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Guided Team Self-Correction

Impacts on Team Mental Models, Processes, and Effectiveness

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This research investigated the effects of guided team self-correction using an empirically derived expert model of teamwork as the organizing framework. First, the authors describe the process used to define this model. Second, they report findings from two studies in which the expert model was used to structure the process of guided team self-correction. Participants were U.S. Navy command and control teams (25 in Study 1, 13 in Study 2). Results indicated that teams debriefed using the expert model-driven guided team self-correction approach developed more accurate mental models of teamwork (Study 1) and demonstrated greater teamwork processes and more effective outcomes (Study 2) than did teams debriefed using a less participative and chronologically organized approach that is more typical for these teams.

Keywords: *teams; mental models; guided team self-correction; debriefs; training; teamwork; team dimensional training*

Team briefings and debriefings, or after-event reviews, are commonly used as a means of team building. It is expected that these briefings enable members to collectively make sense of their environment and to develop a shared vision for how to proceed in the future. It has been demonstrated, however, that simply providing teams with an opportunity to debrief their performance does not necessarily facilitate shared team cognition (Edwards, Day, Arthur, & Bell, 2006; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). Guided team self-correction is a team debriefing strategy in which members are given the responsibility for diagnosing and solving their team's performance problems with guidance as to what topics they should discuss and how to do so constructively (Smith-Jentsch, Zeisig, McPherson, & Acton, 1998). A recent meta-analysis (Salas, Nichols, & Driskell, 2007) found several studies that tested the impact of team training programs in which guided team self-correction was a component. Only one empirical study was found, however, in which guided team self-correction by itself was compared against unguided team self-correction (Blickensderfer, Cannon-Bowers, & Salas, 1997). In this prior study, the guidance provided to teams consisted of training on feedback skills and specific instructions to discuss task expectations during team debriefs. Results indicated that teams that received this guidance developed greater shared task expectations and demonstrated more efficient teamwork processes than did teams that engaged in unguided team self-correction. Performance effectiveness, however, was not significantly improved by the manipulation. The present study builds on this prior research in three primary ways.

First, Blickensderfer et al. (1997) instructed teams to share and negotiate task expectations but did not provide structure to ensure that the shared expectations developed were of high quality. Thus, some of the teams receiving the experimental treatment may have developed shared task expectations that were ineffective. In the present research, we provided teams with a prescriptive expert model of teamwork and instructed them to use this model to structure their self-critique, feedback, and planning.

Second, team performance is a function of both task-work and teamwork processes, and guided team self-correction has the potential to improve both. Some teams, however, may not possess enough task-specific knowledge to identify and fix their task-work problems, and this should limit the impact of the strategy on performance effectiveness. In the Blickensderfer et al. (1997) study, team members were college undergraduates who performed a simulated

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military task with which they had little or no prior experience. This may explain why the manipulation enhanced coordination processes but not task outcomes. In the present study, participants were active duty military personnel involved in job-related team training. Thus, they should be more able to self-correct both their teamwork and task-work processes.

Finally, in the Blickensderfer et al. (1997) study, the entire team was provided with preparatory feedback skills training, and team members were equal in status. In the present research, a debrief facilitator higher in status with respect to task-work expertise (i.e., team leader in Study 1, instructor in Study 2) was assigned to lead the team briefings and debriefings. Only these facilitators were provided with preparatory training regarding what to discuss and how to discuss it. Prior research has demonstrated that confederate leaders can be scripted to brief their teams in such a way so as to shape members' cognitions about norms and role expectations (Marks, Zaccaro, & Mathieu, 2000; Smith-Jentsch, Salas, & Brannick, 2001). The present research extended these findings by investigating whether nonconfederates could be trained to facilitate interactive guided team self-correction briefings and debriefings in such a way so as to facilitate the development of shared and accurate team cognition.

The particular version of guided team self-correction adopted in the present research has been referred to as *team dimensional training* (TDT) in prior publications (e.g., Smith-Jentsch, Zeisig, McPherson, et al., 1998), in descriptions of applied demonstrations (e.g., PSEG Nuclear, 2000), and in training materials developed to support its implementation (i.e., videos, pamphlets, prebriefing and debriefing guides). In the following sections, we detail the theoretical underpinnings of this strategy using mental model theory and findings from prior research. Next, we detail the manner in which we defined and validated the expert model of teamwork that served as an organizing structure for team briefs and debriefs. Finally, we offer hypotheses regarding the expected impacts of guided team self-correction and report results from two validation studies.

Team Mental Models

Team mental models have been described as organized cognitive representations of a team's task, equipment, roles and interaction patterns, and teammates (Cannon-Bowers, Salas, & Converse, 1993). Shared mental model theory suggests that when teammates hold similar cognitive representations, they are better able to anticipate one another's needs and actions, to engage in more efficient searches for information, to jointly interpret cues in their environment, and to negotiate solutions to problems encountered. Consistent with these notions, shared mental models related to task strategies and team interactions have been shown to have independent main effects on team performance (Mathieu et al., 2000). Consequently, a number of training interventions have been designed explicitly to develop shared mental models (e.g., Marks et al., 2000; Smith-Jentsch, Campbell, Milanovich, & Reynolds, 2000).

