team strategic communication fully mediates the effect of leader team multiteam-interaction mental model accuracy on component team multiteam-interaction mental model accuracy (H2c).*

Hypothesis 3. *Component team multiteam-interaction mental model accuracy fully mediates the effect of leader team strategic communication on between-team coordination.*

Methods

The data used in the current study was part of a larger data collection effort investigating the role of leadership in MTS performance, a portion of which is published (DeChurch & Marks, 2006). DeChurch and Marks (2006) paper identified the direct effects

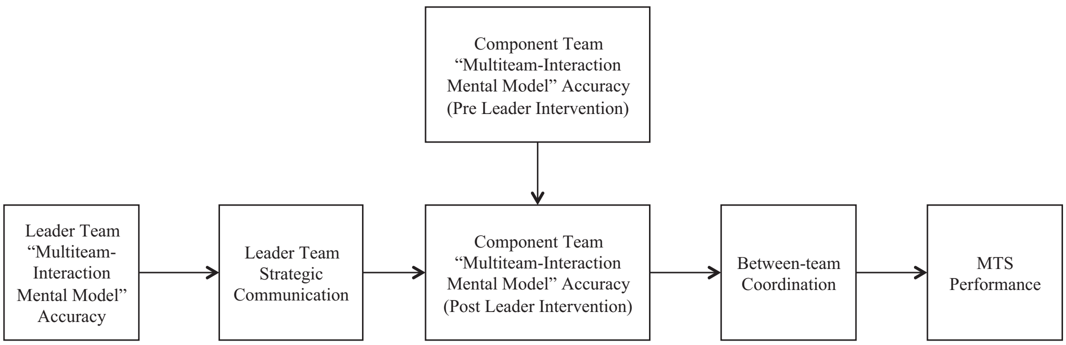

Fig. 1. Proposed effects of leader team multiteam-interaction mental model accuracy and leader team strategic communication on component team multiteam-interaction mental model accuracy, between-team coordination, and MTS performance.

of two leader training manipulations on functional leadership behavior, between-team coordination, and MTS performance. Whereas DeChurch and Marks (2006) showed that MTS functional leadership focused toward between-team processes and coordination was relevant to MTS performance, the current paper extends this work by identifying a cognitive mechanism through which MTS leadership operates—multiteam-interaction mental models. The purpose of the current study is to identify and elaborate the cognitive mechanisms through which leaders shape MTS coordination and performance. Thus, although the leadership manipulations were not part of the substantive focus of the current study, we controlled for their effects in our analyses.

Participants

Undergraduate psychology and business students ($N = 384$) from a large Southeastern United States university participated in the current study. Participants ranged in age from 18 to 28 ($M = 21.65$, SD = 2.09); the overall sample was predominantly female (71%). A total of 64, identically-structured MTSs participated in a laboratory simulation designed to model an MTS situation requiring high levels of interdependence and between-team coordination. Fig. 2 presents a visual depiction of the MTS structure. Each MTS was comprised of one 2-person leadership team and two 2-person component teams (i.e., the air-based flight team and the ground-based flight team, respectively). The leader team was responsible for planning and coordinating the mission of the two flight teams. The two component teams were each responsible for flying their own F-22 aircraft, and locating and disengaging a specific type of enemy in a simulated battlefield (i.e., air targets or ground targets, respectively).

Procedure

MTS simulation

MTSs engaged in a modified version of the Air Combat Effectiveness Simulation (ACES: Mathieu, Cobb, Marks, Zaccaro, & Marsh, 2004). All aspects of the task environment were scripted such that all MTSs encountered identical events and all enemies encountered responded in a predictable manner. All six MTS members participated in the simulation in the same room and were able to see one another easily. MTS members could freely communicate with one another via microphone-equipped headsets, and both within- and between-team communication occurred simultaneously. However, each participant engaged in the simulation on his or her own computer monitor and viewed only the simulation activity displayed on his or her screen.

In each experimental session, MTSs were assigned the goal of eliminating all enemy threats in each of four areas of a simulated battlefield. Within each of the four areas, there were two types of enemy threats—air targets and ground targets. Neutralizing the enemy threats of a given area required elimination of all air and ground targets within that area.

This mission environment encouraged interdependence both within and between the flight teams. First, within each team, one member was assigned to the "pilot" role and one member assigned to the "weapons specialist" role. The "pilot" operated the joystick, which flew the plane and fired weapons; the "weapons specialist" manipulated keyboard functions to navigate, select weapons, and

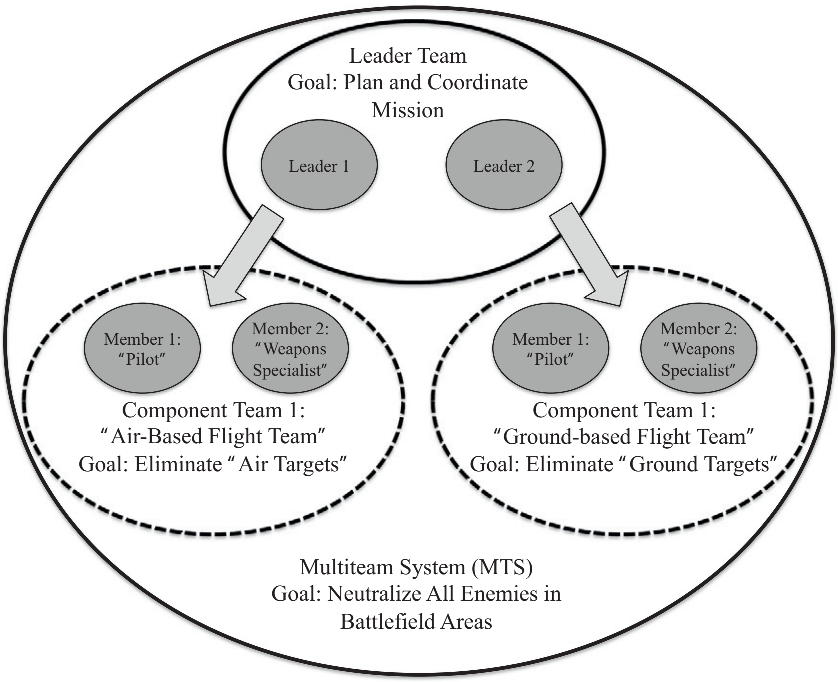

Fig. 2. MTS structure.

lock onto targets. Second, the structure of the MTS task encouraged interdependence between the two flight teams. The air and ground targets were co-located within the mission environment and programmed to attack both teams. Whereas the air-based flight team was equipped only with missiles capable of locking onto and disabling air-based targets, the ground-based flight team was equipped only with missiles capable of locking onto and disabling ground-based targets. Thus, no single team could, in isolation, successfully eliminate all required targets or protect themselves from all attacks.

The experiment also created interdependence between the leader team and the two flight teams. Each leader was responsible for directing the efforts of one of the two flight teams. One leader viewed the ground-based flight team pilot's screen on his or her monitor while the other leader viewed the air-based flight team pilot's screen on his or her monitor. Leaders could monitor information and communicate verbally with component teams but could not assist physically in performing the MTSs task. Although both leaders were aware of how to monitor either team's actions from each of their display screens and were tasked with ensuring overall MTS overall, most MTSs operated by having each leader guide their respective flight team.

