THE EFFECT OF TEAM TRAINING STRATEGIES ON
TEAM MENTAL MODEL FORMATION AND TEAM PERFORMANCE
UNDER ROUTINE AND NON-ROUTINE ENVIRONMENTAL CONDITIONS

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ABSTRACT

The current study examined how the type of training a team receives (team coordination training vs. cross-training) influences the type of team mental model structures that form and how those mental models in turn impact team performance under different environmental condition (routine vs. non-routine). Three-hundred and fifty-two undergraduate students from a large northeastern university participated in the current study (176 dyads). Data were collected through the NeoCITIES simulation, which is a simulated task environment of an emergency management team. Team training was manipulated across subjects while environmental condition was manipulated within subjects. Findings indicated that training type had no main effect on team mental models but did have a significant impact on performance. Specifically, dyads exposed to cross-training had higher levels of performance than those that received team coordination training. In addition, team mental models had a significant main effect on performance, such that the increased accuracy and sharedness of situation mental models, the increased sharedness of teamwork mental models, and the increased accuracy of taskwork mental models resulted in higher levels of performance. Surprisingly, the increased sharedness of taskwork mental models was also found to decrease performance. Finally, contrary to previous findings, the effect of team mental models on team performance was not moderated by environmental condition. The results from ancillary analyses evaluating the relationship between team training and performance and team mental models and performance are discussed, along with the limitations and implications of these findings.
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Chapter 1. INTRODUCTION

Organizations have become increasingly team-based (Lawler, Mohrman, & Ledford, 1992), and well functioning teams are considered to be a high commodity to organizations (Mathieu, Maynard, Rapp, & Gilson, 2008). The team effectiveness literature has shown positive links to, not only individual and team-based outcomes (Johnson et al., 2006; Kirkman & Rosen, 1999; Mathieu & Schulze, 2006), but also organizational variables, such as innovation (Gibson & Gibbs, 2006), financial performance (Carpenter, 2002; Keck, 1997), and customer satisfaction and unit sales (Schneider, Ehrhart, Mayer, Saltz, & Niles-Jolly, 2005). Action teams, in particular, have increasingly been used in organizational work environments (cf. Sundstrom, 1999). Such teams “conduct complex, time-limited engagements with audiences, adversaries, or challenging environments in ‘performance events’ for which teams maintain specialized, collective skill” (Sundstrom, 1999, pp. 20-21). The success of action teams is dependent on the ability of their members to coordinate their actions and work as an interdependent unit (Hollenbeck, DeRue, & Guzzo, 2004). One of the ways that these skills are obtained is through team-based training (e.g., Marks, Sabella, Burke, & Zaccaro, 2002).

About a decade ago, the average investment in training activities in organizations was approximated at 53.3 to 200 billion dollars annually (Bassi & Van Buren, 1999). This investment was speculated to have increased with the aggressive research activities that have taken place in this area (cf. Salas & Cannon-Bowers, 2001). However, despite the large financial investment that has been placed on training activities, there has been little research conducted on the differential impact of team training strategies on team effectiveness (Salas, Nichols, & Driskell, 2007). As described by Salas and colleagues
(2007), “there are a large number of theoretical and conceptual efforts describing needed work [on team training] and a much smaller subset of empirical studies” (p. 485).

The purpose of the current study was to focus on the effect of two of the most researched team training strategies (team coordination training and cross-training; Salas et al., 2007) on team mental models and team performance. The current study also examined if the external environment of the team (routine versus non-routine conditions) moderates the relationship between team mental models and team performance. In addressing these purposes, five contributions to the team literature are presented.

First, multiple types of team training strategies were examined in the same study, allowing for a comparison of the relative contributions of each training strategy on team effectiveness. This will serve as a useful aid for practitioners to determine what to train. Most empirical team studies have only examined the impact of one type of training at a time on team outcomes (e.g., Marks et al., 2002; McCann, Baranski, Thompson, & Pigeau, 2000; Tannenbaum, Smith-Jentsch, & Behson, 1998; Volpe, Cannon-Bowers, Salas, & Spector, 1996). Salas and colleagues’ (2007; 2008) meta-analyses are the only known work to empirically examine the effect of multiple types of team training on team effectiveness. However, meta-analyses are subject to low internal validity because of the aggregation of data from studies with their own inherent flaws into a single set of findings (Bobko & Stone-Romero, 1998). An alternative solution to this issue is “concentrated efforts towards fewer, but larger scope, studies that will have stronger measurement and design characteristics, have sufficient power to model relationships as appropriate, and reduce concerns about model misspecification” (Bobko & Stone-Romero, 1998, pp. 359-360). This solution has also been suggested by Salas and
colleagues (2007), who have noted the absence of experimental designs evaluating multiple types of training. According to Salas and colleagues, there are “a relatively small body…of empirical results that hint at the components of team training that drive enhancements in team performance (Salas et al., 2006). Researchers interested in the problems of bolstering team performance might direct and channel primary level research efforts into these promising directions” (Salas et al., 2007, pp.485-486). The current study followed the recommendations of Salas et al. (2007) by conducting an experimental study on the effect of multiple training types on team effectiveness.

A related second contribution of this study was the examination of the mediating mechanism through which team training impacts team performance. Salas and colleagues (2007) highlighted that in the team training research domain, “we clearly do not have a large body of conclusive research establishing the mechanisms through which team training interventions determine performance” (p. 485). The current study therefore evaluated whether different types of team mental models mediate the relationship between team training and team performance.

A third contribution of the current study was the measurement of situation mental models. Most of the empirical work on team mental models has assessed two broad types of content: taskwork and teamwork (e.g., Banks & Millward, 2007; Lim & Salas, 2006; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005; Smith-Jentsch, Mathieu, & Kraiger, 2005). Although task mental models have been defined as including perceptions and understanding of environmental condition (Cannon-Bowers, Converse, & Salas, 1993), these aspects are not commonly assessed (see Serfaty, Entin, and Johnson (1998) and Waller, Gupta, and Giambatista (2004) for exceptions). However, research on team
adaptation has argued that shared mental models regarding the situation are important for effective adaptation to changing contexts (Burke, Stagl, Salas, Pierce, & Kendall, 2006; Stagl, Burke, Salas, & Pierce, 2006). The degree to which situation mental models impact performance under varying performance conditions was examined in this study.

A related fourth contribution to the team literature was the assessment of the effects of multiple types of team mental models on team effectiveness. Previous studies have mostly examined a single type of team mental model (e.g., Ellis, 2006; Gurtner, Tschan, Semmer, & Nagele, 2007; Marks et al., 2002; Rentsch & Klimoski, 2001). Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers (2000) recommended that future researchers formulate a stronger foundation on what type of knowledge needs to be shared in order for teams to be effective. Heeding this recommendation, the present research assessed the effect of training on three types of team mental models: taskwork (shared knowledge on what needs to be accomplished), teamwork (shared knowledge on how the goal should be accomplished), and situation (shared knowledge on the external team environment).

A fifth contribution was the examination of team task performance under both routine and non-routine environmental conditions. The environment in which teams operate has direct implications for team effectiveness (Ancona & Caldwell, 1992). It is therefore essential to understand the factors that drive team performance during different environmental conditions. Previous researchers examining the antecedents of team adaptation have not compared the effects of the predictors on team performance under both routine and non-routine environmental conditions (e.g., Chen, Thomas, & Wallace, 2005; Lepine, 2003; 2005; Lepine, Colquitt, & Erez, 2000; Moon et al., 2004). This
precludes the possibility of determining whether a variable predicts performance equally well under both routine and non-routine environmental conditions. Additionally, these studies typically do not examine the role of team mental models in the team’s adjustment to the new environment (see Marks, Zaccaro, and Mathieu (2000) and Waller et al. (2004) for exceptions). The current study addressed these limitations by determining predictors of task performance under both routine and non-routine environmental conditions.

The sections that follow provide a detailed literature review of the main variables that were examined in this study. The first section below summarizes empirical reviews on the team training literature. This is followed by an overview of previous research on cross-training, team coordination training, and team mental models. Hypotheses concerning team training, team mental models, team performance, and environmental condition will then be advanced, followed by the methodology and findings of the study.

Empirical Review: Meta-analyses on Team Training

Team training is one of two types of team development interventions (Salas & Cannon-Bowers, 1997). Team building, the second type of team development intervention, differs from team training according to the level of rigor used in its design (Tannenbaum, Beard, & Salas, 1992). Team building tends to be less systematic, less focused on the development of specific skills, and are less likely to be conducted in environments that approximate the team’s general work context than team training interventions (Tannenbaum et al., 1992). Given that team building is typically operationalized in a different way than team training, the review below focuses on the research findings associated with team training.
Three known meta-analyses have been conducted on team training (O’Connor et al., 2008; Salas et al., 2007; 2008). Salas and colleagues (2007) investigated the effect of three team training strategies on team performance: cross-training, team adaptation/coordination training (TACT; a modified version of team coordination training (also known as crew resource management training or CRM), in which team members are taught generic teamwork skills and also shown how to maximize team productivity during changing environmental conditions; Serfaty et al., 1998), and self-correction training. These strategies were selected because they have received the most empirical scrutiny over the past several years (e.g., Cannon-Bowers, Salas, Blickensderfer, & Bowers, 1998; Entin & Serfaty, 1999; Smith-Jentsch, Zeisig, Acton, & McPherson, 1998). From the accumulated research on team training strategies, Salas and colleagues only selected studies that had complete data, did not examine team training as a case study paradigm, and examined the effects of team training on performance. These criteria for inclusion resulted in the selection of only seven studies for the meta-analysis, containing 28 hypothesis tests (Blickensderfer, Cannon-Bowers, & Salas, 1997a; Buller & Bell, 1986; Cannon-Bowers et al., 1998; Cohen, 1993; Dione, 1998; Entin & Serfaty, 1994; Volpe et al., 1996). Among these seven studies, only three represented published research (Buller & Bell, 1986; Cannon-Bowers et al., 1998; Volpe et al., 1996).

Salas and colleagues (2007) found that TACT (r = .607) and self-correction training (.448) both had significant positive effects on team effectiveness, while cross-training did not significantly impact team performance (r = -.092). However, these results should be interpreted with caution. One of the main limitations of Salas and colleagues (2007) was the small subgroups of effect sizes examined in the meta-analysis, which
limited the statistical conclusion validity of their results (cf. Bobko & Stone-Romero, 1999). The authors also restricted the inclusion of studies to only those that demonstrated a relationship between team training and team performance. This restriction precluded the possibility of examining variables that could possibly mediate the relationship between team training and performance. In fact, their finding that cross-training did not significantly impact team performance runs counter to several research studies that have demonstrated the positive effects of cross-training on team performance through team mental models (Cooke, Kiekel, Salas, & Stout, 2003; Marks et al., 2002) and team processes (Cannon-Bowers et al., 1998; McCann et al., 2000).

In a replication and extension of Salas and colleagues (2007), Salas and colleagues (2008) assessed the effect of specific team training types on a global outcome of team effectiveness and evaluated the effect of general team training on specific team-level outcomes. The authors evaluated the relationship between team training and cognitive outcomes (e.g., declarative knowledge; mental models), affective outcomes (e.g., cohesion), team processes (e.g., communication; coordination), and team performance (Salas et al., 2008). Forty-five empirical articles were included in the meta-analysis, of which 52 effect sizes from separate independent samples were retrieved.

Contrary to Salas and colleagues (2007), Salas and colleagues (2008) found that cross-training ($\rho = .44$), team coordination training ($\rho = .47$), TACT ($\rho = .56$), and self-correction training ($\rho = .36$) all had positive effects on team effectiveness. They also extended the work of Salas and colleagues (2007) by demonstrating that team training had a positive effect on cognitive outcomes ($\rho = .42$), affective outcomes ($\rho = .37$), team processes ($\rho = .44$), and team performance ($\rho = .39$). Given that team training had a
stronger effect on cognitive outcomes and team processes than on team performance, the relationship between team training and team performance may be mediated by either of these factors.

The results of Salas et al. (2008) help to demonstrate that training is important for effective team functioning. However, a limitation of Salas et al. (2008) is that all team training strategies were collapsed into a single variable when examining its effect on specific team-level outcomes. The primary reason for doing so included increasing power due to the significantly lower number of studies that have examined the effect of specific training types on specific types of team-level outcomes. However, without these analyses, it is difficult to determine how each type of team training intervention impacts team performance.

The third meta-analysis, O'Connor et al. (2008), was the only one to examine the effect of a specific type of team training, CRM, on multiple team-level outcomes. O’Connor and colleagues (2008) uncovered 74 CRM evaluation studies, of which only 16 were included in the meta-analysis. The primary reason for the exclusion of numerous studies was the insufficiency in the data needed to calculate effect sizes. Based on the studies included in the meta-analysis, O’Connor and colleagues demonstrated that CRM training had a large positive effect on attitudes ($d_{mean} = .94$) and behaviors ($d_{mean} = 1.18$) and a medium positive effect on knowledge building in teams ($d_{mean} = .59$). Among these results, only the positive impact of CRM on attitudes was significant. O’Connor and colleagues (2008) could only confidently conclude that that CRM/ team coordination training has an impact on improving team members’ attitudes towards training. However, similar to Salas and colleagues (2007), one of the primary limitations of this meta-
analysis was the small sample size used. The results should therefore be interpreted with caution (O’Connor et al., 2008).

A key contribution of O’Connor et al. (2008) to the team training literature was their examination of the mechanisms through which a specific type of training impacts team effectiveness. However, the authors failed to evaluate whether the effect of CRM on the specific team-level outcomes exceeds that of other team training strategies. Additionally, neither O’Connor and colleagues (2008), Salas and colleagues (2007), nor Salas and colleagues (2008) elaborated on the situational conditions under which each team training strategy could improve performance. The current study therefore addressed these limitations through examining various types of team mental models as potential mediators between both cross-training and team coordination training and team performance. The current study also evaluated how environmental condition (routine vs. non-routine) moderated the effect of team mental modes on team performance.

Types of Team Training Strategies

Training is “a set of tools and methods that, in combination with required competencies and training objectives, form an instructional strategy” (Salas & Cannon-Bowers, 1997, p. 313). Examples of these tools include feedback, team task analyses, task simulations, and exercises (Salas & Cannon-Bowers, 1997). Training methods are comprised of three main types: information-based (e.g., lectures), demonstration-based (e.g., videos), and practice-based (e.g., guided practice and role plays; Salas & Cannon-Bowers, 1997). Finally, competencies include team-related cognitions, skills, and attitudes (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995). Variations on any of
these three components (i.e., tools, methods, competencies) lead to different types of training strategies.

There are several types of team training strategies, each of which has a different theoretical basis. Cannon-Bowers and Salas (1998) describe ten types of training interventions that are used in team settings (e.g., event-based approach to training, team coordination training, team leader training, cross-training, interpositional knowledge training, self-correction training, part-task training, meta-cognitive training, mastery learning, and stress exposure training). Of these ten training interventions, only four have their foundations in the team performance and effectiveness literature, in which training is based on the development of team-based competencies (e.g., shared mental models, mutual performance monitoring, shared situation awareness; Cannon-Bowers et al., 1995). The four strategies based on this literature are team leader training, self-correction training, cross-training, and team coordination training (Cannon-Bowers & Salas, 1998).

Each of the four team-based training strategies has their own unique traits. Team leader training involves instructing team leaders on how to observe the team’s performance and give members useful feedback (Tannenbaum et al., 1998). In contrast, team members that receive self-correction training are taught how to give themselves feedback between performance episodes (Blickensderfer, Cannon-Bowers, & Salas, 1997b). Cross-training entails sharing details about other teammates’ roles and responsibilities in order to build shared knowledge among team members (Blickensderfer, Cannon-Bowers, & Salas, 1998). Finally, team coordination involves educating team members on teamwork skills that can improve their performance (Salas et al., 2001).
Of these four strategies, self-correction training, cross-training, and team coordination training, have received the most research attention (Salas et al., 2007). A meta-analytic summary of these research findings has shown that TACT (a specific type of team coordination training) and self-correction training are highly positively correlated \( r = .708 \) and had a similar effect on team performance (Salas et al., 2007). On the other hand, cross-training and TACT, and cross-training and self-correction training, were negatively correlated, \( r = -.408 \) and \( r = -.773 \) respectively (Salas et al., 2007). Cross-training also had an effect on team performance that was distinct from TACT and self-correction training (Salas et al., 2007). Given the similarity between TACT and self-correction training, the current study will focus on comparing the relative strengths of cross-training and team coordination training only in determining team performance.

**Cross-Training**

Cross-training is “an instructional strategy in which each team member is trained in the duties of his or her teammates” (Volpe et al., 1996, p.87). As discussed by Blickensderfer and colleagues (1998), there are three types of cross training: positional clarification, positional modeling, and positional rotation. Positional clarification is the verbal presentation of information to fellow teammates about their team members’ roles and responsibilities (Blickensderfer et al., 1998). This is typically done through lectures or other discussion procedures. Positional modeling involves not only receiving a verbal lecture on the teammates’ roles and responsibilities but also witnessing the roles being performed (Blickensderfer et al., 1998). Finally, positional rotation entails team members performing the roles and responsibilities of their fellow teammates (Blickensderfer et al., 1998). The core idea behind these three techniques is that teammates will learn about the
demands of the task from the perspective of their teammates (Cannon-Bowers & Salas, 1998) and therefore be more likely to take these into account when subsequently performing the task.

Only a few studies have been conducted on the effectiveness of cross-training, all of which have indicated the effectiveness of the training strategy in improving team performance through team processes (Cannon-Bowers et al., 1998; McCann et al., 2000; Volpe et al., 1996) and team mental models (Cooke et al., 2003; Marks et al., 2002). In an early study, Volpe and colleagues examined the effect of cross-training (operationalized as positional clarification) on team processes, communication, and task performance. Undergraduate students performing a PC-based military simulation were placed in one of four conditions (i.e., cross-trained and high workload, cross-trained and low workload, not cross-trained and high workload, and not cross-trained and low workload). Volpe and colleagues found that individuals in the cross-training condition volunteered more information, proffered less irrelevant remarks, and had higher team task performance than those that were not in the cross-training condition. Team workload did not seem to impact the effectiveness of the cross-training intervention.

In an extension of Volpe et al.’s (1996) study, Cannon-Bowers and colleagues (1998) examined the joint impact of cross training and workload on team performance using positional rotation cross-training instead of Volpe et al.’s (1996) positional clarification. Cannon-Bowers and colleagues (1998) conducted a PC-based lab simulation using United States Navy recruits as research participants. The two manipulations used in the study were cross-training (i.e., whether or not participants received cross-training) and workload (high vs. low). The authors found a significant interaction between
positional rotation cross-training and workload, such that teams in the high workload condition did better if they were cross-trained than if they did not receive any team training. The main reason for this finding is that under conditions of high workload, cross-trained teams were better able to engage in implicit coordination, which counteracted the negative impact of workload on performance (Cannon-Bowers et al., 1998). The authors also found that cross-trained teams developed more knowledge about others’ positions (i.e., interpositional knowledge or IPK), engaged in more effective teamwork processes, and had a higher level of task performance than teams that were not cross-trained.

Whereas the previous two studies examined different conceptualizations of cross-training in isolation, Marks et al. (2002) examined all three conceptualizations of cross-training (i.e., positional clarification, positional modeling, and positional rotation) in the same study. Using undergraduate student participants engaged in a PC-based military simulation, all three conceptualizations of cross-training were found to increase the level of shared knowledge among team members about how the team’s task should be done (i.e., shared team-interaction mental models). While positional clarification resulted in less sharedness of team-interaction mental models than positional modeling and rotation, there were no significant differences between the positional modeling and positional rotation conditions. This finding suggests that teams can benefit from cross-training through simply observing what other team members are doing without actually having to perform other team members’ tasks. Marks and colleagues (2002) also found that the effect of cross training on team performance was mediated by shared team-interaction mental models and team backup and coordination processes. The authors contributed to
the literature by assessing the effectiveness of various conceptualizations of cross-training as well as examining the mediating mechanisms through which cross-training impacted team performance. This study is one of the few that has evaluated the role team mental models play in the impact of cross-training on team performance.

While Marks and colleagues (2002) only assessed one type of team mental model, Cooke and colleagues (2003) assessed both teamwork and taskwork mental models. Specifically, Cooke and colleagues (2003) examined the effect of cross-training (operationalized as positional modeling and positional rotation) on the development of team mental models using a study similar to that of Marks and colleagues (2002). Investigating undergraduate student participants engaged in a PC-based simulation, Cooke and colleagues found that neither positional modeling nor positional rotation cross-training impacted the formation of teamwork mental models. Only positional rotation led to the development of taskwork mental models. These findings are inconsistent with Marks and colleagues who found no difference between the development of teamwork mental models formed after positional modeling and positional rotation.

Differences in results between the two studies may be explained by team mental model measurement. Marks and colleagues (2002) assessed teamwork mental models using concept maps while Cooke and colleagues (2003) used paired comparison ratings. Because concept mapping blurs the distinction between taskwork and teamwork mental models (Mohammed, Klimoski, & Rentsch, 2000), it is not known whether the significant relationship between positional modeling and teamwork mental models found by Marks and colleagues (2002) was more representative of taskwork than teamwork mental
models. The current study operationalized cross-training as positional clarification and positional modeling and addressed the inconsistencies in the cross-training literature by measuring multiple types of team mental models (i.e., taskwork, teamwork, and situation mental models). These team mental models were assessed using paired comparison ratings, as opposed to concept maps (Marks et al., 2002), to ensure a clearer distinction among all three types of team mental models (Mohammed et al., 2000).

*Team Coordination Training*

Team coordination training is also known as crew resource management (CRM). This training began in the early 1980s to reduce the number of aviation accidents brought about by the lack of coordination among team members in the cockpit (Fisher & Phillips, 2000). The content of coordination training has changed several times since it was first introduced (Helmreich, Merritt, & Wilhelm, 1999). The topics covered have ranged from knowledge and attitudes in the cockpit to organizational cultures and group and individual factors (Helmreich et al., 1999). However, the essential purpose behind team coordination training has remained the same, which is to increase the coordination among team members (Salas et al., 2001).

Coordination in teams is a process that involves “the use of strategies and behavior patterns aimed at integrating and aligning the actions, knowledge, and objectives of interdependent members, with a view to attaining common goals” (Rico, Sanchez-Manzanares, Gil, & Gibson, 2008, p. 163). The ultimate goal of team coordination is to build shared knowledge among team members (Eccles & Tenenbaum, 2004). This is most typically done through explicit processes, namely planning and communicating (Rico et al., 2008). However, teams also increase their coordination
through implicit processes, such as assessing the situation in which they operate (Rico et al., 2008). Situation assessment entails anticipating the needs of team members based on environmental information, such as increased task demands, without having to explicitly communicate with each other or plan the activity (Rico et al., 2008).

A review of the empirical research on CRM has shown that three of the most commonly taught dimensions are communication, situation assessment, and planning/decision making (cf. Salas et al., 2001). Examples of this include Alkov (1991) who conducted a quasi-experimental study in which naval aviation squadrons were trained on communication skills, situation awareness, decision making, pilot judgment, policy and regulations, command authority, workload performance, and use of available resources. Another example is Hansberger, Holt, and Boehm-Davis (1999) who also conducted a quasi-experimental study in which a group of pilots were trained in communication, situation assessment, and planning/decision making. These three dimensions were also taught in training studies by Ikomi, Boehm-Davis, Holt, and Incalcaterra (1999), Incalcaterra and Holt (1999), and Holt, Boehm-Davis, and Hansberger (1999) who all conducted quasi-experimental studies in which pilots were trained on communication, situation assessment, and planning/decision making.

Salas and colleagues (1999) conducted two evaluation studies on the effectiveness of CRM using naval aviators. The pilots were either trained using CRM or received no team-based training. The results demonstrated that, after engaging in a brief computer simulated flight, trained teams engaged in more instances of team coordination than untrained teams. This was especially seen under conditions of higher workload. The teams receiving CRM training also had a more positive reaction to training than those in
the control group. The participants in the CRM group also perceived training to be more important to both flight safety and mission accomplishment than those in the control group.

A more recent and comprehensive review of the CRM literature also demonstrated that the training strategy was associated with increased positive reactions, enhanced learning, and increased team behavioral changes (Salas et al., 2001). Salas and colleagues (2001) reviewed 58 published articles on CRM to evaluate the effectiveness of the training strategy on Kirkpatrick’s (1959) four criteria for training evaluation: reaction, learning, behavioral, and organizational. The authors found that CRM was associated with positive reactions both in utility and affective response. Trainees found the training to be relevant to their job description and enjoyable to complete. This finding was later corroborated in a meta-analysis by O’Connor and colleagues (2008), who found that CRM had a significant positive impact on team-level attitudes.

Salas and colleagues (2001) also found that CRM led to increased learning as measured through changes in knowledge structures, attitude change, and paper and pencil tests. Among the studies reviewed, behavioral criteria were the most commonly assessed. The body of research reviewed showed that trainees were more likely to engage in the teamwork behavior specified in CRM training than individuals that did not receive such training. Mostly anecdotal accounts existed regarding the impact of CRM on organizational outcomes. Those that were found suggested that CRM led to decreased errors and increased safety at the organizational level.

Even though most of the CRM literature has its foundation in aviation, there is some evidence to suggest that these results will generalize to the current study. Marks
and colleagues (2000) conducted an experimental study in which they examined the impact of leader briefings and team-interaction training on team mental model formation and communication processes in routine and non-routine environments. Undergraduate students at a large mid-Atlantic university participated in a brief tank war-game computer simulation. Team interaction training was described as “the training of task information embedded in the necessary teamwork skills for effective task execution” (Marks et al., 2000, p. 974). This training focused on how to work better as a team rather than on how to specifically perform the task. Much like team coordination training or CRM, team interaction training focuses on educating trainees on teamwork based skills that are relevant to the context in which the individuals are situated. The purpose of both types of training is to increase coordination among team members through decreasing any possible process loss. Marks and colleagues found support for their hypotheses that both leader briefings and team-interaction training impacted the formation of team mental models, which had a positive impact on team communication processes and team performance.

The experiment conducted by Mark and colleagues (2000) has many parallels to the current study. First, both studies used a simulated task environment in which to collect data. Second, both studies sampled undergraduate student populations that had no prior experience with the simulation. Third, the duration of the studies is approximately the same (around 2 hours) and takes place at one point in time (one-shot studies). Fourth, both studies investigate the effect of team training on team mental model formation, in which team training serves as a between subjects manipulation. Finally, both manipulate environmental condition within subjects and examine this variable as a moderator.
between team mental models and team performance. The similarities in the overall study design and operationalization of the key independent and moderating variables in the current study and Marks et al. (2000) suggest that their findings may generalize to the current study. The current study also makes provides a key contribution over Marks and colleagues (2000) results by clearly distinguishing between the types of team mental models evaluated. This was done through assessing the construct through paired similarity ratings as opposed to concept maps (Mohammed et al., 2000).

Team Mental Models

Definition and Conceptualization

Mental models were initially conceptualized at the individual level of analysis in the cognitive psychology literature (cf. Johnson-Laird, 1983). They were considered to be an individual’s structural representation of the “state of affairs in the world” (Johnson-Laird, 1983, p. 156). These mental models were assumed to represent a set of logical rules, which aid the speed of reasoning (Johnson-Laird, Bryne, & Schaeken, 1994). The first application of mental models to the team level of analysis was by Cannon-Bowers and Salas (1990), who used the construct to explain differences in performance across teams. Team mental models refer to “team members’ shared, organized understanding and mental representation of knowledge about key elements of the team’s relevant environment” (Mohammed & Dumville, 2001, p. 90). They are considered to be a related but distinct construct from individual mental models (Klimoski & Mohammed, 1994).

The content of team mental models can be divided into four different types: equipment, task, team-interaction, and team (Cannon-Bowers et al., 1993). According to Cannon-Bowers and colleagues (1993), the equipment model refers to team members’
shared understanding of the technology and equipment used to carry out team tasks. Task models are team members’ perceptions and understanding of team procedures, strategies, task contingencies, and environmental conditions. Team-interaction models entail team members’ understanding of fellow teammates’ responsibilities, norms, and interaction patterns. Finally, team mental models refer to team members’ understanding of each others’ knowledge, skills, attitudes, strengths and weaknesses. Mathieu and colleagues (2000) collapsed these four team mental models into two content areas: taskwork (a combination of equipment and task mental models) and teamwork (a combination of team-interaction and team mental models). The aggregation of these team mental models into these two main categories facilitates the ease of measurement of multiple types of team mental models in a single study (Mathieu et al., 2000). This categorization is also consistent with the concept that teams develop two tracks of behavior: taskwork and teamwork (Mathieu et al., 2000).

Team mental models also represent different types of knowledge: declarative, procedural, and strategic (Converse & Kahler, 1992). Declarative knowledge is knowledge of what needs to be done, particularly as it relates to the team’s task. Procedural knowledge concerns how the goals of the team should be executed. Strategic knowledge focuses on the link between the team’s capability to perform the task and the external environmental requirements. Cannon-Bowers and colleagues’ (1993) have classified the situation context as a part of task mental models, however other researchers have limited their measurement of task mental models to the task content (e.g., Banks & Millward, 2007; Lim & Salas, 2006; Mathieu et al., 2005; Smith-Jentsch et al., 2005) excluding the team’s external environmental conditions from consideration. In Converse
and Kahler’s (1992) typology, declarative and procedural knowledge represent types of taskwork and teamwork mental models, respectively, while strategic knowledge captures the situation component of mental models. This typology provides a more nuanced distinction among the different types of team mental models, especially as it relates to taskwork mental models. As suggested by Cooke and colleagues (2003), “more specific measurement of team knowledge can enhance our understanding of team performance and the factors affecting it and provide diagnostic information for team training and design” (p. 180). The current study will therefore adopt Converse and Kahler’s (1992) typology of shared knowledge and evaluate taskwork (declarative knowledge), teamwork (procedural knowledge), and situation (strategic knowledge) mental models.

