

Exploring the Benefits and Boundaries of Transactive Memory Systems in Adapting to Team Member Loss

Jessica Siegel Christian,
Matthew J. Pearsall,
and Michael S. Christian
University of North Carolina

Aleksander P. J. Ellis
University of Arizona

This study examines how teams respond to unplanned member loss. We draw on theory of team compilation and adaptation to suggest that teams with well-developed transactive memory systems (TMS) will be better equipped to withstand the loss of a member. Then, based on role criticality theories, we argue that those effects depend on which member is absent, such that when a more critical member is lost, the performance benefits of a TMS are reduced. Finally, we reason that this interactive effect is because of the team's ability to engage in plan formulation. We tested and found support for our hypotheses using 78 four-member teams engaged in a command-and-control simulation. TMS positively affected team performance following the loss of a member, but the benefits of the TMS were reduced following the loss of a critical member because teams had more difficulty engaging in plan formulation. We discuss how the results of this study add to our understanding of the precursors of successful team adaptation.

Keywords: team adaptation, transactive memory, critical team member

Team-based organizations often operate in dynamic environments where survival depends on the ability to successfully adapt to changing circumstances (Kozlowski, Gully, Nason, & Smith, 1999). Increasing competition, globalization, and technological changes have created a need for more flexible and adaptive responses (Kozlowski & Bell, 2003; Volberda, 1996). Teams are thought to have adaptive advantages over individuals (Kozlowski et al., 1999), leading researchers to turn their focus toward team adaptation as an essential performance criterion (e.g., Burke, Stagl, Salas, Pierce, & Kendall, 2006; Chen, Thomas, & Wallace, 2005; DeRue, Hollenbeck, Johnson, Ilgen, & Jundt, 2008; LePine, 2003, 2005; Marks, Zaccaro, & Ma-

thieu, 2000; Waller, 1999). In organizations, teams must adapt to a wide-ranging set of circumstances, including external contingencies such as communication equipment failures (LePine, 2003, 2005) or unfamiliar performance contexts (Marks et al., 2000) and internal structural contingencies such as planned downsizing (DeRue et al., 2008) or member replacement (e.g., Moreland, 1999). The nature of the contingency is important because it determines both the extent to which specific team processes are disrupted and the team's ensuing response (Burke et al., 2006; Kozlowski & Klein, 2000).

The first purpose of this study is to expand our understanding of the range of contingencies teams face to include situations where a team member is unexpectedly lost or absent and *not* replaced. This situation is commonplace. In action teams such as military units or firefighters, members are sometimes injured or incapacitated, leaving the team short on resources and skills. In project, decision-making, and customer service teams, members may unexpectedly need to travel, fall ill, or be called away on other assignments (see Sundstrom, 1999). For these types of teams with specialized expertise,

Jessica Siegel Christian, Matthew J. Pearsall, and Michael S. Christian, Kenan-Flagler Business School, University of North Carolina; Aleksander P. J. Ellis, The Eller College of Management, University of Arizona.

Correspondence concerning this article should be addressed to Jessica Siegel Christian, University of North Carolina, Kenan-Flagler Business School, McColl Building 4734, Chapel Hill, NC 27599. E-mail: jessica_christian@unc.edu

losing a member can be particularly detrimental because of the concurrent loss of the member's unique knowledge and skills. Despite this, no research has examined factors that predict successful performance in the situation where a member is unexpectedly lost. Research suggests that adjusting to a change in the task or environmental structure requires a series of continuous developmental processes that compile over time (Burke et al., 2006). The unexpected loss of a member represents a different situation and requires the team to quickly find new ways to redirect the remaining members' distributed knowledge to perform at a high level. We are interested in teams' initial response to the loss of a member and how members quickly adjust their behaviors to meet this unexpected challenge.

Our second purpose is to uncover factors that help and hinder adaptation to member loss. In terms of successful adaptation, we examine team performance following the loss of a member. Kozlowski et al.'s (1999) compilation theory suggests that team members are better equipped to deal with losing a team member when they understand the roles and responsibilities of their teammates and how they connect together. Therefore, we suggest that a team's transactive memory system (TMS)—an organized store of knowledge that is contained entirely in the individual memory systems of group members; a set of knowledge-relevant transactive processes that occur among group members (Wegner, Giuliano, & Hertel, 1985)—plays an important role in how teams perform following the loss of a member.

Our study is not the first to examine TMS in adaptive team contexts. Previous research has provided valuable insight into how a TMS impacts team effectiveness when new members are added to a team (e.g., Levine & Choi, 2004; Lewis, Belliveau, Herndon, & Keller, 2007) and how the benefits of a TMS are reduced when team membership is scrambled after training (Moreland, 1999; Moreland & Argote, 2003; Moreland, Argote, & Krishnan, 1996; Moreland & Myaskovsky, 2000). However, these studies have generally viewed TMS as an outcome variable that is negatively affected by the addition of newcomers, or as a mediator of the effects of team training strategies. We take the literature on TMS and team adaptation in a different direction, suggesting that TMS represents an

important predictor of adaptive success (i.e., team performance) in situations where teams lose a member.

However, the potential benefits of a TMS may depend on the role played by the lost team member. Not all positions within a team are equally important to the team's workflow (Arrow & McGrath, 1993; Kozlowski et al., 1999). According to Humphrey, Morgeson, and Mannor's (2009) strategic core theory, team members in highly critical positions are more "core" to the team. We argue that teams with a well-developed TMS will be able to withstand the loss of a less critical team member, but will have more trouble compensating for the loss of a highly critical member.

Our final objective is to uncover the mechanism underlying this conditional relationship. Kozlowski et al. (1999) argued that adaptive teams must have the ability to choose a plan for action. In an effort to respond effectively to new demands, teams must quickly devise a strategy to address the change so that the lost members' responsibilities are not neglected (Burke et al., 2006; Stout & Salas, 1993). We argue that the loss of critical nodes within the TMS will hamper the availability of information required for the team to effectively formulate adaptive plans. Therefore, we expect *plan formulation* to represent a key mechanism explaining why losing a critical member reduces the effects of TMS on team performance following member loss.

With this research, we contribute to the team adaptation literature in several ways. First, we expand the typology of adaptive contexts by examining team performance following the loss of a team member. Second, based on the unique requirements of this form of adaptation, we identify a team's TMS as a key determinant of success. Third, we establish criticality as an important boundary condition that determines the degree to which performance is influenced by TMS. Finally, we uncover and examine plan formulation as a mechanism underlying the interactive effects of TMS and criticality on team performance.

Transactive Memory Systems and Team Performance Following Member Loss

Transactive memory was originally conceived by Wegner and colleagues (Wegner, 1987; Wegner et al., 1985) as a way to explain

the behavior of individuals in close relationships. Wegner noticed that couples tend to have a system for processing information that allows them to do more without exhausting their cognitive resources, which he labeled transactive memory. Each member of a couple develops a specific domain of knowledge and expertise, taking responsibility for any relevant information within that domain. By doing so, they establish information exchange patterns between differentiated memory banks that allows them to more efficiently and effectively complete tasks. For example, a wife may remember family birthdays better than her husband and, therefore, will be recognized as the “expert” in birthday scheduling. This frees the husband from having to encode and store this information in his own memory because he knows that he can access the information regarding birthdays from her at any time.

At the team level, a TMS operates much like a computer network, in which each of the group members are information nodes that their teammates can use to access specific information or to send information to be stored for later retrieval by other members of the team (Wegner, 1995). These systems involve the knowledge of individual group members, combined with a shared awareness of who knows what (Moreland & Myaskovsky, 2000). Wegner et al. (1985) defined transactive memory as having two components: an organized store of knowledge contained within the individual memories of group members, and a set of knowledge-relevant transactive processes that occur across members. By distributing responsibility of different domains of expertise across the team, transactive memory provides an information processing system that enables teams to develop deep, discrete domains of expertise, reducing their cognitive load while providing access to their combined knowledge to all team members (see Hinsz, Tindale, & Vollrath, 1997). Therefore, it enables “quick and coordinated access to deep, specialized knowledge, so that a greater amount of task-relevant expertise can efficiently be brought to bear on team tasks” (Lewis, 2003, p. 587).