Over the course of each experimental session, MTSs engaged in four battle mission tasks, all of which were parallel in structure. The first three missions served as training missions, and the fourth as the experimental mission. During the first two of the training missions, the component teams practiced engaging in the task and working together *without* the leader team. The leader team received leadership training in a separate location during these first two missions. During the third training mission, the leader team was introduced into the MTS.

Study design

The present study utilized a two (leader strategy training vs. control) by two (leader coordination training vs. control) between-subjects design in which MTS leaders were primed to highlight two between-team processes (i.e., strategizing and/or coordinating) in the experimental conditions. The first manipulation was MTS leader strategy training. In both the experimental and control conditions of this manipulation, MTS leaders were trained to understand the information provided in a mission briefing, develop a mission plan, and communicate the plan to component teams during pre-mission planning sessions. In the experimental condition, leaders received additional training teaching them to develop mission plans specifying how the two component teams should coordinate their actions as they engaged in each part of the mission. In other words, leaders in this condition were trained to develop and communicate pre-mission plans that specified appropriate synchronized actions among multiple teams.

The second manipulation was MTS leader coordination training. In both the experimental and control conditions of this manipulation, MTS leaders were trained to monitor the location and progress of teams as they engaged in the simulation and communicate this information throughout the mission. In the experimental condition, leaders received additional training such that leaders were able to monitor the location and progress of their own team as it related to the other team and to communicate this information to the other team throughout the mission.

As noted above, DeChurch and Marks (2006) showed that both manipulations had direct effects on functional leadership behaviors. Because these manipulations were not part of the substantive focus of the current study, we controlled for their effects in our analyses.

Experimental procedure

Experimenters tested each MTS in a separate 5-h session that progressed through three general phases: introduction (1 h), training (3 h), and task engagement (1 h).

Introduction. In the introduction phase, participants completed a measure of intelligence and a survey of demographic information (i.e., age, gender, race, nationality). Based on this information, experimenters assigned participants to teams such that a) leader intelligence scores were the same or higher than flight team members; and b) flight team member demographic composition was stratified across experimental conditions.

Training phase. In the training phase, experimenters first trained teams in separate rooms on the team members' role-specific duties before bringing the teams together to practice working together as a unit. In real-world MTSs, teams of experts are often required to work interdependently with other similarly specialized teams of experts from other fields. Although such teams may be highly informed with regard to their own expertise and that of their own team members, they may not be aware of optimal patterns of interaction with other teams. The role-specific training given to participants was designed to create sample MTSs that mirrored this characteristic of real-world MTSs. Participants developed knowledge and skills relevant to their individual role in their team (e.g., flight team pilot), but the role-specific training did not provide extensive explanation for how component teams in the system should work together. After training, participants completed a four-item competency check measure designed to assess the extent to which each member had acquired his or her role and role-specific task responsibilities. Participants' mean competency check scores were high, ($M = 3.55$ out of 4, $SD = .52$), suggesting that participants understood their role requirements. However, after the participants completed the competency check measure, experimenters continued to work with each participant until he or she understood the answers to any question answered incorrectly.

After the competency checks, the four members of the two flight teams received additional instruction on the MTS task and how to use the simulation. Then, the MTS flew two practice missions without the leader teams' assistance. Simultaneously, the leader team viewed a shortened version of the flight team training and a combination of leader training modules based on their randomly assigned treatment conditions. After the second training mission, component teams completed initial multiteam-interaction mental model measures (explained below in the measures section). Average initial mental model scores ranged from 1 to 4 ($M = 2.34$ out of 4, *SD* = .70) with higher values indicating higher accuracy. Thus, although there was variability in the scores, component teams had, at this time, gained sufficient experience with the simulation to develop an initial understanding of how component teams might synchronize their actions.

Next, the leader team was introduced to the component teams and all three teams engaged in a final practice mission with experimenters providing additional coaching on basic task duties. The first 20 min of the third training mission constituted pre-mission planning or the *transition phase* (Marks, Mathieu, & Zaccaro, 2001). During the transition phase, leaders planned the MTS mission for 10 min while the component teams took a short break and then conveyed these plans to the component teams during the remaining 10 min. The remaining 40 min of the third training mission constituted the *action phase* (Marks et al., 2001) in which the MTS engaged in the simulation.

Task engagement phase. In parallel with the third training mission, the task engagement phase (the fourth mission) began with a 20-min transition phase. During the transition phase, leaders planned the MTS task strategy for the first 10 min and then conveyed these plans to component teams during the second 10 min. Leader strategic communication was assessed during this second 10-min portion of the transition period. Component teams completed their final measure of multiteam-interaction mental model accuracy directly after the transition period. After component teams completed the mental model measure, the MTS engaged in the action phase of the performance mission. Subject Matter Experts (SMEs) completed behavioral ratings of between-team coordination during the action phase of the performance mission, and MTS performance was assessed at the end of the action phase.

Measures

Mental models

At a general level, mental models represent organized knowledge. Klimoski and Mohammed (1994) underscored the importance of first determining the knowledge content of mental models, and then formulating the meaningful structure of knowledge. As discussed in the introduction, team members can hold many different types of mental models simultaneously. For example, mental models can contain information about the team members themselves, the team task, the external environment, and the way that members should interact with one another to reach their goals (Cannon-Bowers et al., 1993). In teams, the vital content for effective team coordination is the knowledge about needed actions and interactions among team members (i.e., team interaction mental models; Marks et al., 2000). In MTSs, the vital content for *between-team* coordination is knowledge about needed actions of and interactions among component teams (i.e., MTS interaction mental models). In other words, regardless of their role in the system, MTS members need to possess accurate knowledge of the way the components of the system should synchronize.

There are numerous techniques in the team cognition literature to capture different types of team mental models (Mohammed et al., 2010). In the current study, we employed an approach that has been used previously to capture the interaction mental models of single teams (Ellis, 2006; Marks et al., 2000). Specifically, we used a rank-order approach falling into one of the traditional mental model measurement categories called *concept mapping* (Marks et al., 1997; Mohammed et al., 2010). Concept mapping techniques capture a hierarchical structure of concepts that are linked together. This approach is consistent with findings from cognitive psychology suggesting that people organize information by conceptualizing concepts and knowledge in a hierarchical structure (Novak, 1990).

Teams scholars have argued that the meaningful structure of knowledge about team interactions is hierarchical, and team interaction mental models can be detected by capturing the way that people organize team actions hierarchically (Ellis, 2006; Marks et al., 2000). Previous studies on team-interaction mental models using the concept mapping technique asked participants to organize pre-identified team action concepts in a hierarchical structure representing their knowledge of team interactions. For example, Ellis (2006) provided participants with two separate task scenarios and asked participants to rank-order eight possible team actions within each scenario. Marks et al. (2000) asked members to select eight concepts from a large collection of various concepts and place them in a hierarchical sequence of importance. Team-interaction mental models assessed in this manner have been shown to predict team coordination and performance (Ellis, 2006; Marks et al., 2000).

To capture members' *mutliteam*-interaction mental models, we used a version of the concept-mapping procedure modified for the MTS context. The battlefield simulation was designed such that certain sequences of team actions would be maximally effective for MTS performance. To capture the degree to which participants understood these effective sequences, experimenters administered a measure assessing the hierarchical structure of MTS members' knowledge about the sequencing of when one team's actions should be taken based on when another team was carrying out a given action. First, participants were asked to consider a list of nine possible team actions that could commence between the two teams during a hypothetical interdependent situation. Then, participants rank-ordered the team actions to reflect the order in which they should occur for the MTS to achieve its superordinate goal.