Among taskwork, teamwork, and situation mental models, the conceptualization of situation mental models is the least developed (Cooke, Stout, & Salas, 1997). Recent efforts have been made to introduce situation mental models into the team mental model literature (Cooke et al., 2003; Rico et al., 2008). Situation mental models have been defined as “the mental representation associated with a dynamic understanding of the current situation (i.e., environment, task, team) that is developed by team members” (Rico et al., 2008, p. 167). Situation mental models have recently been both conceptually (Cooke et al., 1997; 2003; Rico et al., 2008) and empirically linked to increased team effectiveness (Waller et al., 2004).

Related concepts to situation mental models include team situation awareness and situated cognition. Situation awareness consists of three hierarchical levels. The most basic is “the perception of the elements in the environment within a volume of time and space” (Endsley, 1988, p. 97), followed by “the comprehension of their meaning” (p. 97),
and at the highest level “the projection of their status in the near future” (p. 97). Team situation awareness is defined as “the sharedness of a common perspective between two or more individuals regarding current environmental events, their meaning, and projected status” (Wellens, 1993, p. 272). Several studies have shown a positive relationship between shared situation awareness at the team level and team performance (Artman, 1999; Banks & McKeran, 2005; Prince, Ellis, Brannick, & Salas, 2007; Proctor, Panko, & Donovan, 2004).

Situated cognition is a learning theory that suggests that learning is emergent and socially constructed (Brown, Collins, & Duguid, 1989). The construct highlights the importance of learning knowledge and skills in environments that mimic the actual work context in order to increase understanding and retention (Brown et al., 1989). The effectiveness of situated cognition in improving learning has been demonstrated using mostly qualitative methods, including case studies (Derry, DuRussel, & O’Donnell, 1998; Schell & Black, 1997) and ethnographic research (Lave, 1988).

Situation awareness, situated cognition, and situation mental models all highlight the importance of building shared cognition related to the environment in order to improve team learning and performance. However, despite their conceptual similarity, these constructs originate in separate literatures and are measured in different ways. Situation awareness is typically evaluated using the SAGAT (Situation Awareness Global Assessment Technique; Endsley, 1995), which asks knowledge-based questions on a team’s awareness of their environment. Situated cognition is often manipulated, not measured, and is evaluated using qualitative methods that assess the effectiveness of the learning strategy (Derry et al., 1998, Schell & Black, 1997; Lave, 1988). However, both
the SAGAT and the qualitative methods used to evaluate situation awareness and situated cognition only assess the content of the construct. On the other hand, a distinguishing feature of team mental models is the measurement of both content and structure (Mohammed et al., 2000). Situation mental models were measured in the current study through paired comparison ratings. This measure allows researchers to better capture the multi-dimensional nature of team cognition by evaluating both content and structure (Mohammed et al., 2000).

Apart from variations in content, team mental models can also be classified according to their properties (accuracy and sharedness). Sharedness represents the degree to which knowledge structures, regarding a specific content area, converge among team members (Cannon-Bowers et al., 1993). On the other hand, accuracy refers to the degree to which team members’ knowledge structures mimic that of an expert (Webber, Chen, Payne, Marsch, & Zaccaro, 2000). Ideally, both properties of team mental models work in tandem, such that well functioning teams develop accurate knowledge structures that converge across team members (Mathieu et al., 2005). While accuracy may not be easily evaluated in field studies due to the difficulty of determining a single correct model (Mathieu et al., 2005), both properties should be measured, particularly in team training contexts when a model of accuracy is more easily determined (e.g., Smith-Jentsch et al., 2005). In the current study, both accuracy and sharedness were assessed.

Limitations of Previous Research

Most of the previous research on team mental models has demonstrated positive associations between team effectiveness and task (e.g., Edwards et al., 2006; Webber et al., 2000), team (e.g., Rentsch & Klimoski, 2001; Smith-Jentsch, Campbell, Milanovich,
& Reynolds, 2001), and team-interaction mental models (e.g., Ellis, 2006; Gurtner et al., 2007). However, not much empirical research has been conducted on situation mental models. Situation mental models have been mostly discussed from a theoretical perspective (e.g., Burke et al., 2006; Stagl et al., 2006). This is problematic because neither task, team, nor team-interaction mental models adequately assess the awareness of situation factors that are used to guide subsequent strategic decisions (cf. Cannon-Bowers et al., 1993). Situation mental models would therefore appear to be a stronger predictor of team performance within non-routine contexts than would task, team, or team-interaction mental models. Even though many researchers have highlighted the importance of examining team performance in non-routine contexts (e.g., Burke et al., 2006, Salas & Pierce, 2001; Kozlowski, Gully, Nason, & Smith, 1999; Lepine, 2003; Marks et al., 2000; Stagl et al., 2006), limited empirical research exists to-date on situation mental models in any context. Examples of two known studies on situation mental models include the previously reviewed study by Serfaty and colleagues (1998) and a field study by Waller and colleagues (2004).

Waller and colleagues (2004) collected data from crews in nuclear power plant control rooms. The purpose of the study was to assess the effect of team mental models and environmental conditions on team performance. The authors used a quasi-experimental design in which environmental condition were operationalized as teams operating under high versus low workload and a qualitative measure of team mental models. The type of team mental model assessed was sharedness of the “systems they manage, the plan to implement if problems should arise, and the actual problem or problems at hand” (Waller et al., 2004, p. 1536). Although not explicitly labeled as
situation (referred to vaguely as shared mental model development), this team mental model seemed to have a strong situation-based component. The authors found increased sharedness of situation mental models when the crews encountered a changing problem. They also found that high performing teams were more likely to have increased sharedness in situation mental models when the problem was changing than when it was routine. These results suggest that the increased sharedness of situation mental models can aid team adaptation to a changing situation and lead to higher levels of team performance. Waller and colleagues (2004) used a quasi-experimental design, which precludes the possibly of making causal statements regarding situation mental models. In addition, the authors used a qualitative measure of situation mental models which prevents inferences related to the structure of situation mental models to be drawn. To overcome these limitations, the current study will evaluate the impact of situation mental models on team performance in an experimental setting and use a structure-based quantitative technique to measure situation mental models.

A limitation of the team mental model literature is that only one type of team mental model is typically examined per study (e.g., Levesque, Wilson, & Wholey, 2001; Stout, Cannon-Bowers, Salas, & Milanovich, 1999; Webber et al., 2000). However, more recent studies have started to assess both taskwork and teamwork mental models in the same study (e.g., Banks & Millward, 2007; Cook et al., 2003; Mathieu et al., 2000; Smith-Jentsch et al., 2005). More research is still needed on how other types of team mental models, such as those related to strategic knowledge, impact team effectiveness (cf. Converse & Kahler, 1992). The current study addressed this limitation through
assessing situation mental models and comparing their effectiveness to both taskwork and teamwork mental models.

An area in which team mental model research is most prolific is in the evaluation of its relationship with task performance under routine conditions (e.g., Cooke et al., 2003; Edwards et al., 2006; Ellis, 2006; Kang, Yang, & Rowley, 2006; Lim & Salas, 2006; Webber et al., 2000). The second most examined team outcome is team processes (e.g., Banks & Millward, 2007; Marks et al., 2002; Mathieu et al., 2000; 2005). The development of both shared and accurate team mental models has been linked to increased leadership, assertiveness, decision making/mission analysis, adaptability/flexibility, situation awareness, and communication team processes (Mathieu et al., 2005). Other team outcomes that have been examined in the team mental model literature include skill acquisition (Langan-Fox, 2003), safety and efficiency (Smith-Jentsch et al., 2005), decision quality (Kellermanns, Floyd, Pearson, & Spencer, 2008), and team viability and member growth (Rentsch & Klimoski, 2001). Despite the amount of research that has been conducted on team outcomes, only a handful of studies have examined the link between team mental models and team adaptability (i.e., Marks et al., 2000; Waller et al., 2004). This has been a large oversight by researchers, especially because team mental models should better enable team members to “perceive, interpret, and respond to dynamic environments in a synchronized adaptive fashion” (Stagl et al., 2006, p. 129). The current study addressed this research gap through examining the effect of team mental models on team performance under both routine and non-routine environmental conditions.
Even though many studies have been conducted on the outcomes of team mental models, less research has been published on its antecedents. The antecedents that have been examined include team cognitive ability (Edwards et al., 2006), stress (Ellis, 2006), planning (Stout et al., 1999), rank and length of time in service (Smith-Jentsch et al., 2001), and demography, team experience, team member recruitment, and team size (Rentsch & Klimoski, 2001). One type of antecedent that is believed to “fast-track the development of team mental models” is team training (Langan-Fox, Anglim, & Wilson, 2004, pg. 345). Team training, more so than any other predictor, is considered to lead to the formation of more accurate and efficient team mental models (Langan-Fox et al., 2004). As previously reviewed, a few studies have demonstrated that team training leads to the formation of more accurate (e.g., Cooke et al., 2003) and shared (e.g., Marks et al., 2002, Serfaty et al., 1998) taskwork and teamwork mental models among team members. However, no known study has compared the effectiveness of different types of training interventions on team mental model development. Such a comparative analysis of training strategies could provide useful data for prescriptive recommendations on how to train teams. The current study addressed this research gap by assessing the effectiveness of two prominent team training strategies (i.e., team coordination training and cross-training) on the formation of team mental models.

Development of Main Effect Hypotheses Related to Team Training

This section will evaluate how team training impacts team mental models. The theoretical approach to training evaluation has focused on the cognitive perspective to learning theories (cf. Kraiger, Ford, & Salas, 1993). Learning theories can be classified as either behaviorist, cognitivist, or constructivist (Ahsen, 2008). Behaviorists focus on
repeating a particular pattern of behavior until it becomes automatic (Baum, 2005). Cognitivists suggest that new information is compared to existing knowledge structures, called schema, which are altered to accommodate the new data (Wallace, Ross, Davies, & Anderson, 2007). Finally, constructivists believe learners actively create new ideas based on their past knowledge or previous experiences (Driver et al., 1994). The focus on cognitivism in the training evaluation literature may be due to the fact that, unlike behaviorism, cognitivism assumes that each learner is in control of the knowledge he/she retains (Ahsen, 2008), and, unlike constructivists, the context in which information is given is not considered to have much of an impact on the formation of knowledge in cognitivism (Ahsen, 2008). The current study therefore relied on the theoretical perspective of cognitivism when evaluating the effect of team training on team effectiveness.

According to Kraiger and colleagues (1993), there are multiple types of learning outcomes that may be derived from training. These include cognitive, skill-based, and affective outcomes (Kraiger et al., 1993). Each set of outcomes was considered to be multi-faceted, with cognitive outcomes including verbal knowledge, knowledge organization, and cognitive strategies (Kraiger et al., 1993). Given that knowledge organization has been considered to have equal or greater importance than the amount or type of information stored in memory (Johnson-Laird, 1983; Rouse & Morris, 1986), the current study focused on knowledge organization through the measurement of team mental models.

The hypotheses in this section are therefore based on the rationale that the content and structure of knowledge developed among teams (i.e., taskwork, teamwork, and
situation mental models) is dependent on the type of information delivered through the training (i.e., task-based, team-based, or situation-based content). Specific rationale is described in detail below. A summary of all proposed relationships can also be found in Figure 1.

**Figure 1. Model of hypothesized relationships.**

**Cross-Training and Taskwork Mental Model Sharedness and Accuracy**

Cross-training and team coordination training differ mainly on the type of team competencies emphasized during training (Cannon-Bowers & Salas, 1998). Cross-training focuses on details about other teammates’ roles and responsibilities that are used to build shared task knowledge among team members (Blickensderfer et al., 1998). On the other hand, team coordination training educates team members on the importance of various teamwork skills that may be useful in increasing their performance (Salas et al., 2001). Given the type of information conveyed in each type of training, cross-training can be considered to be a more task-specific intervention than team coordination training.
Cross-training should therefore lead to the formation of taskwork mental models more so than team coordination training.

Similarly, the inherent nature of cross-training in developing cross-team knowledge of the task (Blickensderfer et al., 1998) may help to develop transactive memory within the team. Transactive memory is a type of shared cognition in which team members are aware of the type of knowledge or expertise held by each team member (Austin, 2003). The added benefit of knowing who knows what in cross-training condition may be more instrumental in building shared and accurate taskwork mental models in cross-training than in team coordination training. Based on these reasons, the following hypotheses were evaluated:

**Hypothesis 1.** Teams receiving cross training will develop more:

a) shared taskwork mental models than those in the team coordination training condition.

b) accurate taskwork mental models than those in the team coordination training condition.

The type of information acquired through cross-training focuses on specific aspects of the team’s task (Blickensderfer et al., 1998). During cross-training, there is no explicit discussion on the external environment in which the team operates. Teams receiving cross-training should therefore have less of an awareness of their external environment (i.e., situation mental model) than the task requirements of the team (i.e., taskwork mental model). Given this rationale, the following hypothesis is proposed:

**Hypothesis 2.** Teams receiving cross-training will develop more:

a) shared taskwork mental models than situation mental models.
b) accurate taskwork mental models than situation mental models.

**Team Coordination Training and Situation Mental Model Sharedness and Accuracy**

When compared to cross-training, the information delivered during team coordination training is less related to the team’s task and more related to how to manage the team’s interactions (Salas et al., 2007). Team coordination training also highlights the importance of situation assessment, which is considered to be a key implicit team coordination process (Rico et al., 2008). According to Rico and colleagues, the relationship between situation assessment and situation mental models is cyclical, such that effectively assessing the situation will help team members form an accurate and shared representation of their situation, which will in turn shape their ability to assess the situation. Given the close relationship between the situation assessment component of team coordination training and situation mental models, it is probable that:

*Hypothesis 3.* Teams receiving team coordination training will develop more:

a) shared situation mental models than those in the cross-training condition.

b) accurate situation mental models than those in the cross-training condition.

The content of team coordination training is team- and situation-specific, focusing mainly on building effective communication, planning, and situation assessment skills (Salas et al., 2001). It is therefore probable that because information related to the team’s task is not explicitly conveyed during team coordination training, while information related to the team’s external environment is emphasized, the following relationships would be expected:

*Hypothesis 4.* Teams receiving team coordination training will develop more:

a) shared situation mental models than taskwork mental models.
b) accurate situation mental models than taskwork mental models.

*Training and Teamwork Mental Model Sharedness and Accuracy*

The previously reviewed hypotheses predict that cross-training will be more likely to lead to the development of accurate and shared taskwork mental models than team coordination training. On the other hand, team coordination training is expected to generate more accurate and shared situation mental models than cross-training. However, both types of training are expected to impact the accuracy and sharedness of teamwork mental models. The rationale for each of these linkages will be presented below.

As previously stated, cross-training improves teammates’ knowledge about fellow team member’s roles and responsibilities (i.e., inter-positional knowledge; Blickensderfer et al., 1998). This inter-positional knowledge not only enhances team members’ accuracy and sharedness of the team’s task (i.e., taskwork mental models; Cooke et al., 2003) but also generates greater awareness on how team members’ roles combine to accomplish the collective team task (i.e., teamwork mental models; Marks et al., 2002). Teams that receive cross-training have been found to have a better understanding of how others contribute to the team’s success and share significant team-interaction knowledge (Marks et al., 2002). Teams that receive such training should therefore formulate more accurate and shared knowledge on team interactions (i.e., teamwork mental models) than on the environment (i.e., situation mental models). Given the above rationale, the following relationship is expected:

*Hypothesis 5.* Teams receiving cross-training will develop:

a) shared teamwork mental models than situation mental models.

b) accurate teamwork mental models than situation mental models.
The type of knowledge conveyed during team coordination training emphasizes how to work together. There is no explicit description given to the team on the details of the task. It would therefore seem more likely that teams receiving team coordination training would develop more accurate and shared teamwork mental models than taskwork mental models. The current study therefore tested the following hypotheses based on this rationale:

*Hypothesis 6.* Teams receiving team coordination training will develop more:

a) shared teamwork mental models than taskwork mental models.

b) accurate teamwork mental models than taskwork mental models.

**Development of Main Effect Hypotheses Related to Team Mental Models**

When groups of individuals work together, their actual productivity may be decreased by process loss (Steiner, 1972). Process losses may occur in teams due to suboptimal coordination or motivation among team members (Steiner, 1972). The diversity in the organization of knowledge among team members increases processes losses due to poor coordination (Kraiger & Wenzel, 1997). Shared team mental models increase the implicit coordination processes among team members and are therefore an effective means of decreasing process loss due to poor coordination (Kraiger & Wenzel, 1997). The positive effect of both shared and accurate team mental models on team performance has been shown by many researchers (Cooke et al., 2003; Edwards et al., 2006; Ellis, 2006; Lim & Salas, 2006; Marks et al., 2000; Mathieu et al., 2005). However, the specific impact of different types of team mental models on team performance is described below.
**Taskwork Mental Models and Team Performance**

The increased convergence and accuracy of taskwork mental models among team members is expected to translate into increased team performance because members of high performing teams understand what is required of them and know how to accomplish the team’s task (Cannon-Bowers et al., 1993). This process includes being able to recognize the significance of information, know what type of information is needed in a given situation, and understand how that information must be combined and delivered to fellow teammates (Cannon-Bowers et al., 1993). Researchers, such as Cooke and colleagues (2003), Lim and Salas (2006), Mathieu and colleagues (2005), Webber and colleagues (2000), and Edwards and colleagues (2006), have all demonstrated that both the sharedness and accuracy of taskwork mental models help to improve the actual productivity of teams. It is therefore expected that:

*Hypothesis 7a.* Shared taskwork mental models will have a positive impact on team performance.

*Hypothesis 7b.* Accurate taskwork mental models will have a positive impact on team performance.

**Situation Mental Models and Team Performance**

Teams are couched within a specific environmental context, which has direct implications for their performance (Ancona & Caldwell, 1992). Team members that develop increased similarity and accuracy in situation mental models are better able to facilitate communication among each other, which increases their level of situation awareness (Salas, Prince, Baker, & Shrestha, 1995). Teams that have increased situation awareness are able to forecast the occurrence of events and have higher levels of team
performance (Banks & McKeran, 2005). Other researchers, such as Serfaty and colleagues (1998) and Waller and colleagues (2004), have shown a direct positive relationship between the increased sharedness of situation mental models and team productivity. Based on this rationale, the following relationships are expected:

*Hypothesis 7c.* Shared situation mental models will have a positive impact on team performance.

*Hypothesis 7d.* Accurate situation mental models will have a positive impact on team performance.

**Teamwork Mental Models and Team Performance**

The sharedness and accuracy of teamwork mental models are also expected to positively influence performance. Effective team members need to understand their role in the team’s task, how they should interact with other team members, and which members require what information (Cannon-Bowers et al., 1993). Previous research on teamwork mental models has shown that teams with similar teamwork mental models engage in increased helping behaviors and are more coordinated which results in higher levels of team performance (Marks et al., 2002). Marks and colleagues (2000) also demonstrated that an increased sharedness and accuracy of teamwork mental models result in the development of more effective communication strategies, which increases the coordination and productivity of the team (Marks et al., 2000). In addition, Lim and Salas (2006) found that higher performing teams had increased accuracy and sharedness of teamwork mental models than lower performing teams. Given these results, it is expected that:
Hypothesis 7e. Shared teamwork mental models will have a positive impact on team performance.

Hypothesis 7f. Accurate teamwork mental models will have a positive impact on team performance.

Development of Mediation Hypotheses

Team training has been shown to lead to increased team performance (O’Connor et al., 2008; Salas et al.; 2007; 2008). However, more research is needed on the mechanisms through which this takes place. In two separate meta-analyses, Salas and colleagues (2008) demonstrated that team training led to different types of outcomes while Salas and colleagues (2007) showed that different types of training strategies had varying effects on team performance. Not much research has been conducted on the mediators through which team training impacts team performance. The lack of research in this area is problematic because training is believed to impact performance through the generation of various learning outcomes (Kraiger et al., 1993). In fact, learning criteria are considered to be one of the best estimates of training effectiveness (Arthur, Bennett, Edens, & Bell, 2003).

Types of learning criteria include cognitive, skill-based, and affective outcomes (Kraiger et al., 1993). The current study will examine cognitive outcomes, which is one of the most effective outcomes of team training (Salas et al., 2008). Cognitive outcomes refer to the type and quality of knowledge that is obtained through training (Kraiger et al., 1993). According to Kraiger and colleagues (1993), there are three types of cognitive outcomes: verbal knowledge (also known as declarative knowledge), knowledge organization (how information is organization, e.g., mental models), and cognitive
strategies (the knowledge of one's own cognition and the regulation of that knowledge, i.e., self-insight and metacognitive skills). The most commonly examined cognitive outcome in training evaluation studies is declarative knowledge (Ackerman, 1987). However, many team training studies tend to orient their focus on the organization of this knowledge into cognitive structures (e.g., Marks et al., 2002). These knowledge structures are known as team mental models.

The studies that have examined the impact of team training on team mental models and team performance have based their propositions on the input-mediator-output-input (IMOI) model (Marks et al., 2000; 2002; Serfaty et al., 1998; Smith-Jentsch et al., 2001). In the IOMI model, team inputs (e.g., team training) impact team outputs (e.g., team performance) through some mediator (e.g., team mental models). Team outputs then become a type of input which impacts other team outputs through team mediators, hence perpetuating the team effectiveness IOMI cycle (Ilgen, Hollenbeck, Johnson, & Jundt, 2005). The IOMI model is a variation on the classic input-process-output (IPO) model proposed by McGrath (1964). However, researchers such as Ilgen and colleagues (2005) and Marks and colleagues (2001) have recognized that the type of variables that mediate the relationship between team inputs and outputs are not only behavioral but also include cognitive, motivational, and affective states. The current study will adopt Ilgen and colleagues’ (2005) approach to team effectiveness and use an input-mediator-output framework to describe the effect of team training on team performance through team mental models.
Cross-Training, Team Mental Models, and Performance

The main purpose of cross-training is to build shared and accurate knowledge related to the nature of the task and how team member’s roles interact (Blickensderfer et al., 1998). The increased sharedness and accuracy of this knowledge among team members is believed to be the key mechanism through which cross-training impacts team performance (Blickensderfer et al., 1998). Previous research on cross-training has demonstrated that cross-training leads to the increased sharedness and accuracy of taskwork mental models (Cooke et al., 2003) and teamwork mental models (Marks et al., 2002). Researchers have also shown that both the sharedness and accuracy of taskwork mental models and teamwork mental models have a direct relationship with team performance (e.g., Lim & Salas, 2006; Mathieu et al., 2005; Smith-Jentsch et al., 2005). However, a full mediation between the training type, team mental model, and team performance has not been uncovered in the team training literature. Based on the rationale stated above, along with the findings of previous researchers in this area, the following relationships are expected:

*Hypothesis 8a.* Shared taskwork mental models will mediate the relationship between cross-training and team performance.

*Hypothesis 8b.* Accurate taskwork mental models will mediate the relationship between cross-training and team performance.

*Hypothesis 8c.* Shared teamwork mental models will mediate the relationship between cross-training and team performance.

*Hypothesis 8d.* Accurate teamwork mental models will mediate the relationship between cross-training and team performance.
Team Coordination Training, Team Mental Models, and Performance

Team coordination training focuses on the development of effective teamwork coordination strategies (Salas et al., 2001). This intervention is therefore expected to positively impact team performance through the distribution of team and situation-specific information into shared knowledge structures. Research on team-interaction/coordination training has shown that teams receiving such training have higher levels of team performance through the development of more shared and accurate team mental models (Marks et al., 2000). The current study tested the meditational role of teamwork and situation mental models between team coordination training and team performance. This will expand on the results from Marks and colleagues (2000) through the inclusion of multiple measures of mental models as possible mediators between team coordination training and team performance. Based on these findings and the rationale stated above, the following relationships are expected:

*Hypothesis 9a.* Shared teamwork mental models will mediate the relationship between team coordination training and team performance.

*Hypothesis 9b.* Accurate teamwork mental models will mediate the relationship between team coordination training and team performance.

*Hypothesis 9c.* Shared situation mental models will mediate the relationship between team coordination training and team performance.

*Hypothesis 9d.* Accurate situation mental models will mediate the relationship between team coordination training and team performance.
Development of Moderation Hypotheses

Cannon-Bowers and colleagues (1993) were among the first set of researchers to propose that shared mental models would have a differential impact on team performance based on the team’s external environment. According to the authors, teams that have a shared perception of what is going on are better able to predict what their teammates are going to do and what they need in order to get it done (Cannon-Bowers et al., 1993). Shared mental models therefore help teammates to use more uniformly constructed team knowledge to more effectively coordinate with their team under changing conditions (Cannon-Bowers et al., 1993). Based on this rationale, the current study compared the impact of the sharedness of different types of team mental models (taskwork, teamwork, and situation mental models) on team performance under different environmental condition.

Taskwork Mental Models and Environmental condition

Teams with increased sharedness in taskwork mental models have a more consistent perspective on the types of information that are important to the team (Cannon-Bowers et al., 1993). According to Cannon-Bowers et al. (1993), highly proceduralized tasks tend to generate more similarity among team mental models but the value of these knowledge structures becomes more apparent when tasks are unpredictable. Research by Stout, Cannon-Bowers, and Salas (1999) supported this proposition. The authors found that under routine environmental condition team members were able to communicate freely with each other and explicitly develop strategies to accomplish the team’s task. However, under changing environmental condition, explicit coordination strategies were not feasible due to the increased environmental pressure
from workload and time pressure. Team members therefore needed to rely on preexisting knowledge to help them implicitly coordinate their actions (Stout et al., 1999). Higher levels of sharedness on taskwork mental models may therefore have a stronger relationship with team performance under changing environmental condition than under routine conditions. Based on previous research and the rationale discussed above, the following hypothesis is proposed:

*Hypothesis 10a.* The relationship between the similarity of taskwork mental models and team performance will be moderated by environmental condition, such that the relationship will be stronger for teams operating under a non-routine environment than in a routine environment.

*Teamwork Mental Models and Environmental condition*

Several studies have shown support for shared teamwork mental models positively impacting performance under routine conditions (e.g., Cooke et al., 2003; Kang et al., 2006; Levesque et al., 2001; Lim & Klein, 2006; Marks et al., 2002). However, the effect of this variable on team performance is expected to be stronger under non-routine than routine conditions. The only known study that has formally tested the relationship between the sharedness of teamwork mental models and environmental condition on team performance is Marks and colleagues (2000).

Marks and colleagues (2000) conducted a PC-based simulation in which environmental novelty was manipulated by increasing the complexity of the task used during training. The researchers found that shared teamwork mental models had a stronger impact on team performance during non-routine environmental contexts than in routine contexts. More specifically, individuals operating in a non-routine environment
were better able to change their teamwork mental models in similar ways to other team members than those in the routine environment. This resulted in higher team performance (Marks et al., 2000). The positive effect of shared teamwork mental models on performance may be explained by the ability of shared team mental models to decrease the negative effects of time pressure and stress on the team by facilitating implicit coordination and communication among team members (Kleinman & Serfaty, 1989; Salas, Cannon-Bowers, & Johnson, 1997). Based on these reasons, the following relationship was tested:

*Hypothesis 10b.* The relationship between the similarity of teamwork mental models and team performance will be moderated by environmental condition, such that the relationship will be stronger for teams operating under a non-routine environment than in a routine environment.

**Situation Mental Models and Environmental condition**

Situation mental models have also been demonstrated to positively impact team performance under non-routine environmental condition (Waller et al., 2004). In Waller et al. (2004), high performing teams were more likely to have increased sharedness in situation mental models when the problem was nonroutine than when it was routine. These results suggest that the increased sharedness of situation mental models can aid team adaptation to a non-routine situation and lead to higher levels of team performance. Whereas the nature of the quasi-experimental design and qualitative measurement of Waller et al. (2004) subjected the findings to low internal validity, the current study tested the following hypothesis in an experimental design:
Hypothesis 10c. The relationship between the similarity of situation mental models and team performance will be moderated by environmental condition, such that the relationship will be stronger for teams operating under a non-routine environment than in a routine environment.
Chapter 2. PILOT STUDY

Pilot Study: Method

The purpose of the pilot study was to evaluate the effectiveness of the manipulations (i.e., team training and environmental condition) and measurements (i.e., team mental models and the manipulation check items) developed for the actual study. Multiple pilot studies were conducted in which the feedback obtained from the results of each experimental session were used to improve on subsequent pilot sessions. This data was obtained through surveys (quantitative data), open-ended questions (qualitative data), and oral feedback from participants. This section mostly describes the results obtained from the quantitative survey data and includes some anecdotal evidence from the open-ended questions and oral feedback collected from the participants.