In addition to mental model similarity, however, increasing attention has recently been paid to the accuracy or quality of team members' mental models. Edwards et al. (2006) argued that mental models are accurate if they mirror the "true state of the world" (p. 728). Both lab and field studies have demonstrated that the accuracy of teammates' team and task knowledge is positively associated with teamwork processes (Hirschfeld, Field, Giles, Armenakis, & Jordan, 2006; Marks et al., 2000). Moreover, mental model accuracy has been shown to moderate the positive relationship between mental model similarity and performance such that shared mental models regarding teamwork were more positively related to outcomes when they were of high quality (Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005). Mental models will necessarily become more similar as they become more accurate in situations where a single accurate model exists. However, the reverse is not true (i.e., increasing similarity will not necessarily promote accuracy). In such cases, it seems logical that training should focus on achieving mental model accuracy with the expectation that similarity will naturally follow. The term *accuracy* implies that there is only one correct mental model. This may in fact be the case when it comes to mental models about teammates' relative expertise. However, consistent with the notion of equifinality, there may be multiple different ways of organizing task and teamwork knowledge that could conceivably result in the same level of team effectiveness (Mathieu et al., 2005). Is it enough that team members each hold high-quality mental models, or is it important that they hold the same high-quality mental model?

To answer this question, it is necessary to identify and measure multiple expert models. Otherwise, at the high end of quality there will be no variability in team member similarity. This was the approach taken by Mathieu et al. (2005), who found that teammates holding dissimilar high-quality mental models of teamwork actually demonstrated the poorest teamwork processes. This finding suggests that when multiple heterogeneous expert models of teamwork exist, it is important that training be designed such that teammates come to share the same model. Theoretically, as long as team members agree upon which accurate model to adopt, the team's performance should improve. However, as a practical matter, it is important to note that team membership is often unstable, either because individuals move from team to team frequently or because they serve as members of multiple teams concurrently. In these cases, it has been argued that team training should focus on developing knowledge and skills that are transportable and that do not need to be repeatedly retrained and unlearned (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995). Moreover, even teams with stable membership are often required to coordinate with other teams in a multi-team system. Thus, despite the possible existence of multiple expert models, there are many cases in which it should be both more effective and more efficient for an organization to choose only one of these models as the learning objective for team training interventions. This is certainly true for most military teams that are characterized by a high rate of turnover, as well as high demands for interteam coordination. Thus, we sought to define a high-quality mental model of teamwork that could be used to structure guided team self-correction briefings and debriefings for U.S. Navy command and control teams. The following sections describe our approach to achieving this goal.

Defining an Expert Model of Teamwork

Teamwork mental models have been defined as an understanding of the components of effective teamwork, and of the relationships between those components (Smith-Jentsch et al., 2000). Whereas numerous studies have measured the similarity of teammates' knowledge about teamwork, relatively few have measured the accuracy or quality of teamwork knowledge (e.g., Hirschfeld et al., 2006; Lim & Klein, 2006; Mathieu et al., 2005). This is likely due in large part to the relative difficulty of identifying a known true state of the world against which mental models of teamwork can be scored. The typical method employed to date has been to measure the teamwork knowledge of individuals identified a priori as experts with regards to teamwork and to use their mental models as the criterion against which the quality or accuracy of participant mental models are judged. However, as Mathieu et al. (2005) demonstrated, groups of predefined experts may hold multiple heterogeneous mental models of teamwork. If one's goal is to define a single expert model for the purpose of training, one is faced with a number of important questions, such as Which expert model should be trained? Is one expert model better than another? Do my pre-specified experts really hold more accurate teamwork knowledge? To which team tasks are their knowledge applicable?

In this regard, there are a number of ways in which team experience can be indexed for the purpose of identifying experts. Most prior research has employed task-generic indicators of teamwork expertise and knowledge. For instance, Mathieu et al. (2005) used the number of relevant team-related publications, ongoing team research programs, time spent working with teams in applied settings, classes on teams (taught or taken), and publications on team-related topics. However, Rentsch, Heffner, and Duffy (1994) argued that because teamwork requirements appear to differ as a function of team type, one might expect that teamwork knowledge requirements will vary across team types as well. Thus, those with task-specific team experience are likely to hold teamwork mental models that are most relevant for training development purposes. On the other hand, simply having worked longer in a particular team task environment does not necessarily mean that an individual has more accurate teamwork knowledge. For instance, Smith-Jentsch, Zeisig, Cannon-Bowers, and Salas (1998) found no significant relationship between experience working in an air traffic control (ATC) team and either beliefs in the importance of teamwork or declarative knowledge about teamwork. Thus, the identification of those holding accurate teamwork mental models for a particular task type may not be as straightforward as one might think.

For the reasons just described, we took a different approach to defining an expert model of teamwork. This approach involved working backward. Specifically, we first sought to identify a model of teamwork that reliably differentiated experienced and inexperienced Navy command and control teams and predicted effective team performance outcomes in this environment (Smith-Jentsch, Johnston, & Payne, 1998). Next, we examined whether individuals holding mental models consistent with this mathematically derived model differed significantly on relevant experience-related variables (Smith-Jentsch et al., 2000). This brought us to the present research in which we used our expert model of teamwork as the framework for guided team self-correction and tested whether those who were trained using this method would come to share mental models that were more consistent with the expert model (Study 1) and whether they would also demonstrate more effective team performance (Study 2).