Two different yet compatible approaches to studying transactive memory have emerged in the extant organizational and social psychological literatures. Organizational researchers typically break the construct into three dimensions

that reflect emergent cognitive aspects of transactive memory: memory differentiation (development and recognition of specialized areas of expertise within the team), task coordination (effective combination of knowledge), and task credibility (trust in one another’s competence and expertise; Liang, Moreland, & Argote, 1995). TM has been conceptualized as “a combination of knowledge possessed by each individual and a collective awareness of who knows what,” (Austin, 2003, p. 866). Lewis (2003) provided additional refinement of these dimensions, which resulted in a widely used scale measuring *specialization* (the level of memory differentiation within a team), *coordination* (the ability of members to work together effectively), and *credibility* (members’ beliefs about the reliability of other members’ knowledge).

Social psychological researchers have often focused on the communications associated with these emergent cognitions, primarily following Wegner’s (1987) conceptualization of the construct, focusing on *directory updating*, *information allocation*, and *retrieval coordination*. This approach focuses on the “transactions” between team members—encoding and retrieval process (Hollingshead, 1998b, 1998c; Wegner, 1995)—that reflect the emergence and development of the underlying transactive memory system. Directory updating refers to learning what others know, information allocation refers to communicating new information to a member whose expertise will facilitate its storage, and retrieval coordination refers to retrieving information on a needed topic from a member with expertise in the domain of interest. Although this work began with examinations of dyads (Hollingshead, 1998a, 1998c; Wegner, Erber, & Raymond, 1991), it has been extended to work teams (see Ellis, 2006). It is important that the underlying cognitive structure of the TMS precedes the transactions (see Ellis, Porter, & Wolverton, 2008). Thus, research on transactive memory communications (i.e., transactions) assumes that a TMS structure is already in place and is smoothly operating.

Both approaches represent viable operationalization of transitive memory in studies of teams. In our research, we are particularly interested in team processes and thus focus on transactive memory communications because (a) we are interested in how teams behave and communicate in adaptive situations, (b) the

teams examined in this study were formed for a short period of time which makes the *credibility* dimension less applicable, and (c) our study involved “preprogramed” levels of distributed expertise.

To develop hypotheses regarding the effect of transactive memory following member loss, we use Kozlowski et al.’s (1999) compilation theory. Compilation theory argues that teams develop adaptive capabilities over time by shifting their focal level and paying attention to different content, processes, and outcomes in different stages. In the first phase, *team formation*, team members seek basic information about the nature of the team and their place in it. In the second phase, *task compilation*, members focus on demonstrating their task competency and begin to monitor and regulate performance on their individual tasks. In the third phase, *role compilation*, members explore dyadic relationships with other members—they begin to understand how their task outputs affect other members with whom they directly interact. The final phase, *team compilation*, involves a focus on the entire team. In this phase, members develop an understanding of the role linkages among the entire team, and they learn how to improve their network of roles.

According to compilation theory, TMSs develop through dyadic role-based exchanges in the role compilation phase of team development (also see Pearsall, Ellis, & Bell, 2010). Through these role-based exchanges team members learn “who knows what” within the team and begin to coordinate the flow of information with teammates who are responsible for storing or applying it. During this phase of team development, members engage in a “mutual process of role negotiation,” (Kozlowski et al., 1999, p. 266) where they learn how to tailor their interactions and coordinate with other members. The more these activities take place, the more well-developed the TMS (Palazzolo, Serb, She, Su, & Contractor, 2006) and the greater the amount of resources that can be exchanged among members (Balkundi & Harrison, 2006). TMSs therefore allow for greater performance efficiencies as members are required to handle only the information they need while receiving the task-related information necessary to promptly execute their tasks, improving team coordination, performance, and satisfaction (e.g., Lewis,

2004; Liang et al., 1995; Moreland & Myaskovsky, 2000; Ren & Argote, 2011).

When faced with the loss of a member, these benefits translate directly into preserving the team’s ability to function. Compilation theory suggests that adapting to such a change requires team members to have a well-developed understanding of the relationships among members and the ability to coordinate knowledge exchange. When a team member is lost, the team must act quickly to account for the increased workload and the loss of that member’s knowledge. We suggest that a TMS provides these benefits, although this notion has yet to be empirically tested. Previous work in this area has examined membership change and how the TMS and knowledge structure is affected by newcomers or complete membership turnover. Lewis et al. (2007) examined how membership change impacted TMS, finding that partially intact groups relied on an outdated TMS structure in a second experimental session, which hindered team performance compared with intact groups and completely reconstituted groups. Baumann (2001) compared TMS development in intact groups to development in newly composed groups and found that when members were assigned to work with a new group with the same role structure to their previous group, they could still develop a TMS.

Other work has addressed membership changes in teams but has not specifically addressed the role of TMSs. For example, Kane, Argote, and Levine (2005) examined how knowledge was transferred when individuals were rotated among groups, and Levine, Choi, and Moreland (2003) examined conditions that result in newcomer knowledge transfer and persuasive abilities. Summers, Humphrey, and Ferris (2012) showed the importance of flux, a critical emergent state during member change and how it is impacted by which team member is replaced and the newcomer’s relative cognitive ability. Although these works have provided valuable insight into how the TMS functions when a new member is brought into the team (Lewis et al., 2007) and general membership change, they have not addressed the role of the TMS in adapting to losing a member. A key differentiating factor is that in studies of membership change, teams still have a full complement of knowledge, skills, and manpower to accomplish their work. When teams lose a

member—with no replacement—remaining members must shift responsibilities among themselves without having a full set of resources.

A TMS should help the team survive the loss of a member by providing members with an understanding of the patterns of knowledge exchange and the relationships between members, which promotes adaptability by allowing them to rapidly respond with appropriate behaviors (Kozlowski et al., 1999). Teams with a functioning TMS will be better able to actively reassign task duties based on team members' existing knowledge domains and are "more likely to fully utilize members' expertise and realize the value of embedded team knowledge" (Lewis, 2004, p. 1519). Understanding connections between members should help the team "reconfigure the network to meet immediate internal or external contingencies" (Kozlowski et al., 1999, p. 254). As team members are accustomed to frequently searching for and distributing information within the team based on their teammates' knowledge domains, TMS communication patterns within the team will help reduce the amount of information and capacity that is lost along with the missing member and provide performance efficiencies that minimize any loss in team performance. A working TMS creates a shared understanding of member–expertise associations, which helps members to anticipate how other team members will behave and react (Cannon-Bowers, Salas, & Converse, 1993; Lewis, 2004). In a recent review article, Zajac, Gregory, Bedwell, Kramer, and Salas (2013) argued that for teams to successfully adapt in an ill-defined problem situation, members must know who holds what knowledge and how to draw on that knowledge. This shared understanding should positively affect member behavior following a loss, as members will implicitly understand which of the remaining members can fill in for the missing member.

As discussed earlier, a critical question for teams in member loss situations is how they use their existing TMS to respond in the short term. We are interested in unexpected and typically short-term losses as opposed to permanent downsizing that would likely necessitate large-scale modifications to the TMS. When members view losing a member as a temporary situation, they will respond with work-around behavior,

turning their attention to the realignment of work, which is most critical in the short term. Thus, we are specifically interested in how the original TMS functions when a node is removed. We hypothesize the following:

Hypothesis 1: Transactive memory will positively affect team performance following the loss of a member.

The Effects of Lost Member Criticality

Certain positions within the team's workflow are likely to have a greater influence on performance than others. Such positions are considered *critical* in nature, given that their removal "breaks the workflow chain" (Brass, 1984, p. 522) and impair the team's ability to distribute and process information. A critical position is defined by the number of irreplaceable connections a team member has within the relationship network (Pearsall & Ellis, 2006). That is, the relative criticality of a role is determined by the number of other team members that can perform that person's function with the actions of less critical members more easily replaced in the team (Brass, 1984, 1985). Criticality therefore refers to substitutability; if other positions within the workflow network cannot easily replace or substitute for a focal position, the position is high in criticality. Team members who occupy critical roles perform important functions; if these duties are not completed, other members cannot complete their tasks. Thus, a critical member possesses unique knowledge and information (Girvan & Newman, 2002), making this role more crucial for the achievement of performance goals.