Participants

The cumulative number of students that participated in the multiple pilot studies conducted was 149 (74.5 dyads). These were undergraduate students enrolled in various freshman- to junior-level psychology courses at a large northeastern university in the United States. Extra credit was given to students that participated in the study, and an alternative assignment was offered to those who did not wish to participate. The sample was 82.6 percent Caucasian (7.4 percent African American, 3.4 percent Hispanic, 4.7 percent Asian American, and 2.0 percent other ethnic groups), 65.8 percent female, and 32.9 percent freshmen (25.5 percent sophomores, 32.2 percent juniors, and 9.4 percent seniors). The average age of the sample was 19.85 (ranged from 18 to 27). The average amount of full-time work experience was four months, part-time work experience was 33 months (2.75 years), and experience in emergency management settings was one month.
Over half of the students were either moderately comfortable or extremely comfortable working in a virtual/distributed team (58.1 percent). Participants spent an average of 4.30 hours per week playing video games in the past year, with a range of 0 to 43 hours, and only had experience playing two types of games or less (96.7 percent). Table 1 provides a detailed list of the types of games most typically played by the participants.

Table 1

<table>
<thead>
<tr>
<th>Type of Game Played</th>
<th>Percent of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Games</td>
<td>9.4%</td>
</tr>
<tr>
<td>Online Computer Games</td>
<td>14.8%</td>
</tr>
<tr>
<td>Handheld Games (e.g., games on a cellphone, Nintendo DS, or PSP)</td>
<td>13.4%</td>
</tr>
<tr>
<td>Console Games (e.g., X-Box, Playstation, Nintendo)</td>
<td>15.4%</td>
</tr>
<tr>
<td>Online Console Games</td>
<td>0.7%</td>
</tr>
<tr>
<td>Video/Arcade Games</td>
<td>1.3%</td>
</tr>
<tr>
<td>NeoCITIES (the current game)</td>
<td>0%</td>
</tr>
<tr>
<td>None of the Above</td>
<td>10.7%</td>
</tr>
</tbody>
</table>

Design

A 2 (team training: cross-training vs. team coordination training) x 2 (environmental condition: routine vs. non-routine) mixed factorial design was used. Team training was the between-subjects independent variable, and environmental condition was the within-subject independent variable.
The NeoCITIES Simulation

NeoCITIES is a simulated task environment based on the original CITIES task (Civilian Command, Control, and Communication Interactive Task for Identifying Emerging Situations; Wellens & Ergener, 1988). Similar to the CITIES simulation, NeoCITIES is used to evaluate collaborative team decision-making processes, knowledge acquisition, and knowledge management in a command and control computer-mediated environment (McNeese et al., 2005). Inherent characteristics of the simulation, such as high task interdependence, long interaction times, and ambiguous and dynamic problems make NeoCITIES particularly suited to examining distributed team cognition (McNeese et al., 2005). Three previous studies have successfully implemented NeoCITIES as a scaled world simulation used to evaluate decision-making in a distributed context (i.e., Connors, 2006; Jones, 2006; Pfaff, 2008). For teams to effectively work together in NeoCITIES, they require higher levels of shared understanding on taskwork and teamwork processes and an awareness of the situation (Obieta, 2006).

The structure of NeoCITIES and the scenarios encountered by participants closely relate to the real-world emergency management domain. NeoCITIES is comprised of two to three dyads representing Fire, Police, and/or Hazardous Material (Hazmat) functional units (see Figure 2). Each functional unit is comprised of two roles: an Information Manager (IM) and a Resource Manager (RM).
Figure 2. Arrangement of lab space for NeoCITIES simulation.

The IM is responsible for maintaining the communication lines between teams and determining what events need to be addressed by his/her team. On the other hand, the RM allocates resources to events received from the IM and monitors the resolution of the events. Each RM is responsible for different types of resources based on the team to which he/she belongs (see Appendix B). Team members engaged in the simulation are therefore assigned to one of six possible roles (Fire IM or RM, Police IM or RM, or Hazmat IM or RM). Further details on the actual simulation can be found in Chapter 3 on the Main Study.

NeoCITIES Training

All participants received training on the basic operating procedure of NeoCITIES (see Appendices A and B). This training included a description of the roles and
responsibilities of each team member, the types of resources available to them, and
details familiarizing them with the NeoCITIES user interface. The training was role
specific, such that the Information Managers for each team received details on their roles
and responsibilities and an explanation of the icons used to transmit messages to the
Resource Manager. On the other hand, the Resource Managers received details on their
roles and responsibilities and the type and function of the three resources available to
them. The training was delivered using self-paced PowerPoint presentations and took 5
minutes to complete.

Development of Team Training Videos

Team Coordination Training. The team coordination training video material was
developed in a four-step process. First, the team coordination training literature was
reviewed to evaluate how team coordination has been defined in the literature. Marks and
colleagues (2001) defined coordination as "the process of orchestrating the sequence and
timing of interdependent actions" (p. 368). Eccles & Tenenbaum (2004) broke the
construct down into goal setting and planning in the pre-process coordination stage,
communication and use of situational probabilities in the in-process coordination stage,
viewed coordination as the process that occurs when two or more people do the same or
complementary tasks at the same time. Malone and Crowston (1994) defined
coordination as the effective management of interdependencies among subtasks,
resources, and people. Rico and colleagues (2008) generated a conceptual model on team
coordination processes that suggested that coordination could be classified as either
explicit or implicit. Explicit processes included planning/programming, (i.e., articulating
plans, defining responsibilities, negotiating deadlines, seeking information to undertake common tasks) and communication (i.e., giving feedback, exchanging information between two or more team members, integrating informational contributions). On the other hand, implicit coordination processes included sharing workload, monitoring the progress of the activity, and adapting behavior to the expected actions of others. Based on the result of the literature review, the following three components of team coordination were implemented in the team coordination training: planning/decision-making, communicating, and situation assessment. These three components have also been shown to be the most commonly taught dimensions in team coordination training (cf. Salas et al., 2001).

The second step in the development of the training material was to define the three components of team coordination training and develop behavioral examples of each. Effective planning/decision making was defined as seeking out information, making plans, and re-evaluating plans (Austin & Vancouver, 1996; Weldon, Jehn, & Pradhan, 1991). Effective communication involved providing information, checking to make sure you understand each other, and ensuring that communication is clear and concise (Dickinson & McIntyre, 1997; Xiao, Seagull, Mackenzie, Ziegart, & Klein, 2003). Finally, situation assessment/assessing the situation was described as keeping team members informed about team-related or environmental changes, showing that you are paying attention to what you and your team members are doing, and identifying current problems and anticipating future problems (Artman 2000; Jentsch, Barnett, Bowers, & Salas, 1999). Specific behavioral examples of each dimension can be found in Appendix C.
The third step in the process involved generating conversations reflective of effective and ineffective components of each dimension. This was done by first conducting a content analysis of previous chat logs from NeoCITIES 1.0. These communication scripts were obtained from Pfaff (2008) and included the following examples: "I think we should try to conserve resources for bigger events" (illustrating effective planning/decision making), "We're running low on resources" (illustrating effective situation assessment), and "They just told they don't have the proper credentials" (illustrating effective communication). The sample messages from Pfaff's (2008) chat logs were then used to create complete conversations between the Information and Resources Managers that illustrated effective and ineffective forms of each dimension.

The fourth and final step involved videotaping the conversations using actors working on NeoCITIES 1.0. The actors both typed and stated what they were saying out loud. Following their conversation, a voice over was used to review the clip and explain the ineffective and effective behaviors that were demonstrated in the video. Each video clip included PowerPoint slides that defined the construct, video clips that showed how the strategies were used, a quiz to test their knowledge of the material, and a review to check their answers to the quiz. This structure was repeated for each of the three dimensions (planning, communicating, and assessing the situation) of team coordination training.

Cross-Training. A similar process was used to create the video material for the cross-training condition. First, a task analysis of each of the two roles was conducted in order to evaluate the primary responsibilities of both the Information Manager and the
Resource Manager. Participants were exposed to both sets of information on the Information and Resource Managers roles (see Appendix D). Second, the primary responsibilities of the Information Manager were presented. These responsibilities included: interpreting event information and deciding if your team should ignore the event or respond to it, passing relevant events on to the Resource Manager along with your assessment of the situation, and communicating any concerns regarding other team’s events to other Information Managers. Third, a list of the icons available to the Information Manager and their definitions were reviewed. Fourth, a narrated video was shown on the role of the Information Manager, which described the effective behaviors displayed by the team member. This video was customized to each functional unit, such that the Fire team viewed a Fire Information Manager performing his/her role, a Police team viewed a Police Information Manager, and the Hazmat team viewed a Hazmat Information Manager.

Fifth, the primary responsibilities of the Resource Manager were described. These included: interpreting event information and deciding if your team should ignore the event or respond to it, allocating the correct number and appropriate type of resources to events, and monitoring the resources that are allocated to events and communicate event feedback messages to the Information Manager. Sixth, the resources available to the Resource Manager on the specific team to which the participant belonged were described (e.g., a member of the Fire team only viewed descriptions of the role of EMS, Fire Trucks, and Fire Investigators). Finally, the participants watched a narrated video clip that described the effective behaviors shown by the Resource Manager.
Manipulations

Team Training. Both team training conditions were comprised of four main steps that were approximately 30 minutes in duration. First, participants viewed a 15-minute video of the respective team training strategy. The team coordination training and cross-training conditions only differed in the content of the training video used. The team coordination training video focused on planning, communicating, and assessing the situation. On the other hand, the cross-training video discussed the primary responsibilities of both the Information Manager’s and Resource Manager’s roles (positional clarification) and demonstrated them being performed (positional modeling; Blickensderfer et al., 1998). The video included a quiz on the concepts presented (see Appendices E and F). Following the video, participants engaged in a 5-minute practice session using the NeoCITIES simulation and were encouraged to implement what they learned during training. Third, participants were given a reminder sheet on the concepts they learned during training and were asked to note three ways in which they could improve on their performance (see Appendices G and H). Finally, participants had a second opportunity to demonstrate the behaviors they had learned during training in another 5-minute practice session using the NeoCITIES simulation.

Environmental Condition. A previous manipulation of environmental condition included deteriorating a line of communication between team members in the second performance session. In this manipulation, the Information Managers were able to talk to their Resource Managers but were only able to speak to other Information Managers in a circular pattern (i.e., Fire could only send a message to Police, who could only send messages to Hazmat, who could only send messages to Fire). Therefore if the Police
Information Manager wanted to send a message to the Fire unit, he/she had to communicate the message to the Hazmat Information Manager, who would then relay the message to the Fire Information Manager. This manipulation of environmental condition is consistent with that used by Lepine (2003) to evaluate team adaptation to novel situations. However, given that communication between functional units was not necessary for the team to succeed, this manipulation of the communication lines was often not noticed by participants. In addition, the participants that did notice the change in communication lines were able to ignore the adjustment without it negatively impacting their scores.

Based on the feedback from the pilot study, the decision was made to manipulate environmental condition through increasing the time pressure and complexity of events as opposed to deteriorating the communication lines. Time pressure and complexity of events was manipulated by increasing the number, pacing, and severity of events across the first and second performance scenarios. The first performance session had a total duration of 7.08 minutes. It contained 19 events (7 related to the Police team, 6 to the Fire team, and 6 to the Hazmat team). The first event was not dispatched until 5 seconds into the scenario, after which a new event was dispatched every 20 seconds. Most of the Fire and Police events (11 out of 13) had a low initial severity of 1.25 and a long lifespan of 72. Only two events had a heightened severity of 2.00 and a shortened lifespan of 32. The second performance scenario had a total duration of 8.02 minutes and contained 30 events. The first event was fired 1 second into the scenario and new events continued to be dispatched at a pace of every 15 seconds. The Fire and Police events contained a mix of low, moderate, and high severity events. Specifically, 12 were of a low severity
(lifespan = 72; initial severity = 1.25), 4 were of moderate severity (lifespan = 32; initial severity = 2.00), and 4 of high severity (lifespan = 15; initial severity = 3.00). The second performance scenario therefore differed from the first scenario in the increased number, pacing, and severity of events. See Appendix I for a list of the specific events used in each scenario.

Further pilot testing was conducted on this manipulation to determine the optimal pacing and severity of events in each performance scenario. Additional changes were made to the environmental condition manipulation based on consistent feedback from participants on a scenario being too overwhelming, simple, fast-paced, or slow. Feedback was also requested that evaluated their impressions across scenarios, such that, scenarios that were consistently viewed as too similar were made more distinct.

Procedure

The steps involved in conducting the study are highlighted in the script used for the experiment (see Appendix J) and are summarized below. Participants were first randomly assigned to their team and role in NeoCITIES. They then completed and returned the consent forms and began the experiment. PowerPoint slides were used to guide participants throughout the course of the experiment to reduce the amount of experimenter interaction that took place during the study (see Appendix K). An online survey was completed on the control and demographic variables listed in Appendix L. Basic NeoCITIES training was then administered through self-paced PowerPoint slides (see Appendices A and B). Participants then viewed a 15-minute video clip on either cross-training or team coordination training. The type of video watched depended on which condition was being run in that experimental session. The videos were structured
such that information was presented by PowerPoint, followed by a video demonstration of the concepts using NeoCITIES examples, and ended with a quiz (see Appendices E and F) and a review of the concepts (see Appendices C and D for the training video scripts used for cross-training and for team coordination training). Immediately following the training video, participants completed an online survey containing the manipulation check items for team training online (see Tables 2 to 5) and a paper and pencil copy of the taskwork and teamwork mental model measures (see Appendices N and O).

Participants then engaged in two 5-minute practice sessions in the NeoCITIES simulation. Between the practice sessions, participants were given a brief reminder of the information they learned during training and asked to record areas in which they could improve (see Appendices G and H). After both practice sessions were complete, participants engaged in the first 7-minute performance session representative of the routine environmental condition in NeoCITIES. They then completed a paper and pencil survey with the manipulation check items for environmental condition (see Appendix M) and the specific team measure for situation mental models (see Appendix P). Participants then engaged in the final 8-minute performance session representative of the non-routine environment. They were then asked to complete a packet containing the manipulation check items for environmental condition, the specific situation mental models for their team, and a teamwork and taskwork mental model grid. Finally, participants completed an online measure assessing various impressions of the simulation and experiment and engaged in an oral debrief with the experimenter (see Appendix Q).
Measures

Manipulation Check Items for Team Training. All items used to evaluate the manipulation of team training were adjusted in multiple pilot studies. This section describes the final set of items that were used and the process involved in the generation of the final scales. The manipulation check for team training was evaluated using both objective and subjective measures (see Tables 2 and 3). The objective measure was comprised of 10 multiple choice items\(^1\), which were based on the training material from the team coordination training condition (items 1-5) and the cross-training condition (items 6-10). Each correct answer to the multiple choice questions was given 1 point. The subjective items were comprised of 6 questions that asked participants to rate the extent to which they agree with each statement on a scale of 1 (strongly disagree) to 5 (strongly agree). A sample item for the team coordination training condition was, “During training I learned about the core elements of team coordination.” A sample item for the cross-training condition was, “During training I learned about the role of my teammate.”

Based on results from previous pilot investigations, additional questions were added to the list of subjective items to further discriminate between the two conditions. These items included two distracter questions that were similar to but not related to the content of either training condition (see Table 3). For example, a distracter item used for the team coordination training questions stated “During training, I learned about the steps involved in developing different types of trust between me and my teammate.” While trust is considered to be a key component of teamwork (Dirks, 2000), the construct was not discussed in the TCT training condition as a being a dimension of team coordination.

\(^1\) Originally, only six items were included in this scale. However, after analyzing the results from previous pilot data, the decision was made to increase the number of questions to ten.
### Table 2

**Pilot Study Results for Team Training Objective Manipulation Check Items**

<table>
<thead>
<tr>
<th>Team Training</th>
<th>Percent of Sample that Answered Correctly</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCT (N = 70)</td>
<td>CRT (N = 71)</td>
<td>t-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p</td>
</tr>
<tr>
<td><strong>TEAM COORDINATION TRAINING (TCT; α = 0.76)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Which of the following strategies is NOT a core element of team coordination?</td>
<td>90.0</td>
<td>50.7</td>
</tr>
<tr>
<td>2. Seeking out information BEFORE making a decision is used in which of the following strategies?</td>
<td>82.9</td>
<td>38.0</td>
</tr>
<tr>
<td>3. Keeping team members informed about team-related or environmental changes is used in which of the following strategies?</td>
<td>31.4</td>
<td>11.3</td>
</tr>
<tr>
<td>4. Identifying current problems and anticipating future problems is used in which of the following strategies?</td>
<td>87.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>47.7&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>5. Which of the following is a key step in effective communication?</td>
<td>65.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

| CROSS-TRAINING (CRT; α = 0.57) |                                      |              |
| 6. The INFORMATION manager has the ability to communicate with which of the following people: | 15.7 | 60.6 | 6.13 | <.001 |
| 7. The RESOURCE manager has the ability to communicate with which of the following people: | 68.6 | 83.1 | 2.03 | .044 |
| 8. A key difference between the RESOURCE and INFORMATION managers roles is that the INFORMATION manager is responsible for: | 61.4 | 74.6 | 1.69 | .094 |
| 9. ____________ are attached to sent events to provide a quick visual description of each event. | 56.5<sup>a</sup> | 72.7<sup>b</sup> | 1.34 | .185 |
| 10. Your team has _____ types of resources to allocate to events. There are _____ units available of each type of resource. | 60.9<sup>c</sup> | 72.7<sup>b</sup> | 0.99 | .328 |

*Note.* Bolded percentages significantly differed in the expected direction across the TCT and CRT conditions. Analyses were conducted at the individual-level. <sup>a</sup>N = 23. <sup>b</sup>N = 44.
Table 3

*Pilot Study Results for Team Training Subjective Manipulation Check Items*

<table>
<thead>
<tr>
<th>Team Training</th>
<th>TCT (N = 70)</th>
<th>CRT (N = 71)</th>
<th>t-value</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEAM COORDINATION TRAINING (TCT; α = 0.69)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. During training, the core elements of team coordination were EXPLICITLY discussed.</td>
<td><strong>4.09</strong></td>
<td>3.69</td>
<td>-2.91</td>
<td>.004</td>
</tr>
<tr>
<td>2. The training material explicitly discussed how to design plans and evaluate their effectiveness.</td>
<td><strong>3.97</strong></td>
<td>3.63</td>
<td>-2.29</td>
<td>.023</td>
</tr>
<tr>
<td>3. In training, I received details on how to evaluate environmental changes and identify current problems and anticipate future problems.</td>
<td>3.81</td>
<td>3.70</td>
<td>-0.71</td>
<td>.478</td>
</tr>
<tr>
<td>4. During training, I learned about the steps involved in developing different types of trust between me and my teammate.*</td>
<td><strong>2.64a</strong></td>
<td><strong>2.57b</strong></td>
<td>-0.27</td>
<td>.792</td>
</tr>
<tr>
<td>CROSS-TRAINING (CRT; α = 0.87)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. During training, I received detailed descriptions on the primary functions of the Information Manager AND the Resource Manager.</td>
<td>3.59</td>
<td><strong>4.27</strong></td>
<td>4.27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2. The training helped me to understand the responsibilities of the Information Manager AND the Resource Manager.</td>
<td>3.44</td>
<td><strong>4.24</strong></td>
<td>5.26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>3. Based on the knowledge I obtained in training, I would feel prepared to switch roles with the Information Manager or the Resource Manager on my team.</td>
<td>2.96</td>
<td><strong>3.76</strong></td>
<td>4.45</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>4. The training material taught me about the roles and SPECIFIC TYPES OF RESOURCES available to ALL teams in the system (i.e., all the resources of the Police, Fire, and Hazmat teams).*</td>
<td><strong>2.25a</strong></td>
<td><strong>2.48c</strong></td>
<td>0.70</td>
<td>.484</td>
</tr>
</tbody>
</table>

*Note. Bolded means significantly differed in the expected direction across the TCT and CRT conditions.

a Item 4 on each scale is the distracter item. No mean differences are expected on this item. Analyses were conducted at the individual-level. Means range from 1 (strongly disagree) to 5 (strongly agree).

aN = 28. bN = 44. cN = 40.
Therefore, non-significant differences on these items helped to demonstrate that there was no acquiescence bias among participants in responding to the questions.

Difficulties were still encountered in discriminating between both training conditions in the objective and subjective manipulation check items. Oral feedback from pilot study participants on the subjective team training items revealed that individuals in the cross-training condition felt they had received details on team coordination techniques through the mere fact that they watched a video on team members interacting. A set of comparison-based questions were therefore added to the study that compared each of the two training types and required participants to make a choice between them (see Table 4). Given that each statement contained details on both training types, participants’ perceptions of the training type they received were automatically established through their agreement or disagreement with the statement. A sample item from the scale was “The training focused MORE ON the steps involved in planning THAN on the specific roles of the Information and Resource Managers.”

Given that there were not significant mean differences these four items, forced choice items were administered. Unlike the comparison-based items, these questions did not ask participants to rate the extent to which they agreed with each statement. Instead, participants were given two choices and asked to select the statement that most accurately represented the training they received. A sample item was “The training material focused more on: i.) Describing details on the role of my teammate ii.) Describing teamwork skills/coordination strategies.” In responding to this item, participants had to make a ‘forced-choice’ between the content of the TCT and CRT training conditions. These items were most effective in discriminating between the two training conditions.
Qualitative data in the form of an open-ended question was also used to capture anecdotal evidence from participants on how they implemented the knowledge they learned in training. The specific question asked after each performance session was: “How did you use the information learned in training in the NeoCITIES simulation you just completed?”

Table 4

Pilot Study Results for Team Training Comparison-Based Manipulation Check Items

<table>
<thead>
<tr>
<th>COMPARISON-BASED ITEMS</th>
<th>Team Training</th>
<th>Means</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(α = 0.85)</td>
<td>TCT (N = 7)</td>
<td>CRT (N = 12)</td>
<td>t-value</td>
</tr>
<tr>
<td>1. The training material focused MORE ON describing the role of my teammate THAN on describing generic teamwork skills/coordination strategies. Please rate the extent to which you agree with each statement below on the scale provided.</td>
<td>2.14</td>
<td>3.83</td>
<td>4.14</td>
</tr>
<tr>
<td>2. The training focused MORE ON the steps involved in planning THAN on the specific roles of the Information and Resource Managers.</td>
<td>3.57</td>
<td>2.50</td>
<td>-2.84</td>
</tr>
<tr>
<td>3. During training, I learned MORE about how to assess the situation THAN on the primary functions of the Information and Resource Managers' roles.</td>
<td>3.71</td>
<td>2.83</td>
<td>-1.97</td>
</tr>
<tr>
<td>4. The training presented details on the responsibilities of the Information and Resource Managers’ roles MORE SO THAN strategies on how to effectively coordinate as a team.</td>
<td>2.29</td>
<td>3.92</td>
<td>4.40</td>
</tr>
</tbody>
</table>

Note. Bolded means significantly differed in the expected direction across the TCT and CRT conditions. Analyses were conducted at the individual-level. Means range from 1 (strongly disagree) to 5 (strongly agree).

The manipulation check items for team training were therefore adapted to include more objective measures (number of items increased from 6 to 10), distracter subjective items (to detect a possible acquiescence bias), comparison-based items, forced choice
items, and open-ended questions asking how the information they learned in training was implemented in each performance episode.

**Manipulation Check Items for Environmental Condition.** The manipulation of environmental condition was evaluated by asking each team member to compare the familiarity of the environment of each scenario with that of the practice sessions in training. The familiarity of the environment was evaluated on the following three components: the pace at which events were received, the severity of events, and the speed at which events were resolved (see Appendix M). Participants responded on a 1 (completely new) to 5 (completely familiar) Likert-scale. This manipulation check is similar to the measure used by Marks and colleagues (2000) in their manipulation of environmental novelty. Based on the feedback from the pilot study, changes were made to the manipulation check items for environmental condition, such that the direction of the anchors used to rate each item were more intuitive (i.e., the rating scale was changed from 1 = completely novel and 5 = completely familiar to 1 = completely familiar and 5 = completely novel).

**Team Mental Model Measurement Adjustments.** Oral feedback from participants in the pilot study revealed that several individuals found these measures difficult to complete. The top three features of the measure that confused participants were the grid format in which it was presented, the broad range of possible scores that could be used, and the seeming distinctiveness of all the dimensions in the grids. In order to address these problems, an additional page was added to the front of each packet which contained instructions on how to complete the grid and a completed football example. The specific football example used was taken from Burke (2000), in which the terms quarter-back,
throw-pass, catch pass, huddle, and pass receiver were rated a scale of 1 (not related) to 7 (extremely related).

Participants were first given a chance to review the instructions and example on the first page of the packet (see Appendix N) then received the following explanation of the grids and the football example (also see Appendix J):

“The idea here is that you’re relating each concept in the grid. You’re only going to complete the white spaces. The scale is on 1 to 7 (so there are no 0’s or 10’s). In this example, the quarter-back and throw-pass is rated 7 because the quarter-back is the only one that can throw the ball. Huddle and throw and catch pass are rated 1 because you never throw or catch a pass in a huddle and Pass receiver and Huddle are rated 4 because the Pass receiver could be in the huddle or he couldn’t be. It’s likely that he’ll be there but it’s not necessary.

“When completing the grids, it’s best to read through all the definitions before you attempt to fill in any numbers just so you know what each of the columns mean. Once you know what the dimensions are, it’s best to fill in the extreme numbers first. So fill in the ones that you think are obviously not related (1) and extremely related (7). Then you can fill in the ones that are bit fuzzier in the middle. Let me know if you have any questions.”

Providing detailed explanations of both the instructions and the football example, helped the participants better understand how to complete the measures and how relatedness was being conceptualized in the study for each set of team mental models.

The rating scale of the measure was also decreased from the original 1 (not related) to 9 (extremely related) scale to 1 (not related) to 7 (extremely related). The
reduction in the number of anchors, was intended to make the measure less cognitively challenging to complete. Finally, the relationship between the dimensions in each team mental model measure was made more apparent by more closely relating the dimensions in the task mental model to task training, the dimensions in the team mental model to team coordination training, and the dimensions in the situation mental model included more interconnected events from each performance episode. These combined changes helped to reduce the restriction of range in the ratings and the time taken to complete the measures. The operationalization of the team mental model measured used in the actual study is described below.

**Taskwork Mental Models.** All team mental model measures were assessed using paired comparison ratings. Paired similarity ratings measure the content of mental models through collecting related judgments of a series of concepts, which are then evaluated on how closely they are linked (Mohammed et al., 2000). A careful analysis of the NeoCITIES simulation indicated that the main task-related information was rooted in the primary functions of the Information and Resource Managers. These functions included: interpreting information received about events and deciding whether or not the team should ignore the event or respond to the event, allocating the correct number and appropriate type of resources to events, and communicating event-related information to fellow teammates. This translated into the following seven task-related dimensions: prioritize events, classify events, filter information, relay information, allocate resources, monitor events, and re-evaluate decisions. Each of these dimensions was placed in a 6 x 7 grid and rated for relatedness on a scale of 1 (not related) to 7 (extremely related). The final list of dimension used in the main study can be found in Appendix N.
Teamwork Mental Models. The teamwork mental model also consisted of seven dimensions that were placed in a 6 x 7 grid and rated for relatedness on a scale of 1 (not related) to 7 (extremely related). However, the actual content of the dimensions differed from the taskwork mental model measure. An evaluation of the processes associated with the primary functions of the Information Manager and Resource Manager resulted in the identification of seven teamwork dimensions: develop plans, revise strategy, gather details, convey information, clarify statements, monitor changes, and identify problems. These teamwork behaviors are consistent with previous ratings of teamwork dimensions provided by Mathieu and colleagues (2000; 2005), who also included an assessment of decision-making, mission analysis, leadership, and communication. A brief description of each of the final seven teamwork dimensions used in the main study can be found in Appendix O.

Situation Mental Models. The development of shared knowledge structures regarding the situation may be reflected in the detection of underlying storylines in the events addressed during the simulation (Obieta, 2006). Situation mental models were therefore measured through the assessment of interconnected events from each performance episode. Given that the measure could only be evaluated after team members had a chance to engage in the performance episode, situation mental models were evaluated after each performance episode. This measure was unique to each dyad across each performance episode. The grids used for the first performance session consisted of 6 events rated in a 5 x 6 grid on a scale of 1 (not related) to 7 (extremely related). In the second performance episode, a list of 8 events was rated in a 7 x 8 grid on
a scale of 1 (not related) to 7 (extremely related). See Appendix P for a description of the dimensions used in the final study.

*Post-Pilot Items and Oral Debrief.* Following the pilot study a post-pilot questionnaire was administered, which asked participants about their reactions to the study (see Appendix Q). The questionnaire was comprised of 11 items evaluating the difficulties associated with working in the experiment and the simulation along with the perception of the inter-relatedness of events taken from Pfaff (2008). Participants were asked to indicate the extent to which they agreed with each statement on a scale of 1 (strongly disagree) to 5 (strongly agree). A sample item included: “I had difficulty comprehending the events in the simulation.” Participants were also asked to list the top three things that went well while working in NeoCITIES and the top three things that did not go well while working in NeoCITIES. Following the completion of the study, participants were also asked a series of questions on the simulation, training, and team mental model measures in an oral debrief (see Appendix Q).

Pilot Study: Results and Discussion

*Manipulation Check Items*

*Team Training.* The items in the objective measure for the team training manipulation check had an acceptable reliability (above .70; Nunnaly, 1978) for the team coordination training condition (TCT; $\alpha = 0.76$) but not for the cross-training condition (CRT; $\alpha = 0.57$). A closer examination of the individual items revealed that four out of five (80 percent) of the TCT items had significant differences in the means across the TCT and CRT conditions, while the means of only two out of five (40 percent) of the
CRT items significantly differed across training conditions (see Table 2). Even though these differences were not significant, the means were in the expected direction.