Prior work has judged the accuracy of team interaction mental models assessed with the concept-mapping rank-order technique by comparing participant knowledge structures to those of subject matter experts (SMEs; e.g., Ellis, 2006). Similarly, in this study, the accuracy of multiteam-interaction mental models was indexed using a SME-developed scoring system. The group of SMEs consisted of a team of two faculty members and four graduate research assistants who had designed the battlefield simulation. Developing the mental model measure and corresponding scoring system was a two-step process. First, the game developers independently generated a list of scenarios the MTS might encounter as well as a list of appropriate sequences of effective MTS actions corresponding to each scenario. The simulation was designed such that certain sequences of team actions were more effective than others. Then, SMEs met as a group to identify and discuss points of overlap and discrepancies between their views of the correct sequencing of actions in different scenarios. For example, all experts ranked item 9 (eagle targets and destroys the SU-27) lower than item 7 (work targets and destroys the first tank). This pattern indicated that all three SMEs agreed that the air combat team needed to destroy the plane before the ground combat team should destroy the tank. Therefore, one criterion for multiteam-interaction mental model accuracy was whether or not item 9 received a lower ranking than item 7. Hypothetical scenarios were only included in the final measure if all six SMEs agreed on all aspects of the corresponding ordering of team-to-team sequencing. In total, four hypothetical scenarios with nine corresponding team actions were developed based on SME evaluations of the game. SMEs then developed a set of decision rules to classify multiteam-interaction mental model accuracy on a scale of 0 = "completely inaccurate" to 4 "completely accurate."

We operationalized component team multiteam-interaction mental model accuracy as the mean of the four component team members' scores. Component team mental model scores ranged from 1.25 to 4.00 ($M = 2.83$, $SD = .70$) with higher values indicating higher levels of accuracy. We operationalized leader team mental model accuracy as the mean of the two leaders' scores. Leader team mental model accuracy ranged from 2.00 to 4.00 ($M = 3.63$, $SD = .53$).

Leader team strategic communication

SMEs rated leader team strategic communication during the transition phase of the MTS performance mission using a behaviorally anchored rating scale (BARS) created for this study. Response anchors ranged from 1 = "The leader team does not specify a coherent plan. Either the plan is totally vague or the leader team does not make its plan clear. There is no mention of a) the order in which teams should fly or b) the order in which targets should be destroyed." to 5 = "The leader team very clearly articulates a plan to MTS members that specifies a) the order in which teams should fly throughout the mission, b) the order in which targets should be destroyed. The plan is very specific and is made clear to all MTS members." Two SMEs rated the content of leaders' communications during the performance mission transition phase; inter-rater reliability was assessed by correlating the two ratings ($r = .78$, $p < .05$). SME ratings were averaged, and the composite was used in subsequent analyses. Leader team strategic communication scores ranged from 1.00 to 5.00 ($M = 2.89$, $SD = 1.21$).

All raters of leader team strategic communication were research assistants who were blind to the study hypotheses. SME rater training was a three-part process designed to develop a common frame of reference (Schleicher & Day, 1998). First, the raters were provided with initial instructions for using the rating scale and for understanding the types of behaviors the scale anchors represent. Then, using the BARS, the SMEs rated leader team behaviors in a series of videos of pilot data independently. Next, the raters reconvened to discuss their initial independent ratings of the pilot data, identifying instances of disagreement. Then, the SMEs re-watched all pilot study videos as a group to discuss the reasoning behind their initial ratings and come to a consensus on the interpretations of each observed behavior.

Between-team coordination

SMEs rated between-team coordination during the action phase of the performance mission using a BARS developed for the current study. The rating scale provided a judgment of the component teams' skill at smoothly synchronizing joint actions; anchors ranged from 1 = "no or hardly any skill" to 5 = "complete skill." Two SMEs rated the content of the MTS performance mission action phase, and inter-rater reliability was assessed by correlating the two ratings ($r = .69$; $p < .01$). SME ratings were averaged and the composite was used in subsequent analyses. Between-team coordination scores ranged from 1.00 to 5.00 ($M = 2.94$, $SD = 1.06$).

Between-team coordination was rated by a different group of research assistants than the group of who rated leader team strategic communication. However, as with leader strategic communication, all raters of between-team coordination were blind to all study hypotheses. Between-team coordination raters engaged in an identical rater training process to develop a common frame of reference as the group of leader strategic communication raters. Specifically, SMEs were provided with initial instructions regarding the use of the BARS, they rated pilot data videos independently, and then reconvened to discuss and come to consensus on the ratings of all observed behaviors.

MTS performance

Broadly, MTS performance is the extent to which superordinate goals are achieved. Thus, MTS performance metrics need to identify the collective goal and quantify the degree of goal attainment. The MTSs in this study were assigned the ultimate goal of disabling four enemy bases on the simulated battlefield during the final mission, requiring the coordinated actions of both component teams. Therefore, MTS performance was operationalized as the number of bases successfully destroyed. In other words, MTS performance was a game-derived score based on the systems' assigned goal of neutralizing each of the four bases. Sample MTS performance on this index ranged from 0 = "no bases destroyed" to 4 = "all four bases destroyed" ($M = 1.84$, $SD = .98$). Because all MTSs encountered identical events and all enemies encountered responded in a predictable manner, MTS performance was a standardized and comparable performance index across all 64 MTSs.

Furthermore, the MTS performance metric was developed to capture the goal attainment of the MTS, as opposed to just summing an index of component team performance (e.g., number of targets destroyed). Whereas component team performance was calculated based on the number of specific enemy targets that the team destroyed, MTS performance was calculated based on the number of the four enemy areas that were completely neutralized (i.e., both air and ground enemies were destroyed). Therefore, it was possible for two MTSs to have identical aggregate component team performance scores but different MTS performance scores. For example, if the air team destroyed all air targets only in Battlefield Areas 1 and 2, and the ground team destroyed all ground targets only in Battlefield Areas 3 and 4, the two component teams would have each destroyed half of their targets and the MTS would have an *aggregate* team performance score of 50%. However, none of the four areas would be completely neutralized (the MTS goal); thus, the MTSs would have a performance score of 0%. On the other hand, if both teams neutralized their targets only in Battlefield Areas 1 and 2, the

MTS would have an aggregate team performance score of 50% *and* the overall MTS performance score would be 50% (i.e., two out of four areas completely neutralized).

Analyses

Path analysis was used to test model data fit, using the R package "lavaan" (Rosseel, 2012). Due to the sensitivity of the chi-square statistic to differences in large-sample data (Bentler & Bonett, 1980), we employed a set of fit indices to assist in determining the model fit and misspecification (Bentler, 2007; Hu & Bentler, 1998, 1999), comparative fit indices (CFI: Bentler, 1990), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA). These indices were selected based on their sensitivity to model misspecification and insensitivity to sample size (Hu & Bentler, 1998). Whereas, SRMR is sensitive to simple misspecification, CFI and RMSEA have been found to be suitable for detecting complex model misspecification. CFI is not sensitive to distribution and sample size (Tanguma, 2001), and RMSEA is not sensitive to distribution but is sensitive to small sample size ($n < 250$). Cutoff points were set at .95 for CFI, .08 for SRMR and .06 for RMSEA based on the recommendations of Hu and Bentler (1999).