Teams are often designed to include a critical member such that "one role is more tightly linked to the overall performance of the team than are other roles" (Humphrey et al., 2009, p. 49). Such roles are more "core" to the team because, according to the theory of the strategic core, these individuals (a) encounter more problems that must be overcome in the team, (b) have greater exposure to team tasks, and (c) are more central to the workflow of the team. Core roles are more critical in terms of resources and workflow and therefore more critical to TMS, given that a core member completes tasks that cannot be completed by other members. This

argument is consistent with work on structural holes in networks; individuals who occupy core roles have greater access to information within the network and greater control over the network (Burt, 1992, 1995).

In essence, the criticality of a missing member determines the size of the “hole” in the team’s TMS left by his or her absence. When a more critical team member is lost, the size of the “hole” is substantially larger than if a less critical team member is missing. Although each possesses unique skills and expertise, the responsibilities of the less critical role are more easily filled by one or more of their teammates. Further, because of their importance to the patterns of interaction within the team the loss of a more critical role is most likely to affect the whole team (Kozlowski et al., 1999), whereas the loss of a noncritical member has less impact on knowledge sharing and coordination within the team. When a critical member is lost, it is more likely that workflow systems that the team previously relied on will no longer function properly, causing a breakdown in the TMS. As such, the benefits of TM during team performance following the loss of a member will diminish as the criticality of the lost member increases. As a result, we hypothesize:

Hypothesis 2: The effects of transactive memory on team performance will be moderated by the criticality of the lost team member, such that the benefits of transactive memory will be reduced when a team loses a more critical member.

The Mediating Role of Plan Formulation

Compilation theory (Kozlowski et al., 1999) and other theories of adaptation (Burke et al., 2006) suggest that plan formulation plays a significant role in the relationship between TM, criticality, and team performance in member loss situations. Plan formulation is defined by Burke et al. (2006) as “deciding on a course of action, setting goals, clarifying member roles and responsibilities with the context of a course of action, discussing relevant environmental characteristics and constraints, prioritizing tasks, clarifying performance expectations, and sharing information related to task requirements” (p. 1194). During plan formulation, teams generate a sequence of actions designed

to transform the current environmental state into the desired or goal state (Burke et al., 2006; Rosen et al., 2011), and plans function as “a guiding framework, aiding team members with their interpretation and reaction to the environment” (Rosen et al., 2011, p. 110).

This type of planning helps teams following a nonroutine event. For example, Waller (1999) found that teams that quickly engaged in adaptive planning behaviors following a nonroutine event outperformed teams that did not engage in such behaviors or began engaging in such behaviors at a much later stage, and Zajac et al. (2013) discussed the crucial role of plan formulation in helping teams to adapt to ill-defined environments. Within the context of adapting to member loss, we define plan formulation as communications that serve to “cover” the missing members’ responsibilities, such as redistributing task duties or reprioritizing tasks to account for the loss. To effectively respond to an emergent demand such as the loss of a team member, teams must quickly engage in these types of communications so that the lost member’s responsibilities are not neglected (Burke et al., 2006; Stout & Salas, 1993).

We argue that although plan formulation is crucial for adaptive performance in general (e.g., Burke et al., 2006; Waller, 1999; Zajac et al., 2013), the degree of its occurrence following member loss (and resultant impact on team performance) is driven by the interaction between transactive memory and lost member criticality. Plan formulation is influenced by the combination of transactive memory and lost member criticality, such that when either of these factors is altered, plan formulation will also be more or less likely to occur (see Figure 1). This is because when a team loses a more peripheral member, the team members are able to use their TMS to work around the absence and formulate a plan for dealing with the loss. However, when teams lose a more critical member, the benefits of a TMS will be reduced because it will be more difficult for team members to come up with a plan of attack in dealing with the loss. In essence, more “nodes” will need to be reconfigured, communication channels will need to be restructured, knowledge will need to be absorbed into team members’ knowledge domains, and workload will need to be redistributed within the team. Summers et al. (2012) argued that teams experiencing mem-

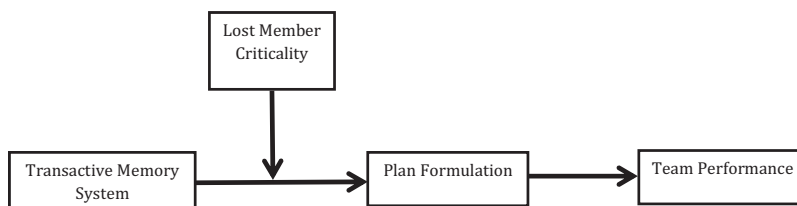


Figure 1. Hypothesized model.

ber change to more strategically core roles should have more difficulty developing new patterns of interaction and routines; an idea which was supported by their data. Team members will need to establish new patterns of interactions to accomplish all of their tasks, given that a “resource hub” is missing. Therefore, we hypothesize the following:

Hypothesis 3: Plan formulation will mediate the interactive effects of lost member criticality and transactive memory on team performance following the loss of a team member.

Method

Participants

Participants included 312 undergraduate students from a large Southwestern United States university who were arrayed into 78 four-person teams. Of the 312 participants, 59.4% were female, 67.9% were White, and their average age was 21 years. Participants received class extra credit in exchange for their participation and were also eligible to receive \$40 each (\$160 per team) based on their team’s performance.

Task

Participants engaged in a modified version of distributed dynamic decision-making (DDD) simulation (see Miller, Young, Kleinman, & Serfaty, 1998). The DDD is a computerized, dynamic command and control simulation requiring participants to monitor and defend a geographic zone against enemy targets. The objective of the task is to protect the region by identifying targets as friendly or enemy and

destroying any enemy targets as quickly as possible.

Geographic region. The geographic region is partitioned into four quadrants of equal size, one for each team member. In the center of the square is a 4×4 square titled the “highly restricted zone.” This square is nested in a larger 12×12 square titled the “restricted zone.” Outside the restricted zone is neutral space.

Bases and vehicles. In terms of monitoring the restricted zone, team members have a home base in the center of their quadrant. Each quadrant has a detection ring around it allowing team members to detect the presence or absence of targets within their base. To detect targets that are not covered by team members’ detection ring, they must request aid from teammates or use the vehicles stationed at their base. Team members were assigned to have four of a certain type of vehicle stationed at each base. There are four different types of vehicles: (a) AWACS (surveillance planes), (b) tanks, (c) helicopters, and (d) jets. Vehicle assets vary along five capabilities: range of vision, speed, duration of operability, identification ability, and power. Assets are distributed such that each vehicle has strengths and weaknesses. For example, AWACS has the greatest range of vision but no power to destroy enemy targets. Tanks have the most power but are the slowest vehicles and have a very limited range of vision. Although all vehicles can detect targets, only AWACS has the ability to identify targets as friendly or enemy and share the information with the rest of the team.

Targets. When targets enter any team member’s detection ring, they show up as unidentified. Once the target is identified by the AWACS plane, any other team member can

engage it with a tank, helicopter, or jet, depending on the strength of the particular target. If the vehicle has the correct level of power (greater than or equal to the target), then the target can be successfully destroyed. In this study, teams faced four different types of targets: E, F, G, and H. The E targets are friendly with a power of 0, and all other targets are unfriendly (enemy targets). The H targets have a power of 1, the G targets have a power of 3, and the F targets have a power of 5.

Team member roles. During the developmental and experimental tasks, team members were given specific areas of responsibility and expertise. These areas of expertise were created by giving each member control over only one type of vehicle and dividing the knowledge about the target power levels among the teammates. During these tasks, DM1 had four AWACS planes and knew that E targets were Power Level 0 (friendly), DM2 had four tanks and knew that F targets were Power Level 5, DM3 had four helicopters and knew that G targets were Power Level 3, and DM4 had four jets and knew that H targets were Power Level 1.