What makes a team of experts an expert team? On the basis of structured interviews, focus groups, and direct observation of Navy command and control teams, 38 teamwork behaviors were identified as being important for shipboard combat information center (CIC) teams (Dickinson & McIntyre, 1997; McIntyre & Salas, 1995). Later, this list of teamwork behaviors was revised to eliminate or collapse behaviors that could not be reliably discriminated by raters (Smith-Jentsch, Johnston, et al., 1998). To achieve this, several focus groups were convened that included both Navy subject matter experts and researchers holding doctoral degrees in industrial psychology or related disciplines (e.g., human factors). This resulted in a list of 11 teamwork behaviors. Rating scales were developed to assess each component behavior. Next, 30-min exercises were created that depicted scenarios from a Navy CIC (Johnston, Porier, & Smith-Jentsch, 1998). One-hundred 5-person teams varying in military task and team experience performed these exercises, and audio recordings of the teams' performances were rated by Navy subject matter experts. Factor analysis of the data indicated that the 11 teamwork behavior ratings loaded onto four higher order teamwork dimensions (Smith-Jentsch, Johnston, et al., 1998).

The first dimension was labeled *information exchange* and consisted of the following component behaviors: passing relevant information to the right teammate at the right time, seeking information from all relevant sources, and providing periodic situation updates that summarize the big picture. The second dimension was labeled *communication delivery* and consisted of the following component behaviors: using proper terminology, avoiding excess chatter, speaking clearly (audibly), and delivering complete standard reports containing data in the appropriate order. The third dimension was labeled *supporting behavior* and consisted of the following components: offering, requesting, and accepting backup when needed, and noting and correcting errors, as well as accepting correction. The fourth and final dimension was labeled *initiative and leadership*. The components of this dimension were explicitly stating priorities and providing guidance, suggestions, or direction to other team members.

Behavioral ratings of the component behaviors were averaged within the four dimensions to form composite ratings. These ratings demonstrated both convergent and discriminant validity as evidenced by correlations among same and different dimension ratings within and across scenario events (Smith-Jentsch, Johnston, et al., 1998). Teams were then split into groups known to differ on a number of experience- and training-related variables (task or team related). Comparisons of these groups with respect to ratings of the four teamwork dimensions supported the notion that teams with greater experience outperformed those with lesser experience (Smith-Jentsch, Johnston, et al., 1998). Finally, ratings of the four dimensions were collected for an independent group of submarine command-and-control teams as a cross-validation study. Results indicated that the four dimension ratings each accounted for unique variance in team performance outcomes (Smith-Jentsch, Milanovich, & Merket, 2001).

Together, the findings from this research provided empirical support for the predictive validity of our mathematically derived expert model of teamwork. It is important to note, however, that mathematical models can be predictive of human performance without being diagnostic of the mental processes that individuals engage in when performing (Campbell, Buff, Bolton, & Holness, 2001). Thus, we next sought to examine whether those with greater team-related experience in this task domain tended to hold mental models of teamwork that mirrored the "true state of the world" we had a priori defined behaviorally.

Do experts think as experts do? Typically, the stimuli used to measure teamwork mental models are experimenter-generated teamwork terms or definitions. For instance, participants may be asked to rate the relationship between assertiveness and leadership. This can force participants to represent their teamwork mental models using constructs that are not included in those mental models. Instead, we asked participants to sort critical incidents involving teamwork (e.g., "The Tactical Action Officer told his team that the unknown helicopter was actually a CNN [Cable News Network] aircraft") into piles reflecting teamwork constructs that made sense to them and to label those constructs in their own words.

Teamwork mental model accuracy was then computed by calculating the correlation between a participant's card sort and a sorting of the cards that would be consistent with the mathematically derived predictive model of teamwork. Two indicators of experience were collected: (a) length of time in a Navy team task environment and (b) Navy rank. Results indicated that rank, but not overall Navy experience, was positively associated with similarity to the expert model (Smith-Jentsch et al., 2000). It is also noteworthy that length of Navy experience was only weakly correlated with military rank, because it is difficult to move from the enlisted ranks to the ranks of an officer. In terms of team-related experience, military rank is most closely associated with the length and breadth of experience as a Navy team leader. Promotions to higher ranks are typically preceded by successful lateral rotations to positions of team leadership across a variety of team tasks. For instance, a Navy lieutenant in the surface community may serve one tour as chief engineer, the next as tactical action officer, and a third as the chief navigation officer before being promoted to lieutenant commander. Lieutenant commanders then serve as executive officers on two or more different ships before being promoted to captain of their own ship, and so forth. Thus, the experiences Navy personnel acquire en route to promotion are likely to lead them to have abstracted general rules of teamwork that transcend superficial differences in command-and-control tasks. In support of this argument, the literature on expert-novice differences in general (Hillerbrand & Claiborn, 1990), and on teamwork knowledge specifically (Rentsch et al., 1994), indicates that those with greater expertise tend to use more abstract categories to represent their knowledge than inexperienced individuals. Moreover, our own research has demonstrated that those who adopted an abstract grouping strategy when completing our card-sorting measure tended to sort the cards in a manner more consistent with the expert model (Smith-Jentsch, Sanchez, Lima, Rosopa, & Crippen, 2003). Together, these findings help to explain why those higher in rank within the Navy, but not necessarily having spent more time in a Navy command-and-control environment, held mental models of teamwork that were more similar to our mathematically derived expert model.