There are a number of explanations for the lack of significant differences between conditions for the majority of objective cross-training items, including a smaller sample size in two out of the three questionable items. Sixty-seven individuals from latter pilot sessions completed these items (23 in the TCT condition and 44 in the CRT condition) as opposed to the 141 participants that completed the previous three items (70 in the TCT condition and 71 in the CRT condition). Another reason is the likelihood that participants may have been better at guessing the taskwork-related cross-training items more so than the teamwork-related team coordination training items simply based on the NeoCITIES training they received. Previous research has demonstrated that the reliability of items in multiple choice measures can be compromised by the “testwiseness” of participants (Rogers & Yang, 1996). Participants with increased testwiseness have a better chance of accurately guessing the answers to multiple choice tests than other participants (Rogers & Harley, 1999). If this were the case, the assumption that all guessing on the measure was random, which is typically associated with estimating reliability was violated and the reliability coefficient for the objective items for cross-training was underestimated (Rogers & Harley, 1999). Based on these observations, the decision was made to retain the current set of objective items and gather additional data.

The items in the subjective measure for the team training manipulation check had fairly acceptable reliability for the team coordination training condition ($\alpha = 0.69$) and good reliability for the cross-training condition ($\alpha = 0.87$). An independent samples t-test was used to compare the means of the individual subjective items across both training
conditions (see Table 3). The results indicated that the means of two out of three TCT items and three out of three CRT items significantly differed across both team training conditions in the expected direction. As expected, neither of the subjective measures in either condition had a significant mean difference on the distracter item (i.e., item 4), indicating low acquiescence among participants in responding to the questions.

The comparison-based items had an acceptable reliability ($\alpha = 0.85$). Results from an independent samples t-test also showed that all items significantly differed across the team coordination training and cross-training conditions in the expected direction (see Table 4), with the exception of one item that only differed across conditions at a marginal level ($p < .10$). The lack of significance of this item may have been due to the small size of the sample ($N = 19$). This item was therefore retained.

Whereas the comparison-based items for the team training manipulation check had a set of items that asked participants to indicate which statement they agreed with on a scale of 1 to 5, the forced choice items forced participants to choose one statement that either related to the cross-training condition or the team coordination training condition. Only a small subset of the pilot study participants received this measure. The sample size for the forced choice items was therefore fairly small ($N = 8$). However, despite the small sample size of the measure, the reliability among the four items of the measure was fairly high ($\alpha = 0.97$). All eight participants selected the statement that best represented the team training condition to which they had been assigned, with the exception of one individual in the team coordination training condition (see Table 5).
Table 5

Pilot Study Results for Team Training Forced Choice Manipulation Check Items

<table>
<thead>
<tr>
<th>FORCED CHOICE ITEMS (α = 0.97)</th>
<th>Team Training</th>
<th>% Participants in each Condition that Selected the Correct Option</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TCT (N = 4)</td>
<td>CRT (N = 4)</td>
<td>t-value^a</td>
</tr>
<tr>
<td>The training material focused MORE on:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(NOTE: Select only ONE)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. i) Describing details on the role of my teammate.</td>
<td>100</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>ii) Describing teamwork skills/coordination strategies.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. i) The specific roles of the Information and Resource Managers.</td>
<td>100</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>ii) The specific steps involved in effective planning.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. i) The primary functions of the Information and Resource Managers' roles.</td>
<td>100</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>ii) The primary ways to assess the team and environmental situation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. i) The responsibilities of the Information and Resource Managers' roles.</td>
<td>75</td>
<td>100</td>
<td>3.00</td>
</tr>
<tr>
<td>ii) The strategies on how to effectively coordinate as a team.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *Significance values could not be calculated for items 1 to 3 due to low variability in the standard deviation of each condition. Analyses were conducted at the individual-level.

In addition to the four sets of measures previously reviewed (i.e., the objective items, subjective items including the distracters, and both sets of forced choice measures), an additional fifth measure was used to provide supporting qualitative data on differences across training conditions. The question asked: “How did you use the information learned in training in the NeoCITIES simulation you just completed?” Most participants described engaging in behaviors listed on their reminder sheets for each training type. Sample responses from participants in the cross-training condition include, “communicated with other Information Managers”, “monitored resources”, and
“monitored feedback from events.” Sample responses from participants in the team coordination training condition include, “communicated changes in pace of events”, “asked for clarification on ambiguous events”, and “communicated when running low on resources.”

*Environmental Condition.* The three items used to evaluate environmental condition had acceptable reliabilities at both Time 1 (after the first performance session; $\alpha = 0.77$) and Time 2 (after the second performance session; $\alpha = 0.85$). However, a paired samples t-test was conducted in which the mean environmental condition at Time 2 was compared to the mean environmental condition at Time 1. No significant mean differences were found in the familiarity of the environment across time ($t = 0.87$, $p = .389$; mean for Time 1 = 2.18; mean for Time 2 = 2.28; $N = 120$). Oral feedback from participants indicated that some individuals misunderstood the anchors on the scale rated items higher if they found the environment more novel. This difference in ratings may have led to consistent responses in the opposite direction than expected and the reduction of mean differences between time points. The direction of the anchors for the scale was therefore changed from 1 = completely novel and 5 = completely familiar to 1 = completely familiar and 5 = completely novel.

After changing the direction in the anchors of the scale, additional data was collected on the measure. A second paired samples t-test was conducted on split-halves of the data, such that the mean differences from participants that had completed the earlier version of the measure ($N = 43$) were evaluated separately from those that had completed the later version of the measure ($N = 77$). As expected, the results showed no significant differences in the perceptions of environmental condition among the participants that had
completed the earlier version of the measure (t = 0.39, p = .696; mean for Time 1 = 2.66; mean for Time 2 = 2.73; N = 43). However, among participants that had completed the adjusted measure, significant mean differences (at a marginal level, p < .10) were found between the first and second performance session (t = -1.85, p = .068; mean for Time 1 = 2.98; mean for Time 2 = 2.68; N = 77). Even though these differences were in the opposite direction than expected (Time 2 was perceived as less novel than Time 1), qualitative data from open-ended survey responses and oral feedback from participants indicated that participants had trouble keeping up with the pace of events in the second condition as opposed to the first.

**Post-Pilot Items**

The results from the post-pilot questionnaire are summarized in Table 6. Among the 11 items listed, the top three concerns indicated by the participants were: “I felt like I needed more information to make correct decisions,” “all of the events happened independently of each other,” and “the training video I watched was too long.” The first concern differed significantly across team training conditions (t = -2.49, p = .018) such that individuals in the team coordination training condition were more likely to agree with this statement (TCT mean = 3.67) than individuals in the cross-training condition (CRT mean = 2.89). Oral feedback from participants revealed that these differences were due to not knowing much about their teammates’ role and to the role of other teams in the system. Given that the training material could not be adjusted to convey additional information on their teammates’ role (since this is the key manipulation for cross-training), additional information was added to the training slides for NeoCITIES to briefly illustrate the role of other teams. The additional training material likened the
NeoCITIES simulation to that of an emergency response team in which all teams
received the same events but it was up to them to decide whether or not their unit should
respond to the call.

Table 6

Results from Post-Pilot Questionnaire

<table>
<thead>
<tr>
<th>Post Pilot Items</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. I think each team had a part in resolving some related events.</td>
<td>4.06</td>
<td>0.71</td>
</tr>
<tr>
<td>4. I found the NeoCITIES training material beneficial.</td>
<td>3.69</td>
<td>0.79</td>
</tr>
<tr>
<td>10. I think there were connections between some of the events.</td>
<td>3.53</td>
<td>0.91</td>
</tr>
<tr>
<td>7. I felt like I needed more information to make correct decisions.</td>
<td>3.28</td>
<td>1.00</td>
</tr>
<tr>
<td>9. All of the events happened independently of each other.</td>
<td>3.17</td>
<td>0.97</td>
</tr>
<tr>
<td>1. The training video I watched was too long.</td>
<td>3.00</td>
<td>1.05</td>
</tr>
<tr>
<td>5. I felt like I knew what other teams were doing during the simulation.</td>
<td>2.92</td>
<td>1.18</td>
</tr>
<tr>
<td>8. I did not see any connections between events.</td>
<td>2.78</td>
<td>1.12</td>
</tr>
<tr>
<td>6. I was unsure about how to communicate with other teams.</td>
<td>2.72</td>
<td>1.16</td>
</tr>
<tr>
<td>2. The measures I completed were confusing.</td>
<td>2.57</td>
<td>0.94</td>
</tr>
<tr>
<td>3. I had difficulty comprehending the events in the simulation.</td>
<td>2.28</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Note. N = 36. Items were rated on a scale of 1 (strongly disagree) to 5 (strongly agree) and are sorted in descending order according to their means.

The second concern that “all of the events happened independently of each other”
was addressed through creating a distinct storyline for the events in the Performance 1
and 2 conditions. The theme for the events was a football weekend in State College. The
first performance session was the game before the actual football game and included
events such as disturbance of the peace calls from loud tailgate parties (Police event) and
individuals that were passed out from too much drinking (Fire event). The second performance session reflected events that took place on game day. These included a barbeque fire (Fire event) and a student riot at Beaver Stadium (Police event). Connections between events were also clarified through including more interconnected events within each performance session. Two events for the Fire team that illustrate this are: “A fire from a nearby grill has ignited a young woman’s blanket and tent. Units needed to extinguish the flames” and “Units requested to treat young woman for very minor burns from barbeque fire.” Both events take place within three events of each other and are both located along Park Ave.

The third concern that “the training video I watched was too long” was more difficult to address than the other two. Care needed to be taken to ensure that essential information related to the content of each team training type was not excluded. Both training videos were shortened from their original 20 minute duration to 15 minutes by only including the narrated explanations of each behavioral example. The previous versions of the videos contained multiple iterations of the same video, once as an example and a second time with a narrated explanation of the example. Making these edits helped to slightly decrease the length of the video and participants’ perceptions of their repetitiveness.

Pilot Study: Conclusion

The purpose of the pilot study was to evaluate the effectiveness of the manipulations (i.e., team training and environmental condition) and measures used in the study. Several changes were made to the current study based on the results obtained in the pilot study included: 1) the team training manipulation and manipulation check items,
2) environmental condition manipulation and manipulation check items, and 3) the team mental model measure. Based on the changes made to the key manipulations in the study and the accumulated evidence in the manipulation check measures, it was concluded that the conditions were distinct and that differences were adequately captured by the measures. Additionally, at the end of the pilot studies, the team mental model measures were more easily understood by the research participants by the inclusion of detailed instructions and a clear example. The decision was therefore made to conclude the pilot studies and collect data for the main study.
Chapter 3. THE MAIN STUDY

Method

Participants

Three hundred and fifty-two undergraduate students (176 dyads; 88 multi-team systems) enrolled in five psychology courses at a large northeastern university in the United States participated in the main study. Extra credit was given to students that participated in the study, and an alternative assignment was offered to those that did not wish to participate. The sample was 84.6 percent Caucasian (5.0 percent African American, 4.2 percent Hispanic, 4.7 percent Asian American, and 1.5 percent other ethnic groups), 59.5 percent female, and 34.1 percent freshman-level students (15.4 percent sophomore-level, 32.1 percent junior-level, and 18.4 percent senior-level). The average age of the sample was 20.46 (range: 18-55). The average amount of full-time work experience was 9.7 months, part-time work experience was 37.3 months (3.11 years), and experience in emergency management settings was 1.5 months (ranged from 0 to 5.63 months). Most of the students were moderately to extremely comfortable working in a virtual/distributed team (91.9 percent). Participants spent an average of 3.54 hours per week playing video games in the past year, with a range of 0 to 100 hours, and most only had experience playing two types of games or less (84.1 percent). Table 7 provides a detailed list of the types of games most typically played by the participants.

Design

A 2 (team training: cross-training vs. team coordination training) x 2 (environmental condition: routine vs. non-routine) mixed factorial design was used. Team training was the between-subjects independent variable and environmental condition was
the within-subject independent variable. The dependent variables assessed were the accuracy and similarity of taskwork, situation, and teamwork mental models, and team performance. Each of these variables was measured twice.

Table 7

Main Study: Percentage of Participants that Play Different Game Types

<table>
<thead>
<tr>
<th>Type of Game Played</th>
<th>Percent of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Games</td>
<td>22.9%</td>
</tr>
<tr>
<td>Online Computer Games</td>
<td>32.4%</td>
</tr>
<tr>
<td>Handheld Games (e.g., games on a cellphone, Nintendo DS, or PSP)</td>
<td>22.1%</td>
</tr>
<tr>
<td>Console Games (e.g., X-Box, Playstation, Nintendo)</td>
<td>51.1%</td>
</tr>
<tr>
<td>Online Console Games</td>
<td>7.5%</td>
</tr>
<tr>
<td>Video/Arcade Games</td>
<td>3.6%</td>
</tr>
<tr>
<td>NeoCITIES (the current game)</td>
<td>0.6%</td>
</tr>
<tr>
<td>None of the Above</td>
<td>21.5%</td>
</tr>
</tbody>
</table>

The NeoCITIES Simulation

NeoCITIES is a simulated task environment based on the original CITIES task (Civilian Command, Control, and Communication Interactive Task for Identifying Emerging Situations; Wellens & Ergener, 1988). Similar to the CITIES simulation, NeoCITIES is used to evaluate collaborative team decision-making processes, knowledge acquisition, and knowledge management in a command and control computer-mediated environment (McNeese et al., 2005). Inherent characteristics of the simulation, such as high task interdependence, long interaction times, and ambiguous and dynamic problems make NeoCITIES particularly suited to examining distributed team cognition (McNeese
et al., 2005). Three previous studies have successfully implemented NeoCITIES as a scaled world simulation used to evaluate decision-making in a distributed context (i.e., Connors, 2006; Jones, 2006; Pfaff, 2008). For teams to effectively work together in NeoCITIES, they require higher levels of shared understanding on taskwork and teamwork processes and an awareness of the situation (Obieta, 2006).

The structure of NeoCITIES and the scenarios encountered by participants closely relate to the real-world emergency management domain. This was done through the use of field observation and knowledge elicitation of 911 dispatch workers (Terrell, McNeese, & Jefferson, 2004). NeoCITIES was modeled on a city’s emergency management system, which represents different functional units in an emergency response team. Participants in the simulation are required to work together in order to maintain the health of State College and the Pennsylvania State University campus. The use of this location was expected to increase the experimental realism of the simulation for Penn State undergraduate student participants.

The NeoCITIES simulation consists of different versions. The current study used NeoCITIES 1.0, which involves four to six persons working together in an emergency management multi-team system (MTS). Multi-team systems (MTS) are “two or more teams that interface directly and interdependently in response to environmental contingencies toward the accomplishment of collective goals. MTS boundaries are defined by virtue of the fact that all teams within the system, while pursuing different proximal goals, share at least one common distal goal; and in so doing exhibit input, process, and outcome interdependence with at least one other team in the system” (Mathieu, Marks, & Zaccaro, 2001, p. 290). A key difference between MTSs and
organizations is that organizations usually contain both loosely and tightly coupled team structures and include members that do not have clearly defined team roles (Mathieu et al., 2001). MTSs are a collection of teams with high interdependences (Mathieu et al., 2001). MTSs are also not bounded by the dimensions of the organization and at times span multiple companies (Mathieu et al., 2001). For example, individuals from the fire department may work closely with those from the police department in emergency response circumstances. Finally, while organizations have many goals or mixed motives, MTSs only have one uniting goal for the network of teams (Mathieu et al., 2001).

The emergency management multi-team system used in NeoCITIES is comprised of two to three dyads representing Fire, Police, and/or Hazardous Material (Hazmat) functional units (see Figure 2). Each functional unit is comprised of two roles: an Information Manager (IM) and a Resource Manager (RM). The IM is responsible for maintaining the communication lines between teams and determining what events need to be addressed by his/her team. On the other hand, the RM allocates resources to events received from the IM and monitors the resolution of the events. Each RM is responsible for different types of resources based on the team to which he/she belongs (see Appendix B). Team members engaged in the simulation are therefore assigned to one of six possible roles (Fire IM or RM, Police IM or RM, or Hazmat IM or RM).

The current study used a four-person MTS (only Fire and Police units) instead of a six-person MTS (Fire, Police, and Hazmat units). The key rationale for this design was that logistically, it was easier to recruit four persons into the lab at one time than 6 persons. An evaluation of the chat logs and performance data showed that there were no meaningful differences between the four-person and six-person systems. The cognitive
load of the task was kept the same in the four-person MTS as the six-person MTS by having participants sort through the same number and type of events (i.e., Fire, Police, and Hazmat events). To reduce the random allocation of resources to Hazmat events, the teams were told at the beginning of the simulation that the Hazmat team would not be joining them and that they should ignore any events they thought were related to Hazmat.

Team members participate in scenarios, which are comprised of a series of emergency events. In order to adequately address these events, the resources of the Fire, Police, or Hazmat team are required. Scenarios take place over a period of 10 minutes in real time but take place over a period of hours in simulation time. During this time, different emergency events occur at timed intervals. Scenario files are balanced such that team members respond to the same number of events and use the same total number of resources within the same amount of time.

The user interface of NeoCITIES includes a map, event tracker, resource panel, and a text-based chat panel (see Appendices A and B). The map displays where the emergency event occurs. The event tracker describes the nature of the event (e.g., shots were fired from the Old Main parking lot) along with the status of the event (e.g., new or closed) and the time at which the event occurred. The event tracker also allows participants to monitor the progression of events in the simulation. The resource panel informs the RM of the number of resources they have available (e.g., fire has 1 out of 3 fire trucks available). Resources that are en-route, on scene, or returning from events are unavailable to be sent out to other events. This helps to reduce the chance of the RM over-allocating resources to address events faster. The chat panel is used by participants to communicate with other individuals in the emergency response system only through
text-based messages. Participants are more likely to utilize the chat panel when they are informed that there was a problem with the resources used to address an event. Communication pathways are restricted such that the RM can only communicate with the IM from his/her specific team, while the IMs can communicate freely with IMs from other teams.

When a new event occurs, the IMs are notified through the event tracker and the map. An icon pops up on the map showing both the location and nature of the event (e.g., civil unrest/riotting). After reviewing the details of the event, IMs then have the option to either send the event to the RM or ignore the event. Events sent by the IM appear in the event tracker of the RM who has to decide whether to allocate resources to the event or ignore the event. Events that are ignored in error either by the IM or RM contribute negatively to both the dyad’s and the emergency management system’s performance. These events may also start to escalate and result in even higher penalties being applied to the dyad and system-level scores. However, events are only allowed to escalate to a certain point, in which a maximum penalty is assigned to the event (e.g., a trash can fire burns down all the buildings on campus). If the IM decides to respond to an event and the RM chooses to allocate resources, the RM will be asked to specify the type and number of resources to send to the event. When resources arrive on scene, feedback is sent to the RM on the status of the event (e.g., Units have arrived on-scene, but do not have the proper credentials to address this situation. Units are returning to headquarters). The RM then needs to determine whether the reason for the mission failure is due to sending inappropriate or insufficient resources or responding to the wrong event. Events that are
successfully completed are closed. After all events in the scenario have been delivered (which takes place over a 10-minute time period), the simulation closes.

_NeoCITIES Scenarios_

The scenarios used in the current study consisted of multiple events for which multiple features were specified. These features are explained below.

The duration of each scenario was determined by specifying three components: the initial sleep timer (in milliseconds), the event sleep timer (in milliseconds), and the event counter kill switch. The initial sleep timer was used to set the initial delay before the simulation began to fire events, the event sleep timer set the time delay between events, and the event counter kill switch set the time increment at which the simulation terminated both the server and client application (Pfaff, 2008). The event counter kill switch related to the number of events in the scenario, such that scenarios with a total of 9 events and a kill switch of 11 would terminate two time steps after the 9th event was dispatched. The event counter kill switch was kept constant in this study so that the simulation always ended two time steps after the last event was fired. The total duration of each scenario was determined using the following formula:

\[ \text{Total duration} = \text{initial sleep} + (\text{event counter kill switch}) \times (\text{sleep between events}) \]

Each event within the scenarios was composed of the following properties: order, description, lifespan (i.e., the number of time steps available to complete the event), resource required (i.e., the solution to effectively resolving the event), initial severity, degree of escalation, and the x and y coordinates for the location of the event on the map. The degree of escalation referred to the rate at which events escalated (i.e., changes to the slope of the graph at which an event would escalate), on the other hand, the initial
severity related to the starting value at which escalation began. Events escalated in a curvilinear fashion, such that events with a higher initial severity required more resources to be effectively resolved than those with a lower severity. The current study kept the degree of escalation constant throughout all events and only manipulated escalation through the initial severity of the events. Lifespan and initial severity were related such that events with a higher initial severity had a shorter lifespan.

Given that data were collected only from Fire and Police teams, all Hazmat-related events were given a high lifespan and low initial severity (lifespan = 200 time steps; initial severity = 0.25). Hazmat events would therefore escalate slowly and would not resolve until the end of the simulation. This was done to reduce the chance of irresolvable Hazmat events, appearing as "failed" in the event tracker.

Four scenarios were used in the current study. These included two practice scenarios and two performance scenarios. The total duration of the practice scenarios was 4.71 minutes. The initial sleep before the simulation started was 8000 milliseconds, the time increment used for the event counter kill switch was 11, and the degree of lag between events (i.e., the event sleep timer) was 25000 milliseconds (total duration = 8000 + (11*25000) = 283000 milliseconds or 4.71 minutes). The specifications used in the timing of events in the practice sessions allowed participants to have 8 seconds before the first event was fired to orient themselves with the interface and 25 seconds to focus on the review of each event. Both practice scenarios contained 9 events (3 events related to each team: Fire, Police, and Hazmat). The events related to the Fire and Police teams had high lifespans (72 time steps) and low initial severities (1.25). These participants were less likely to run out of time in addressing each event because all events had a long
duration. This gave participants additional time to correct their mistakes and find the correct solutions to the events.

The first performance scenario used in the study had a total duration of 7.08 minutes. The initial sleep timer was 5000 milliseconds, the event counter kill switch was 21, and the event sleep timer was 20000 milliseconds (total duration = 5000 + (21*20000) = 425000 milliseconds or 7.08 minutes). Participants had 5 seconds (instead of 8 seconds) to orient themselves with the interface before the first event was dispatched and 20 seconds to focus on the review of each event (as opposed to 25 seconds in the practice sessions). The first performance scenario contained 19 events (6 Fire events, 7 Police events, and 6 Hazmat events). Among the Fire and Police events, 11 had a lifespan of 72 and an initial severity of 1.25, while two had a lifespan of 32 and an initial severity of 2.00. In this scenario, the participants in each team were given one event of a heightened severity to give them an initial orientation to resolving such an event. An example of a Police-related event with an initial severity of 1.25 is “Units needed to direct game day traffic at the intersection of Curtin Rd and University Dr.” In this situation only one Squad Car is needed to direct traffic. An event with a heightened severity of 2.00 is “Infuriated students have stormed the field at Beaver Stadium. Many fights have broken out between Penn State students and Ohio State fans. Units needed to disperse the crowd and arrest subjects.” This event is classified as having higher severity due to the urgency of the event, the size of the disaster, and the fact that multiple resources are needed within the functional unit (i.e., a Squad Car and SWAT units) to effectively resolve it.
The second performance scenario had a total duration of 8.02 minutes. This scenario therefore differed from the first performance scenario in the increased number, pacing, and severity of events. The initial sleep timer was 1000 milliseconds, the event counter kill switch was 32, and the event sleep timer was 15000 milliseconds (total duration = 1000 + (32*15000) = 481000 milliseconds or 8.02 minutes). Participants only had 1 second to orient themselves with the interface before the first event was dispatched and 15 seconds to focus on the review of each event (as opposed to 20 seconds in the first performance session). This scenario contained 30 events (10 events related to each team) that were comprised of a mix of low, moderate, and high severity events. Among the Fire and Police events, 12 were of a low severity (lifespan = 72; initial severity = 1.25), 4 were of moderate severity (lifespan = 32; initial severity = 2.00), and 4 were of high severity (lifespan = 15; initial severity = 3.00).

Care was taken to ensure that the events used in the scenarios modeled actual occurrences from emergency management settings. This was done through generating events based on previous research done on NeoCITIES with focus groups and interviews with emergency management personnel (cf. Jones, 2006) and the revision of articles in local newspapers on events that occur during Penn State’s football weekend. The first performance scenario represented routine events that occurred the day before game day, while the second scenario represented non-routine events that occurred on game day. The events across all four scenarios were balanced so that no one team received events in a row or in a predictable fashion. This helped to reduce the chance that any one team felt overloaded or unchallenged by the simulation. Pilot testing helped to determine and fine-tune this balance. The list of events used in each scenario can be found in Appendix I.
Manipulations

Team Training Overview. Both team training conditions were comprised of four main steps that were approximately 30 minutes in duration. First, participants viewed a 15-minute video of the respective team training strategy. During the video, participants responded to a quiz on the concepts they learned (see Appendix E and F) and got a chance to review their responses. Following the video, participants engaged in a 5-minute practice session using the NeoCITIES simulation and were encouraged to implement what they learned during training. Third, participants were given a reminder sheet on the concepts they learned during training and were asked to note three ways in which they could improve on their performance (see Appendices G and H). Finally, participants had a second opportunity to demonstrate the behaviors they had learned during training in another 5-minute practice session using the NeoCITIES simulation.

Team Coordination Training Content. The team coordination training video focused on defining the three components of team coordination training (planning, communicating, and assessing the situation) and demonstrating effective and ineffective examples of each in short clips of the Information and Resource Managers interacting using NeoCITIES. Effective planning/decision making was defined as seeking out information, making plans, and re-evaluating plans. Effective communication involved providing information, checking to make sure you understand each other, and ensuring that communication is clear and concise. Finally, situation assessment/ assessing the situation was described as keeping team members informed about team-related or environmental changes, showing that you are paying attention to what you and your team members are doing, and identifying current problems and anticipating future problems.
Sample statements illustrating effective team coordination included: “I think we should try to conserve resources for bigger events” (illustrating effective planning), “We're running low on resources” (illustrating effective situation assessment), and “They just told me that they don't have the proper credentials” (illustrating effective communication). Additional sample statements of each dimension of team coordination can be found in Appendix C.

*Cross-Training Content.* The cross-training video gave both a detailed description of the primary responsibilities of the first the information manager and then the resource manager (positional clarification; Blickensderfer et al., 1998) and demonstrated the team members performing each of their roles (positional modeling; Blickensderfer et al., 1998). The responsibilities of the Information Manager that were highlighted included: interpreting event information and deciding if your team should ignore the event or respond to it, passing relevant events on to the Resource Manager along with your assessment of the situation, and communicating any concerns regarding other team’s events to other Information Managers. These responsibilities were followed by a list of the icons available to the Information Manager and their definitions. The responsibilities of the Resource Manager that were described included: interpreting event information and deciding if your team should ignore the event or respond to it, allocating the correct number and appropriate type of resources to events, and monitoring the resources that are allocated to events and communicate event feedback messages to the Information Manager. The resources available to the Resource Manager on the specific team to which the participant belonged were described (e.g., a member of the Fire team only viewed descriptions of the role of EMS, Fire Trucks, and Fire Investigators). Each video was
customized to each functional unit, such that the Fire team viewed a Fire Information Manager and Resource Manager performing their role, and the Police team viewed a Police Information Manager and Resource Manager performing their role.

Environmental Condition. Environmental condition was manipulated by increasing the time pressure and complexity of events. This was done by increasing the number, pacing, and severity of events across the first and second performance scenarios. The first performance session had a total duration of 7.08 minutes. It contained 19 events (7 related to the Police team, 6 to the Fire team, and 6 to the Hazmat team). The first event was not dispatched until 5 seconds into the scenario, after which a new event was dispatched every 20 seconds. Most of the Fire and Police events (11 out of 13) had a low initial severity of 1.25 and a long lifespan of 72. Only two events had a heightened severity of 2.00 and a shortened lifespan of 32. The second performance scenario had a total duration of 8.02 minutes and contained 30 events. The first event was fired 1 second into the scenario and new events continued to be dispatched at a pace of every 15 seconds. The Fire and Police events contained a mix of low, moderate, and high severity events, 12 were of a low severity (lifespan = 72; initial severity = 1.25), 4 were of moderate severity (lifespan = 32; initial severity = 2.00), and 4 of high severity (lifespan = 15; initial severity = 3.00). The second performance scenario therefore differed from the first scenario in the increased number, pacing, and severity of events. See Appendix I for a list of the specific events used in each scenario.

Procedure

Participants were randomly assigned to their team and role in NeoCITIES. They then completed and returned the consent forms and began the experiment. PowerPoint
slides were used to guide participants throughout the course of the experiment to reduce the amount of experimenter interaction that took place during the study (see Appendix H). An online survey was completed on the control and demographic variables listed in Appendix N. Basic NeoCITIES training was then administered through self-paced PowerPoint slides (see Appendices A and B). Participants then viewed a 15 minute video clip on either cross-training or team coordination training. Immediately following the training video, participants completed an online survey containing the manipulation check items for team training online (see Appendix M) and a paper and pencil copy of the taskwork and teamwork mental model measures (see Appendices N and O). Participants then engaged in two 5-minute practice sessions in the NeoCITIES simulation. Between the practice sessions, participants were given a brief reminder of the information they learned during training and asked to record areas in which they could improve (see Appendices G and H). After both practice sessions were complete, participants engaged in the first 7-minute performance session representative of the routine environmental condition in NeoCITIES. They then completed an online survey with the manipulation check items for environmental condition (see Appendix M), an open-ended question on how they used the information learned in training in the NeoCITIES simulation they just completed, and the specific team measure for situation mental models (see Appendix P).