Procedure

Only one team was run through the experiment at a time. Upon entering the laboratory, participants were randomly assigned to one of the four stations (DM1, DM2, DM3, or DM4) as part of a four-person team. Teams were randomly assigned to one of two conditions (more critical team member loss vs. less critical team member loss). In the laboratory, the four stations were situated close enough so that team members could comfortably hear one another verbally, but not closely enough that they could view the computer screens of their teammates. Throughout the experiment team members communicated with each other verbally. After being seated at their stations, participants were trained on the declarative and procedural knowledge necessary to complete the tasks through audio training for approximately 15 min. Following the audio training, participants engaged in a 30-min training task where they learned how to launch vehicles, identify and engage enemy targets, and began working as a team without a specific area of expertise.

After the training task, teams performed a 40-min developmental task, in which each member had a specific area of expertise. Team members were given a “specialty sheet” that illustrated their role for the game, which they were able to keep during the entire task. For example, DM1’s specialty sheet stated that he or she would play the role of AWACS and that E targets had a power level of 0 (friendly). The purpose of the developmental task was to simulate the role compilation phase of team development, allowing team members to begin interacting together and providing them an opportunity to develop their transactive memory systems (see Kozlowski et al., 1999; Pearsall et al., 2010). During this task, teams played the simulation and worked together as a team to identify targets and destroy unfriendly targets in the restricted zone. During this task, the researchers coded transactive memory. At the end of 40 min, the experimenter ended the simulation.

At this point, teams experienced the lost member criticality manipulation (see Lost Member Criticality Manipulation section). Teams were given no time to strategize or plan; instead, the three remaining members immediately began performing the 10-min experimental task, during which plan formulation behavior was coded. The experimental task was not qualitatively different from the developmental task in any way—teams still had the same responsibilities of identifying targets and destroying unfriendly targets. The only difference was the lost member. Team performance was recorded at the end of the experimental task.

Lost Member Criticality Manipulation

Immediately prior to the 10-min experimental task, one member was removed from the team. Criticality is based on the number of alternative workflow channels remaining if a team member is removed from a team; the higher the number of routes, the less critical the team member (Brass, 1984, 1985). Following Ellis, Bell, Ployhart, Hollenbeck, and Ilgen (2005) and Pearsall and Ellis (2006), the criticality of all the roles was created by distributing assets unequally between team members. We then manipulated the relative criticality of the removed member such that teams in the high-

criticality condition had a more critical member removed (DM3), whereas teams in the low-criticality condition lost a less critical member (DM4). In this task, whereas DM3 (who controls the helicopters) can destroy enemy targets of both Power Levels 1 and 3, DM4 (who controls the jets) can only destroy enemy targets with Power Level 1. When DM4 is removed, therefore both DM2 and DM3 can assume the responsibilities of the missing member and destroy the enemy targets for which DM4 was mainly responsible: Power Level 1 targets. However, when DM3 is removed, only DM2 can assume the duties of the missing member (destroying Power Level 3 enemies), making DM3's role more critical to the team's workflow (and less substitutable) than DM4's. The team was simply told that at this point in the game, DM3 (DM4) was removed from every team and that DM3 (DM4) was now free to leave.

Measures

Transactive memory. Transactive memory was coded by the researchers during the developmental task. On the basis of the conceptualization of TMS by Hollingshead (Hollingshead, 1998b, 1998c, 2000), Ellis (2006), and Ellis et al. (2008), we operationalized TMS based on the number of times that team members engaged in directory updating, information allocation, or retrieval coordination based on their areas of expertise. Directory updating refers to members sharing or requesting information concerning one another's expertise. Information allocation refers to team members directing the information to the member with the correct area of expertise. Retrieval coordination refers to team members using the knowledge of who knows what to request information from the correct expert (Wegner, 1995). These communications were coded as the number of occurrences; each time a communication occurred, the coder marked a "1" to create a count measure. An additive index (i.e., sum) represented the number of behaviors (see Ellis, 2006). Directory updating occurred when members shared their expertise or requested specific information from a teammate (e.g., "I'm DM3 and I have helicopters"). Information allocation occurred when members communicated infor-

mation to the team member with the correct specialty to handle the piece of information (e.g., "DM2, there's an F target in the top left corner of my zone"). Retrieval coordination occurred when members asked for information known to be part of another team member's specialized information (e.g., "DM4, what power are H targets again?"). Teams engaging in frequent TM communications, therefore, received higher TM scores than teams engaging in fewer transactions. This variable was centered prior to analysis (see Aiken & West, 1991).

We chose the coding approach described above because in the laboratory, TMS behaviors are observable, which is in line with Wegner, Giuliano, and Hertel's (1985) conceptualization. A strength of this approach is that it shows evidence of an effective and functioning TMS, which can be observed by an outsider. According to Ren and Argote (2011), our approach represents the transactive processes that occur during encoding, storage, and retrieval of information in a group's collective memory, which goes beyond the simple presence of knowledge within the team.

Plan formulation. Plan formulation was coded by the researchers during the experimental task, following the removal of one team member from each group. Following LePine (2003) and Waller (1999) and as recommended by Rosen et al. (2011), we operationalized plan formulation as any communication between team members within the first 5 min that involved specifying the order of importance of tasks or redistributing task duties among members to respond to the loss of a specific member (Burke et al., 2006). Examples include "Let's remember to send vehicles into DM4's (the missing member's) quadrant first," or "DM2 you will need to take out all G targets since we don't have DM3."

For both transactive memory and plan formulation, three experimenters were in charge of observing teams and coding specific communications as they occurred. All three experimenters participated in training sessions where (a) they were fully trained on the DDD task so that they would understand which TM and plan formulation behaviors were accurate, and (b) they were trained to identify transactive memory and plan formulation be-

haviors. During training, the experimenters discussed and reviewed construct definitions for each behavior, were given a list of example behaviors, and coded several practice teams to gain consensus and resolve disagreements.

To establish interrater reliability, the experimenters coded 18 of the teams in pairs. Specifically, Experimenters 1 and 2 coded six teams together, Experimenters 2 and 3 coded six teams together, and Experimenters 1 and 3 coded six teams together. Fleiss's (1971) κ provides an index of interrater agreement for three or more raters. In this study, $\kappa = .74$ for transactive memory, and $\kappa = .79$ for plan formulation behaviors, indicating acceptable levels of agreement for both (see Landis & Koch, 1977). Coding disagreements were resolved by averaging together each coder's ratings. Following these results, the remaining 60 teams were divided equally between the experimenters.

The coders were not blind to the general hypotheses that the focal behaviors were beneficial but had no way of determining performance for teams in each experimental condition (and would therefore be unable to inadvertently code more instances of plan formulation behaviors for higher performing teams).

Team performance. The team performance measure focused on the team's main objective—maximizing the number of points in both their offensive and defensive scores (see Ellis et al., 2003; Pearsall & Ellis, 2006). A team's offensive score went up by 5 points each time an enemy target was destroyed in the restricted zone. However, if any team member destroyed a friendly target or any target outside the restricted zone, the team offensive score dropped by 25 points. The team lost 1 point per second on their defensive score for each enemy that resided within the restricted zone and 2 points per second for each enemy that resided in the highly restricted zone. Team performance was measured by standardizing and combining the team's offensive and defensive scores during the 10-min experimental task. Although teams were aware of their nominal score, they received no feedback concerning their performance relative to other teams and therefore had no means of assessing their performance relative to other teams.

Results

All analyses presented were conducted at the team level. Intercorrelations and descriptive statistics are presented in Table 1.¹

Hypotheses Testing

Hypotheses were tested using hierarchical regression analyses. To test our hypotheses, we first entered team performance from the earlier 40-min developmental task in Step 1 of our regression to control for between-teams performance differences and overall ability prior to the loss manipulation (e.g., DeRue et al., 2008). Hypothesis 1 predicted that Team TMS would be positively related to team performance following the loss of a team member. TMS was positively related to team performance ($\beta = .23, p = .05$), providing support for Hypothesis 1.