In sum, this model described how more effective and experienced teams behaved and also how those with greater leadership experience represented their knowledge about teamwork. Thus, although the model may not be the only high-quality representation of teamwork that exists for these types of teams, it appeared reasonable to accept it as one legitimate high-quality model. As such, in the present research, the intended purpose of guided team self-correction was to lead team members to share this particular mental model of teamwork and to use it as a framework from which to diagnose and solve their own performance problems.

Guided Team Self-Correction

Smith-Jentsch, Zeisig, McPherson, et al. (1998) detailed a number specific reasons why unstructured team debriefing opportunities may not lead to shared or accurate mental models. First, without specific guidance there is always the risk that a team will come to share a mental model of teamwork that is incorrect or highly situation-specific. For instance, teams tend to organize their debriefings chronologically and to evaluate their performance against scenario-specific event outcomes. In other words, they ask themselves “Did we make the right decision in this set of circumstances?” rather than asking “Did we make the decision right, using processes that across different circumstances increase our odds of success?” The latter focus enables teams to discern general rules of behavior that transcend the specifics of a given scenario (i.e., seeing the forest for the trees), whereas the former approach can lead to the development of cue-strategy associations that are highly specific to the concrete features of a particular scenario. A focus on general rules should foster adaptation to novel situations, whereas a focus on scenario-specific rules should only facilitate transfer to other highly similar scenarios. In fact, it may lead to negative learning if trainees attempt to generalize context-specific lessons from scenarios that depict rarely occurring events (Leboe, Whittlesea, & Milliken, 2005).

Second, without a prespecified framework from which to discuss their performance, teammates holding dissimilar mental models (even high-quality ones) may find it difficult to communicate their observations to one another or to collectively negotiate a mutually satisfying solution to problems noted. Instead, the team debrief may be filled with unproductive conflict and process loss as teammates attempt to explain their perspectives and convince others of their positions. This may be particularly true when team members hold dissimilar mental models of high quality, given that these are likely to be the most resistant to change.

A third reason why team briefings and debriefings can be ineffective is that they often focus on either positive or negative feedback, but not both. On one hand, highly cohesive teams may focus solely on positive performance instances in order to keep the peace. On the other hand, many instructors and team leaders view the discussion of positives as a waste of valuable training time and focus almost exclusively on performance problems (Tannenbaum, Smith-Jentsch, & Behson, 1998). Ellis and Davidi (2005) found that when after-event reviews included a discussion of both successful and failed performance events, trainees developed richer mental models (greater number of nodes and links) and more effective performance in training than when after-event reviews focused only on failed performance events. Similarly, research on behavioral models in training has found that trainees are better able to generalize what they learn about interpersonal skills if they view both effective and ineffective models than if they view only positive models (Taylor, Russ-Eft, & Chan, 2005).

In sum, team briefings and debriefings can be ineffective at improving performance because (a) teammates develop mental models that are inaccurate or highly scenario-specific, (b) teammates hold dissimilar mental models that limit their ability to engage in effective team self-correction, and (c) teams focus solely on discussing positive or negative aspects of their performance, but not both. Smith-Jentsch, Zeisig, McPherson, et al. (1998) described a method for guided team self-correction designed to remedy these problems. Both the briefing and debriefing are explicitly organized around a prespecified expert model of teamwork. Following this outline, a facilitator (team leader or instructor) asks the team to describe both positive and negative instances of their own performance that illustrate each component within the expert model and, on the basis of this discussion, identify and agree upon process-oriented goals for improvement. Two studies were conducted to test the effectiveness of this strategy using teams for which the expert model was appropriate (i.e., military command-and-control teams). The following sections lay out our theoretical rationale for the hypotheses offered.

Teamwork mental models. In guided team self-correction, team members are explicitly told that the primary purpose of the brief and debrief is to learn the expert model and to use the expert model to evaluate and improve their performance. Feedback provided and goals set are explicitly tied to the abstract components of teamwork defined in the expert model. This should motivate team members to focus on learning the expert model. Repeatedly listening to positive and negative examples of teamwork labeled as manifestations of abstract components within the expert model should aid team members in understanding those components at a construct level. Finally, team members are likely to experiment with and attend to components of the model during performance episodes. This should reinforce cue-strategy linkages, further crystallizing the expert model in memory. Thus, we posited that

> *Hypothesis 1:* Teams that participate in briefs and debriefs using the guided team self-correction method will develop mental models of teamwork that are more similar to the expert model than will those who participate in more traditional, chronologically structured Navy prebriefs and debriefs.

As team members' mental models converge on the same expert model, they should naturally become more similar to one another. By contrast, prior research has demonstrated that teammate mental models do not necessarily become more similar when briefings and debriefings are not specifically structured with this goal in mind. Thus, we posited that

> *Hypothesis 2:* Teams that participate in briefings and debriefings using the guided team self-correction method will develop more similar mental models of teamwork than will teams that participate in more traditional, chronologically structured Navy briefings and debriefings.