Participants then engaged in the final 8-minute performance session representative of the non-routine environment. Participants then completed an online survey containing the manipulation check items for environmental condition, another open-ended question on how they used the information learned in training in the NeoCITIES simulation they just completed, and a packet containing the specific situation
mental models for their team, a teamwork mental model, and a taskwork mental model. The order of the measures was counterbalanced, such that the taskwork mental model measure was administered before the teamwork mental model measure in the first survey administration and the teamwork mental model measure was placed before the taskwork mental model measure in the second survey administration. Finally, participants completed an online measure assessing what went well and did not go well in NeoCITIES and were thanked for their participation. The entire study took about an hour and forty-five minutes to complete.

**Measures**

*Control Variables.* Given that NeoCITIES is a dynamic simulated task environment, the potential control variables included video game experience, polychronicity, and cognitive ability. It has been demonstrated that individuals with increased experience playing video games perform better in NeoCITIES (e.g., Pfaff, 2008). Participants were asked to report the number of hours they spent per week playing video games, along with indicating the types of games played (see Appendix L).

Similarly, participants were required to engage in several behaviors at once; therefore, individuals high in polychronicity (which is an individual’s preference to engage in multiple tasks; Hall & Hall, 1990), were expected to have less difficulty adapting to the working context of NeoCITIES. Polychronicity was measured using a 10-item self-report measure which asks participants to rate the extent to which they agree with each statement on a scale of 1 (strongly disagree) to 5 (strongly agree; Bluedorn, Kalliath, Strube, & Martin, 1999). A sample polychronicity item is “I like to juggle several
activities at the same time.” Cognitive ability was evaluated using a self-report measure of the participants’ overall G.P.A. and SAT scores.

Based on their prevalence in the training effectiveness literature (cf. Colquitt, Lepine, Noe, 2000), self-efficacy and training satisfaction were also included as possible control variables. Self-efficacy was assessed using an 8-item measure that was rated on a scale of 1 (strongly disagree) to 5 (strongly agree; Bell & Kozlowski, 2002). A sample item from the scale is “I can meet the challenges of my role in this simulation.” Training satisfaction was measured with 4-items that were also rated on a scale of 1 (strongly disagree) to 5 (strongly agree). A sample item is “I am satisfied with the amount of training I received.”

All scales had acceptable levels of reliability (polychronicity: α = .84; training satisfaction: α = .85; self-efficacy: α = .91).

Demographic variables. Participants were asked to indicate their race, sex, year in college, age, level of comfort working in a virtual/distributed team, number of years of experience in a full-time job, number of years of experience in a part-time job, and number of years of experience in an emergency management setting.

Manipulation Check Items for Team Training. The manipulation check for team training was evaluated using both objective and subjective measures (see Appendix M). The objective measures were comprised of 10 multiple choice items, which were based on the training material from the team coordination training condition (items 1-5) and the cross-training condition (items 6-10). Each correct answer to the multiple choice questions was given 1 point. The subjective items were comprised of 6 questions that asked participants to rate the extent to which they agree with each statement on a scale of
1 (strongly disagree) to 5 (strongly agree). A sample item for the team coordination training condition was, “During training I learned about the core elements of team coordination.” A sample item for the cross-training condition was, “During training I learned about the role of my teammate.” These items included two distracter questions (that were similar to but not related to either training condition). A set of comparison-based questions and forced choice items were also asked, which required participants to compare and choose between the two training conditions (see Appendix M).

**Manipulation Check Items for Environmental condition.** The manipulation of environmental condition was evaluated by asking participants to compare the familiarity of the environment they just experienced to the practice sessions in training. The familiarity of the environment was evaluated on the following three components: the speed at which events were received, the severity of events, and the speed at which events were resolved (see Appendix M). Participants responded on a 1 (completely familiar) to 5 (completely new) Likert-scale. This manipulation check is similar to the measure used by Marks and colleagues (2000) in their manipulation of environmental novelty.

**Team Performance.** The scores for each of the two performance scenarios were determined through first, aggregating the severity of each event at each time step (using the event growth formula), then averaging the total magnitudes across all time steps for each event (event score formula), and finally, summing the scores across each event in the scenario (final dyad score formula; Obieta, 2006). Each of these formulae are described in detail below.

The event growth formula is computed as the following:
\[ M_t = a (M_{t-1}) + b (M_{t-1})^2 + c (R_{\text{correct}}) \]

In this formula, \( M_t \) reflects the total penalties applied to an event at each time step. This total is aggregated across all time steps in the scenario for each specific event. \( M_{t-1} \) is the score of the event at a particular time step. \( R_{\text{correct}} \) is the number of appropriate resources that have been dispatched to the event. The values \( a, b, \) and \( c \) are set constants determined in the original CITIES simulation (\( a = 0.995, b = 0.0075, \) and \( c = 0.04996; \) Wellens & Ergener, 1988). These values generate both linear and curvilinear trends in the growth curve for each event.

As the simulation progresses, a record is made at each time step of the correct resources applied to each specific event (\( R_{\text{correct}} \)). If the appropriate resources are sent to an event within a timely fashion then the overall penalty for that event will be low (\( M_t \)). The penalty associated with each event continues to accrue until the correct resources are allocated. Therefore participants are not rewarded for responding quickly to events with the incorrect resources. Participants need to both respond to the event in a timely fashion and allocate the correct number of resources to events in order to receive a low penalty.

Based on this configuration, team members are able to respond to events after inappropriate resources are sent. However, if the event is not resolved within a preset time limit, the event continues to escalate and the maximum penalty for that event is applied.

Each event starts out with varying magnitudes/ initial severities (see Appendix I). Events with a low magnitude, such as apprehending a pickpocket, start out with a low initial severity of 1.25. On the other hand, larger events, such as arresting a group of organized criminals from a bank robbery, start off with a higher magnitude of 3. Given
that events continue to escalate until a preset time limit, participants would have more
time to resolve the small event than the large event before the escalation reached the
highest magnitude. However, responding to the less severe event rather than the more
severe event involved incurring a greater penalty for failing to respond to the more severe
event.

Once the final penalties are computed at each time step using the event growth
formula, the event score is computed as shown below:

\[ E_i = \sum_{t=0}^{t_{\text{max}}} M_t \]

In this formula, the \( E_i \) is the sum of the event magnitude values (\( M_t \)) over the lifetime of
an event. This formula reflects the total penalty applied across all time steps in the
scenario and is computed for each event.

The final formula used to determine the scores for each dyad is the following:

\[ S_T = S_{\text{max}} - \sum_{i=1}^{i} E_i \]

In this formula, \( S_T \) represents the final dyad score in the scenario. \( S_{\text{max}} \) is the highest
possible score that is attainable. This value is based on the number and severity of events
in the scenario. \( \sum E_i \) is the sum of the maximum penalties applied to all events in the
scenario. This value is subtracted from the maximum score possible to determine the final
dyad score.

**Team Mental Model Measurement: Overview**

Measures that have been used to evaluate team mental models include concept
mapping (Ellis, 2006; Marks et al., 2000; 2002), card sorting (Smith-Jentsch et al., 2001),
qualitative coding (Waller et al., 2004), and questionnaires (Smith-Jentsch et al., 2005).
However, paired comparison ratings have been the most used approach that assesses
both content and cognitive structure (how knowledge is organized within teams) (Banks & Millward, 2007; Cooke et al., 2003; Gurtner et al., 2007; Edwards et al., 2006; Lim & Salas, 2006; Mathieu et al., 2000; 2005; Stout et al., 1999). Paired comparison ratings also have the added benefit of being able to clearly distinguish between different types of team mental models, unlike concept mapping, which tends to blur the distinction between taskwork and teamwork mental models (Mohammed et al., 2000). Based on these reasons, all team mental model measures were assessed using paired comparison ratings.

Paired comparison ratings involved participants completing a series of grids that assessed taskwork, teamwork, and situation mental models. The grids were organized in a two-dimensional pattern, such that names of each concept were listed in the first row of the grid and their definitions listed in the left-hand column of the grid. The perceived similarity between each concept was rated on a 7-point scale ranging from 1 (not related) to 7 (extremely related). Prior to completing the grids, participants were given detailed instructions and a football-related example to help illustrate how relatedness was being defined in the current study.

The actual content and structural indices calculated from the paired comparison ratings are described in further detail below.

*Team Mental Model Measurement: Content*

*Taskwork Mental Models.* A careful analysis of the NeoCITIES simulation indicated that the main task-related information was rooted in the primary functions of the Information and Resource Managers. These functions included: interpreting information received about events and deciding whether or not the team should ignore the event or respond to the event, allocating the correct number and appropriate type of
resources to events, and communicating event-related information to fellow teammates. This translated into the following seven task-related dimensions: prioritize events, classify events, filter information, relay information, allocate resources, monitor events, and re-evaluate decisions. Each of these dimensions was placed in a 6 x 7 grid and rated on a scale of 1 (not related) to 7 (extremely related; see Appendix N) to indicate the extent to which the participant believed there was a connection between them.

**Teamwork Mental Models.** The teamwork mental model also consisted of seven dimensions that were placed in a 6 x 7 grid and rated on a scale of 1 (not related) to 7 (extremely related). However, the actual content of the dimensions differed from the taskwork mental model measure. An evaluation of the teamwork processes needed to complete the primary functions of the Information Manager and Resource Manager resulted in the identification of seven teamwork dimensions: develop plans, revise strategy, gather details, convey information, clarify statements, monitor changes, and identify problems. These teamwork behaviors are consistent with previous ratings of teamwork dimensions provided by Mathieu and colleagues (2000; 2005). A brief description of each of the seven teamwork dimensions can be found in Appendix O.

**Situation Mental Models.** The development of shared knowledge structures regarding the situation may be reflected in the detection of underlying storylines in the events addressed during the simulation (Obieta, 2006). Situation mental models were therefore measured through the assessment of interconnected events from each performance episode. An example of two highly interconnected events from the Fire team’s list of events in the second performance session was the tent fire and minor burns events (see Appendix P). The description of the tent fire states that “A fire from a nearby
grill has ignited a young woman’s blanket and tent. Unit needed to extinguish the flames.” On the other hand, the minor burns event is described as “Units requested to treat young woman for minor burns from barbeque fire.” These two events are interconnected because they are both linked to the fire that was started by the tailgater’s grill. Events that had low interconnection were tent fire and twisted leg (i.e., “Student caller twisted his leg running from Beaver Stadium. Unit requested for treatment”). In this example, the event of the caller twisting his leg had no direct relationship with the tent fire.

Situation mental models were evaluated at the end of each performance episode because team members needed to be exposed to the actual events in each scenario before completing the measure. This measure was therefore unique to each team across each performance episode. The grids used for the first performance session consisted of 6 events rated in a 5 x 6 grid on a scale of 1 (not related) to 7 (extremely related). In the second performance episode, a list of 8 events were rated in a 7 x 8 grid on a scale of 1 (not related) to 7 (extremely related; see Appendix P). A slightly larger grid was used for the second performance episode because this scenario contained 30 events (as opposed to 19 events in the first performance episode).

*Team Mental Model Measurement: Structure*

*Sharedness.* A meta-analytic review of the team mental model literature has shown that different indices of sharedness produce different results (Dechurc & Mesmer-Magnus, in press). Based on this finding, multiple indices were used to evaluate the structure of team mental models. These included Euclidean distance (Scott, 1991) and QAP correlations (Mathieu et al., 2000).
Euclidean distance reflects the shortest distance between two points (Scott, 1991). Each team mental model consisted of a vector of scores (i.e., a set of cell values within each grid). The 6x7 grid used to evaluate taskwork mental model contained a vector of 21 scores for each team member. The teamwork mental model also contained a vector of 21 scores (6x7 grid). The first situation mental measure contained a vector of 16 scores (5x6 grid), while the second situation mental model measure included 28 scores (7x8 grid). The vector of scores for each team mental model measure was compared between dyad members. The distance between these two sets of scores between teammates reflected the Euclidean distance. Euclidean distance demonstrates the distribution of scores or lack of sharedness between dyad members. Therefore, higher distance indicates lower sharedness.

The second index calculated was the quadratic assignment proportion index (QAP correlation). This index reflects the relative similarity between dyad members (Mathieu et al., 2000). Network analysis programs, such as UCINET (Borgatti, Everett, & Freeman, 1992), are typically used to calculate QAP correlations (e.g., Mathieu et al., 2000; 2005). However, the current study computed the index using a similar procedure in SPSS 17.0, in which the vector of scores on each team mental model were compared between each pair of dyad members (Probber, 1999). The index represented a correlation and therefore ranged from -1 (counter-sharedness), through 0 (no sharedness), to 1 (complete sharedness). Euclidean distance and QAP correlations are independent of each other, i.e., low distance does not necessarily mean high correlation. An example of this is shown in Figure 3.
In the distribution of scores shown in Figure 3, participants A and B both have highly correlated scores. However, given the differences between these values, participants also have high distance in their ratings. On the other hand, participants C and D have low distance in their ratings but given that participant C has a reshuffled order in his/her position means, this dyad has a low correlation in their ratings (Probber, 1999).

Accuracy. Accuracy ratings of the team mental model measures were also evaluated using the indices Euclidean distance and QAP correlations. These ratings were generated in a three-step process. First, two subject matter experts (SMEs) in NeoCITIES completed individual ratings on the taskwork mental model measure and each situation mental model measure. These SMEs included a senior-level PhD student in Psychology with approximately a year of experience with the NeoCITIES interface, task demands,
and scenarios. The second SME was an Assistant Professor with at least four years of experience with the NeoCITIES interface, task demands, and scenarios. Two SMEs also provided accuracy ratings on the teamwork mental model measure. These SMEs were a senior-level PhD student in Psychology with approximately seven years of experience with team research and an Associate Professor in Psychology with at least fifteen years of experience in team research, particularly as it related to team cognition.

Second, discrepancies among ratings that were greater than two points were discussed between each pair of SMEs until some agreement or compromise was reached on ratings. The correlations between the vectors of scores in experts’ ratings were above .70 for taskwork, teamwork, and situation mental models (see Table 8).

Table 8

<table>
<thead>
<tr>
<th>Team Mental Model</th>
<th>Correlations</th>
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<tbody>
<tr>
<td>Taskwork</td>
<td>.914</td>
</tr>
<tr>
<td>Teamwork</td>
<td>.781</td>
</tr>
<tr>
<td>Situation</td>
<td></td>
</tr>
<tr>
<td>Time 1</td>
<td></td>
</tr>
<tr>
<td>Fire</td>
<td>.987</td>
</tr>
<tr>
<td>Police</td>
<td>.914</td>
</tr>
<tr>
<td>Hazardous Materials</td>
<td>.944</td>
</tr>
<tr>
<td>Time 2</td>
<td></td>
</tr>
<tr>
<td>Fire</td>
<td>.891</td>
</tr>
<tr>
<td>Police</td>
<td>.898</td>
</tr>
<tr>
<td>Hazardous Materials</td>
<td>.792</td>
</tr>
</tbody>
</table>

Third, the scores from both expert ratings were averaged to create an overall expert rating of the ‘true score’ for each measure. Euclidean distances and QAP correlations were computed, which compared the ratings of each dyad member to the true score (expert ratings). These ratings were averaged across dyads to create an overall accuracy rating (as indexed by distance and correlation) for each dyad.
In total, there were twelve measures computed that related to the sharedness and accuracy of team mental models. These were: taskwork sharedness (indexed by both distance and correlation), teamwork sharedness (indexed by distance and correlation), situation sharedness (indexed by distance and correlation), taskwork accuracy (indexed by distance and correlation), teamwork accuracy (indexed by distance and correlation), and situation accuracy (indexed by distance and correlation).

Results

Preliminary Analyses

Imputing Team Mental Model Data. Most of the sample (69.3 percent) had complete data in all 127 cell values across all grids. Among those with missing data, 72.9 percent contained grids with 0.6 percent or less (i.e., 2 values or less) that were missing. Most data seemed to be missing at random with the exception of one indicator that was used to assess the second situation mental model among fire team participants. This indicator was shaded incorrectly on the grid, which led participants to skip the item. However, this error was corrected during data collection and only 97 out of 352 individuals skipped this item. Given that most of the data were missing at random, missing data were replaced using the mean of each cell value.

Normality and Distribution of Outcome Variables Across Time. Table 9 shows the distribution of the means in the outcome variables (team mental models and performance) and their mean differences across time. Skewness levels higher than 2 and a kurtosis greater than 3 are considered a violation of the assumption of normality (Hildebrand, 1986).
Table 9

**Main Study: Distribution of the Outcome Variables and their Mean Differences Across Time**

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>Time 1: Descriptives</th>
<th>Time 2: Descriptives</th>
<th>Mean Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Skewness</td>
</tr>
<tr>
<td>Team Mental Models</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharedness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork</td>
<td>11.47</td>
<td>2.32</td>
<td>0.07</td>
</tr>
<tr>
<td>Situation</td>
<td>8.62</td>
<td>2.73</td>
<td>0.28</td>
</tr>
<tr>
<td>Teamwork</td>
<td>10.28</td>
<td>2.51</td>
<td>0.12</td>
</tr>
<tr>
<td>QAP Correlation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork</td>
<td>0.19</td>
<td>0.25</td>
<td>-0.37</td>
</tr>
<tr>
<td>Situation</td>
<td>0.45</td>
<td>0.30</td>
<td>-0.53</td>
</tr>
<tr>
<td>Teamwork</td>
<td>0.19</td>
<td>0.25</td>
<td>-0.03</td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork</td>
<td>12.08</td>
<td>1.02</td>
<td>-0.06</td>
</tr>
<tr>
<td>Situation</td>
<td>7.36</td>
<td>1.94</td>
<td>0.45</td>
</tr>
<tr>
<td>Teamwork</td>
<td>8.51</td>
<td>1.10</td>
<td>0.13</td>
</tr>
<tr>
<td>QAP Correlation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork</td>
<td>0.15</td>
<td>0.16</td>
<td>-0.73</td>
</tr>
<tr>
<td>Situation</td>
<td>0.59</td>
<td>0.21</td>
<td>-0.77</td>
</tr>
<tr>
<td>Teamwork</td>
<td>0.27</td>
<td>0.16</td>
<td>-0.03</td>
</tr>
<tr>
<td>Performance</td>
<td>58.48</td>
<td>6.80</td>
<td>-0.02</td>
</tr>
</tbody>
</table>
The skewness and kurtosis of all measures were below absolute values of 0.77 and 2.43, respectively. Based on these indices, both sets of team mental model and performance data across Time 1 and 2 appeared to be normally distributed (also see Figures 4 and 5 for the Performance 1 and 2 distributions).

Figure 4. Histogram with normal distribution curve for performance 1 scores (N = 352).
The means of all team mental models were expected to differ significantly across time, such that each type of mental model would become more shared or similar with increased team interaction. Contrary to this view, some team mental models became less shared/ more divergent across time. The patterns in these results were inconsistent across the type, property, and index used to evaluate the measure.

Among the taskwork mental model measures, increased convergence/sharedness across Times 1 and 2 was observed for shared taskwork mental models. However, this effect was only evident when the variable was indexed through distance ratings\(^2\) \(t(175) = 5.39, p < .001,\) mean at Time 1 = 11.47, mean at Time 2 = 10.42). On the other hand,

\(^2\) Note: Higher distance indicates lower sharedness or convergence among team mental models.
team mental models became more divergent across time for shared taskwork mental models indexed as QAP correlations \( t(175) = 2.35, p = .020, \) mean at Time 1 = 0.19, mean at Time 2 = 0.14) and accurate taskwork mental models (indexed as distance ratings: \( t(175) = -5.27, p < .001, \) mean at Time 1 = 12.08, mean at Time 2 = 12.57 and when indexed as QAP correlations: \( t(175) = 5.33, p < .001, \) mean at Time 1 = 0.15, mean at Time 2 = 0.07).

Similarly, accurate situation mental models became less shared across time when indexed through both distance ratings \( t(175) = -13.56, p < .001, \) mean at Time 1 = 7.36, mean at Time 2 = 10.81) and QAP correlations \( t(175) = 2.17, p = 0.031, \) mean at Time 1 = 0.59, mean at Time 2 = 0.54). Consistent with these results, shared situation mental models among dyad members were more divergent across time when indexed through distance ratings \( t(175) = -10.87, p <.001, \) mean at Time 1 = 8.62, mean at Time 2 = 11.83). However, shared situation mental models converged over time when indexed through QAP correlations \( t(175) = -2.45, p = 0.015, \) mean at Time 1 = 0.45, mean at Time 2 = 0.51).

Finally, shared teamwork mental models became more shared across time, when indexed through distance ratings \( t(175) = 2.58, p = 0.011, \) mean at Time 1 = 10.28, mean at Time 2 = 9.74) but less shared across time when indexed through QAP correlations \( t(175) = 2.76, p = 0.006, \) mean at Time 1 = 0.19, mean at Time 2 = 0.12). A similar pattern was seen in the accuracy of teamwork mental models, such that accuracy increased across time when indexed through distance ratings \( t(175) = 2.63, p = 0.009, \) mean at Time 1 = 8.51, mean at Time 2 = 8.27) but decreased across time when indexed
through QAP correlations ($t(175) = 3.94$, $p < .001$, mean at Time 1 = 0.27, mean at Time 2 = 0.21).

In summary, contrary to expectations, most types, properties, and indices of team mental models decreased in sharedness across time. Exceptions to this pattern in results include distance indices of shared taskwork mental models, shared teamwork mental models, and accurate teamwork mental models and the QAP index of shared situation mental models. A possible reason for this finding is that dyad members in Time 2 communicated less due to the increased time pressure of the non-routine scenario. Less communication across time would have limited the opportunity for mental models to become more convergent among team members (Levesque et al., 2001).

Unlike team mental models, the team performance scores were expected to decrease across time. This difference was expected because the second performance session was more complex than the first performance session. Consistent with this view, team performance scores were significantly lower across Times 1 and 2 ($t(175) = 14.01$, $p = < .001$, mean at Time 1 = 58.48, mean at Time 2 = 51.49).

**Mean Comparisons.** There were several variables that varied across experimental sessions during data collection that may have confounded the results of the current study. These variables included time of day (morning vs. afternoon/evening), experimenter (5 different experimenters were used to run the study at different times), and class type (PSYCH 100, PSYCH 281, PSYCH 301W, PSYCH 484, PSYCH 485). T-tests and Analysis of Variance tests were used to compare the effect of each of these variables on the mean levels of the key dependent variables in the study (i.e., team mental models and performance). The results demonstrated that there were no significant mean differences in
performance across time of day ($t(174) = 0.43$, $p = .666$ for performance 1; $t(174) = 1.88$, $p = .061$ for performance 2), experimenter ($F(5, 175) = 0.74$, $p = .595$ for performance 1; $F(5, 175) = 0.29$, $p = .916$ for performance 2), or class type ($F(7, 171) = 0.35$, $p = .931$ for performance 1; $F(7, 171) = 0.52$, $p = .818$ for performance 2).

Similarly, no significant mean differences were found across all team mental model measures based on time of day, experimenter, or class type. These variables were therefore not considered as confounds in the study and not modeled in subsequent analyses.

**Team Training Manipulation Check.** Four different survey measures were used to evaluate the manipulation of team training type (i.e., objective, subjective, and two sets of forced choice measures). Each measure was found to have acceptable reliabilities across both training conditions (i.e., coefficient alpha greater than or equal to .70), with the exception of the objective items for the cross-training condition ($\alpha = .57$; see Table 10). The lower alpha found for cross-training may be explained by the disparate nature of the questions asked in this scale, in that, the questions in this measure were less similar to each other than those that were asked about team coordination training.

The items for the objective measures were further examined using a factor analysis. A principal axis extraction method with a Promax rotation was used to allow the factors to correlate (Ford, McCallum, & Tait, 1986). The scree plot suggested a three-factor solution best fit the data but the factors in this solution did not show simple structure. The pattern of eigenvalues, however, showed a two-factor solution best fit the data. The first factor was team coordination training (eigenvalue = 2.97, 29.74% of the variance) and the second factor was cross-training (eigenvalue = 1.45, 14.54% of the
This solution accounted for 44.28% of the variance in the item responses. All of the objective items loaded cleanly on one of the two factors with the exception of question 1 for team coordination training and question 4 for cross-training (see Table 10). However, deleting these items did not offer much improvement to each measure (change in reliability from .54 to .56 for cross-training and from .75 to .73 for team coordination training). Given the lack of additional evidence indicating poor consistency in these items, no adjustments were made to this scale.

The subjective items were also evaluated using factor analysis (principal axis extraction method with a Promax rotation) from which two factors emerged. The first factor was cross-training (eigenvalue = 3.31, 41.40% of the variance) and the second was team coordination training (eigenvalue = 1.86, 23.21% of the variance). This solution accounted for 64.61% of the variance in the item responses. All items loaded on one of the two factors with the exception of the distracter item used for cross-training (see Table 11). The distracter items are used to detect acquiescence biases in student responses. It is therefore not expected that students in the cross-training condition would respond consistently on this item. Based on these results, no adjustments were made to this scale.

Differences across conditions were examined using an independent samples t-test. Results showed significant mean differences in the expected direction for all items and scales. For the objective items related to the team coordination training condition (TCT), individuals in the TCT condition were more than twice as likely to get the items correct than individuals in the cross-training condition (t (350) = -25.34, p < .001, mean percent for TCT = 85.8, mean percent for CRT = 32.6). Individuals in the cross-training condition were also significantly more likely to get their objective questions correct than
Table 10

*Exploratory Factor Analysis for the Team Training Objective Manipulation Check Items*

<table>
<thead>
<tr>
<th>Table Training</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEAM COORDINATION TRAINING (TCT; α = 0.75)</td>
<td>TCT</td>
</tr>
<tr>
<td>1. Which of the following strategies is NOT a core element of team coordination?</td>
<td>0.395</td>
</tr>
<tr>
<td>2. Seeking out information BEFORE making a decision is used in which of the following strategies?</td>
<td><strong>0.763</strong></td>
</tr>
<tr>
<td>3. Keeping team members informed about team-related or environmental changes is used in which of the following strategies?</td>
<td><strong>0.602</strong></td>
</tr>
<tr>
<td>4. Identifying current problems and anticipating future problems is used in which of the following strategies?</td>
<td><strong>0.800</strong></td>
</tr>
<tr>
<td>5. Which of the following is a key step in effective communication?</td>
<td><strong>0.461</strong></td>
</tr>
<tr>
<td>CROSS-TRAINING (CRT; α = 0.54)</td>
<td></td>
</tr>
<tr>
<td>6. The INFORMATION manager has the ability to communicate with which of the following people:</td>
<td>-0.179</td>
</tr>
<tr>
<td>7. The RESOURCE manager has the ability to communicate with which of the following people:</td>
<td>0.089</td>
</tr>
<tr>
<td>8. A key difference between the RESOURCE and INFORMATION managers roles is that the INFORMATION manager is responsible for:</td>
<td>-0.015</td>
</tr>
<tr>
<td>9. __________ are attached to sent events to provide a quick visual description of each event.</td>
<td>0.021</td>
</tr>
<tr>
<td>10. Your team has _____ types of resources to allocate to events. There are _____ units available of each type of resource.</td>
<td>0.065</td>
</tr>
</tbody>
</table>

*Note.* Items highlighted in bold distinctively loaded on the correct factor.
### Table 11

*Exploratory Factor Analysis for the Team Training Subjective Manipulation Check Items*

<table>
<thead>
<tr>
<th>Team Training</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor 2</td>
</tr>
<tr>
<td>TEAM COORDINATION TRAINING (TCT; α = 0.78)</td>
<td></td>
</tr>
<tr>
<td>1. During training, the core elements of team coordination were EXPLICITLY discussed.</td>
<td>0.580</td>
</tr>
<tr>
<td>2. The training material explicitly discussed how to design plans and evaluate their effectiveness.</td>
<td>0.843</td>
</tr>
<tr>
<td>3. In training, I received details on how to evaluate environmental changes and identify current problems and anticipate future problems.</td>
<td>0.689</td>
</tr>
<tr>
<td>4. During training, I learned about the steps involved in developing different types of trust between me and my teammate.</td>
<td>0.637</td>
</tr>
<tr>
<td>CROSS-TRAINING (CRT; α = 0.87)</td>
<td></td>
</tr>
<tr>
<td>1. During training, I received detailed descriptions on the primary functions of the Information Manager AND the Resource Manager.</td>
<td>0.034</td>
</tr>
<tr>
<td>2. The training helped me to understand the responsibilities of the Information Manager AND the Resource Manager.</td>
<td>0.020</td>
</tr>
<tr>
<td>3. Based on the knowledge I obtained in training, I would feel prepared to switch roles with the Information Manager or the Resource Manager on my team.</td>
<td>-0.101</td>
</tr>
<tr>
<td>4. The training material taught me about the roles and SPECIFIC TYPES OF RESOURCES available to ALL teams in the system (i.e., all the resources of the Police, Fire, and Hazmat teams).</td>
<td>0.397</td>
</tr>
</tbody>
</table>

*Note.* Items highlighted in bold distinctively loaded on the correct factor.
individuals in the team coordination training condition (t (350) = 9.77, p < .001, mean percent for CRT = 80.6, mean percent for TCT = 56.1). See Table 12 for the differences in individual items across conditions.