The remaining hypothesis tests are shown in Table 2. Hypothesis 2 predicted that the criticality of the lost member would moderate the relationship between TMS and team performance, such that the benefits of the TMS would diminish when a team loses a more critical member. As shown in Table 2 (column 2), the interaction between lost member criticality and TMS was significantly related to team performance ($\beta = -.31, p < .05$). Further, as shown in Figure 2, teams with a well-developed TMS that lost a less critical member outperformed teams with a less well-developed TMS. However, teams with a well-developed TMS that lost a more critical member performed significantly worse than those who lost a less critical member, at levels similar to teams with a less well-developed TMS. A simple slopes test indicated that TMS was positively related to team performance when teams lost a less critical member ($\beta = .45, t = 3.19, p < .01$), but it had no significant effect on team performance when teams lost a more critical member ($\beta = .03, t = 0.21, ns$). In other words, the positive effects of

¹ Consistent with previous research, transactive memory was positively related to task performance prior to the loss ($r = .29, p < .01$). Prior performance and performance following the loss of a member were positively, though not significantly, related ($r = .15$). The relatively weak correlation is likely because of the ineffectiveness of prior team routines and processes when faced with an adaptive shock to the system.

Table 1
Means, Standard Deviations, and Intercorrelations Among Variables of Interest

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5
1. Prior performance (preloss)	0.05	0.77	—				
2. TMS	17.60	5.08	.29**	—			
3. Lost member criticality	0.50	0.50	.05	.00	—		
4. Plan formulation	0.72	0.53	.03	.25*	.19	—	
5. Team performance	0.00	0.68	.15	.26*	-.35**	.30**	—

Note. *N* = 78 teams. Criticality is coded as 1 = more critical member lost, 0 = less critical member lost. Team performance refers to performance after the member loss manipulation. TMS = transactive memory systems.
* *p* < .05. ** *p* < .01.

the TMS on team performance remained strong following the loss of a less critical team member, but losing a more critical member reduced the team’s ability to use its TMS to successfully adapt. Therefore, Hypothesis 2 was supported.

Hypothesis 3 proposed that plan formulation behavior would mediate the interactive effects of criticality and transactive memory on team performance following the loss of a team member. To test Hypothesis 3, we followed the procedures for mediated moderation outlined by Muller, Judd, and Yzerbyt (2005). The first criterion, for the interaction between the independent variable and the moderator to significantly predict the dependent variable, was evidenced by the support for Hypothesis 2. The second criterion, for the interaction between the moderator and the independent variable to significantly predict the mediator, was also met. The interaction between lost member criticality and transactive memory was significantly related to plan formulation behavior ($\beta = -.32, p < .05$),

see Table 2 (column 1). The third criterion, for the mediator to significantly predict the dependent variable when controlling for the interactions between the moderator and the independent variable and between the moderator and the mediator, was also met. As shown in Table 2 (column 3), plan formulation significantly predicted team performance when controlling for the two interaction terms ($\beta = .39, p < .01$). Finally, the relationship between the independent variable and the dependent variable decreased significantly after entering the mediator, as the relationship between the TMS-lost member criticality interaction and team performance decreased from $\beta = -.31, p < .05$ to $\beta = -.19, ns$ (see Table 2). We then tested the significance of the indirect path using Preacher and Hayes’s (2004) bootstrapping mediation technique with 2,000 resamples. In the presence of plan formulation behavior, the effects of the interaction between transactive memory and lost member criticality on team performance

Table 2
Regression Results of the Effects of Transactive Memory and Lost Member Criticality on Plan Formulation and Team Performance

Variable	Team performance					
	Plan formulation		Step 1		Step 2	
	β	<i>t</i>	β	<i>t</i>	β	<i>t</i>
Prior performance (preloss)	-.03	-0.26	.14	1.33	.17	1.62
Transactive memory (TM)	.48**	3.25	.43**	3.02	.24	1.58
Lost member criticality (Crit)	.19	1.83	-.35**	-3.45	-.21	-1.08
TM × Crit	-.32*	-2.16	-.31*	-2.22	-.19	-1.35
Plan formulation (PF)					.39**	3.07
PF × Crit					-.26	-1.25
<i>R</i> ²	.16		.25		.33	

Note. *N* = 78 teams. Team performance refers to performance after the member loss manipulation.
* *p* < .05. ** *p* < .01.

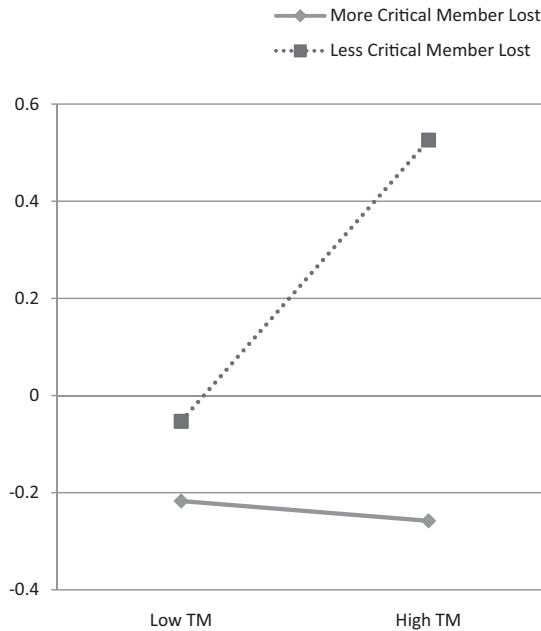


Figure 2. The effects of the interaction between transactive memory and lost member criticality on team performance. Graph depicts standardized mean for team performance.

were significantly reduced (95% confidence interval [CI] $-.042$ to $-.002$). Therefore, plan formulation mediated the relationship between the TMS-lost member criticality interaction and team performance, providing support for Hypothesis 3.

Discussion

Keeping teams together at all times is nearly impossible in modern workplaces, where teams operate lean and members are often temporarily absent because of responsibilities on other projects and other teams, illness, travel, family emergencies, or other commitments. We believe it is important to expand our conceptualization of adaptive contexts to include member loss to ensure that we fully understand how teams react to changes in their environment. Therefore, the purpose of this study was to focus specifically on loss adaptation and to theoretically identify predictors of team performance in situations where teams suddenly need to operate without their full complement of knowledge and skill. On the basis of Kozlowski et al.'s (1999) compilation theory, we found that TM represents an important emergent resource

through which the team can marshal its skills and expertise to successfully adapt to this loss. Then, using Humphrey et al.'s (2009) theory of the strategic core, we identified an important boundary condition by showing that the advantages of TMS are moderated by the member criticality. Specifically, teams with a well-developed TMS can survive the loss of a peripheral member, but the benefits of the TMS are significantly reduced following the loss of a more critical member. Finally, we were interested in identifying the mechanism underlying the interactive effects of TMS and criticality on team performance following member loss. We found that the effects of this interaction occur in part because teams lose the ability to engage in plan formulation following the loss of a more critical member.

Theoretical Implications

With this research, we are able to extend our understanding of team adaptive demands to include adaptation to member loss. Similarly to Pulakos, Arad, Donovan, and Plamondon (2000), who expanded adaptive typologies at the individual level, we help to broaden our

understanding of the adaptive performance domain at the team level. This is an important issue given that team members are often suddenly absent because of travel, illness, and rotation among work teams (Barry, Kemerer, & Slaughter, 2006; Mathieu, Maynard, Rapp, & Gilson, 2008). Although researchers have begun to examine changes in team structure (DeRue et al., 2008; Lewis et al., 2007; Moreland, 1999), their focus has been on strategic planned reorganizations and realignment of resources or on the effects of a newcomer, rather than the sudden removal of a member for which teams are not formally briefed or given the opportunity to plan. For example, Lewis et al. (2007) compared the performance of intact groups with that of reconstituted groups with varying numbers of newcomers, finding that a TMS actually hindered the performance of partially intact groups because such groups relied on an outdated TMS structure. In contrast, our study indicates that the effects of a TMS are largely dependent on the adaptive context. When a team member is abruptly removed from the team, a TMS can actually help the team adjust to the loss. Our study helps to differentiate between adaptive contexts, indicating that a reliance on inaccurate cognitions represents a hindrance when newcomers join a previously intact group, yet a TMS can be beneficial when groups must “cover” for a missing member.

We are also able to extend the literature examining the benefits and boundaries of TMS. Although TMS has been shown to positively influence learning, performance and satisfaction for intact teams (Lewis, Lange, & Gillis, 2005; Liang et al., 1995; Moreland & Myaskovsky, 2000) across a variety of task environments (e.g., Lewis, 2003, 2004; Majchrzak, Jarvenpaa, & Hollingshead, 2007), we show that developing a TMS is one way that teams can attempt to mitigate the impact of the loss of a member on performance. Therefore, we help to answer recent calls for research on transactive memory in adaptive situations (Zajac et al., 2013).