Teamwork processes. Effective teamwork processes have previously been linked to both shared (e.g., Mathieu et al., 2000) and accurate (e.g., Hirschfeld et al., 2006; Lim & Klein, 2005; Mathieu et al., 2005) mental models of teamwork. Accurate mental models of teamwork should direct team members' efforts appropriately and help them to make sense of performance breakdowns stemming from ineffective teamwork. The guided team self-correction method is designed to develop accurate teamwork mental models and also to provide a forum whereby team members can explicitly use the model to critique their performance, develop solutions to teamwork problems, and set goals for improving their teamwork processes. Thus, we expected that

> *Hypothesis 3:* Teams that participate in briefs and debriefs using the guided team self-correction method will develop more effective teamwork processes than will teams that participate in more traditional, chronologically structured Navy briefs and debriefs.

Performance outcomes. The expert model of teamwork used to structure guided team self-correction was shown in prior research to differentiate experienced and inexperienced teams, as well as to predict performance outcomes (Smith-Jentsch, Johnston, et al., 1998). Consequently, by improving the specific teamwork processes that make up the expert model, guided team self-correction should positively affect team performance outcomes. Thus, our final hypothesis stated

> *Hypothesis 4:* Teams that participate in briefs and debriefs using the guided team self-correction method will achieve more effective posttraining performance outcomes than will teams that participate in more traditional, chronologically structured Navy brief and debriefs.

Two studies were conducted to test these experimental hypotheses. Both studies were conducted in the context of actual Navy team training. As such, practical constraints associated with each training situation limited our ability to collect desired measures. Thus, we tested Hypotheses 1 and 2 in Study 1 and Hypotheses 3 and 4 in Study 2.

Study 1 Method

Participants and Study Design

Participants in Study 1 were 385 male members of 25 intact U.S. Navy submarine attack center teams. Team size ranged from 7 to 21, with an average size of 15.40. Data were collected during the teams' predeployment training and evaluation week. A cohort design was employed. Data were collected over a period of 2 years. The first year, data on 15 teams were collected. These teams were prebriefed and debriefed using the existing Navy method. Next, the instructors received training on how to brief and debrief teams using the guided team self-correction method. In the year following, data were collected on 10 teams that had been briefed and debriefed by instructors who had participated in this facilitator training.

Facilitator Training

Facilitator training lasted approximately two 8-hr days and had two primary objectives. The first involved teaching the instructors to understand and apply the expert model. The second involved teaching the instructors to facilitate the guided team self-correction process. Specifically, instructors received approximately 4 hr of classroom training. During this portion of the training, instructors were introduced to the expert model and to the guided team self-correction method, received active practice categorizing examples within the expert model, critiqued videotaped debrief facilitators, role-played portions of a guided team self-correction debrief, and received feedback (see Smith-Jentsch, Zeisig, McPherson, et al., 1998, for a more detailed description). The remaining day and a half involved hands-on practice using guided team self-correction to train intact teams. Participants took turns facilitating briefs and debriefs, and they received feedback on their performance from the lead author.

Procedure

All teams in both conditions participated in two briefing-exercise-debriefing training cycles. The simulation exercises were each 3 hr long and took place in a high-fidelity simulator that closely resembled the physical equipment and layout of a submarine attack center. The exercise scenarios were secret and thus could not be recorded for later coding. However, we were able to collect the identical measure of participants' teamwork mental models in both conditions following the second team debrief.

Control condition. Briefs in the control condition communicated information related to the particular scenario that a team was to perform, such as their mission, their location in the world, the equipment, and data that they would have access to during the exercise. Additionally, instructors communicated the task and team skills that would be evaluated. With respect to team skills, teamwork was discussed in a very general sense. Postexercise debriefs involved a chronological discussion of the events that took place during the exercise. Discussion of task and teamwork issues was interspersed in the order that they arose in the exercise.

Experimental condition. Briefs in the experimental condition began with the same exercise-specific information that was presented to teams in the control condition. However, in this condition instructors explicitly stated that a key objective of the training was to learn the expert model of teamwork and to use it as a framework from which to continuously improve their teamwork processes. They were also told that they would be asked to critique themselves during the postexercise debrief using this model as a guide. The dimensions and their component behaviors were then defined, and the team practiced categorizing a few concrete examples of situations that might occur within the expert model.

The team debrief began with a quick summary of the key events that took place during the exercise. Next, the instructor reminded the team that a key purpose of the debrief was to teach them to understand the expert model of teamwork and to use it to continuously improve the team's processes. The instructor then used the framework of the expert model as a means of organizing the subsequent discussion. Specifically, a briefing and debriefing guide was provided to the instructors who walked them through the following steps for each of the four dimensions within the expert model. First, the dimension was redefined, and the components within it listed. Second, the instructor asked the team to describe first a positive (e.g., "Can someone please describe for me a time when backup was provided from one teammate to another?") and then a negative instance ("Can someone describe a time when backup was needed but not provided?") of each component within the dimension from the exercise they had just performed. Instructors were trained to elicit two to three examples per category before moving on to the next category. For each positive example, the instructors asked the follow-up question of "How did this help the team's performance?" For each negative example, the instructor asked "How did this or how might this have hurt the team's performance?" and "What can be done differently next time?" After the last component within the last dimension was discussed, the instructor asked the team to generate four specific goals for improvement—one per dimension.