For the subjective scale, that rated agreement on a scale of 1 (strongly disagree) to 5 (strongly agree), individuals in the team coordination training condition had higher means on the items that related to the TCT condition than individuals in the CRT condition (t (350) = -11.94, p < .001, mean for TCT = 3.67, mean for CRT = 2.58). Individuals in the cross-training condition also had higher means on the cross-training items in the subjective scale than those in the team coordination condition (t (350) = 16.42, p < .001, mean for CRT = 4.45, mean for TCT = 3.14). Mean differences in individual items across conditions are shown in Table 13.

Finally, items on both the comparison-based and forced choice questions showed significant differences across conditions in the expected direction (comparison-based measures: t (350) = 24.26, p < .001; forced choice measures: t (350) = -43.48, p < .001). See Table 14 and 15, respectively for mean differences at the item-level. Based on the overall results, the team training manipulation was successful, in that individuals were able to accurately distinguish between the content of each training type.

*Environmental Condition Manipulation Check.* Only the items used to evaluate participants’ perceptions of their environmental condition after performance 2 (time 2) had an acceptable reliability above .70 (α = .84). The reliability of the measure after performance 1 (time 1) was .67. However, an exploratory factor analysis (with principal axis extraction and Promax rotation) showed that the items were distinctly loaded on two separate factors that explained 68.11 percent of the variation in item responses.
Table 12

Main Study Results for the Team Training Objective Manipulation Check Items

<table>
<thead>
<tr>
<th>Team Training</th>
<th>Percent of Sample that Answered Correctly</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEAM COORDINATION TRAINING (TCT; α = 0.75)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCT (N = 178)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRT (N = 174)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Which of the following strategies is NOT a core element of team coordination?</td>
<td>96.6</td>
<td>53.4</td>
</tr>
<tr>
<td>2. Seeking out information BEFORE making a decision is used in which of the following strategies?</td>
<td>94.4</td>
<td>35.1</td>
</tr>
<tr>
<td>3. Keeping team members informed about team-related or environmental changes is used in which of the following strategies?</td>
<td>71.9</td>
<td>2.3</td>
</tr>
<tr>
<td>4. Identifying current problems and anticipating future problems is used in which of the following strategies?</td>
<td>92.1</td>
<td>48.9</td>
</tr>
<tr>
<td>5. Which of the following is a key step in effective communication?</td>
<td>74.2</td>
<td>23.6</td>
</tr>
<tr>
<td>CROSS-TRAINING (CRT; α = 0.54)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The INFORMATION manager has the ability to communicate with which of the following people:</td>
<td>16.9</td>
<td>69.0</td>
</tr>
<tr>
<td>7. The RESOURCE manager has the ability to communicate with which of the following people:</td>
<td>69.7</td>
<td>86.8</td>
</tr>
<tr>
<td>8. A key difference between the RESOURCE and INFORMATION managers roles is that the INFORMATION manager is responsible for:</td>
<td>57.3</td>
<td>83.3</td>
</tr>
<tr>
<td>9. ___________ are attached to sent events to provide a quick visual description of each event.</td>
<td>69.1</td>
<td>79.9</td>
</tr>
<tr>
<td>10. Your team has _____ types of resources to allocate to events. There are _____ units available of each type of resource.</td>
<td>67.4</td>
<td>83.9</td>
</tr>
</tbody>
</table>

Note. Bolded percentages significantly differed in the expected direction across the TCT and CRT conditions. Analyses were conducted at the individual-level (N = 352).
Table 13

**Main Study Results for the Team Training Subjective Manipulation Check Items**

<table>
<thead>
<tr>
<th>TEAM COORDINATION TRAINING (TCT; α = 0.78)</th>
<th>Team Training</th>
<th>TCT (N = 178)</th>
<th>CRT (N = 174)</th>
<th>t-value</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. During training, the core elements of team coordination were EXPLICITLY discussed.</td>
<td>TEAM COORDINATION</td>
<td>3.98</td>
<td>3.19</td>
<td>-6.82</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2. The training material explicitly discussed how to design plans and evaluate their effectiveness.</td>
<td>TEAM COORDINATION</td>
<td>3.40</td>
<td>2.50</td>
<td>-7.45</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>3. In training, I received details on how to evaluate environmental changes and identify current problems and anticipate future problems.</td>
<td>TEAM COORDINATION</td>
<td>3.63</td>
<td>2.05</td>
<td>-14.58</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>4. During training, I learned about the steps involved in developing different types of trust between me and my teammate.</td>
<td>TEAM COORDINATION</td>
<td>2.69</td>
<td>2.10</td>
<td>-5.11</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CROSS-TRAINING (CRT; α = 0.87)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. During training, I received detailed descriptions on the primary functions of the Information Manager AND the Resource Manager.</td>
<td>CROSS-TRAINING</td>
<td>3.28</td>
<td>4.61</td>
<td>13.36</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2. The training helped me to understand the responsibilities of the Information Manager AND the Resource Manager.</td>
<td>CROSS-TRAINING</td>
<td>3.39</td>
<td>4.56</td>
<td>12.85</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>3. Based on the knowledge I obtained in training, I would feel prepared to switch roles with the Information Manager or the Resource Manager on my team.</td>
<td>CROSS-TRAINING</td>
<td>2.76</td>
<td>4.18</td>
<td>15.08</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>4. The training material taught me about the roles and SPECIFIC TYPES OF RESOURCES available to ALL teams in the system (i.e., all the resources of the Police, Fire, and Hazmat teams).</td>
<td>CROSS-TRAINING</td>
<td>2.11</td>
<td>2.55</td>
<td>3.54</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note. Bolded means significantly differed in the expected direction across the TCT and CRT conditions. Item 4 on each scale is the distracter item. Low mean differences are expected on this item. Analyses were conducted at the individual-level (N = 352). Means range from 1 (strongly disagree) to 5 (strongly agree).
Table 14

**Main Study Results for the Team Training Comparison-Based Manipulation Check Items**

<table>
<thead>
<tr>
<th>COMPARISON-BASED ITEMS (α = 0.85)</th>
<th>Team Training Means</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TCT (N = 178)</td>
<td>CRT (N = 174)</td>
</tr>
<tr>
<td>1. The training material focused MORE ON describing the role of my teammate THAN on describing generic teamwork skills/coordination strategies. Please rate the extent to which you agree with each statement below on the scale provided.</td>
<td>2.49</td>
<td><strong>3.80</strong></td>
</tr>
<tr>
<td>2. The training focused MORE ON the steps involved in planning THAN on the specific roles of the Information and Resource Managers.</td>
<td><strong>3.88</strong></td>
<td>2.11</td>
</tr>
<tr>
<td>3. During training, I learned MORE about how to assess the situation THAN on the primary functions of the Information and Resource Managers' roles.</td>
<td><strong>3.77</strong></td>
<td>2.21</td>
</tr>
<tr>
<td>4. The training presented details on the responsibilities of the Information and Resource Managers' roles MORE SO THAN strategies on how to effectively coordinate as a team.</td>
<td>2.50</td>
<td><strong>4.10</strong></td>
</tr>
</tbody>
</table>

*Note.* Bolded means significantly differed in the expected direction across the TCT and CRT conditions. Analyses were conducted at the individual-level (N = 352). Means range from 1 (strongly disagree) to 5 (strongly agree).
Table 15

**Main Study Results for the Team Training Forced Choice Manipulation Check Items**

<table>
<thead>
<tr>
<th>Team Training</th>
<th>% Participants in each Condition that Selected the Correct Option</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FORCED CHOICE ITEMS <em>(α = 0.94)</em></td>
<td>TCT (N = 178)</td>
</tr>
<tr>
<td></td>
<td>The training material focused MORE on: (NOTE: Select only ONE)</td>
<td></td>
</tr>
<tr>
<td>1. Describing details on the role of my teammate. Describing teamwork skills/coordination strategies.</td>
<td>91.9</td>
<td>90.8</td>
</tr>
<tr>
<td>2. The specific roles of the Information and Resource Managers. The specific steps involved in effective planning.</td>
<td>92.7</td>
<td>97.7</td>
</tr>
<tr>
<td>3. The primary functions of the Information and Resource Managers' roles. The primary ways to assess the team and environmental situation.</td>
<td>79.8</td>
<td>97.1</td>
</tr>
<tr>
<td>4. The responsibilities of the Information and Resource Managers' roles. The strategies on how to effectively coordinate as a team.</td>
<td>88.8</td>
<td>97.7</td>
</tr>
</tbody>
</table>

*Note.* Analyses were conducted at the individual-level *(N = 352).*
As shown in Table 16, the first factor was time 2 perceptions of the environmental condition (eigenvalue = 2.79, 46.56% of the variance) and the second was time 1 perceptions of environmental condition (eigenvalue = 1.29, 21.55% of the variance). Based on these results, no changes were made to the measure.

Table 16

*Exploratory Factor Analysis for the Environmental Conditions Manipulation Check Items*

<table>
<thead>
<tr>
<th>Environmental Conditions</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PERCEPTIONS AT TIME 1</strong></td>
<td><strong>Factor 1</strong></td>
</tr>
<tr>
<td>(α = .67)</td>
<td><strong>TIME 2</strong></td>
</tr>
<tr>
<td>1. The speed at which events were received.</td>
<td>-0.002</td>
</tr>
<tr>
<td>2. The severity of events.</td>
<td>-0.006</td>
</tr>
<tr>
<td>3. The speed at which events were resolved.</td>
<td>0.023</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PERCEPTIONS AT TIME 2</th>
<th><strong>Factor Loadings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(α = .84)</td>
<td></td>
</tr>
<tr>
<td>1. The speed at which events were received.</td>
<td><strong>0.876</strong></td>
</tr>
<tr>
<td>2. The severity of events.</td>
<td><strong>0.841</strong></td>
</tr>
<tr>
<td>3. The speed at which events were resolved.</td>
<td><strong>0.660</strong></td>
</tr>
</tbody>
</table>

Note. Items highlighted in bold distinctively loaded on the correct factor.

A paired samples t-test was conducted on the overall scale for environmental condition between each time point (time 1 and time 2). The results showed significant differences in participants’ perceptions of their environmental condition between both time 1 and time 2 (t (351) = -2.57, p = .010) in which individuals perceived the environment in the second performance session to be more novel (mean = 3.11) than the first performance session (mean = 2.95). As shown in Table 17, these differences related
to participants’ perceptions of the speed at which events were received and their severity as opposed to the speed at which events were resolved. In summary, this within-subjects manipulation seemed to be effective, in that, participants perceived differences in novelty across both environmental condition in the direction expected.

Table 17

<table>
<thead>
<tr>
<th>Environmental Conditions Items</th>
<th>Means</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIME 1 (α = .67)</td>
<td>TIME 2 (α = .84)</td>
<td>t-value</td>
</tr>
<tr>
<td>1. The speed at which events were received.</td>
<td>2.91</td>
<td>3.10</td>
</tr>
<tr>
<td>2. The severity of events.</td>
<td>2.93</td>
<td>3.23</td>
</tr>
<tr>
<td>3. The speed at which events were resolved.</td>
<td>3.01</td>
<td>2.99</td>
</tr>
</tbody>
</table>

Note. Bolded means significantly differed in the expected direction. Means range from 1 (completely familiar) to 5 (completely novel).

Correlations. Dyad-level bivariate correlations of the variables examined in the study are shown in Tables 18 to 20. As shown in Tables 18, among the possible control variables, only self-efficacy and training satisfaction were consistently correlated with the substantive variables used in the study. Both self-efficacy and training satisfaction were significantly correlated with team training. These correlations indicated that individuals in the cross-training condition had higher levels of self-efficacy (r = -0.42, p < .001) and satisfaction with training (r = -0.45, p < .001) than those in the team coordination training condition.

Self-efficacy and training satisfaction were also significantly correlated with team mental models. Training satisfaction was positively correlated with the QAP index of
Table 18

Dyad-Level Correlations between the Control and Substantive Variables at Time 1 and Time 2

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Control Variables</th>
<th>TIME 1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Polychronicity</td>
<td>Video Game Experience</td>
<td>Cognitive Ability (G.P.A.)</td>
<td>Training Satisfaction</td>
</tr>
<tr>
<td>Team Training</td>
<td>-0.04</td>
<td>-0.09</td>
<td>0.06</td>
<td>-0.42**</td>
</tr>
</tbody>
</table>

Mediators

Property: Sharedness

<table>
<thead>
<tr>
<th></th>
<th>TSK MM Distance</th>
<th>TSK MM QAP</th>
<th>SIT MM Distance</th>
<th>SIT MM QAP</th>
<th>TMM MM Distance</th>
<th>TMM MM QAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.02</td>
<td>0.03</td>
<td>-0.02</td>
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<tr>
<td>TIME 1</td>
<td>-0.09</td>
<td>-0.05</td>
<td>0.14</td>
<td>0.17*</td>
<td>0.01</td>
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<tr>
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<td>0.04</td>
<td>-0.04</td>
<td>0.05</td>
<td>0.03</td>
<td>-0.03</td>
<td></td>
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<tr>
<td></td>
<td>-0.03</td>
<td>-0.03</td>
<td>0.08</td>
<td>0.00</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.07</td>
<td>-0.12</td>
<td>0.07</td>
<td>-0.13</td>
<td>0.01</td>
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</tbody>
</table>

Property: Accuracy

<table>
<thead>
<tr>
<th></th>
<th>TSK MM Distance</th>
<th>TSK MM QAP</th>
<th>SIT MM Distance</th>
<th>SIT MM QAP</th>
<th>TMM MM Distance</th>
<th>TMM MM QAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.06</td>
<td>0.03</td>
<td>-0.00</td>
<td>0.14</td>
<td>0.17*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.08</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
<td>0.01</td>
<td></td>
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<tr>
<td></td>
<td>-0.00</td>
<td>-0.00</td>
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<td>-0.00</td>
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<tr>
<td></td>
<td>-0.06</td>
<td>0.01</td>
<td>0.02</td>
<td>0.06</td>
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<td>-0.08</td>
<td>0.13</td>
<td>0.02</td>
<td>-0.12</td>
<td></td>
</tr>
</tbody>
</table>

Dependent Variable

Performance

|                      | 0.03            | 0.08       | 0.08            | 0.28**     | 0.20**          |

Mediators

Property: Sharedness

<table>
<thead>
<tr>
<th></th>
<th>TSK MM Distance</th>
<th>TSK MM QAP</th>
<th>SIT MM Distance</th>
<th>SIT MM QAP</th>
<th>TMM MM Distance</th>
<th>TMM MM QAP</th>
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<tr>
<td></td>
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<td>0.01</td>
<td>-0.02</td>
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<td>0.02</td>
<td>0.10</td>
<td>0.15</td>
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<tr>
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<td>0.01</td>
<td>0.03</td>
<td>0.10</td>
<td>-0.05</td>
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<tr>
<td></td>
<td>0.01</td>
<td>-0.01</td>
<td>0.08</td>
<td>0.03</td>
<td>-0.04</td>
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<tr>
<td></td>
<td>0.10</td>
<td>-0.00</td>
<td>-0.09</td>
<td>-0.05</td>
<td>0.02</td>
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<tr>
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<td>0.05</td>
<td>0.01</td>
<td>0.09</td>
<td>0.06</td>
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</table>

Property: Accuracy

<table>
<thead>
<tr>
<th></th>
<th>TSK MM Distance</th>
<th>TSK MM QAP</th>
<th>SIT MM Distance</th>
<th>SIT MM QAP</th>
<th>TMM MM Distance</th>
<th>TMM MM QAP</th>
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</thead>
<tbody>
<tr>
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<tr>
<td></td>
<td>-0.04</td>
<td>0.00</td>
<td>0.08</td>
<td>-0.06</td>
<td>-0.06</td>
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<tr>
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<td>0.07</td>
<td>0.08</td>
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<td>-0.03</td>
<td>-0.00</td>
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<tr>
<td></td>
<td>0.00</td>
<td>0.16*</td>
<td>-0.04</td>
<td>0.06</td>
<td>0.04</td>
<td></td>
</tr>
</tbody>
</table>

Dependent Variable

Performance

|                      | -0.01           | 0.05       | 0.06            | 0.29***    | 0.24**          |

Note. N = 176 dyads; Team Training is coded as 1 = Cross-training, 2 = Team coordination Training; TSK = Taskwork; TMW = Teamwork; SIT = Situation; MM = Mental Model; *p<.05; **p<.001.
Table 19

*Descriptive Statistics and Correlations at the Dyad-Level For Time 1*

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td>1. Team Training</td>
<td>1.51</td>
<td>0.50</td>
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<tr>
<td>Mediators</td>
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<tr>
<td>Property: Sharedness</td>
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<tr>
<td>2. TSK MM Distance</td>
<td>11.47</td>
<td>2.32</td>
<td>-0.04</td>
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<tr>
<td>3. TSK MM QAP</td>
<td>0.19</td>
<td>0.25</td>
<td>-0.03</td>
<td>-0.64*</td>
<td></td>
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<td>4. SIT MM Distance</td>
<td>8.62</td>
<td>2.73</td>
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<td>5. SIT MM QAP</td>
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<td>-0.06</td>
<td>-0.64*</td>
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<td>6. TMM MM Distance</td>
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<td>-0.06</td>
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<tr>
<td>7. TMM MM QAP</td>
<td>0.19</td>
<td>0.25</td>
<td>-0.02</td>
<td>0.07</td>
<td>-0.48**</td>
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<tr>
<td>Property: Accuracy</td>
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<tr>
<td>8. TSK MM Distance</td>
<td>12.08</td>
<td>1.02</td>
<td>-0.13</td>
<td>0.19*</td>
<td>0.11</td>
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<tr>
<td>9. TSK MM QAP</td>
<td>0.15</td>
<td>0.16</td>
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<td>-0.68**</td>
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<td>10. SIT MM Distance</td>
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<tr>
<td>11. SIT MM QAP</td>
<td>0.59</td>
<td>0.21</td>
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<td>0.00</td>
<td>0.49**</td>
<td>0.60**</td>
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<td>0.03</td>
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<td>-0.88**</td>
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<tr>
<td>12. TMM MM Distance</td>
<td>8.51</td>
<td>1.10</td>
<td>-0.02</td>
<td>0.29**</td>
<td>0.18*</td>
<td>-0.15*</td>
<td>0.58**</td>
<td>-0.20**</td>
<td>0.30**</td>
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<td>-0.12</td>
<td>0.18*</td>
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<td>0.31**</td>
<td>-0.01</td>
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<td>0.17*</td>
<td>-0.54**</td>
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<td>Dependent Variable</td>
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<td>14. Performance</td>
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<td>-0.03</td>
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<td>-0.09</td>
<td>0.12</td>
<td>-0.13</td>
<td>0.15*</td>
<td>-0.07</td>
<td>0.00</td>
<td>-0.09</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

*Note. N = 176 dyads; Team Training is coded as 1 = Cross-training, 2 = Team coordination Training; TSK = Taskwork; TMW = Teamwork; SIT = Situation; MM = Mental Model; *p<.05; **p<.001.
Table 20

Descriptive Statistics and Correlations at the Dyad-Level For Time 2

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Mean</th>
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<th>4</th>
<th>5</th>
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<th>9</th>
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<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Team Training</td>
<td>1.51</td>
<td>0.50</td>
<td></td>
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<tr>
<td><strong>Mediators</strong></td>
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</tr>
<tr>
<td>2. TSK MM Distance</td>
<td>10.42</td>
<td>2.73</td>
<td>-0.05</td>
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<td>3. TSK MM QAP</td>
<td>0.14</td>
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<td>-0.25**</td>
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<tr>
<td>4. SIT MM Distance</td>
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<td>-0.15</td>
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<td>-0.05</td>
<td>-0.05</td>
<td>0.04</td>
<td>-0.62**</td>
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<td>11. SIT MM QAP</td>
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<td>0.50**</td>
<td>0.44**</td>
<td>-0.07</td>
<td>-0.11</td>
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<td>12. TMM MM Distance</td>
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<td>-0.03</td>
<td>0.66**</td>
<td>-0.06</td>
<td>0.21**</td>
<td>-0.08</td>
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<td>13. TMM MM QAP</td>
<td>0.21</td>
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<td>0.10</td>
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<td>0.31**</td>
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<td>-0.37**</td>
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<td>0.02</td>
<td>-0.15*</td>
<td>0.16*</td>
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</table>

Note. N = 176 dyads; Team Training is coded as 1 = Cross-training, 2 = Team coordination Training; TSK = Taskwork; TMW = Teamwork; SIT = Situation; MM = Mental Model; *p<.05; **p<.001.
shared taskwork mental models \((r = 0.17 \text{ at Time 1, } p < .001)\) and self-efficacy was positively correlated with the accuracy of taskwork mental models, indexed through distance ratings\(^3\) \((r = 0.17 \text{ at Time 1, } p < .05)\). Another control variable, video game experience significantly correlated with team mental models, specifically the accuracy of teamwork mental models indexed through QAP correlations \((r = 0.16 \text{ at Time 2, } p < .05)\).

Finally, only self-efficacy and training satisfaction were significantly correlated with team performance. There was a positive correlation between training satisfaction and performance \((r = 0.28, p < .001)\) and self-efficacy and performance \((r = 0.20, p < .001)\). The correlations at Time 2 between training satisfaction and performance \((r = 0.29, p < .001)\) and self-efficacy and performance \((r = 0.24 p < .001)\) were similar to those seen at Time 1.

Tables 19 and 20 display the inter-correlations between the substantive variables at Time 1 (Table 19) and Time 2 (Table 20). As shown in Table 19, team training, coded as 1 for dyads receiving cross-training and 2 for dyads receiving team coordination training, was negatively correlated with performance \((r = -0.55, p < .001)\). This meant that dyads in the cross-training condition had higher levels of performance than those in the team coordination training condition. This correlation was also observed at Time 2 \((r = -0.41, p < .001; \text{ see Table 20})\). Team training was not significantly correlated with any other variables, including team mental models.

There was a consistent positive relationship between the distance and QAP correlation indices of shared taskwork \((r = 0.64, p < .001)\), teamwork \((r = 0.48, p < .001)\), and situation \((r = 0.72, p < .001)\) mental models at Time 1. These correlations were also

\(^3\) Note: Distance ratings have been reverse scored to be in the same direction as QAP correlations. Higher distance therefore indicates higher sharedness.
significant for taskwork (r = 0.25, p < .001), teamwork (r = 0.22, p < .001), and situation (r = 0.75, p < .001) mental models at Time 2. A similar pattern between the distance and QAP correlation indices of accurate mental models were seen at Time 1 for taskwork (r = 0.68, p < .001), teamwork (r = 0.54, p < .001), and situation (r = 0.88, p < .001) mental models. These correlations were also significant for taskwork (r = 0.62, p < .001), teamwork (r = 0.37, p < .001), and situation (r = 0.88, p < .001) mental models at Time 2.

Significant correlations were also observed among the different types of team mental models. Shared taskwork and teamwork mental models were positively correlated when both were indexed as distance ratings (r = 0.37 at Time 1, p < .001). This relationship seemed to be stronger at Time 2 (r = 0.55, p < .001). The accuracy of team mental models demonstrated a similar pattern in sharedness, such that both taskwork and teamwork mental models (indexed as distance ratings) were also significantly correlated at Time 1 (r = 0.30, p < .001) and at Time 2 (r = 0.21, p < .001). In addition, accurate teamwork and situation mental models indexed as QAP correlations were positively related (r = 0.17 at Time 1, p < .05). On the other hand, a negative relationship was observed among the sharedness of teamwork mental models indexed as distance ratings and taskwork mental models indexed through QAP correlations (r = -0.19 at Time 2, p < .05).

The different properties (sharedness and accuracy) of team mental models were also significantly correlated. Team mental model sharedness and accuracy were positively correlated when indexed through distance for taskwork (r = 0.19 at Time 1, p < .05; not significant at Time 2), teamwork (r = 0.58 at Time 1, p < .001; r = 0.66 at Time 2, p < .001), and situation (r = 0.59 at Time 1, p < .001; r = 0.61 at Time 2, p < .001).
mental models. A positive relationship was also observed between the sharedness and accuracy of team mental models when indexed through QAP correlations for situation (r = 0.60 at Time 1, p < .001; r = 0.44 at Time 2, p < .001) and teamwork mental models (r = 0.31 at Time 1, p < .001; r = 0.31 at Time 2, p < .001). Shared situation mental models (indexed as distance ratings) were positively correlated with accurate situation mental models, when indexed through QAP correlations (r = 0.49 at Time 1, p < .001; r = 0.50 at Time 2, p < .001). Similarly, shared situation mental models (indexed through QAP correlations) were positively correlated with accurate situation mental models, when indexed as distance ratings (r = 0.47 at Time 1, p < .001; r = 0.44 at Time 2, p < .001).

The properties of team mental models (sharedness and accuracy) also correlated across different types of mental models. Accurate teamwork mental models (indexed as distance ratings) were positively related to shared taskwork mental models when indexed through distance ratings (r = 0.29 at Time 1, p < .001; r = 0.46 at Time 2, p < .001) and negatively correlated with shared situation mental models, when indexed through QAP correlations (r = -0.15 at Time 1, p < .05; not significant at Time 2). In addition, accurate teamwork mental models (indexed as distance ratings) were positively related to shared situation mental models, when indexed through distance ratings (r = 0.18 at Time 1, p < .001; not significant at Time 2). On the other hand, accurate teamwork mental models (indexed as distance ratings) were positively related to shared situation mental models, when indexed through distance ratings (r = 0.18 at Time 1, p < .05; not significant at Time 2). Shared teamwork mental models (indexed as QAP correlations) were negatively correlated with accurate taskwork mental models, when indexed as QAP correlations (r = -0.17 at Time 1, p < .05; not significant at Time 2). Accurate situation mental models
(indexed as QAP correlations) were negatively related to shared taskwork mental models indexed through distance ratings \( r = -0.17 \) at Time 1, \( p < .05 \) and positively related to shared teamwork mental models when indexed through QAP correlation \( r = 0.17 \) at Time 1, \( p < .05 \). However, these correlations were only significant at Time 2.

In addition to training satisfaction, self-efficacy, and team training, team mental models were significantly related to dyad performance. A significant positive relationship was observed between the accuracy of taskwork mental models indexed through QAP correlations and performance at Time 1 \( r = 0.15, p < .05 \). This relationship was not significant at Time 2. However, performance at Time 2 was positively related to accuracy of situation mental models indexed as distance \( r = -0.15, p < .05 \) and accurate situation mental models indexed through QAP correlations \( r = 0.16, p < .05 \). No other indices, properties, or types of team mental models were correlated with performance at Time 1 or Time 2.

**Control Variables.** Among the control variables included in Tables 18 and 19, neither polychronicity nor cognitive ability (measured through G.P.A.) were significantly related to team training, team mental models, or performance. Similarly, video game experience was not related to team training or performance and was only significantly correlated with teamwork mental models at Time 2 but not at Time 1. On the other hand, training satisfaction and self-efficacy were significantly correlated with team training, a few team mental model indices, and team performance. These correlations were consistent across both Time 1 and Time 2. Based on these results, training satisfaction and self-efficacy were used as the only two control variables in subsequent analyses.

**Hierarchical Linear Modeling**
The data used in the current study are organized in a hierarchical pattern in which time of measurement was nested within dyads, which was nested within the four-person emergency management multi-team system. This represents a three-level model in which time, dyad, and MTS are the Levels 1, 2, and 3 variables, respectively. When data is structured in a nested pattern, the assumption of independence is typically violated (Luke, 2004). Based on this nested structure, hierarchical linear modeling (HLM) was used to model the data at all three levels of analyses. Unlike typical ordinary least squares (OLS) analyses, HLM relaxes the assumption that errors are uncorrelated and independent of each other (Luke, 2004).

The equations used to model relationships in HLM resemble those used in OLS (Luke, 2004), in that the intercept of the dependent variable, slope/coefficient for each predictor, and the error term for unmodeled variance are estimated. However, a key difference between OLS and HLM is that HLM computes these variables at multiple levels of analysis simultaneously, such that each Level 1 model is estimated for each of the ‘j’ (Level 2) units within each ‘k’ (Level 3) unit (Luke, 2004). The following equation is representative of a Level 1 model, in which the outcome is at the level of time.

Level 1: \( Y_{ijk} = \pi_{0jk} + \pi_{1jk}a_{1jk} + \ldots + \pi_{pjk}a_{pjk} + e_{ijk} \)

In this equation, \( Y_{ijk} \) is the dependent variable from a specified level of time ‘i,’ in a particular dyad ‘j,’ and across a particular MTS ‘k,’ \( \pi_{0jk} \) is the intercept for a particular dyad ‘j’ in the MTS ‘k,’ \( \pi_{1jk} \) is the slope of predictor \( a_{1jk} \) and \( e_{ijk} \) is the error term for the regression. The following equation illustrates a Level 2 model, in which the outcome is at the level of the dyad.