This research also contributes to the understanding of mediating factors that help to explain the negative impact of losing a critical team member. The breakdown occurs in part because teams that lose a more critical member can no longer engage in plan formulation, a vital adaptive behavior (Burke et al., 2006). Similar to other team adaptation research (LeP-

ine, 2003; Waller, 1999), our results indicate that the team’s ability to quickly analyze and respond to emergent demands on or within the team represents a crucial step in successful team adaptation, particularly when teams must reconfigure their network structure and redistribute task responsibilities.

Finally, this study contributes to our understanding of role distribution in teams. We extend previous work identifying the importance of “core” team members (Humphrey et al., 2009) and team member criticality (Pearsall & Ellis, 2006) to examine how the role of the lost member influences team interaction and performance. This study provides further support for the idea that some role positions are more critical than others within a team and that the internal distribution of role knowledge and responsibilities has implications for how teams use information to actively adapt to member loss. Although adopting a distributed, functional structure allows teams to take advantage of the diverse knowledge of skilled team members (Cohen & Bailey, 1997; Smith-Jentsch, Mathieu, & Kraiger, 2005), it leaves them vulnerable to the unexpected loss of a member and all the skills and expertise associated with that role.

Practical Implications

Our findings suggest that should a loss occur team members and managers need to first determine how critical the missing member was within the network; a process that can be expedited if managers identify criticality levels during team formation. Although the team can survive the loss of a less critical member, if a more critical member is unavailable the team needs to be made aware of the issue, and managers may need to intervene to formulate a plan for responding to the temporary loss. One way of intervening is to hold a “plan formulation” meeting where the team is forced to come up with a strategic response before reconvening and attempting to complete the task.

Another option for managers would be to have a critical team member loss contingency plan already in place. Perhaps this plan involves replacing the lost member with someone else in the organization with the same set of knowledge and skills that is aware that they are on standby in case a problem occurs. Further, because the

quick recognition of the loss is so important, more critical members can be held responsible for alerting the team of their absence as early as possible.

Managers should also act preemptively before a loss occurs and actively encourage team members to engage in extensive role-based communications during the role compilation phase of team development (Kozlowski et al., 1999; Pearsall et al., 2010), through which they can develop shared cognition. However, although these early interactions are critical for establishing a base knowledge of “who knows what” within the team, communications aimed at a deeper understanding of the breadth and boundaries of teammates’ domains must continue to occur over time to strengthen and maintain the network. Lewis et al. (2005) referred to these exchanges as higher order communications, through which members more fully comprehend their teammates’ roles and expertise and the interdependencies within the team. Managers should also encourage team members to engage in reflection concerning the team’s TMS structure and relevance. In a supplemental study, Lewis et al. (2007) found that an intervention focusing team members on the requirements of their specific role, and another teammate’s specific role allowed for greater flexibility and efficiency in TMS processes and higher performance when integrating a newcomer into the team. Although we did not directly test this idea as applicable to member loss, these findings concerning reflection may generalize to member loss situations.

For many teams, it might be just as effective to eliminate the need for a well-developed TMS altogether by shifting the structure of the team from one that is more functional or specialized to one that is divisional, where members evidence a high degree of overlap in knowledge and skill. Researchers have shown that divisional structures can be particularly effective in unstable task environments (see Hollenbeck et al., 2002), and teams are very amenable to shifting from functional to divisional structures where they can operate more autonomously within their environment (Johnson et al., 2006). However, although structural shifts may be feasible for some types of teams (e.g., sales teams), they may be problematic in others (e.g., automotive design teams).

Limitations and Future Directions

As with any study, this study had several limitations, including that this research focused on one type of team. In this study, we examined teams that closely resemble action teams and thus only represent one distinct type of work team. Action teams work together closely, usually for short periods of time, and are composed of members who possess specific areas of expertise. Although other types of teams may also experience member loss, the current research might not completely generalize to teams with longer tenures or less reliance on specialized information. For example, manufacturing or assembly teams tend to have longer life cycles than action or project teams (Sundstrom, 1999). In such teams, the loss of a critical member may have less impact as the team may have developed functional behaviors for dealing with situations they have faced previously. In contrast, established teams who rarely deal with unplanned changes may fall into patterned behavioral routines and take much longer to respond to the loss of a member (Gersick & Hackman, 1990). Or, we can imagine that there are some situations where knowledge distributed among team members is so specialized that even with a transactive memory system and plan formulation behavior, members are not able to cover for one another. Therefore, future research should address how teams’ respond to the loss of a member in different contexts and at more advanced developmental stages.

Second, because this study was conducted in a laboratory context, future research needs to examine the external validity of these results. Although the nature of the team task did not exactly mirror those of real organizational assignments, features of this task provided “mundane realism” (Berkowitz & Donnerstein, 1982). As well, participants were engaged in a psychologically absorbing task with the promise of cash bonuses for top performing teams, this study also provided “psychological realism” (Berkowitz & Donnerstein, 1982). Humphrey, Hollenbeck, Ilgen, and Moon (2004) noted that simulations such as the DDD “bridge the gap between field operations and university-based theoretical research” (p. 201) and “allow for an increase in the level of mundane realism while increasing the level of experimental rigor” (p. 202). Further, given that we are inter-

ested in teams' initial reactions to member loss, we examined adaptation to member loss during a short time period. Therefore, our results may not generalize to the time period following the initial response to member loss.

Third, we examined the effects of member loss in relatively small teams. In larger teams the loss of a single member may be easier to overcome, as the potential impact of a missing member will necessitate less of a shift from existing, functional behaviors. Or, as the number of members increases, the missing member's absence may be less noticeable, and other team members may fail to cover that person's responsibilities. Future research on team adaptation to member loss in larger teams would allow for a better understanding of this issue.

Fourth, we conceptualized our measure of plan formulation as any communication between team members that involved specifying the order of importance of tasks or redistributing task duties among members regardless of the plan's quality. It is possible that following the loss, team members may have developed a poor or unproductive plan for how to respond to the loss. However, Waller (1999) found that teams that engaged in any type of plan formulation immediately following a nonroutine event outperformed teams that failed to respond to the nonroutine event and plan any type of action. In effect, the implementation of any plan led to higher performance than no plan at all. However, future work may find that teams with well-developed transactive memory systems consistently develop high-quality plans compared with teams with less well-developed systems. In terms of our coding procedures, we also coded team interactions live as they occurred, which we acknowledge is not consistent with traditional communications coding procedures that use transcriptions (e.g., Hollingshead, 1996).

Future research should also examine forms of adaptive behavior other than plan formulation, and how these behaviors are affected by the criticality of a lost member. For example, DeRue et al. (2008) examined two different types of adaptive behaviors—quantitative and qualitative. They found that teams where hierarchy was eliminated by the removal of a team leader—a “shock” to the system—engaged in both types of behaviors. These findings contrast with the results found in our study. It is possible that plan

formulation as defined in our study represents a qualitatively different adaptive mechanism than the behaviors examined by DeRue et al. (2008). Perhaps the relationships differ with the removal of a team leader versus a team member, which is a question that warrants investigation in future research.

Finally, researchers should examine other potential moderators for the relationship between transactive memory and team performance following member loss. For instance, teams with more defined leaders may have a buffer against the detrimental effects of losing a more critical member. Formal team leaders may have more knowledge concerning the missing member's role responsibilities and be more willing and able to redistribute tasks among members, ameliorating the confusion resulting from the change in role structure. Although there is certainly room for future work in this area, this research has provided an important step in expanding the definition of team performance and illuminating a factor that benefits teams in member loss situations.