Measure of Teamwork Mental Models

Participants were presented with 33 index cards. Each card described a critical incident in the context of a submarine attack center that illustrated a component of teamwork from the expert model. Three examples (cards) were included for each of the 11 teamwork components within the model. Participants were asked to sort the cards into piles according to whatever natural categories of teamwork they felt the examples fell into. Card sorts were scored in the following manner. Each possible pairing of cards was assigned a 1 or a 0, based on whether the participant grouped the cards in the same pile. To determine a participant's similarity to the expert model, or their *accuracy*, we computed the correlation between their string of 0's and 1's and a predetermined string of 0's and 1's that was consistent with a sorting of the cards according to the expert model. This expert card sort had been determined previously (Smith-Jentsch et al., 2000) using subject matter experts who were highly familiar with the expert model. Team member mental model accuracy was then averaged to arrive at a team-level score. We computed similarity of teammates' mental models of teamwork by correlating each member's string of 0's and 1's with each other member of their team and then taking an average of those values.

Study 1 Results

As expected, a strong and positive correlation was found between teamwork mental model accuracy and similarity ($r = .78$, $p < .01$). Average teamwork mental model accuracy was greater for teams in the experimental condition ($n = 10$, $M = .44$, $SD = .08$) than for teams in the control condition ($n = 15$, $M = .34$, $SD = .07$). In support of Hypothesis 1, results from a one-tailed independent-samples *t* test revealed that this difference was statistically significant, $t(23) = –3.37$, $p < .01$. The standardized delta associated with this test was $\Delta = 1.3$, which represented a large effect for guided team self-correction on the accuracy of teamwork mental models.

The average level of teammate similarity with respect to teamwork mental models was also greater for teams that were prebriefed and debriefed using guided team self-correction ($n = 10$, $M = .36$, $SD = .09$) than for teams in the control condition ($n = 15$, $M = .30$, $SD = .10$). However, results from a one-tailed independent-samples *t* test revealed that this difference was not statistically significant, $t(23) = –1.49$, $p > .05$. Thus, Hypothesis 2 was not supported. The standardized delta associated with this test was $\Delta = 0.6$, which would have represented a small to medium effect.

Study 2 Method

Participants and Design

Participants were 65 male lieutenants in the U.S. Navy undergoing team training to prepare them for their first assignment as a department head on a Navy surface ship. These participants were randomly assigned to 13 five-person teams. Teams were then randomly assigned to either the experimental or the control condition. Team leaders were separated from their teams for 2 hr and individually received training during this time.

Team Leader Training

Leaders randomly assigned to the control condition received task-work-oriented training related to the CIC, whereas those assigned to the experimental condition received instruction on how to facilitate guided team self-correction. Training for those in the experimental condition was a 2-hr condensed version of the 4-hr classroom training described in Study 1. Because only one team could be run per day, each leader received training individually and practiced role-playing the guided team self-correction method using two role-players as mock teammates. As we have reported previously (Tannenbaum et al., 1998), a manipulation check of briefings and debriefings conducted by team leaders in this study indicated that those in the experimental condition were in fact more likely to guide the team to consider the teamwork behaviors included in the expert model, and members of their teams were more likely to critique themselves and to offer suggestions to others regarding these same teamwork behaviors.

Procedure

As in Study 1, each team performed two briefing-exercise-debriefing training cycles. However, in Study 2, the exercises were only 30 min in length, were standardized across teams, and were not secret. Moreover, teams performed a third and final evaluation exercise in which we had the opportunity to collect audio recordings of their performance. This final exercise was identical for all teams and was evaluated after the fact by two condition-blind subject matter experts. Another difference between the two studies was that team leaders, instead of instructors, led their teams' briefs and debriefs. Because team members were equal in rank, an ad hoc leader was selected for each team on the basis of their relative prior task experience in a CIC.

Measures of Teamwork Processes

Based on audio recordings of the teams' performance in the third and final 30-min exercise, two subject matter experts (retired Navy officers) used Likert-type scales to assign ratings of 1 (*highly ineffective*) to 5 (*highly effective*) for each of the four dimensions: information exchange, communication delivery, supporting behavior, and initiative and leadership. These raters were employed as consultants and were tasked to support the Navy training command. First, the two raters reviewed the tapes independently and without knowledge of experimental condition. The interrater reliability of these ratings was .83 for team initiative and leadership, .70 for supporting behavior, .63 for communication delivery, and .62 for information exchange. Next, the two raters discussed each team's performance and negotiated a consensus rating for each of the four dimensions of teamwork. These consensus ratings were used in all further analyses.

Measures of Performance Effectiveness

Performance effectiveness involved rating the accuracy of the teams' situation assessment. Specifically, it was judged whether the team had correctly evaluated the status of key aircraft (i.e., hostile or friendly). This variable had a conceivable range from 0 to 5; the actual range observed was 2 to 5. Because all teams performed the identical scenario, whereby the status of all aircraft was scripted, performance effectiveness ratings were fairly objective. Two subject matter experts, highly experienced in surface warfare and familiar with the scripted scenario, jointly reviewed audiotapes of the team's performance and came to consensus regarding the accuracy of each team's situation assessment.