Mediation analysis

We employed the mediation approach recommended by James, Mulaik, and Brett (2006). Mediation is confirmed if the following conditions are met: (a) the model has an acceptable fit; (b) the relationship between the predictor and mediator is significant; (c) the relationship between the mediator and outcome is significant. Additionally, following the recommendation by MacKinnon, Lockwood, Hoffman, West, and Sheets (2002) and MacKinnon, Lockwood, and Williams (2004) we employed a bootstrapping procedure (Rosseel, 2012) to examine indirect effects. Because indirect effects can be non-normal in their distributions, McKinnon et al. recommend that researchers use a nonparametric procedure that does not assume normal distribution shapes. This bootstrapping procedure produces a sampling distribution to compute point estimates and confidence intervals (CIs) for indirect effects. In particular, we used bias-corrected CIs to examine the statistical significance of indirect effects because these bias-corrected CIs have been shown to outperform other types of CIs (MacKinnon et al., 2004). If the bias-corrected CIs do not include zero, indirect effects are considered statistically significant. In the current study, we conducted 5000 iterations for all bootstrapping analyses.

Control variables

We controlled for the effects of the two manipulations in all analyses by dummy-coding each manipulation (Cohen, Cohen, West, & Aiken, 2003) and specifying paths from each manipulation to each focal variable in the path analysis model (i.e., leader team MTS interaction mental model, leader team strategic communication, component team MTS interaction mental model, between-team coordination, and MTS performance). By controlling for the manipulations, we were able to rule out alternative explanations for observed relationships among focal variables that were due to the manipulations.

Additionally, as noted in the experimental procedure, the two component teams worked together during two training missions without the leader team. Initial component team mental models were assessed at the end of the second mission, before interacting with the leader team. Thus, in addition to the leadership training manipulations, we controlled for the effect of component team mental models measured *before* the leader team intervention on component team mental models measured *after* the leader teams were introduced to the system. This allowed investigation of the degree to which MTS leaders impacted the subsequent development of component team mental models.

Results

Table 1 presents a summary of means, standard deviations, and bivariate correlations for all study variables.

Model fit

Before testing specific hypotheses, we first assessed the fit of the overall hypothesized path model (Model 1; see Fig. 3). Obtained fit indices for Model 1 were highly acceptable, χ^2 (10, $n = 64$) = 8.42, *ns*; CFI = 1.00, SRMR = .04, RMSEA = .00. However, according to MacCallum and Austin (2000), in any sample there may be multiple models that fit the data equally well. Therefore, we tested the

Table 1
Means, standard deviation, and correlations.

		M	*SD*	1	2	3	4	5
1	LT Multiteam-Interaction Mental Model Accuracy	3.63	.53					
2	LT Strategic Communication	2.89	1.21	.53**				
3	CT Multiteam-Interaction Mental Model Accuracy (Time 1)	2.34	.59	.15	−.03			
4	CT Multiteam-Interaction Mental Model Accuracy (Time 2)	2.83	.70	.27*	.25*	.48		
5	Between-team Coordination	2.94	1.06	.32*	.35**	.26*	.20**	
6	MTS Performance	1.84	.98	.24†	.06	−.00	.16	.45**

Note. LT = Leadership Team; CT = Component Team; *n* varies from 57 to 64.
†$p < .10$, *$p <. 05$, **$p < .01$.

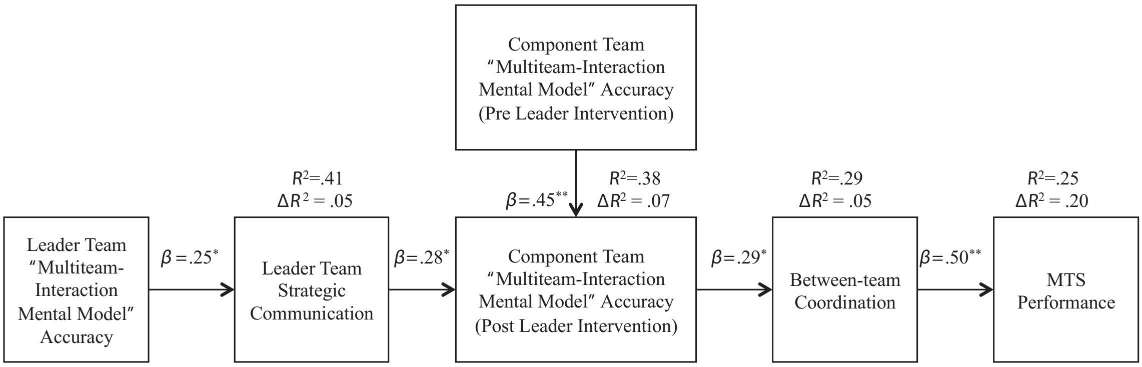

Fig. 3. Path analysis results. *Note.* *$p < .05$, **$p < .01$, $\chi^2_{(64,\, df\, =\, 10)} = 8.42$, *ns*, CFI = 1.00, RMSEA = .00, RSMR = .04. Standardized path coefficients are listed. Analyses control for: leader strategy training and coordination training with each of the focal variables (leader team mental model accuracy, leader team strategic communication, component team mental model accuracy, between-team coordination, and MTS performance).

fit of three alternative models, which hypothesized partial, rather than full, mediation relationships. The first alternative model, Model 2, proposed a partial mediation effect of leader team strategic communication on component team mental model accuracy by adding a direct path from leader team mental model accuracy to component team mental model accuracy. Model 3 allowed partial mediation of between-team coordination on MTS performance by adding a direct path from component team mental model accuracy to MTS performance. Assessing the fit of these two alternative models allowed us to determine whether the two hypothesized mediation paths were partial or full. The third alternative model (Model 4) was created based on prior research, which showed a direct effect of leader communication on MTS coordination (Davison et al., 2012; DeChurch & Marks, 2006). This model allowed a partial mediation effect of component team mental model accuracy on between-team coordination by adding a direct path from leader team strategic communication to between-team coordination.

The fit of all the alternative models was assessed and compared against the hypothesized model (see Table 2). None of the alternative models showed fit statistics that were significantly improved as compared to the original hypothesized model (Model 2: $\Delta\chi^2(_{df\,=\,1}) = .05$, *ns*; Model 3: $\Delta\chi^2(_{df\,=\,1}) = .05$, *ns*; Model 4: $\Delta\chi^2(_{df\,=\,1}) = .14$, *ns*). Because Model 1 was more parsimonious than these alternative models, we used Model 1 to test the hypotheses. The standardized path coefficients of this model along with their effect sizes are summarized in Fig. 3.

Effects of control variables

Focusing first on the control variables, leader strategy training significantly positively predicted leader team mental model accuracy ($\beta = .49$, $p < .01$), leader team strategic communication ($\beta = .48$, $p < .01$), and between-team coordination ($\beta = .32$, $p < .01$). However, leader strategy training did not predict component team mental model accuracy ($\beta = .09$, *ns*) or MTS performance ($\beta = -.19$, *ns*). Leader coordination training did not significantly predict any of the focal variables (leader team mental model accuracy: $\beta = .10$, *ns*; leader team strategic communication: $\beta = -.04$, *ns*; component team mental model accuracy: $\beta = -.01$, *ns*; between-team coordination: $\beta = .18$, p = *ns*; MTS performance: $\beta = .13$, *ns*). The third control variable, component team mental model accuracy measured before the leader team intervention, was a significant positive predictor of mental model accuracy measured after the leader team intervention ($\beta = .45$, $p < .01$).