References

- Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.
- Arrow, H., & McGrath, J. E. (1993). Membership matters: How member change and continuity affect small group structure, process, and performance. *Small Group Research, 24*, 334–361. doi:10.1177/1046496493243004
- Austin, J. R. (2003). Transactive memory in organizational groups: The effects of content, consensus, specialization, and accuracy on group performance. *Journal of Applied Psychology, 88*, 866–878. doi:10.1037/0021-9010.88.5.866
- Balkundi, P., & Harrison, D. (2006). Ties, leaders, and time in teams: Strong inference about network structure's effects on team viability and performance. *Academy of Management Journal, 49*, 49–68. doi:10.5465/AMJ.2006.20785500
- Barry, E., Kemerer, C., & Slaughter, S. (2006). Environmental volatility, development decisions, and software volatility: A longitudinal analysis. *Management Science, 52*, 448–464. doi:10.1287/mnsc.1050.0463
- Baumann, M. R. (2001). *The effects of manipulating salience of expertise and membership change on transactive memory*. Unpublished doctoral dissertation, University of Illinois at Urbana-Champaign.

- Berkowitz, L., & Donnerstein, E. (1982). External validity is more than skin deep: Some answers to criticisms of laboratory experiments. *American Psychologist*, *37*, 245–257. doi:10.1037/0003-066X.37.3.245
- Brass, D. (1984). Being in the right place: A structural analysis of individual influence in an organization. *Administrative Science Quarterly*, *29*, 518–539. doi:10.2307/2392937
- Brass, D. (1985). Men's and women's networks: A study of interaction patterns and influence in an organization. *Academy of Management Journal*, *28*, 327–343. doi:10.2307/256204
- Burke, C. S., Stagl, K., Salas, E., Pierce, L., & Kendall, D. (2006). Understanding team adaptation: A conceptual analysis and model. *Journal of Applied Psychology*, *91*, 1189–1207. doi:10.1037/0021-9010.91.6.1189
- Burt, R. S. (1992). *Structural holes*. Cambridge, MA: Harvard University Press.
- Burt, R. S. (1995). *Structural holes: The social structure of competition*. Cambridge, MA: Harvard University Press.
- Cannon-Bowers, J. A., Salas, E., & Converse, S. A. (1993). Shared mental models in expert decision making teams. In N. J. Castellan Jr. (Ed.), *Current issues in individual and group decision making* (pp. 221–246). Hillsdale, NJ: Erlbaum.
- Chen, G., Thomas, B., & Wallace, J. C. (2005). A multilevel examination of the relationships among training outcomes, mediating regulatory processes, and adaptive performance. *Journal of Applied Psychology*, *90*, 827–840. doi:10.1037/0021-9010.90.5.827
- Cohen, S. G., & Bailey, D. E. (1997). What makes teams work: Group effectiveness research from the shop floor to the executive suite. *Journal of Management*, *23*, 239–290. doi:10.1177/014920639702300303
- DeRue, D. S., Hollenbeck, J. R., Johnson, M. D., Ilgen, D. R., & Jandt, D. K. (2008). How different team downsizing approaches influence team-level adaptation and performance. *Academy of Management Journal*, *51*, 182–196. doi:10.5465/AMJ.2008.30776769
- Ellis, A. P. J. (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. doi:10.5465/AMJ.2006.21794674
- Ellis, A. P. J., Bell, B. S., Ployhart, R. E., Hollenbeck, J. R., & Ilgen, D. R. (2005). An evaluation of generic teamwork skills training with action teams: Effects on cognitive and skill-based outcomes. *Personnel Psychology*, *58*, 641–672. doi:10.1111/j.1744-6570.2005.00617.x
- Ellis, A. P. J., Hollenbeck, J. R., Ilgen, D. R., Porter, C. O. L. H., West, B. J., & Moon, H. (2003). Team learning: Collectively connecting the dots. *Journal of Applied Psychology*, *88*, 821–835. doi:10.1037/0021-9010.88.5.821
- Ellis, A. P. J., Porter, C. O. L. H., & Wolverton, S. A. (2008). Learning to work together: An examination of transactive memory system development in teams. In V. I. Sessa & M. London (Eds.), *Work group learning: Understanding, improving, and assessing how groups learn in organizations* (pp. 91–115). New York, NY: Taylor & Francis.
- Fleiss, J. (1971). Measuring nominal scale agreement among many raters. *Psychological Bulletin*, *76*, 378–382. doi:10.1037/h0031619
- Gersick, C. J. G., & Hackman, J. (1990). Habitual routines in task-performing groups. *Organizational Behavior and Human Decision Processes*, *47*, 65–97. doi:10.1016/0749-5978(90)90047-D
- Girvan, M., & Newman, M. (2002). Community structure in social and biological networks. *Proceedings of the National Academy of Sciences of the United States of America*, *99*, 7821–7826. doi:10.1073/pnas.122653799
- Hinsz, V. B., Tindale, R., & Vollrath, D. (1997). The emerging conceptualization of groups as information processors. *Psychological Bulletin*, *121*, 43–64. doi:10.1037/0033-2909.121.1.43
- Hollenbeck, J. R., Moon, H., Ellis, A. P. J., West, B. J., Ilgen, D. R., Sheppard, L., . . . Wagner, J. A. (2002). Structural contingency theory and individual differences: Examination of external and internal person-team fit. *Journal of Applied Psychology*, *87*, 599–606. doi:10.1037/0021-9010.87.3.599
- Hollingshead, A. B. (1996). Information suppression and status persistence in group decision making: The effects of communication media. *Human Communication Research*, *23*, 193–219. doi:10.1111/j.1468-2958.1996.tb00392.x
- Hollingshead, A. B. (1998a). Communication, learning, and retrieval in transactive memory systems. *Journal of Experimental Social Psychology*, *34*, 423–442. doi:10.1006/jesp.1998.1358
- Hollingshead, A. B. (1998b). Distributed expertise and communication processes in groups. In E. Mannix, M. A. Neale, & D. H. Gruenfeld (Eds.), *Research on managing groups and teams* (Vol. 1, pp. 105–125). Greenwich, CT: JAI Press.
- Hollingshead, A. B. (1998c). Retrieval processes in transactive memory systems. *Journal of Personality and Social Psychology*, *74*, 659–671. doi:10.1037/0022-3514.74.3.659
- Hollingshead, A. B. (2000). Perceptions of expertise and transactive memory in work relationships. *Group Processes & Intergroup Relations*, *3*, 257–267. doi:10.1177/1368430200033002
- Humphrey, S. E., Hollenbeck, J. R., Ilgen, D. R., & Moon, H. (2004). The changing shape of large-scale programs of research: MSU-DDD as an il-