Study 2 Results

The four teamwork dimension ratings were averaged in order to derive a single teamwork rating, and mean differences between teams in the experimental and control conditions were tested. Inspection of the means indicated that teams in the experimental condition had higher overall teamwork ratings ($n = 7$, $M = 3.61$, $SD = 0.90$) than did teams in the control condition ($n = 6$, $M = 2.61$, $SD = 0.91$). Results from an independent-samples t test revealed that this difference was statistically significant, $t(11) = -1.98$, $p < .05$ (one-tailed), in support of Hypothesis 3. The standardized delta of $\Delta = 1.1$ associated with this test represented a large effect for guided team self-correction on teamwork overall. We then proceeded to investigate differences between the two conditions using the four dimension ratings as separate dependent variables. Teams that participated in guided team self-correction received significantly higher ratings than did control teams with respect to initiative and leadership (guided team self-correction: $n = 7$, $M = 3.71$, $SD = 0.87$; control: $n = 6$, $M = 2.39$, $SD = 0.65$), $t(11) = -3.06$, $p < .05$ (one-tailed); supporting behavior (guided team self-correction: $n = 7$, $M = 3.71$, $SD = 0.89$; control: $n = 6$, $M = 2.78$, $SD = 0.84$), $t(11) = -1.94$, $p < .05$ (one-tailed); and information exchange (guided team self-correction: $n = 7$, $M = 3.76$, $SD = 0.92$; control: $n = 6$, $M = 2.67$, $SD = 1.01$), $t(11) = -2.04$, $p < .05$ (one-tailed). Although in the predicted direction, the difference between the control and experimental groups with respect to ratings for communication delivery was not statistically significant (guided team self-correction: $n = 7$, $M = 3.24$, $SD = 1.13$; control: $n = 6$, $M = 2.61$, $SD = 1.25$), $t(11) = -0.95$, $p > .05$.

Finally, we compared teams in the two conditions with respect to performance outcomes. Inspection of the means indicated that teams in the experimental condition demonstrated more effective performance outcomes ($n = 7$, $M = 4.57$, $SD = 0.79$) than did teams in the control condition ($n = 6$, $M = 2.17$, $SD = 0.41$). Results from an independent samples t-test revealed that this difference was statistically significant, $t(11) = -6.72$, $p < .01$ (one-tailed). Thus, Hypothesis 4 was also supported. The standardized delta associated with this test was $\Delta = 4.1$, indicating a very large effect for guided team self-correction on performance outcomes.

Discussion

This research demonstrated that teams that participated in facilitator-led guided team self-correction structured around an empirically derived expert model of teamwork developed more accurate (but not more similar) mental models of teamwork, demonstrated greater teamwork processes, and achieved more effective performance outcomes after two training cycles than did those briefed and debriefed using a more traditional Navy method. Results from this research have a number of theoretical and practical implications.

Guided Team Self-Correction

Prior research has demonstrated that the manner in which confederate leaders conducted their briefings significantly affected team members' understanding of norms and role expectations and in turn their behavior toward team members (Marks et al., 2000; Smith-Jentsch et al., 2001). The present research extended this prior work by investigating the impact of briefs and debriefs using real teams that engaged in two-way interaction with leaders and instructors who were not scripted confederates of the experiment. Facilitators trained to lead experimental briefs and debriefs used the expert model of teamwork to help their teams make sense of their performance successes and failures. This was intended to put the focus on learning general rules regarding teamwork that transcend the details of any particular training scenario. By contrast, the structure of briefings and debriefings led by those in the control conditions was not dictated by us. Left to their own devices, facilitators of these debriefs tended to organize them chronologically—moving event by event through issues as they arose. This structure is more common of typical military debriefs and, we believe, leads team members to develop mental models that are organized in terms of concrete task features. Individuals with such mental models of teamwork should be less likely to generalize lessons learned in novel scenarios to which they have not yet been exposed.

It is unclear how much of the performance improvement seen in Study 2 is directly related to mental model accuracy and how much is associated with the model-based self-correction that teams engaged in. Note that a comparison was not made between teams that were trained on the expert model but did not subsequently use the model to self-correct with those who both learned and used the model for team self-correction. We did, however, report findings that could be seen as evidence that the self-correction process itself is important and that simply developing more accurate mental models of teamwork (e.g., through computer-based training) would not yield the same level of results. Of the four dimensions within the expert model, communication delivery is the only one that did not significantly improve due to the manipulation in Study 2. Two of the components within this dimension require specific task-related knowledge in order to improve: "uses appropriate phraseology" and "sends standard reports that are complete and in the appropriate order." Each of the remaining three dimensions contained components that could be improved through trial, error, and problem solving. However, teams without a single member who possessed knowledge regarding appropriate phraseology and standard reporting procedures would have no way of figuring out on their own how to improve these components. Thus, our findings suggest that guided team self-correction improves performance, in part, due to the act of targeted self-critique and problem solving and not simply because team members come to share an understanding of the expert model.

It is important to note that the effect size for guided team self-correction on performance outcomes was greater than was the effect size on teamwork processes. Although we did not test for mediation, these findings clearly suggest that teamwork processes could have only partially mediated the impact of this strategy. Although we did not measure task-work skills, it is reasonable to assume that the feedback teammates provided each other during the self-correction process improved these skills as well. Related to this point is the notion that guided team self-correction will have stronger effects on performance outcomes for experienced teams that collectively possess enough task-work knowledge to effectively solve their own problems.