Tests of hypotheses

Hypothesis 1a predicted that component team mental model accuracy would positively predict between-team coordination. In support of this hypothesis, results indicated that the path coefficient for this relationship was statistically significant and positive ($\beta = .29$, $p < .05$, $\Delta R^2 = .05$). Hypotheses 1b and H1c predicted that between-team coordination would positively predict MTS performance (H1b) and that between-team coordination fully mediates the relationship between component team mental model

Table 2
Chi-square and fit indexes for path-analyses.

Model number	χ^2	*df*	$\Delta\chi^2$	Δdf	SRMR	CFI	RMSEA
Model 1 (hypothesized)	8.42	10			.05	1.00	.00
Model 2	8.37	9	.05	1	.04	1.00	.00
Model 3	8.37	9	.05	1	.04	1.00	.00
Model 4	8.28	9	.14	1	.04	1.00	.00

Note. Model 1 is the hypothesized model; Model 2 tested the direct path from leader mental model accuracy to component team mental model accuracy; Model 3 tested the direct path from component team mental model accuracy to MTS performance; Model 4 tested the direct path from leader strategic communication to between-team coordination.

accuracy and MTS performance (H1c). Following the approach by James et al. (2006), we first examined the three preconditions for testing mediation with path analysis. Results demonstrated that each of these conditions was met: the model fit the data well, the previous analysis supported the H1a path from component team mental model accuracy to between-team coordination, and the path from between-team coordination to MTS performance ($\beta = .50$, $p < .01$, $\Delta R^2 = .20$) was significant. Additionally, bootstrapping analyses indicated that the bias-corrected 95% CI around the indirect effect of component team mental model accuracy on MTS performance via between-team coordination did not include zero (unstandardized $B_{\text{indirect}} = .20$, bias-corrected 95% CI [.03, .43]; see Table 3). Thus, these results supported both H1b and H1c.

Hypothesis 2a predicted that leader team mental model accuracy would positively predict leader team strategic communication. In support of this hypothesis, the coefficient for leader team mental model accuracy was statistically significant and positive after controlling for leader strategy and coordination training ($\beta = .25$, $p < .05$, $\Delta R^2 = .05$). In Hypotheses 2b and 2c, we argued that leader strategic communication would be positively related to component team mental model accuracy (H2b) and that leader team strategic communication would fully mediate the effect of leader team mental model accuracy on component team mental model accuracy (H2c). In support of H2b, results indicated that the path coefficient from leader team strategic communication to component team mental model accuracy was statistically significant and positive after controlling for leader strategy and coordination training ($\beta = .28$, $p < .05$, $\Delta R^2 = .07$). Further in support of H2c, our results satisfied the conditions outlined by James et al.'s (2006) approach. The model fit the data well, the previous analysis supported the H2a path from leader team mental model accuracy to leader team strategic communication, and the path from strategic communication to component team mental model accuracy was significant ($\beta = .28$, $p < .05$, $\Delta R^2 = .07$). In addition, bootstrapping analyses indicated that the bias-corrected 95% CI around the indirect effect of leader team mental model accuracy on component team mental model accuracy via leader team strategic communication did not include zero (unstandardized $B_{\text{indirect}} = .10$, bias-corrected 95% CI [.01, .28]). Thus, both H2b and 2c were supported.

Hypothesis 3 predicted that component team mental model accuracy would fully mediate the effect of leader team strategic communication on between-team coordination. The model supporting Hypotheses 1a and 2b met the conditions outlined by James et al.'s (2006) approach. In addition, bootstrapping analyses indicated that the bias-corrected 95% CI around the indirect effect of leader team mental model accuracy on component team mental model accuracy via leader team strategy communication did not include zero (unstandardized $B_{\text{indirect}} = .08$, bias-corrected 95% CI [.01, .22]). Thus, these results support Hypothesis 3.

Finally, as noted above, whereas the leader coordination training manipulation did not significantly impact the development of leader multiteam-interaction mental models, strategy training was a significant predictor of this type of cognition among leaders. In other words, training designed to teach leaders to shift their pre-mission planning strategy from planning their *own* teams' actions to planning the actions that *link* component teams infused variance into leaders' mental model accuracy. These results augment previous findings, which showed a direct effect of leader strategy training on functional leader behavior and between-team coordination, by demonstrating that accurate multiteam-interaction mental models are a key psychological mechanism through which strategy training improves leader behavior and collective performance. We elaborate the implications of these findings in the discussion.

Discussion

Prior research has firmly established the importance of collective cognition for coordination and performance in single teams (DeChurch & Mesmer-Magnus, 2010; Marks et al., 2000; Mathieu et al., 2000). The current study extends this work by considering the interaction mental model construct in a more complex social unit, the MTS. Our results reveal that the development of accurate multiteam-interaction mental models throughout the system is one mechanism leaders can harness to shape MTS coordination and performance.

Table 3
Bootstrap analyses of the indirect effects.

Indirect effects	PE[a]	SE	Bias corrected confidence interval[b] Lower	Upper
LT Mental Model Accuracy → LT Strategic Communication → CT Mental Model Accuracy	.10	.07	.01	.28
LT Strategic Communication → CT Mental Model Accuracy → Between-team Coordination	.08	.05	.01	.22
CT Mental Model Accuracy→ Between-team Coordination → MTS Performance	.20	.10	.03	.43

$n = 65$.[a]Unstandardized point estimate; 5000 bootstrap re-samples.[b]95% level of confidence for confidence interval.
Note. LT = Leadership Team; CT = Component Team. In each analysis, leadership strategy and coordination training, and component team mental model before leadership team intervention were controlled for.

Theoretical contributions

Our study contributes to theory on leadership and multiteam effectiveness in three key ways. First, although team research has established collective cognition as an important mechanism for enhancing coordination and performance in teams, there is scant research investigating the effect of cognition at the MTS level. Thus, a primary contribution of this work is that it identifies the importance of MTS cognition, but more specifically, reveals a beneficial type of mental model in MTSs. Whereas research on single teams shows members' understanding of the task and team is critical, our findings clarify that component teams in MTSs need accurate models of how distinct teams should synchronize their interactions.

Consistent with past literature on team cognition (Marks et al., 2000, 2002; Mathieu et al., 2000), we found that the benefits of multiteam-interaction mental models are similar to those of team-interaction mental models. The degree to which component teams understand the appropriate sequencing of team-to-team interactions positively impacts their between-team coordination. Furthermore, our findings demonstrate that the effect of component teams' mental models is transmitted to MTS performance through between-team coordination. Central to theories of team cognition is the idea that mental model accuracy allows members to anticipate the needs and behaviors of other members (Cannon-Bowers et al., 1993). As evidenced by the significant full mediation effect of between-team coordination, we suggest that the processes related to MTS cognition function similarly to those occurring at the team-level. MTS component teams may rely on their beliefs about between-team action sequencing in order to anticipate one another's actions and thereby coordinate seamlessly across teams.

Our second key contribution is to clarify the role of leadership in building MTS cognition. In alignment with prior work establishing leaders' cognitions as an antecedent of followers' cognitions (e.g., McIntyre & Foti, 2013; van Ginkel & van Knippenberg, 2012) our results showed that mental model accuracy within MTS leader teams impact subsequent mental model accuracy in component teams. Additionally, the path-analytic model showing that leader strategic communication fully mediates the positive relationship between leader team mental models and component team mental models highlights leaders' communications about strategic plans as a key leadership behavior for shaping component teams' cognition.