- illustrative example. In S. Schiflett, L. Elliott, E. Salas, & M. Coovert (Eds.), *Scaled worlds: Development, validation and applications* (pp. 200–219). Burlington, VT: Ashgate.
- Humphrey, S. E., Morgeson, F. P., & Mannor, M. J. (2009). Developing a theory of the strategic core of teams: A role composition model of team performance. *Journal of Applied Psychology, 94*, 48–61. doi:10.1037/a0012997
- Johnson, M. D., Hollenbeck, J. R., Humphrey, S. E., Ilgen, D. R., Jundt, D. K., & Meyer, C. J. (2006). Cutthroat cooperation: Asymmetrical adaptation to changes in team reward structures. *Academy of Management Journal, 49*, 103–119. doi:10.5465/AMJ.2006.20785533
- Kane, A. A., Argote, L., & Levine, J. M. (2005). Knowledge transfer between groups via personnel rotation: Effects of social identity and knowledge quality. *Organizational Behavior and Human Decision Processes, 96*, 56–71. doi:10.1016/j.obhdp.2004.09.002
- Kozlowski, S. W. J., & Bell, B. S. (2003). Work groups and teams in organizations. In W. Borman, D. R. Ilgen, & R. Klimoski (Eds.), *Handbook of psychology* (Vol. 12, pp. 333–375). Hoboken, NJ: Wiley. doi:10.1002/0471264385.wei1214
- Kozlowski, S. W. J., Gully, S. M., Nason, E. R., & Smith, E. M. (1999). Developing adaptive teams: A theory of compilation and performance across levels and time. In D. Ilgen & E. Pulakos (Eds.), *The changing nature of work performance: Implications for staffing, personnel actions, and development* (pp. 240–292). San Francisco, CA: Jossey-Bass.
- Kozlowski, S. W. J., & Klein, K. J. (2000). A multilevel approach to theory and research in organizations: Contextual, temporal, and emergent processes. In K. J. Klein & S. W. J. Kozlowski (Eds.), *Multilevel theory, research, and methods in organizations: Foundations, extensions, and new directions* (pp. 3–90). San Francisco, CA: Jossey-Bass.
- Landis, J. R., & Koch, G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*, 159–174. doi:10.2307/2529310
- LePine, J. A. (2003). Team adaptation and postchange performance: Effects of team composition in terms of members' cognitive ability and personality. *Journal of Applied Psychology, 88*, 27–39. doi:10.1037/0021-9010.88.1.27
- LePine, J. A. (2005). Adaptation of teams in response to unforeseen change: Effects of goal difficulty and team composition in terms of cognitive ability and goal orientation. *Journal of Applied Psychology, 90*, 1153–1167. doi:10.1037/0021-9010.90.6.1153
- Levine, J. M., & Choi, H. S. (2004). Impact of personnel turnover on team performance and cognition. In E. Salas & S. M. Fiore (Eds.), *Team cognition: Understanding the factors that drive process and performance* (pp. 153–176). Washington, DC: American Psychological Association. doi:10.1037/10690-008
- Levine, J. M., Choi, H. S., & Moreland, R. L. (2003). Newcomer innovation in work teams. In P. Paulus & B. Nijstad (Eds.), *Group creativity: Innovation through collaboration* (pp. 202–224). New York, NY: Oxford University Press. doi:10.1093/acprof:oso/9780195147308.003.0010
- Lewis, K. (2003). Measuring transactive memory systems in the field: Scale development and validation. *Journal of Applied Psychology, 88*, 587–604. doi:10.1037/0021-9010.88.4.587
- Lewis, K. (2004). Knowledge and performance in knowledge-worker teams: A longitudinal study of transactive memory systems. *Management Science, 50*, 1519–1533. doi:10.1287/mnsc.1040.0257
- Lewis, K., Belliveau, M., Herndon, B., & Keller, J. (2007). Group cognition, membership change, and performance: Investigating the benefits and detriments of collective knowledge. *Organizational Behavior and Human Decision Processes, 103*, 159–178. doi:10.1016/j.obhdp.2007.01.005
- Lewis, K., Lange, D., & Gillis, L. (2005). Transactive memory systems, learning, and learning transfer. *Organization Science, 16*, 581–598. doi:10.1287/orsc.1050.0143
- Liang, D., Moreland, R., & Argote, L. (1995). Group versus individual training and group performance: The mediating role of transactive memory. *Personality and Social Psychology Bulletin, 21*, 384–393. doi:10.1177/0146167295214009
- Majchrzak, A., Jarvenpaa, S. L., & Hollingshead, A. B. (2007). Coordinating expertise among emergent groups responding to disasters. *Organization Science, 18*, 147–161. doi:10.1287/orsc.1060.0228
- 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. doi:10.1037/0021-9010.85.6.971
- Mathieu, J., Maynard, M., Rapp, T., & Gilson, L. (2008). Team effectiveness 1997–2007: A review of recent advancements and a glimpse into the future. *Journal of Management, 34*, 410–476. doi:10.1177/0149206308316061
- Miller, D. L., Young, P., Kleinman, D., & Serfaty, D. (1998). *Distributed dynamic decision-making simulation: Phase I. Release notes and user's manual*. Woburn, MA: Aptima.
- Moreland, R. L. (1999). Transactive memory: Learning who knows what in work groups and organizations. In L. Thompson, D. Messick, & J. M. Levine (Eds.), *Shared cognition in organizations: The management of knowledge* (pp. 3–31). Mahwah, NJ: Erlbaum.
- Moreland, R. L., & Argote, L. (2003). Transactive

- memory in dynamic organizations. In R. Peterson & E. Mannix (Eds.), *Understanding the dynamic organization* (pp. 135–162). Mahwah, NJ: Erlbaum.
- Moreland, R. L., Argote, L., & Krishnan, R. (1996). Socially shared cognition at work: Transactive memory and group performance. In J. L. Nye & A. M. Brower (Eds.), *What's so social about social cognition? Social cognition research in small groups* (pp. 57–84). Thousand Oaks, CA: Sage.
- Moreland, R. L., & Myaskovsky, L. (2000). Exploring the performance benefits of group training: Transactive memory or improved communication? *Organizational Behavior and Human Decision Processes*, 82, 117–133. doi:10.1006/obhd.2000.2891
- Muller, D., Judd, C. M., & Yzerbyt, V. Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology*, 89, 852–863. doi:10.1037/0022-3514.89.6.852
- Palazzolo, E., Serb, D., She, Y., Su, C., & Contractor, N. (2006). Coevolution of communication and knowledge networks in transactive memory systems: Using computational models for theoretical development. *Communication Theory*, 16, 223–250. doi:10.1111/j.1468-2885.2006.00269.x
- Pearsall, M. J., & Ellis, A. P. J. (2006). The effects of critical team member assertiveness on team performance and satisfaction. *Journal of Management*, 32, 575–594. doi:10.1177/0149206306289099
- 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. doi:10.1037/a0017781
- Preacher, K., & Hayes, A. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers*, 36, 717–731. doi:10.3758/BF03206553
- Pulakos, E. D., Arad, S., Donovan, M. A., & Plamondon, K. E. (2000). Adaptability in the workplace: Development of a taxonomy of adaptive performance. *Journal of Applied Psychology*, 85, 612–624. doi:10.1037/0021-9010.85.4.612
- Ren, Y., & Argote, L. (2011). Transactive memory systems 1985–2010: An integrative framework of key dimensions, antecedents, and consequences. *The Academy of Management Annals*, 5, 189–229. doi:10.1080/19416520.2011.590300
- Rosen, M. A., Bedwell, W. L., Wildman, J. L., Fritzsche, B. A., Salas, E., & Burke, C. S. (2011). Managing adaptive performance in teams: Guiding principles and behavioral markers for measurement. *Human Resource Management Review*, 21, 107–122. doi:10.1016/j.hrmr.2010.09.003
- Smith-Jentsch, K. A., Mathieu, J., & 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. doi:10.1037/0021-9010.90.3.523
- Stout, R., & Salas, E. (1993). *The role of planning in coordinated team decision making: Implications for training*. Paper presented at the Human Factors and Ergonomics Society, Santa Monica, CA.
- Summers, J. K., Humphrey, S. E., & Ferris, G. R. (2012). Team member change, flux in coordination, and performance: Effects of strategic core roles, information transfer, and cognitive ability. *Academy of Management Journal*, 55, 314–338. doi:10.5465/amj.2010.0175
- Sundstrom, E. (1999). *Supporting work team effectiveness: Best management practices for fostering high performance*. San Francisco, CA: Jossey-Bass.
- Volberda, H. (1996). Toward the flexible form: How to remain vital in hypercompetitive environments. *Organization Science*, 7, 359–374. doi:10.1287/orsc.7.4.359
- Waller, M. J. (1999). The timing of adaptive group responses to nonroutine events. *Academy of Management Journal*, 42, 127–137. doi:10.2307/257088
- Wegner, D. M. (1987). Transactive memory: A contemporary analysis of the group mind. In G. Mullen & G. Goethals (Eds.), *Theories of group behavior* (Vol. 185, pp. 185–208). New York, NY: Springer-Verlag. doi:10.1007/978-1-4612-4634-3_9
- Wegner, D. M. (1995). A computer network model of human transactive memory. *Social Cognition*, 13, 319–339. doi:10.1521/soco.1995.13.3.319
- Wegner, D. M., Erber, R., & Raymond, P. (1991). Transactive memory in close relationships. *Journal of Personality and Social Psychology*, 61, 923–929. doi:10.1037/0022-3514.61.6.923
- Wegner, D. M., Giuliano, T., & Hertel, P. (1985). Cognitive interdependencies in close relationships. In W. J. Ickes (Ed.), *Compatible and incompatible relationships* (pp. 253–276). New York, NY: Springer-Verlag. doi:10.1007/978-1-4612-5044-9_12
- Zajac, S., Gregory, M. E., Bedwell, W. L., Kramer, W. S., & Salas, E. (2013). The cognitive underpinnings of adaptive team performance in ill-defined task situations: A closer look at team cognition. *Organizational Psychology Review*, 1–25.

Received July 17, 2012

Revision received August 26, 2013

Accepted October 19, 2013 ■