Finally, we had expected that as teammates' mental models converged on the expert model, and became more accurate by our standards, teammates' mental models would necessarily become more similar to one another. However, although the means were in the appropriate direction, differences between the experimental and control groups on mental model similarity were not statistically significant. When interpreting these results, one must note that we did not examine pre-post change in mental model similarity. Thus, our findings do not necessarily indicate that guided team self-correction did not increase mental model similarity but that it did not increase similarity to a greater degree than did the control debriefs. Whereas the teamwork mental models of members within the guided team self-correction condition converged on our expert model (by design), the mental models of those in the control condition may have also converged, but onto other models of teamwork. The fact that control teams underperformed relative to experimental teams in Study 2 suggests that if control teams did develop shared mental models of teamwork, those mental models were likely lower in quality (Mathieu et al., 2005).

In sum, our results suggest that the effects of guided team self-correction on team performance outcomes can be quite large relative to those demonstrated by other team training and team building strategies (Salas, Rozell, Mullen, & Driskell, 1999; Salas et al., 2007). We argue that these effects are likely mediated by both teamwork and task-work mental models and processes. Furthermore, we believe that guided team self-correction works in part because teams develop accurate and generalizable mental models and in part because they use these models to critique and solve performance problems. Because of this, the effectiveness of the strategy should naturally be moderated by the validity of the expert model used to structure team discussions and also the human capital that team members possess and use to solve the problems they uncover.

Study Limitations and Future Research

The generalizability of our results may be limited by the nature of the teams that participated in our research and also the manner in which briefs and debriefs were conducted in the control conditions. Future research should compare the effects of guided team self-correction with those of other existing briefing and debriefing methods for different group and team types. Related, additional research is needed to test the present method of guided team self-correction using expert mental models other than the particular one employed here.

Second, the fact that both Studies 1 and 2 were conducted in the context of U.S. Navy team training strengthens the external validity of our findings. However, it also limited our sample size and prevented us from collecting data on teamwork mental models, teamwork processes, and outcomes in the same study. Thus, we were unable to test for mediation in either study. However, prior research has demonstrated that accurate teamwork knowledge is positively associated with teamwork processes (Hirschfeld et al., 2006) and outcomes (Lim & Klein, 2005) and that teamwork processes partially mediate the impact of accurate teamwork knowledge on team performance outcomes (Marks et al., 2000). Thus, theoretically, one would expect that the positive effects of guided team self-correction on teamwork processes and outcomes in Study 2 were due in part to the fact that mental models of teamwork became more accurate, as was demonstrated in Study 1. However, it is unclear how much of an impact on team performance may have been due simply to the fact that those who participated in guided team self-correction were more likely to critique themselves and to offer suggestions to others.

Practical Implications

Team training. Results from this study provide support for the use of guided team self-correction as a means of briefing and debriefing teams in conjunction with simulated or actual performance events. Subsequent tests of guided team self-correction suggested that it is practical for use in a variety of team contexts both within and outside the military. For instance, guided team self-correction has been used to augment team simulation exercises for Navy aircrews, engineering, seamanship, damage control, and combat systems teams (Smith-Jentsch, Zeisig, McPherson, et al., 1998), as well as civilian firefighting teams (Volusia County [FL] Fire Services, n.d.), law enforcement teams (Office of Law Enforcement Technology Commercialization, 2003), and teams of corrections officers (Quinn, 2001). Finally, it has been used as a tool to support on-the-job performance improvement through accident investigations within the nuclear power industry (PSEG Nuclear, 2000) and was used by the lead author to debrief one multiteam organization's response to the terrorist attacks of 9/11. Guided team self-correction will likely be more effective the more experienced team members are with their tasks. When used to train less experienced teams, the effectiveness of the strategy would likely be improved by assigning an instructor with advanced task-specific knowledge to facilitate the team's discussion to ensure that the problems identified are effectively resolved.

Team training needs analysis. Consistent with the notion of equifinality (Mathieu et al., 2005), there may be multiple expert models of teamwork that predict team performance equally well in a particular team task domain. In this case, results from prior research suggest that it is not enough for teammates to hold high-quality teamwork knowledge. This knowledge must also be shared in order to have a positive impact on team performance. Thus, the goal of training should be to ensure that teams develop both shared and accurate teamwork knowledge. This means that if multiple expert models exist, the organizational objective should be to select one of these and train all to share it.

We have described an empirically based approach to identifying the particular expert model of teamwork that served as an organizing framework for guided team self-correction in the present research. To be clear, we do not mean to suggest that this model of teamwork is universally applicable. However, the approach we took to defining this model should be. Rather than assuming we could identify experts who had insight into the "true state of the world" with respect to teamwork a priori, we determined empirically what the true state of the world was first, then determined whether those who held mental models more similar to this view tended to have greater team experience. We hope that researchers continue to investigate methods of training shared and accurate mental models and to examine the generalizability of those methods across various task types. Results from this research indicate that facilitator-led guided team self-correction structured around an expert model of teamwork can be a highly effective strategy for improving team mental models, processes, and performance.

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