Level 2: \( \pi_{pjk} = \beta_{p0k} + \beta_{p1k}X_{1jk} + \ldots + \beta_{pQk}X_{Qjk} + r_{pjk} \)
In this equation, $\pi_{pjk}$ indicates how each of the Level 1 variables operate as functions of the Level 2 predictors and variability. In other words, the slope of each predictor used in the Level 1 equation is modeled as the dependent variable in Level 2. At this level, additional variables may be added to evaluate how they interact with Level 1 variables. The term $\beta_{p0k}$ in the equation is the intercept. This value reflects the mean of the Level 1 dependent variable, after controlling for the Level 2 predictor. $\beta_{p1k}$ is the slope of the predictor for variable $X_{ijk}$. Finally, $r_{pjk}$ is the error or unmodeled variability for unit ‘$j$’ nested within unit ‘$k$.’

The final equation listed below models the variance attributable to the MTS:

Level 3: $\beta_{pqk} = \gamma_{pq0} + \gamma_{pq1}W_{1k} + \gamma_{pqS}W_{S_{pqk}} + u_{pqk}$

In this equation, $\beta_{pqk}$ is the slope of each predictor used in Level 2, which is modeled as a dependent variable in Level 3. $\gamma_{pq0}$ is the intercept of the model, which also represents the mean of the Level 2 dependent variable, after controlling for the Level 3 predictor. $\gamma_{pq1}$ is the slope of the predictor for variable $W_{1k}$ and $u_{pqk}$ is the unmodeled variance in the dependent variable (also known as the error term for the regression equation).

In order to build more complex models using HLM, one has to first evaluate the unconstrained or null model (i.e., no predictors). Performance was therefore entered as the Level 1 outcome with no additional estimates added. This model is illustrated in the following equation:

Level 1: Performance $ijk = \pi_{0jk} + e_{ijk}$

The variance component of each level in the null model was then used to calculate how strongly units in the same group resemble each other (i.e., the intra-class correlations; ICCs). The ICCs reflect a ratio of between group variance to total variance in the
measure. They were therefore calculated by dividing the variance component of each level by the total variance in the model (Raudenbush & Bryk, 2001). The ICCs revealed that 71.85 percent of the variability in the performance scores could be explained by time, 4.87 percent accounted for by dyad membership, and 23.50 percent explained by system in which the dyads operated. Based on the structure of the data and the results of the ICCs, the data were believed to violate the assumption of independence and thus more complex models were analyzed using HLM.

Tests of Hypotheses

Main Effect of Training Type on Team Mental Models. Hypotheses 1 to 5 stated that training type would have a main effect on team mental models. These hypotheses were tested in a three-step process. First, the variance in the dependent variable associated with each level of the data (i.e., time, dyad, and system) was modeled. This represented the null model and was used to calculate the change in the unexplained variance in each level of the dependent variable (also referred to as the pseudo $R^2$, Liao & Subramony, 2008; Raudenbush & Bryk, 2001). Second, Model 1 was calculated in which the control variables (training satisfaction and self-efficacy) were added to the Level 2 equation. Third, Model 2 was generated in which the independent variable training type was added to the Level 2 equation. These results are presented in Tables 21 to 23 and summarized below.

Additional analyses were also conducted (using SPSS 17.0) on Hypotheses 2, 4, 5, and 6, which related to the comparative effect of each training type on two sets of team mental models. These analyses were done through first running a split file function to separate analyses on the data by two groups, i.e., cross-training and team coordination
### Table 21

**Main Effect of Training Type on Taskwork Mental Models**

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<th>Independent Variables</th>
<th>Distance</th>
<th>QAP</th>
<th>Distance</th>
<th>QAP</th>
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**Variance Estimates**

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<th>Level 2 residual intercept variance</th>
<th>Level 3 residual intercept variance</th>
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**Model 1: Controls**

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**Variance Estimates**

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**Pseudo ΔR²**

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**Model 2: Training Type**

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**Variance Estimates**

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<th>Level 3 residual intercept variance</th>
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**Pseudo ΔR²**

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*Note.* N (Level 1 = 352); N (Level 2 = 176); N (Level 3 = 88). MM = Mental Model. Entries represent fixed effects, with robust standard errors. All variables were grand-mean centered, except for training type which was coded as 1 = cross-training and 2 = team coordination training. Pseudo ΔR² = (residual variance (previous model) – residual variance (current model))/residual variance (previous model). **p<.001; *p<.05; †p<.10.
## Table 22

### Main Effect of Training Type on Situation Mental Models

<table>
<thead>
<tr>
<th>Independent Variables</th>
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<th>QAP</th>
<th>Distance</th>
<th>QAP</th>
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</thead>
<tbody>
<tr>
<td><strong>Null Model</strong></td>
<td></td>
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</tr>
<tr>
<td>Level 1 Intercept</td>
<td>-0.00</td>
<td>0.00</td>
<td>-0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Level 1 residual variance</td>
<td>11.884</td>
<td>0.063</td>
<td>8.208</td>
<td>0.038</td>
</tr>
<tr>
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<td>0.027</td>
<td>0.008</td>
<td>0.003</td>
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</tr>
<tr>
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<td>0.002</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Model 1: Controls</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
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<td>-0.00</td>
<td>0.00</td>
<td>-0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Level 2 Training Satisfaction</td>
<td>0.95*</td>
<td>0.03</td>
<td>0.86*</td>
<td>0.04†</td>
</tr>
<tr>
<td></td>
<td>Self-efficacy</td>
<td>-1.10*</td>
<td>-0.05</td>
<td>1.02*</td>
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<tr>
<td><strong>Variance Estimates</strong></td>
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<tr>
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<td>0.063</td>
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</tr>
<tr>
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<td>0.006</td>
<td>0.002</td>
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</tr>
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<td>0.628</td>
<td>0.003</td>
<td>0.001</td>
<td>0.000</td>
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<td><strong>Pseudo ΔR²</strong></td>
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<td></td>
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<tr>
<td>Level 1</td>
<td>0.02</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>Level 2</td>
<td>0.26</td>
<td>0.25</td>
<td>0.33</td>
<td>0.00</td>
</tr>
<tr>
<td>Level 3</td>
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<td>-0.50</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>0.49</td>
<td>0.04</td>
<td>0.53</td>
<td>0.01</td>
</tr>
<tr>
<td>Level 2 Training Satisfaction</td>
<td>0.89*</td>
<td>0.02</td>
<td>0.79*</td>
<td>0.04†</td>
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<td>Self-efficacy</td>
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<td>-0.06</td>
<td>-1.15*</td>
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<td>-0.03</td>
<td>-0.35</td>
<td>-0.01</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1 residual variance</td>
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<td>0.063</td>
<td>8.030</td>
<td>0.038</td>
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<td>0.006</td>
<td>0.002</td>
<td>0.000</td>
</tr>
<tr>
<td>Level 3 residual intercept variance</td>
<td>0.622</td>
<td>0.003</td>
<td>0.001</td>
<td>0.000</td>
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<tr>
<td><strong>Pseudo ΔR²</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Level 1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Level 2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Level 3</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Note.** N (Level 1 = 352); N (Level 2 = 176); N (Level 3 = 88). MM = Mental Model. Entries represent fixed effects, with robust standard errors. All variables were grand-mean centered, except for training type which was coded as 1 = cross-training and 2 = team coordination training. Pseudo ΔR² = (residual variance (previous model) – residual variance (current model))/residual variance (previous model). **p<.001; *p<.05; †p<.10.
Table 23

**Main Effect of Training Type on Teamwork Mental Models**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependent Variable: Teamwork MM</th>
<th>Sharedness</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Distance</td>
<td>QAP</td>
</tr>
<tr>
<td><strong>Null Model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1 Intercept</td>
<td></td>
<td>0.00</td>
<td>-0.00</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
<td>Level 1 residual variance</td>
<td>4.000</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td>Level 2 residual intercept variance</td>
<td>2.666</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>Level 3 residual intercept variance</td>
<td>0.510</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Model 1: Controls</strong></td>
<td>Level 1 Intercept</td>
<td>0.00</td>
<td>-0.00</td>
</tr>
<tr>
<td></td>
<td>Level 2 Training Satisfaction</td>
<td>-0.77*</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Self-efficacy</td>
<td>0.62</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
<td>Level 1 residual variance</td>
<td>3.998</td>
<td>0.056</td>
</tr>
<tr>
<td></td>
<td>Level 2 residual intercept variance</td>
<td>2.601</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>Level 3 residual intercept variance</td>
<td>0.464</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Pseudo ΔR²</strong></td>
<td>Level 1</td>
<td>0.00</td>
<td>-0.12</td>
</tr>
<tr>
<td></td>
<td>Level 2</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Level 3</td>
<td>0.09</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Model 2: Training Type</strong></td>
<td>Level 1 Intercept</td>
<td>0.66</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Level 2 Training Satisfaction</td>
<td>-0.86*</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Self-efficacy</td>
<td>0.47</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Level 2 Training Type</td>
<td>-0.43</td>
<td>-0.01</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
<td>Level 1 residual variance</td>
<td>3.998</td>
<td>0.056</td>
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<tr>
<td></td>
<td>Level 2 residual intercept variance</td>
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<td>Level 3 residual intercept variance</td>
<td>0.487</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Pseudo ΔR²</strong></td>
<td>Level 1</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Level 2</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Level 3</td>
<td>-0.05</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*Note.* N (Level 1 = 352); N (Level 2 = 176); N (Level 3 = 88). MM = Mental Model. Entries represent fixed effects, with robust standard errors. All variables were grand-mean centered, except for training type which was coded as 1 = cross-training and 2 = team coordination training. Pseudo ΔR² = (residual variance (previous model) – residual variance (current model))/residual variance (previous model). **p<.001; *p<.05; †p<.10.
training. Once the data was separated according to training conditions, a series of paired comparison t-tests were conducted. Given that Hypotheses 2, 4, 5, and 6 suggested that a specific type of team training would develop more of one type of team mental model over the another type of team mental model, analyzing the data using paired samples t-test provided a more accurate evaluation of these hypotheses than HLM. The results of the t-tests are shown in Table 24 and the team mental model means by condition are should in Table 25 and are summarized for the respective hypothesis below. For all analyses, the distance ratings of all team mental models were reverse scored to be in the same direction as QAP correlations. Therefore higher distance indicated higher sharedness.

Hypothesis 1 stated that teams receiving cross training would develop more shared and accurate taskwork mental models than those in the team coordination training condition. The results in Model 2 from Table 21 show that training type did not have a significant effect on the sharedness of taskwork mental models when indexed as distance ($\pi = -0.09, p > .10$), or QAP correlations ($\pi = 0.02, p > .10$). Similarly, training type did not significantly impact the accuracy of taskwork mental models when indexed as distance ($\pi = -0.19, p > .10$), or QAP correlations ($\pi = -0.02, p > .10$). Therefore no support was found for Hypothesis 1.

Hypothesis 2 stated that teams receiving cross-training would develop more shared and accurate taskwork mental models than situation mental models. As previously discussed, training type did not have a significant impact on the sharedness or accuracy of taskwork mental models (Table 21). Similarly, training type, did not have a significant effect on shared situation mental models when indexed as distance ($\pi = -0.33, p > .10$), or QAP correlations ($\pi = -0.03, p > .10$). Training type also did not significantly impact the
Table 24

Paired Difference Ratings between each Team Mental Models across the Cross-Training and Team Coordination Training Conditions

<table>
<thead>
<tr>
<th>Team Mental Model Measure</th>
<th>Mean Diffs.</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CRT Condition (df = 173)</strong></td>
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<td></td>
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<tr>
<td>Sharedness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork - Situation</td>
<td>0.73</td>
<td>4.26</td>
<td>2.27</td>
<td>.025</td>
</tr>
<tr>
<td>Teamwork - Situation</td>
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<td>4.66</td>
<td>-0.57</td>
<td>.566</td>
</tr>
<tr>
<td>Teamwork - Taskwork</td>
<td>-0.93</td>
<td>2.78</td>
<td>-4.43</td>
<td>.000</td>
</tr>
<tr>
<td>QAP Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork - Situation</td>
<td>-0.32</td>
<td>0.36</td>
<td>-11.60</td>
<td>.000</td>
</tr>
<tr>
<td>Teamwork - Situation</td>
<td>-0.33</td>
<td>0.37</td>
<td>-11.83</td>
<td>.000</td>
</tr>
<tr>
<td>Teamwork - Taskwork</td>
<td>-0.01</td>
<td>0.35</td>
<td>-0.44</td>
<td>.664</td>
</tr>
<tr>
<td>Accuracy</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork - Situation</td>
<td>3.27</td>
<td>2.90</td>
<td>14.85</td>
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<tr>
<td>Teamwork - Situation</td>
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<td>3.19</td>
<td>-2.25</td>
<td>.026</td>
</tr>
<tr>
<td>Teamwork - Taskwork</td>
<td>-3.81</td>
<td>1.37</td>
<td>-36.74</td>
<td>.000</td>
</tr>
<tr>
<td>QAP Correlation</td>
<td></td>
<td></td>
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<tr>
<td>Taskwork - Situation</td>
<td>-0.45</td>
<td>0.24</td>
<td>-25.35</td>
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<tr>
<td>Teamwork - Situation</td>
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<td>0.24</td>
<td>-18.81</td>
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<tr>
<td>Teamwork - Taskwork</td>
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<td>0.22</td>
<td>6.72</td>
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<td><strong>TCT Condition (df = 177)</strong></td>
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<td>Sharedness</td>
<td></td>
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</tr>
<tr>
<td>Distance</td>
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</tr>
<tr>
<td>Taskwork - Situation</td>
<td>0.71</td>
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<tr>
<td>Teamwork - Situation</td>
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<td>4.48</td>
<td>-0.70</td>
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<tr>
<td>Teamwork - Taskwork</td>
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<td>2.58</td>
<td>-4.86</td>
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</tr>
<tr>
<td>QAP Correlation</td>
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</tr>
<tr>
<td>Taskwork - Situation</td>
<td>-0.31</td>
<td>0.37</td>
<td>-10.99</td>
<td>.000</td>
</tr>
<tr>
<td>Teamwork - Situation</td>
<td>-0.32</td>
<td>0.34</td>
<td>-12.52</td>
<td>.000</td>
</tr>
<tr>
<td>Teamwork - Taskwork</td>
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<td>0.34</td>
<td>-0.40</td>
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</tr>
<tr>
<td>Accuracy</td>
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<tr>
<td>Distance</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Taskwork - Situation</td>
<td>3.22</td>
<td>2.88</td>
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<tr>
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<tr>
<td>Teamwork - Taskwork</td>
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<td>1.53</td>
<td>-35.42</td>
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</tr>
<tr>
<td>QAP Correlation</td>
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</tr>
<tr>
<td>Taskwork - Situation</td>
<td>-0.46</td>
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<tr>
<td>Teamwork - Situation</td>
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<td>0.24</td>
<td>-17.46</td>
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</tr>
<tr>
<td>Teamwork - Taskwork</td>
<td>0.15</td>
<td>0.23</td>
<td>8.66</td>
<td>.000</td>
</tr>
</tbody>
</table>

Note. CRT = Cross-training; TCT = Team coordination training.
Table 25

Descriptive Statistics for each Team Training Condition on all Team Mental Model Measures and Indices

<table>
<thead>
<tr>
<th>Team Mental Model Measure</th>
<th>Team Training: Descriptives</th>
<th>CRT (N = 174)</th>
<th>TCT (N = 178)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Sharedness</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork</td>
<td>10.83</td>
<td>2.43</td>
<td></td>
</tr>
<tr>
<td>Situation</td>
<td>10.09</td>
<td>3.52</td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td>9.89</td>
<td>2.83</td>
<td></td>
</tr>
<tr>
<td>QAP Correlation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork</td>
<td>0.17</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Situation</td>
<td>0.49</td>
<td>0.26</td>
<td></td>
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<tr>
<td>Teamwork</td>
<td>0.16</td>
<td>0.26</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taskwork</td>
<td>12.22</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>Situation</td>
<td>8.95</td>
<td>2.96</td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td>8.41</td>
<td>1.08</td>
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</tr>
<tr>
<td>QAP Correlation</td>
<td></td>
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</tr>
<tr>
<td>Taskwork</td>
<td>0.11</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Situation</td>
<td>0.57</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td>0.23</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

Note. CRT = Cross-training; TCT = Team coordination training.

accuracy of situation mental models when indexed as distance ($\pi = -0.35, p > .10$), or QAP correlations ($\pi = -0.01, p > .10$; see Table 22). Based on the results of the HLM analyses, no support was found for Hypothesis 2.

Hypotheses 2 was also tested by entering shared taskwork and situation mental models as a paired mean comparison rating in a t-test, along with a comparison of the means in accurate taskwork and situation mental models. The results demonstrated that, when team mental models were indexed as distance, teams receiving cross-training developed significantly more shared situation mental models than taskwork mental models ($t (173) = 2.27, p = .025$). Teams also developed more accurate situation mental
models than taskwork mental models in the cross-training condition \((t(173) = 14.85, p < .001)\). Similar results were found when team mental models were indexed as QAP correlations, such that teams receiving cross-training developed significantly more shared situation mental models than taskwork mental models \((t(173) = -11.60, p < .001)\) and also developed more accurate situation mental models than taskwork mental models \((t(173) = -25.35, p < .001)\). Both sets of findings were in the opposite direction of the anticipated results. Therefore, consistent with the results from the HLM analyses, Hypothesis 2 was not supported.

Hypothesis 3 proposed that teams receiving team coordination training would develop more shared and accurate situation mental models than those in the cross-training condition. On the other hand, Hypothesis 4 suggested that teams receiving team coordination training would develop more shared and accurate situation mental models than taskwork mental models. Given that training type did not significantly impact either situation or taskwork mental models (see Tables 20 and 21), neither Hypothesis 3 nor 4 were supported using HLM.

Hypothesis 4 was also tested using paired mean comparison ratings in t-tests. The means of shared taskwork and situation mental models, and accurate taskwork and situation mental models were compared within the team coordination training condition. The results showed that teams receiving team coordination training developed a marginally significant higher level of shared situation mental models than taskwork mental models \((t(177) = 1.94, p = .054)\) and significantly more accurate situation mental models than taskwork mental models \((t(177) = 14.89, p < .001)\) when indexed through distance ratings. The same results were also found across team mental models assessed
using QAP correlations, for the sharedness (t (177) = -10.99, p < .001) and accuracy (t (177) = -23.98, p < .001) of the situation and taskwork mental models. Using this analytic method, Hypothesis 4 was supported.

Hypothesis 5 stated that teams receiving cross-training would develop more shared and accurate teamwork mental models than situation mental models. As shown in Table 24, training type did not have a significant effect on shared teamwork mental models when indexed as distance (π = -0.43, p > .10) or QAP correlations (π = -0.01, p > .10). Training type also did not have a significant impact on the accuracy of teamwork mental models when indexed as distance (π = -0.01, p > .10) or QAP correlations (π = -0.03, p > .10). Hypothesis 5 was therefore not supported using HLM.

Hypothesis 5 was also tested using paired comparison t-tests between teamwork and situation mental models. These t-tests showed that for cross-training, there were no differences in the sharedness of either type of teamwork mental models and situation mental models when indexed as distance ratings (t (173) = -0.57, p = .566) or QAP correlations (t (173) = -11.83, p < .001). However, teams receiving cross-training developed more accurate teamwork mental models than situation mental models when indexed through distance ratings (t (173) = -2.25, p = .026) and more accurate situation than teamwork mental models when indexed through QAP correlations (t (173) = -18.81, p < .001). Given that the sharedness results were in the opposite direction of what was predicted and the accuracy results demonstrated mixed support, the t-test analyses, like the HLM analyses, demonstrated that Hypothesis 5 was largely unsupported.

Hypothesis 6 stated that that teams receiving team coordination training would develop more shared and accurate teamwork mental models than taskwork mental
models. Given that training type did not significantly impact teamwork or taskwork mental models (see Tables 20 and 22), this hypothesis was not supported using HLM.

Hypothesis 6 was also evaluated by conducting a paired comparison ratings between taskwork and teamwork mental models. Teams in the team coordination training condition had higher mean levels of shared teamwork mental models than taskwork mental models when indexed by distance ratings \( t(177) = -4.86, p < .001 \) but not when indexed by QAP correlations \( t(177) = -0.40, p = .688 \). However, these teams had higher levels of accuracy for teamwork mental models than taskwork mental models when indexed through both distance ratings \( t(177) = -35.42, p < .001 \) and QAP correlations \( t(177) = 8.66, p < .001 \). Therefore, using this paired samples t-test approach for analysis, Hypothesis 6 was supported.

**Main Effect of Team Mental Models on Team Performance.** Hypothesis 7 related to the impact of team mental models on team performance. This hypothesis was tested by first creating a null model using performance as the dependent variable, including the control variables training satisfaction and self-efficacy on Level 2 of the equation in Model 1, and the respective team mental model property on Level 1 of the equation in Model 2. The results from each of these tests are described in detail below.

Hypothesis 7a proposed that shared taskwork mental models would have a positive impact on team performance. Contrary to this prediction, the shared taskwork mental models had a negative effect on team performance when indexed as distance \( \pi = -0.56, p < .001 \), such that more similar scores on taskwork mental models resulted in lower levels of performance. The dissimilarity among taskwork mental models helped to explain an additional 9 percent in the variation of performance scores across time above
the variance accounted for by the control variables (see Table 26). The changes in $R^2$ at
the dyad and system levels were negative and were therefore not interpreted because
HLM sometimes estimates increases in the residual variance, which are due to the use of
complex models and maximum likelihood estimation methods (Raudenbush & Bryk,
2001). These estimates result in uninterpretable changes in $R^2$.

As expected, shared taskwork mental models, when indexed through QAP
correlations, had a positive impact on team performance ($\pi = 3.03$, $p < .10$), but this result
was only marginally significant. The increased sharedness of taskwork mental models
was associated with higher levels of performance. This effect was strongest at the dyad
level, explaining an additional 14 percent of the variance in performance above the
control variables (see Table 26). Given that the distance ratings were in the opposite
direction of what was expected and the QAP correlations were in the expected direction,
but were marginally significant, Hypothesis 7a was largely unsupported.

Hypothesis 7b predicted that accurate taskwork mental models would have a
positive impact on team performance. Both the distance and QAP correlations indices of
taskwork mental model accuracy had a significant impact on team performance in the
expected direction. The accuracy of taskwork mental models, when indexed as distance,
had a positive impact on performance, such that dyads with more similarity between their
ratings and the expert ratings had higher levels of performance than those with less
similarity ($\pi = 0.90$, $p < .05$). Similarly, when taskwork mental model accuracy was
indexed as QAP correlations, dyads with higher levels of similarity between their ratings
and the expert ratings had higher levels of performance than those with less similarity ($\pi
= 7.65$, $p < .05$). Hypothesis 7b was therefore supported (see Table 27).
### Table 26

**Interactive Effect of Taskwork Mental Models and Time on Performance**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependent Variable: Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Null Model</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1 Intercept</td>
<td>55.01**</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1 residual variance</td>
<td>46.187</td>
</tr>
<tr>
<td>Level 2 residual intercept variance</td>
<td>2.988</td>
</tr>
<tr>
<td>Level 3 residual intercept variance</td>
<td>15.106</td>
</tr>
<tr>
<td><strong>Model 1: Controls</strong></td>
<td></td>
</tr>
<tr>
<td>Level 2 Training Satisfaction</td>
<td>2.93*</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1 residual variance</td>
<td>46.187</td>
</tr>
<tr>
<td>Level 2 residual intercept variance</td>
<td>3.259</td>
</tr>
<tr>
<td>Level 3 residual intercept variance</td>
<td>3.256</td>
</tr>
<tr>
<td><strong>Pseudo ΔR²</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>-0.09</td>
</tr>
<tr>
<td>Level 3</td>
<td>0.78</td>
</tr>
<tr>
<td><strong>Model 2: Team Mental Model: Property</strong></td>
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</tr>
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<td>Level 1</td>
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<tr>
<td>Level 3</td>
<td>0.78</td>
</tr>
<tr>
<td><strong>Model 3: Moderator</strong></td>
<td>Time</td>
</tr>
<tr>
<td>Level 1 Time</td>
<td>-6.77**</td>
</tr>
<tr>
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</tr>
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<td><strong>Model 4: Interaction</strong></td>
<td>Taskwork MM x Time</td>
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<td>Level 2</td>
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</tr>
<tr>
<td>Level 3</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Note.** N (Level 1 = 352); N (Level 2 = 176); N (Level 3 = 88). MM = Mental Model. Entries represent fixed effects, with robust standard errors. All variables were grand-mean centered, except for training type which was coded as 1 = cross-training and 2 = team coordination training. Pseudo ΔR² = (residual variance (previous model) – residual variance (current model))/residual variance (previous model). **p<.001; *p<.05; †p<.10.
Table 27

**Interactive Effect of Situation Mental Models and Time on Performance**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependent Variable: Performance</th>
</tr>
</thead>
<tbody>
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<td><strong>Null Model</strong></td>
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<td><strong>Variance Estimates</strong></td>
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<tr>
<td>Level 2 residual intercept variance</td>
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</tr>
<tr>
<td>Level 3 residual intercept variance</td>
<td>15.106</td>
</tr>
<tr>
<td><strong>Model 1: Controls</strong></td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>2.93*</td>
</tr>
<tr>
<td>Training Satisfaction</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1 residual variance</td>
<td>46.187</td>
</tr>
<tr>
<td>Level 2 residual intercept variance</td>
<td>3.259</td>
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<tr>
<td>Level 3 residual intercept variance</td>
<td>3.256</td>
</tr>
<tr>
<td><strong>Pseudo $\Delta R^2$</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>0.00</td>
</tr>
<tr>
<td>Level 2</td>
<td>-0.09</td>
</tr>
<tr>
<td>Level 3</td>
<td>0.78</td>
</tr>
<tr>
<td><strong>Model 2: Team Mental Model: Property</strong></td>
<td>Sharedness</td>
</tr>
<tr>
<td>Level 1</td>
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<tr>
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</tr>
<tr>
<td>Level 1</td>
<td>-6.81**</td>
</tr>
<tr>
<td>Time</td>
<td>-6.99**</td>
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<td><strong>Variance Estimates</strong></td>
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<td><strong>Model 4: Interaction</strong></td>
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<tr>
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<tr>
<td><strong>Pseudo $\Delta R^2$</strong></td>
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<tr>
<td>Level 1</td>
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</tr>
<tr>
<td>Level 2</td>
<td>0.02</td>
</tr>
<tr>
<td>Level 3</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

*Note. N (Level 1 = 352); N (Level 2 = 176); N (Level 3 = 88). MM = Mental Model. Entries represent fixed effects, with robust standard errors. All variables were grand-mean centered, except for training type which was coded as 1 = cross-training and 2 = team coordination training. Pseudo $\Delta R^2 = (\text{residual variance (previous model)} - \text{residual variance (current model)})/\text{residual variance (previous model)}. **p<.001; *p<.05; †p<.10.*
Hypothesis 7c suggested that shared situation mental models would have a positive impact on team performance. As shown in Table 27, even though shared situation mental models, indexed as QAP correlations, did not have a significant effect on performance ($\pi = -1.39$, $p > .10$), shared situation mental models, indexed as distance, did ($\pi = 0.67$, $p < .001$). Specifically, dyads that had more similar scores on situation mental models had a higher level of performance than those with more similar scores. This variable accounted for an additional 18 percent in the variation of performance scores at Level 1. Some support was therefore found for Hypothesis 7c.

Hypothesis 7d stated that accurate situation mental models would have a positive impact on team performance. Support was found for this hypothesis for both distance and QAP correlation indices (see Table 27). Dyads with more similarity their ratings and the expert ratings had higher levels of performance than those with less similarity (distance ratings: $\pi = 0.97$, $p < .001$; QAP correlations: $\pi = 4.29$, $p < .05$).

Hypothesis 7e proposed that shared teamwork mental models would have a positive impact on team performance. Model 2 from Table 28 shows that the shared teamwork mental models, indexed as QAP correlations, had a positive effect on performance ($\pi = 3.46$, $p < .05$). This effect explained 4 percent of incremental variance in performance at Level 1 above training satisfaction and self-efficacy. However, shared teamwork mental models, indexed as distance, did not have a significant negative impact on team performance ($\pi = 0.04$, $p > .10$). Therefore, Hypothesis 7e was partially supported.

Hypothesis 7f predicted that accurate teamwork mental models would have a positive impact on team performance. Neither QAP correlation ($\pi = 4.80$, $p > .10$) nor
distance ($\pi = -0.14, p > .10$) indices regarding the accuracy of teamwork mental model ratings had a significant impact on performance (see Table 28). Hypothesis 7f was therefore not supported.

*Mediation Effect between Training Type and Performance.* Hypotheses 8 and 9 stated that team mental models would mediate the effect of training type on team performance. These hypotheses were tested using Baron and Kenny’s (1986) test for mediation. This test is a three step process in which the extent to which training type accounts for significant variance in team performance was evaluated, then whether the respective team mental model is significantly related to performance was determined. If these both of these paths were significant, then the last step in the process was to examine the impact of training type on team performance after controlling for the respective team mental model. Full mediation was supported if the last step in the process was significant.

Previous research has suggested that Baron and Kenny’s (1986) test for mediation is a very conservative test and suffers from low statistical power (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Mediation was also therefore evaluated using MacKinnon and colleagues’ (2002) test of the joint significance of effects in which the significance of the effect of training type on the respective team mental model and the effect of team mental models on team performance were assessed at the same time. This is also known as the Sobel test (MacKinnon et al., 2002).