Interestingly, the significant effect of leader strategic communication on later component team mental models after accounting for initial component team mental models suggests that leaders are capable of intervening in the ongoing developmental process of MTS cognition to aid coordination. The teams in the current study were formed, and functioned *prior* to their introduction to the leadership teams. In fact, component teams completed two missions without a leadership team, and thus had already developed initial mental models. In many real world leadership scenarios, leaders must intervene in the context of groups that have a history of working together and therefore an understanding of their needed interactions. These findings suggest multiteam leaders, by expressing strategic multiteam plans, can reshape collective cognition in a way that is functional for inter-team coordination.

Further, this study links MTS research with research on intergroup leadership (e.g., Hogg et al., 2012; Pittinsky, 2009) by advancing the multiteam-interaction mental model construct as another mechanism to enhance intergroup collaboration. Findings from intergroup leadership research have highlighted collective identity and affect-based constructs as fundamental to effective leadership across multiple groups (Pittinsky, 2010; Pittinsky & Simon, 2007). Building a common frame of reference—for example, by developing followers' multiteam-interaction mental models—is another such mechanism that can help remedy communication and interaction breakdowns among disparate groups (Li & Hambrick, 2005; Marks et al., 2000).

However, future research is needed to further investigate the role of MTS leaders in shaping member cognition. For example, research is needed to identify the degree to which component team members' cognitions can be shaped by leaders of *other* component teams. Inter-group leadership theory suggests messages are most likely to be accepted by followers when they are expressed by a member of the follower's own subgroup (Hogg et al., 2012). A leader of one component team may need to expend extra effort to gain influence over members of another component team. Ironically, however, leaders who interact too frequently and closely with members of other groups can lose credibility within their own groups if they begin to be perceived as an outgroup leader (Hogg et al., 2012). Thus, the two-step top-down approach to developing MTS cognition might be warranted in which: (a) MTS leaders collectively make sense of the MTS environment and agree on appropriate coordination timing and action sequencing for component teams; and (b) leader teams diffuse their knowledge throughout the system, especially focusing on developing the cognition within their own component teams. This approach may be appropriate for the MTS context because it allows MTS leaders to maintain their ingroup leadership status while developing strategic consensus in the leadership team. Future research should seek to establish the efficacy of this approach.

Lastly, our analyses extend DeChurch and Marks (2006) findings by establishing collective cognition as an intervening mechanism through which functional leadership affects MTS performance. Importantly, the present work answers calls for research that not only identifies effective training content, but also elaborates why particular types of training are effective (i.e., the mediators of training–performance relationships; Kozlowski & Bell, 2006). Research that disentangles these elements of training can facilitate theory-building and inform leader training and development. In our sample MTSs, leaders were exposed to two unique training manipulations—one teaching them to seek out information related to MTS-level interactions and goals and to integrate this information into their strategic plans (i.e., strategy training), and one designed to affect their direct intervention in coordination during MTS action phases (i.e., coordination training). Whereas, the manipulation designed to affect leaders' direct intervention in between-team coordination during the action phase did not significantly impact leader mental model accuracy, the manipulation designed to affect the type of information leaders pay attention to during planning phases did have a significant impact on subsequent leader (and follower) mental models. This finding aligns with theoretical depictions of team leadership: leader information search is thought to provide "the grist for meaning making and sensegiving to team members, allowing the development of more comprehensive and effective team mental models" (Zaccaro et al., 2001, p. 461). Our results underscore the importance of leader information search and strategic planning by identifying the implications of these leadership processes for accurate MTS cognition.

Moreover, our study provides an actionable suggestion for leaders of multiple teams. Our findings suggest that to develop a common frame of reference throughout the system, MTS leaders should strive to develop their own system-wide understanding during planning periods by seeking out information related not only to the functioning of their own team but also to the interactive nature of the system as a whole. Then, leaders can help build an effective system-wide cognitive architecture by relaying this information to followers through strategic plans.

Limitations and future research directions

As with most research, the current study has several limitations that open up avenues for future research. The first is the relatively small size of our sample MTSs. It is possible that in larger MTSs, cognitive structures may function slightly differently. However, the sample MTS were carefully constructed to mirror the defining features of MTSs (Mathieu et al., 2001). The two component teams had different, and somewhat competing proximal goals (i.e., allocating effort to helping the other team may threaten the team's survival and ability to destroy its own targets), but teams shared a distal MTS goal. Establishing the effect of cognition in a relatively small MTS is necessary to ground future work on larger and more complex MTSs, so that possible fractal as well as non-fractal qualities can be recognized.

Further, we argue that the importance of MTS cognition and the top-down process of leaders shaping it may even increase in larger systems. First, in large MTSs, members may find it even more difficult to understand the knowledge possessed and functions enacted by all other members. This may decrease the likelihood that teams understand how they should interact with other teams—and when they should rely on other teams to engage in certain behaviors. Second, to establish collective cognition through a bottom-up emergent process requires communication and interaction among many of the members in the collective (Pearsall et al., 2010). As collectives increase in size, the number of possible communication relationships that could be formed among them increases exponentially (the law of *N*-squared: Krackhardt, 1994). Thus, the role of leadership in the top-down development of MTS cognition likely becomes more necessary in more complex systems. Future research could seek to verify this proposition.

The second study limitation is that the sample was comprised of undergraduate students participating in a short-lived, simulated MTS task. Although, the present sample provided the benefit of allowing comparison across 64 identical systems of interdependent teams, additional research is needed to verify these relationships in existing "real-world" systems. Further, in longer-term MTSs, where members may have more opportunities to interact with one another within and across teams, MTS cognition may emerge out of types of social conduits other than leader behavior. Thus, members may not need to rely as much on their leaders to understand what other teams value or prioritize. Although this is a concern for the generalizability of the present results, we argue that even when component teams have more opportunity to interact in less structured ways, the efficiency and stability that can be gained when leaders drive system cognition are still beneficial.

Further, all sample teams and MTSs were assembled at the same time. In many real-world situations, however, new component teams join or leave previously established MTSs as task demands shift (Tannenbaum, Mathieu, Salas, & Cohen, 2012). As teams enter or leave these dynamically changing systems, both new and existing teams need to adapt their understanding of how component teams should interact. Findings from the current study are appropriately generalized to MTSs where component teams join the system at the same entry point, and provide a comparison point for future studies of more dynamic MTSs. Nonetheless, we underscore the need for future work that sheds light on the adaptive processes involved in shifting MTS cognition as teams cycle in and out of the MTS.

A final study limitation is the use of the same sample of MTSs as DeChurch and Marks (2006). Although each study contributes uniquely to the basic understanding of MTS leadership, and explains distinct mechanisms through which leaders enable MTS success, they are based on different data obtained from the same sample of MTSs. And so, these studies should not be construed as providing independent evidence (in general) of the utility of leadership in enabling the success of MTSs. We especially note this study attribute for any future meta-analyses of leadership. Future research is needed that explores the role of leadership in multiteam and intergroup collaboration in a variety of MTSs with different compositional and linkage attributes (Zaccaro, Marks, & DeChurch, 2012).

Finally, because MTSs often require coordination among multiple leaders (Davison et al., 2012; DeChurch & Marks, 2006), we suggest future research that investigates how leaders influence one another toward developing accurate MTS cognition. In MTSs, developing perceptions of how teams should interact with one another can be political and complex. MTS leaders, who are often representatives of each component team (Zaccaro & DeChurch, 2012), may need to engage in negotiation and compromising processes as they develop collective cognition. However, as suggested by our findings, the consequences for MTS functioning of developing accurate MTS mental models can be substantial. Thus, understanding the processes through which multiple MTS leaders negotiate their collective understanding is an essential direction for the study of MTS cognition.

Conclusion

As organizations have restructured work around teams, there is an increasing need for those teams to integrate their efforts to achieve superordinate goals; patient-centered health care, inter-agency disaster response, international joint ventures, to name a few, require close integration between specialized teams. Leaders are crucial in preventing MTS failures that would arise as teams fall into the chasm of misunderstanding. This study contributes an important piece of the puzzle of how leaders facilitate between-team coordination and thereby enable multiteam success. Our results highlight a critical mechanism through which leader teams can effectively command systems—multiteam-interaction mental models. Our results demonstrate that leaders need to "mind the gap" between teams by strategically communicating an accurate understanding of how each component teams' actions are related to those of the other teams in the system.

Acknowledgments

This research was funded in part by the Air Force Office for Sponsored Research Contract F49620-98-1-0278. The views expressed in this article are those of the authors and do not reflect the official policy or position of the U.S. Air Force, Department of Defense, or U.S. government. This research was supported in part by the Army Research Institute for the Social and Behavioral Sciences under contract W5J9CQ12C0017. The views, opinions, and/or findings contained in this report are those of the authors, and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documents. This material is based upon work supported by the National Science Foundation under Grant No. SES-1219469. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

Ancona, D.G., & Caldwell, D. F. (1992). Bridging the boundary: External activity and performance in organizational teams. *Administrative Science Quarterly*, *37*, 634–665.
Ancona, D.G., & Chong, C. L. (1996). Entrainment: Pace, cycle, and rhythm in organizational behavior. *Research in Organizational Behavior*, *18*, 251–284.
Bentler, P.M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, *107*, 238–246.
Bentler, P.M. (2007). On tests and indices for evaluating structural models. *Personality and Individual Differences*, *42*, 825–829.
Bentler, P.M., & Bonett, D.G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, *88*, 588–606.
Cannon-Bowers, J. A., Salas, E., & Converse, S. (1993). Shared mental models in expert team decision-making. In J. N. Castellan (Ed.), *Individual and group decision-making* (pp. 221–246). Hillsdale, NJ: Lawrence Erlbaum.
Carter, D. R., & DeChurch, L. A. (2014). Leadership in multiteam systems: A network perspective. In D. V. Day (Ed.), *Oxford handbook of leadership* (pp. 482–501). Oxford University Press.
Caruso, H. M., Rogers, T., & Bazerman, M. H. (2013). Boundaries need not be barriers. In T. L. Pittinsky (Ed.), *Crossing the divide: Intergroup leadership in a world of difference* (pp. 142–154). Harvard Business Press.
Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum.
Davison, R. B., Hollenbeck, J. R., Barnes, C. M., Sleesman, D. J., & Ilgen, D. R. (2012). Coordinated action in multiteam systems. *Journal of Applied Psychology*, *97*, 808–824.
DeChurch, L. A., & Marks, M.A. (2006). Leadership in multiteam systems. *Journal of Applied Psychology*, *91*, 311–326.
DeChurch, L. A., & Mesmer-Magnus, J. R. (2010). The cognitive underpinnings of effective teamwork: A meta-analysis. *Journal of Applied Psychology*, *95*, 32–53.
DeChurch, L. A., & Zaccaro, S. J. (2010). Perspectives: Teams won't solve this problem. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *52*, 329–334.
Edwards, B.D., Day, E. A., Arthur, W., & Bell, S. T. (2006). Relationships among team ability composition, team mental models, and team performance. *Journal of Applied Psychology*, *91*, 727–736.
Ellis, A. P. (2006). System breakdown: The role of mental models and transactive memory in the relationship between acute stress and team performance. *Academy of Management Journal*, *49*, 576–589.
Ernst, C., & Chrobot-Mason, D. (2011). Flat world, hard boundaries-how to lead across them. *MIT Sloan Management Review*, *52*, 81–88.
Fiedler, F. E. (1967). *A theory of leadership effectiveness.* New York: McGraw-Hill.
French, J. R. P., & Raven, B. (1959). The bases of social power. In D. Cartwright (Ed.), *Studies in social power* (pp. 150–167). Oxford, Ann Arbor: University of Michigan.
Hogg, M.A., van Kippenberg, D., & Rast, D. E. (2012). Intergroup leadership in organizations: Leading across group and organizational boundaries. *Academy of Management Review*, *37*, 232–255.
House, R. J. (1971). A path goal theory of leadership effectiveness. *Administrative Science Quarterly*, *16*, 321–338.
Hu, L., & Bentler, P.M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods*, *3*, 424–453.
Hu, L., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*, 1–55.
Iaquinto, A. L., & Fredrickson, J. W. (1997). Top management team agreement about the strategic decision process: A test of some of its determinants and consequences. *Strategic Management Journal*, *18*, 63–75.
James, L. R., Mulaik, S. A., & Brett, J. M. (2006). A tale of two methods. *Organizational Research Methods*, *9*, 233–244.
Kazanjian, R. K., Drazin, R., & Glynn, M.A. (2000). Creativity and technological learning: The roles of organization architecture and crisis in large-scale projects. *Journal of Engineering and Technology Management*, *17*, 273–298.
Klimoski, R., & Mohammed, S. (1994). Team mental model: Construct of metaphor? *Journal of Management*, *20*, 403–437.
Kozlowski, S. W. J., & Bell, B. J. (2006). Disentangling achievement orientation and goal setting: Effects on self-regulatory processes. *Journal of Applied Psychology*, *91*, 900–916.
Kozlowski, S. W. J., & Doherty, M. L. (1989). Integration of climate and leadership: Examination of a neglected issue. *Journal of Applied Psychology*, *74*, 546–553.
Krackhardt, D. (1994). Constraints on the interactive organization as an ideal type. In C. Heckscher, & A. Donnellan (Eds.), *The post-bureaucratic organization: New perspectives on organizational change* (pp. 211–222). Beverly Hills, CA: Sage.
Lanaj, K., Hollenbeck, J. R., Ilgen, D. R., Barnes, C. M., & Harmon, S. J. (2013). The double-edged sword of decentralized planning in multi-team systems. *Academy of Management Journal*, *56*, 1–61.
Lau, D. C., & Murnighan, J. K. (1998). Demographic diversity and faultlines: The compositional dynamics of organizational groups. *Academy of Management Review*, *23*, 325–340.
Levesque, L. L., Wilson, J. M., & Wholey, D. R. (2001). Cognitive divergence and shared mental models in software development project teams. *Journal of Organizational Behavior*, *22*, 135–144.
Li, J., & Hambrick, D. C. (2005). Factional groups: A new vantage on demographic faultlines, conflict, and disintegration in work teams. *Academy of Management Journal*, *48*, 794–813.
MacCallum, R. C., & Austin, J. T. (2000). Applications of structural equation modeling in psychological research. *Annual Review of Psychology*, *51*, 201–226.
MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods*, *7*, 83.
MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research*, *39*, 99–128.
Marks, M.A., Burke, C. S., Parker, C. W., Higgins, J. M., Zaccaro, S. J., & Perez, R. S. (1997, April). Improving team effectiveness through team interaction training. *Paper presented at the meeting of the Society for Industrial/Organizational Psychology, St. Louis, MO*.
Marks, M.A., DeChurch, L. A., Mathieu, J. E., Panzer, F. J., & Alonso, A. (2005). Teamwork in multiteam systems. *Journal of Applied Psychology*, *90*, 964–971.
Marks, M.A., Mathieu, J. E., & Zaccaro, S. J. (2001). A temporally based framework and taxonomy of team processes. *Academy of Management Review*, *26*, 356–376.
Marks, M.A., Sabella, M. J., Burke, C. S., & Zaccaro, S. J. (2002). The impact of cross-training on team effectiveness. *Journal of Applied Psychology*, *87*, 3–13.

Marks, M.A., Zaccaro, S. J., & Mathieu, J. E. (2000). Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. *Journal of Applied Psychology*, *85*, 971–986.
Mathieu, J. E., Cobb, M.A., Marks, M.A., Zaccaro, S. J., & Marsh, S. (2004). Multiteam ACES: A research platform for studying multiteam systems. In S. G. Schiflett (Ed.), Burlington, VT: Ashgate Publishing Company.
Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Cannon-Bowers, J. A., & Salas, E. (2005). Scaling the quality of teammates' mental models: Equifinality and normative comparisons. *Journal of Organizational Behavior*, *26*, 37–56.
Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology*, *85*, 273–283.
Mathieu, J. E., Marks, M.A., & Zaccaro, S. J. (2001). Multiteam systems. In N. Anderson, D. S. Ones, H. K. Sinangil, & C. Viswesvaran (Eds.), *Handbook of industrial, work, and organizational psychology*, *Vol. 2*, London: Sage Publications.
McIntyre, H. H., & Foti, R. J. (2013). The impact of shared leadership on teamwork mental models and performance in self-directed teams. *Group Processes and Intergroup Relations*, *16*, 46–57.
Mohammed, S., Ferzandi, L., & Hamilton, K. (2010). Metaphor no more: A 15-year review of the team mental model construct. *Journal of Management*, *36*, 876–910.
Murase, T., Resick, C. J., Jiménez, M., Sanz, E., & DeChurch, L. A. (2011). Leadership and emergent collective cognition. In E. Salas, S. M. Fiore, & M. P. Letsky (Eds.), *Theories of team cognition: Cross-disciplinary perspectives*. New York, NY: Routledge.
Novak, J.D. (1990). Concept maps and Venn diagrams: Two metacognitive tools to facilitate meaningful learning. *Instructional Science*, *19*, 29–52.
Pearsall, M. J., Ellis, A. P. J., & Bell, B.S. (2010). Building the infrastructure: The effects of role identification behaviors on team cognition development and performance. *Journal of Applied Psychology*, *95*, 192–200.
Pfeffer, J., & Salancik, G. R. (1977). Organization design: The case for a coalitional model of organizations. *Organizational Dynamics*, *6*, 15–29.
Crossing the divide: Intergroup leadership in a world of difference. Pittinsky, T. L. (Ed.). (2009). Harvard Business Press.
Pittinsky, T. L. (2010). A two-dimensional model of intergroup leadership: The case of national diversity. *American Psychologist*, *65*, 194.
Pittinsky, T. L., & Simon, S. (2007). Intergroup leadership. *The Leadership Quarterly*, *18*, 586–605.
Randall, K. R., Resick, C. J., & DeChurch, L. A. (2011). Building team adaptive capacity: The roles of sensegiving and team composition. *Journal of Applied Psychology*, *96*, 525–540.
Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*, 1–36.
Salancik, G. R., & Pfeffer, J. (1978). A social information processing approach to job attitudes and task design. *Administrative Science Quarterly*, *23*, 224–253.
Schleicher, Deidra J., & Day, David V. (1998). A cognitive evaluation of frame-of-reference rater training: Content and process issues. *Organizational Behavior and Human Decision Processes*, *73*(1), 76–101.
Schneider, B., Ehrhart, M. G., Mayer, D.M., Saltz, J. L., & Niles-Jolly, K. (2005). Understanding organization-customer links in service settings. *Academy of Management Journal*, *48*, 1017–1032.
Seyranian, V. (2014). Social Identity Framing communication strategies for mobilizing social change. *The Leadership Quarterly*, *25*, 468–486.
Smith-Jentsch, K. A., Cannon-Bowers, J. A., Tannenbaum, S. I., & Salas, E. (2008). Guided team self-correction impacts on team mental models, processes, and effectiveness. *Small Group Research*, *39*, 303–327.
Smith-Jentsch, K. A., Mathieu, J. E., & Kraiger, K. (2005). Investigating linear and interactive effects of shared mental models on safety and efficiency in a field setting. *Journal of Applied Psychology*, *90*(523), 535.
Standifer, R., & Bluedorn, A. (2006). Alliance management teams and entrainment: Sharing temporal mental models. *Human Relations*, *59*, 903–927.
Tajfel, H., & Turner, J. C. (1979). An integrative theory of intergroup conflict. In W. G. A. S. Worchel (Ed.), *The social psychology of intergroup relations* (pp. 33–47). Monterey, CA: Brooks/Cole.
Tanguma, J. (2001). Effects of sample size on the distribution of selected fit indices: A graphical approach. *Educational & Psychological Measurement*, *61*, 759–776.
Tannenbaum, S. I., Mathieu, J. E., Salas, E., & Cohen, D. (2012). Teams are changing: Are research and practice evolving fast enough? *Industrial and Organizational Psychology*, *5*, 2–24.
Thompson, J.D. (1967). *Organizations in action*. New York: McGraw-Hill.
Turner, J. C. (1984). Social identification and psychological group formation. In H. Tajfel (Ed.), *The social dimension: European developments in social psychology*, *Vol. 2*. (pp. 518–538). Cambridge, England: Cambridge University Press.
van Ginkel, W. P., & van Knippenberg, D. (2008). Group information elaboration and group decision making: The role of shared task representations. *Organizational Behavior and Human Decision Processes*, *105*, 82–97.
van Ginkel, W. P., & van Knippenberg, D. (2009). Knowledge about the distribution of information and group decision making: When and why does it work? *Organizational Behavior and Human Decision Processes*, *108*, 218–229.
van Ginkel, W. P., & van Knippenberg, D. (2012). Group leadership and shared task representations in decision making groups. *The Leadership Quarterly*, *23*, 94–106.
van Knippenberg, D., De Dreu, C. K. W., & Homan, A.C. (2004). Work group diversity and group performance: An integrative model and research agenda. *Journal of Applied Psychology*, *89*, 1008–1022.
Waller, M. J., Gupta, N., & Giambatista, R. C. (2004). Effects of adaptive behaviors and shared mental models on control crew performance. *Management Science*, *50*, 1534–1544.
Zaccaro, S. J., & DeChurch, L. A. (2012). Leadership forms and functions in multiteam systems. In S. J. Zaccaro, M.A. Marks, & L. A. DeChurch (Eds.), *Multiteam systems: An organizational form for dynamic and complex environments*. New York: Routledge.
Zaccaro, S. J., Marks, M.A., & DeChurch, L. A. (2012). Multiteam systems: An introduction. In S. J. Zaccaro, M.A. Marks, & L. A. DeChurch (Eds.), *Multiteam systems: An organizational form for dynamic and complex environments*. New York: Routledge.
Zaccaro, S. J., Rittman, A. L., & Marks, M.A. (2001). Team leadership. *The Leadership Quarterly*, *12*, 451–483.