The first step for mediation was significant. As shown in Model 2 of Table 29, training type had a significant impact on performance.
### Table 28

**Interactive Effect of Teamwork Mental Models and Time on Performance**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependent Variable: Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Null Model</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1 Intercept</td>
<td>55.01**</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1 residual variance</td>
<td>46.187</td>
</tr>
<tr>
<td>Level 2 residual intercept variance</td>
<td>2.988</td>
</tr>
<tr>
<td>Level 3 residual intercept variance</td>
<td>15.106</td>
</tr>
<tr>
<td><strong>Model 1: Controls</strong></td>
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</tr>
<tr>
<td>Level 2 Training Satisfaction</td>
<td>2.93*</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>Variance Estimates</strong></td>
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</tr>
<tr>
<td>Level 1 residual variance</td>
<td>46.187</td>
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<tr>
<td>Level 2 residual intercept variance</td>
<td>3.259</td>
</tr>
<tr>
<td>Level 3 residual intercept variance</td>
<td>3.256</td>
</tr>
<tr>
<td><strong>Pseudo ΔR²</strong></td>
<td>Level 1: 0.00</td>
</tr>
<tr>
<td></td>
<td>Level 2: -0.09</td>
</tr>
<tr>
<td></td>
<td>Level 3: 0.78</td>
</tr>
<tr>
<td><strong>Model 2: Team Mental Model: Property</strong></td>
<td></td>
</tr>
<tr>
<td>Level 1 Teamwork MM</td>
<td>Distance 0.04 QAP 3.46*</td>
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<tr>
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<td>Accuracy -0.14 QAP 4.80</td>
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<td>Level 2: 0.05</td>
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<td>Level 3: 0.78</td>
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<tr>
<td><strong>Model 3: Moderator</strong></td>
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</tr>
<tr>
<td>Level 1 Time</td>
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<td><strong>Variance Estimates</strong></td>
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</tr>
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<td>Level 3: -0.02</td>
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<td><strong>Model 4: Interaction</strong></td>
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<tr>
<td></td>
<td>Level 3: 0.00</td>
</tr>
</tbody>
</table>

*Note.* N (Level 1 = 352); N (Level 2 = 176); N (Level 3 = 88). MM = Mental Model. Entries represent fixed effects, with robust standard errors. All variables were grand-mean centered, except for training type which was coded as 1 = cross-training and 2 = team coordination training. Pseudo ΔR² = (residual variance (previous model) – residual variance (current model))/residual variance (previous model). **p<.001; *p<.05; †p<.10.
Table 29

Main Effect of Training Type on Performance

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependent Variable: Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Null Model</strong></td>
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<td>Level 1</td>
<td>Intercept</td>
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<tr>
<td>Variance Estimates</td>
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<td>Level 1 residual variance</td>
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<tr>
<td>Level 2 residual intercept variance</td>
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<td>Level 3 residual intercept variance</td>
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<tr>
<td><strong>Model 1: Controls</strong></td>
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<tr>
<td>Level 2 Training Satisfaction</td>
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<td>Self-efficacy</td>
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<td>Variance Estimates</td>
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<td>Level 2 residual intercept variance</td>
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<td>Pseudo $\Delta R^2$</td>
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<td>Level 2</td>
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<tr>
<td>Level 1 residual variance</td>
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<td>Level 2 residual intercept variance</td>
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<td>Level 3 residual intercept variance</td>
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<tr>
<td>Pseudo $\Delta R^2$</td>
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<td>Level 1</td>
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<td>Level 2</td>
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<tr>
<td>Level 3</td>
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</table>

Note. N (Level 1 = 352); N (Level 2 = 176); N (Level 3 = 88). Entries represent fixed effects, with robust standard errors. All variables were grand-mean centered, except for training type which was coded as 1 = cross-training and 2 = team coordination training. Pseudo $\Delta R^2 = (\text{residual variance (previous model)} - \text{residual variance (current model)})/\text{residual variance (previous model)}$. **p<.001; *p<.05; †p<.10.

Teams in the cross-training condition had a higher levels of performance than those in the team coordination training condition ($\pi = -6.39$, p < .001). This explained an additional 31 percent in the variation of performance scores at Level 2 over training satisfaction and self-efficacy.
The second step for mediation that evaluated the effect of training type on team mental models was not significant. As previously discussed in relation to Hypotheses 1 to 6 and shown in Tables 20 to 22, training type did not have a significant impact on taskwork, teamwork, or situation mental models with regards to sharedness or accuracy when indexed through distance or QAP indices. Given that the second step in the test for mediation was not significant, no support was found for Hypotheses 8 and 9, according to Baron and Kenny’s (1986) or MacKinnon and colleagues’ (2002) tests for mediation.

*Moderation of Environmental condition on Training Type and Performance.* Hypothesis 10 suggested that environmental condition (routine vs. non-routine) would moderate the relationship between team mental models and performance, such that the relationship would be stronger for teams operating under a non-routine environment than in a routine environment. Following the recommendations of Aiken and West (1991), all team mental model variables were first mean-centered to avoid multi-collinearity with the independent variable and interactive term. An interaction term was then created by multiplying the respective team mental model variable and the dichotomous variable for environmental condition represented by time (Time 1: routine vs. Time 2: non-routine) in Tables 25 to 27. A series of analyses were run in HLM in which dyad performance was the dependent variable. Model 1 (the control variables training satisfaction and self-efficacy), Model 2 (the respective team mental model and property), Model 3 (the moderator of time, representing each environmental condition), and Model 4 (the interaction term between the respective team mental model and environmental condition) were then computed. Moderation occurs if the interaction term on Model 4 is significant.
Hypothesis 10a proposed that the relationship between shared taskwork mental models and team performance would be moderated by environmental condition, such that the relationship would be stronger for teams operating under a non-routine environment than in a routine environment. As previously discussed in Table 2, shared taskwork mental models had significant effects on performance when indexed as distance \( (\pi = -0.56, p < .001) \) and, marginally, when indexed as a QAP correlation \( (\pi = 3.03, p < .10) \). In addition, a main effect results for environmental condition \( (\pi = -6.77, p < .001) \), such that dyads performed significantly better in the routine than in the non-routine environment. Unexpectedly, the interaction term between environmental condition and shared taskwork mental models, when indexed as distance \( (\pi = -0.05, p > .10) \) or QAP correlation \( (\pi = 2.74, p > .10) \), did not have a significant effect on performance. Hypothesis 10a was therefore not supported.

Hypothesis 10b predicted that the relationship between shared teamwork mental models and team performance would be moderated by environmental condition, such that the relationship would be stronger for teams operating under a non-routine environment than in a routine environment. As shown in Model 4 of Table 2, support was found for this hypothesis. The interactive term between the shared teamwork mental models (indexed as QAP correlations) and time was significant \( (\pi = -4.77, p < .05) \). However, no difference was found in the slopes of these lines when graphed. This effect was therefore considered to be spurious. Hypothesis 10b was not supported.

Hypothesis 10c stated that the relationship between the shared situation mental models and team performance would be moderated by environmental condition, such that the relationship would be stronger for teams operating under a non-routine environment.
than in a routine environment. As shown in Table 27, even though both shared situation mental models (indexed as distance; $\pi = 0.67, p < .001$) and environmental condition ($\pi = -6.81, p < .001$) had significant effects on performance in the expected direction, the interaction term was not significant ($\pi = -0.12, p > .10$). Hypothesis 10c was therefore not supported.

Ancillary Analyses

*Interactive Effects between Training Type and Environmental Condition*

The current study revealed that training type had a significant effect on performance, such that dyads in the cross-training condition had a higher level of performance than dyads in the team coordination training condition. However, the content of team coordination training focuses on developing team process strategies (planning/decision making, communicating, situation assessment) that have been found to help teams effectively cope with non-routine environments (e.g., Marks et al., 2000). Environmental condition could therefore moderate the relationship between training type and team performance, such that dyads receiving team coordination training would have higher performance in the non-routine condition than dyads in the cross-training condition. A two-way ANOVA was conducted using SPSS 17.0 in which performance was the dependent variable and training type (1 = cross-training; 2 = team coordination training) and environmental condition (1 = routine; 2 = non-routine) were fixed factors. No support was found for an interaction between training type and environmental conditions in predicting team performance ($F (1, 351) = 0.81, p = .368$).

As summarized in Tables 20-24 (Hypotheses 1-6), even though there were mean differences in the types of team mental model formed within each training condition,
these differences did not vary across training conditions. However, environmental condition could have masked the effect of training type on team mental models, such that dyads receiving cross-training developed team mental models that were more similar and accurate in the routine condition, while dyads receiving team coordination training developed increased shared and accurate team mental models in the non-routine condition. This proposition was tested through a series of two-way ANOVAs, in which the respective team mental model variable was the dependent variable and training type and environmental condition were the fixed factors. Counter to this proposition, no support was found for an interaction between training type and environmental condition on any of the indices (distance or QAP correlations), properties (accuracy or sharedness), or types (taskwork, teamwork, or situation) of team mental models.

Interactive Effects between Team Mental Model Properties

Previous research has demonstrated that the sharedness of teamwork mental models may interact with accuracy in predicting performance (Mathieu et al., 2005). For example, in Mathieu and colleagues (2005), the worst performing teams were found to have high accuracy and low sharedness in teamwork mental models. Given these results, the current study evaluated the interactive effects between the properties of team mental models using HLM 3.0. The analyses were conducted in a series of steps in which each of the following models were tested, using dyad performance as the dependent variable: Model 1 (the control variables training satisfaction and self-efficacy), Model 2 (the sharedness of the respective team mental model), Model 3 (the accuracy of the respective team mental model), and Model 4 (the interaction term between the sharedness and accuracy of the team mental model). These analyses were executed using both the
distance and QAP correlation metrics of the team mental model measures. The results failed to demonstrate significant interactions between the properties of each type of team mental model.

**Interactive Effects between Team Mental Model Types**

Smith-Jentsch and colleagues (2005) demonstrated that taskwork (positional goal-interdependencies) and teamwork mental models (cue-strategy associations) interacted in predicting team performance (safety and efficiency). Specifically, best performing teams had consistent shared mental models on both types (Smith-Jentsch et al., 2005). Based on this finding, the current study tested the interactive effect between shared teamwork and situation mental models, shared taskwork and situation mental models, and shared taskwork and teamwork mental models as indexed through distance and QAP correlations.

The analyses were conducted using HLM 3.0. The following models were evaluated using dyad performance was the dependent variable: Model 1 (the control variables training satisfaction and self-efficacy), Model 2 (the respective team mental model type), Model 3 (the other team mental model type), and Model 4 (the interaction term between the two types of sharedness team mental models).

Two marginal effects and one significant interactive effect were found. The first effect demonstrated that shared teamwork interacted with shared situation mental models in predicting performance when both were indexed as QAP correlations ($\pi = -9.33, p = .063$). This interaction was plotted using procedures described by Aiken and West (1991). The nature of the interaction was somewhat unexpected, in that situation mental models weakened the effect of teamwork mental models on team performance. Specifically,
when situation mental models were less similar, shared teamwork mental models had a stronger effect on team performance than when situation mental models were more similar. In other words, high performing teams had high levels of sharedness on teamwork mental models but low sharedness on situation mental models (see Figure 6).

![Figure 6](image)

**Figure 6.** Interactive effect between teamwork and situation mental models on team performance.

The second marginally significant interaction was between shared taskwork mental models and shared situation mental models, both indexed as QAP correlations ($\pi = -10.34, p = .083$). After graphing the interaction, a similar pattern to Figure 6 was seen, in which situation mental models also weakened the effect of taskwork mental models on team performance. When situation mental models were less similar, shared taskwork mental models had a stronger effect on team performance than when situation mental models were more similar. High performing teams therefore had high levels of
sharedness on taskwork mental models but low levels of sharedness on situation mental models (see Figure 7).

Figure 7. Interactive effect between taskwork and situation mental models on team performance.

Finally, shared taskwork mental models and shared teamwork mental models, when indexed as distance had a significant interactive effect on performance ($\pi = -0.08$, $p = .025$). As previously discussed, shared taskwork mental models (when indexed through distance) had an unexpected positive impact on performance. This means that lower sharedness in taskwork mental models were associated with higher levels of performance.

The interaction between shared taskwork and teamwork mental models (indexed through distance) demonstrated that the negative impact of shared taskwork mental models on team performance was weakened by the increased sharedness of teamwork mental models. When teamwork mental models are more similar, the dissimilarity of taskwork mental models has a weaker effect on team performance than when teamwork mental
models are diverse among team members. High performing teams had high levels of sharedness on teamwork mental models and low levels of sharedness on taskwork mental models (see Figure 8).

![Figure 8](image)

*Figure 8.* Interactive effect between taskwork and teamwork mental models on team performance.

**Discussion**

The purpose of this study was to compare the effect of team coordination training and cross-training on team mental models and performance in routine and non-routine environmental conditions. Through addressing this purpose, several contributions were made to the team training literature. First, multiple types of team training strategies were compared in the same study. Such a design allows for the comparison of the relative contributions of each training strategy on team effectiveness. Second, the potential mediators between training type and team performance were investigated through team mental models. Third, multiple types of team mental models were assessed (taskwork,
teamwork, and situation mental models). Relatedly, situation mental models were evaluated in this study, while previous research has tended to neglect the role of this variable in the team mental model – team performance relationship (see Serfaty et al. (1998) and Waller et al. (2004) for exceptions). Finally, the effect of team mental models on team performance was examined under both routine and non-routine environmental conditions, which helps to address calls for team researchers to account for the role of context in conceptual models (Ancona & Caldwell, 1992).

Summary of Results

The results of the current study highlight four main findings. First, different types of team training (cross-training or team coordination training) did not result in the formation of different types of team mental models. Second, even though different training types did not differ according to the types of team mental model developed, they did differ according to their impact on team performance. Third, the effect of team mental models on team performance was inconsistent. It was dependent on the type, property, and index that was examined. Fourth, the effect of team mental models on team performance did not vary according to the context in which the team performance. These results provide mixed support for the conceptual model. The nature of these findings is discussed in greater detail in the following section, along with possible reasons for unexpected results. A list of supported and unsupported hypotheses can also be found in Table 30.

Explanation of Results

Training Type and Team Mental Models. Unexpectedly, there were no differences in the types of team mental models that developed among team members that received
### Summary of Supported and Unsupported Hypotheses

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Supported</th>
<th>Unsupported</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H1. Teams receiving cross training will develop more:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) shared taskwork mental models than those in the team coordination training condition.</td>
<td>X</td>
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<tr>
<td>b) accurate taskwork mental models than those in the team coordination training condition.</td>
<td>X</td>
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<tr>
<td><strong>H2. Teams receiving cross-training will develop more:</strong></td>
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<tr>
<td>a) shared taskwork mental models than situation mental models.</td>
<td>X</td>
<td></td>
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<tr>
<td>b) accurate taskwork mental models than situation mental models.</td>
<td>X</td>
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<tr>
<td><strong>H3. Teams receiving team coordination training will develop more:</strong></td>
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</tr>
<tr>
<td>a) shared situation mental models than those in the cross-training condition.</td>
<td>X</td>
<td></td>
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<tr>
<td>b) accurate situation mental models than those in the cross-training condition.</td>
<td>X</td>
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<td><strong>H4. Teams receiving team coordination training will develop more:</strong></td>
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<tr>
<td>a) shared situation mental models than taskwork mental models.</td>
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<td></td>
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<tr>
<td>b) accurate situation mental models than taskwork mental models.</td>
<td>X</td>
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<tr>
<td><strong>H5. Teams receiving cross-training will develop:</strong></td>
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<tr>
<td>a) shared teamwork mental models than situation mental models.</td>
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<tr>
<td>b) accurate teamwork mental models than situation mental models.</td>
<td>X</td>
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<tr>
<td><strong>H6. Teams receiving team coordination training will develop more:</strong></td>
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<tr>
<td>a) shared teamwork mental models than taskwork mental models.</td>
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<tr>
<td>b) accurate teamwork mental models than taskwork mental models.</td>
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<tr>
<td><strong>H7a. Shared taskwork mental models will have a positive impact on team performance.</strong></td>
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<tr>
<td><strong>H7b. Accurate taskwork mental models will have a positive impact on team performance.</strong></td>
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<tr>
<td><strong>H7c. Shared situation mental models will have a positive impact on team performance.</strong></td>
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<tr>
<td><strong>H7d. Accurate situation mental models will have a positive impact on team performance.</strong></td>
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<tr>
<td><strong>H7e. Shared teamwork mental models will have a positive impact on team performance.</strong></td>
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<tr>
<td><strong>H7f. Accurate teamwork mental models will have a positive impact on team performance.</strong></td>
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<tr>
<td><strong>H8a. Shared taskwork mental models will mediate the relationship between cross-training and team performance.</strong></td>
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<td><strong>H8b. Accurate taskwork mental models will mediate the relationship between cross-training and team performance.</strong></td>
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<td><strong>H8c. Shared situation mental models will mediate the relationship between cross-training and team performance.</strong></td>
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<tr>
<td><strong>H8d. Accurate situation mental models will mediate the relationship between cross-training and team performance.</strong></td>
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<tr>
<td><strong>H9a. Shared teamwork mental models will mediate the relationship between team coordination training and team performance.</strong></td>
<td>X</td>
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<tr>
<td><strong>H9b. Accurate teamwork mental models will mediate the relationship between team coordination training and team performance.</strong></td>
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<td></td>
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<tr>
<td><strong>H9c. Shared situation mental models will mediate the relationship between team coordination training and team performance.</strong></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>H9d. Accurate situation mental models will mediate the relationship between team coordination training and team performance.</strong></td>
<td>X</td>
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<tr>
<td><strong>H10a. The relationship between the similarity of taskwork mental models and team performance will be moderated by environmental conditions.</strong></td>
<td>X</td>
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<tr>
<td><strong>H10b. The relationship between the similarity of teamwork mental models and team performance will be moderated by environmental conditions.</strong></td>
<td>X</td>
<td></td>
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<tr>
<td><strong>H10c. The relationship between the similarity of situation mental models and team performance will be moderated by environmental conditions.</strong></td>
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</table>
cross-training or team coordination training. Two possible explanations of this finding are
that neither cross-training nor team coordination training led to the development of team
mental models or both cross-training and team coordination training had similar effects
on the formation of team mental models. Given the lack of a ‘no training’ control group
in the design of the current study, it is difficult to determine the reason behind the
absence of a main effect.

However, a closer examination of the patterns in the paired mean differences
between each type of team mental model would suggest that the latter explanation is
more plausible. Specifically, both cross-training and team coordination training led to the
development of more similar and accurate situation mental models than taskwork mental
models among dyads. Similarly, dyads in either training condition developed
significantly more shared situation mental models than teamwork mental models. Dyads
in either training condition also developed significantly more accurate situation mental
models than teamwork mental models (when team mental models were measured through
QAP correlations) and developed significantly more accurate teamwork mental models
than situation mental models (when team mental models were indexed through distance
ratings). Finally, both training types resulted in the formation of significantly more
similar and accurate teamwork mental models than taskwork mental models.

Given the pattern of these results, in which each training type demonstrated the
same mean differences on each type of team mental models, it would seem that team
training did impact team mental model formation. However, this effect only differed
within and not across training conditions. Future research should evaluate the effect of
training on team effectiveness using a research design with a ‘no training’ control group.
This will enable researchers to more accurately assess the incremental benefit of each training type on the formation of shared and accurate team mental models.

*Training Type and Team Performance.* Even though different types of training did not lead to the formation of different types team mental models, cross-training was associated with higher levels of performance than team coordination training. A possible explanation of this finding is that cross-training had a higher task content than team coordination training. The cross-training material focused on explaining both the roles of the Information and Resource Managers in each dyad. Participants in this condition received additional information on their own roles that was not presented in the team coordination training condition. This resulted in higher levels of taskwork declarative knowledge in the cross-training condition than in the team coordination training condition (t (350) = 14.09, p < .001; mean CRT = 0.81; mean TCT = 0.56; declarative knowledge is indexed as the percent of correct answers on the multiple choice items for cross-training). Relatedly, the simulation rewarded task behaviors more than teamwork behaviors. Specifically, dyads that were able to quickly identify to which events their team should respond and knew the correct resources to send to events had the lowest penalty applied to their scores (Obieta, 2006). In addition, the teamwork skills emphasized in team coordination training may not have been critical to team performance based on the low to moderate interdependence between team members. The content of cross-training was therefore inherently more beneficial to dyad performance than the teamwork-based knowledge conveyed in team coordination training. Future research should evaluate the generalizability of these findings to teams whose effectiveness is more reliant on teamwork knowledge (e.g., service teams, Sundstrom, 1999).
Team Mental Models and Performance. Team mental models were significant contributors to team performance, however, the nature of their effect on performance varied by type, property, and the index used to operationalize the construct. Consistent effects were found for situation mental models, such that both increased accuracy and sharedness of situation mental models were associated with higher levels of team performance. A probable explanation for these consistent results is that situation mental models were more specific to the scenarios than taskwork or teamwork mental models. Situation mental models therefore had a more direct relationship with team performance than the other mental models assessed in the study.

Inconsistent effects were found among the properties used to evaluate taskwork and teamwork mental models. As anticipated, the accuracy of taskwork mental models and the sharedness of teamwork mental models had positive relationships with team performance. However, unexpectedly, the sharedness of taskwork mental models had a negative relationship with team performance and the accuracy of teamwork mental models did not have a significant impact on team performance. Possible reasons for the inconsistent results found for taskwork and teamwork mental models related to the specialized roles of the dyads in the simulation.

In the current study, each dyad member had a specialized role. The Information Manager was responsible for determining to which events the team should respond, while the Resource Manager allocated the appropriate resources to each event. Dyads were more likely to have increased sharedness in taskwork mental models if they had an accurate assessment of all the tasks involved in playing NeoCITIES (i.e., the roles of both the Information Managers and the Resources Managers). However, in this context,
knowing more about one’s own role is a greater contributor to his/her success than knowing both roles fairly well. Therefore the increased sharedness of taskwork mental models may have been detrimental to the team by the likelihood that there was decreased shared knowledge within teams of one’s own role in favor of comprehending the responsibilities of both teammates. Mohammed and Dumville (2001) have suggested that among such teams with specialized roles, optimal team effectiveness is associated with high shared teamwork mental models and low shared taskwork mental models. Ancillary analyses examining the interaction between taskwork and teamwork mental models provided additional support for this proposition. These analyses showed that teams with highly shared teamwork mental models and low sharedness of taskwork mental models had the highest levels of performance. Future research should attempt to replicate this finding using teams with varying levels of interdependence.

The ancillary analyses examining the interaction between different types of team mental models also demonstrated that shared situation mental models weakened the positive effect of taskwork mental models on team performance and teamwork mental models on team performance. A possible explanation for these results is that shared situation mental models may be a more distinct type of shared knowledge than taskwork and teamwork mental models. The current study found that among the various indices of sharedness for the team mental model measures, taskwork and teamwork mental models were significantly positively correlated (r = .37 at Time 1 and r = .55 at Time 2), while taskwork and situation, and teamwork and situation mental models were not correlated. This uniqueness in knowledge structures may have caused teams high in shared situation mental models and taskwork mental models (or teamwork mental models) to have lower
levels of performance by creating conflicting views on task completion. For example, one
team member may think it is important to pay closer attention to the situation in resolving
events, while another may think it is more important to focus on the task or team. This
diversity in views may have lead to higher levels of conflict in the team and lower levels
of team performance (Jehn, Northcraft, & Neale, 1999). Future research is needed that
evaluates the effect of heterogeneity/diversity in the various types of team mental models
on team performance.

*Team Mental Models and Environmental Condition.* Contrary to prior
propositions, the effect of shared team mental models on performance did not vary
according to the environmental condition in which the team operated. A possible reason
for this non-significant finding is that the team mental models assessed in this brief one-
shot experiment were not fully developed to the point in which they approximated those
of an expert. The development of team mental models has been proposed to progress
through three phases (Langan-Fox, 2003). First, the teams familiarize themselves with the
task, team, and situation in which they are operating (i.e., the orientation/negotiation
stage). This knowledge is then further refined through the increased interaction with
fellow teammates (i.e., the refinement/learning stage). As time passes, this knowledge
reaches the level of high performance in which the team mental models approximate
those of an expert (i.e., the expert mental model stage). Teams that reach this level of
development in team mental models would have a higher probability of benefiting from
implicit team coordination in the non-routine context than the routine context. Previous
research that has found differences in team performance based on the sharedness of team
mental models has collected data using established teams in a field setting (Waller et al.,
2004) or have had teams engage for a longer period of time in multiple non-routine contexts (Marks et al., 2000; Stout et al., 1999). Future research should therefore evaluate the interaction between shared team mental models and environmental condition on team performance among teams with a longer history.

Limitations and Future Research Directions

The current study was the first to present primary-level data comparing the effectiveness of two types of team training on team effectiveness. The selection of the two training types examined in this study was based on the fact that cross-training and team coordination training are the two most researched strategies in the team training literature (Salas et al., 2007) and there is a low non-significant correlation between them (r = -.092; Salas et al., 2007). However, the results of this study show that training type did not have a significant main effect on team mental models. This finding suggests that the effect of cross-training and team coordination training on team cognitive outcomes may not be distinct. Both training types emphasize teamwork knowledge, which may have a similar impact on the formation of team mental models.

Future research should further investigate this lack of significant effects found in this study through the inclusion of a ‘no training’ control group. Given that the purpose of the current study was to compare the effectiveness of different types of team training on team performance, a ‘no training’ control group was not employed. Instead, the effects of cross-training on the formation of team mental models were compared to those in the team coordination training group. However, the use of a ‘no training’ control group in future research will allow for more precise analyses to evaluate the relative impact of both types of training on team mental model formation.
Similarly, future researchers should compare the effectiveness of more distinct types of training on team cognitive outcomes. One such example is team coordination training and mastery learning (i.e., training team members to focus on their own learning processes in order to improve their self-efficacy and performance; Kozlowski, Gully, Smith, Nason, & Brown, 1995). Given the emphasis of mastery learning on team member development, as opposed to the development of team interaction processes, it is possible that teams exposed to this training may develop less shared team mental models than those receiving team coordination training. Future research should provide an empirical test of this proposition.

A second limitation is the restriction in generalizability of findings due to the exclusive focus on action teams. Action teams were examined because they have been increasingly used in organizational work environments (cf. Sundstrom, 1999). These findings therefore relate to a broader range of teams. However, action teams, place a strong emphasis on task-based outcomes and are composed of individuals with a high degree of role specialization (Sundstrom, 1999). Such an emphasis helps to explain the significant impact of the task-based training type, cross-training, on team performance and the negative impact of taskwork mental models on team performance. However, these findings may not generalize to other types of teams, such as service teams, which place a greater emphasis on customer service outcomes than action teams and typically have low specialization in team roles (Sundstrom, 1999).

Apart from the exclusive focus on action teams, the current study was also limited by the focus on dyads. There are many differences in the dynamics that take place in dyads (small teams) and large teams. Large teams tend to experience greater process
losses than smaller teams that are the result of lower motivation, poorer coordination, and higher conformity (Steiner, 1972). These teams also engage in additional team processes, such as coalition formation (Rosinowska & De Swart, 2008), and may benefit from better quality decision making due to the greater diversity in viewpoints among the team (Jackson & Joshi, 2004; Milliken & Martins, 1996). Given these differences in the processes of large and small teams, the teamwork skills emphasized in team coordination training may have been more critical to effective team performance in larger teams than those evaluated in the current study. Similarly, the benefits of implicit coordination processes attained from increased sharedness in team mental models may have been more useful to teams of a larger size in non-routine environments than small teams. Future research is needed to explore these various propositions.

A fourth limitation of the current study is the short tenure of the teams. All teams had low familiarity prior to completing the study and worked together in a brief computer-mediated 2-hour task. Dyads therefore had limited time to chat and develop shared perceptions. Previous research has shown that the level of interaction that exists among teams is a key contributor to the development of team mental models (Levesque et al., 2001). Apart from limiting team mental model formation, the short tenure of the teams may have restricted team members’ perceptions of the environmental context. Specifically, performance may not have had enough time to become routinized prior the team’s exposure to the non-routine context. It is also possible that team mental models developed at the same rate as the increase in time pressure and complexity of the performance sessions. Such as scenario, could help to explain why team mental models did not have a stronger relationship with team performance in routine than in non-routine
contexts. Future research should evaluate the generalizability of these findings among more established teams.

A fifth limitation of the study is the failure to examine other potential mediators between team training and team performance. A principal purpose of the current study was to demonstrate the differential mechanisms through which cross-training and team coordination training influence performance. Given that neither training type had a main effect on any of the three types of team mental models, this purpose was not attained. Future research is needed to determine whether cross-training and team coordination training are distinct team training strategies through the examination of other potential mediators between training type and team performance. One such mediating variable may be team processes. Previous research by Marks and colleagues (2002) has shown that coordination and backup behaviors mediate the relationship between cross-training and performance. Marks and colleagues (2000) also found that the effect of team coordination training on performance was mediated by communication.

Another potential mediating variable is other cognitive outcomes of training, such as transactive memory (Austin, 2003). Transactive memory is a type of shared cognition in which team members are aware of the type of knowledge or expertise held by each team member (Austin, 2003). Researchers have focused on task training as a key antecedent to the development of transactive memory in teams (Moreland, 1999; Moreland & Myaskovsky, 2000). More recently, Prichard and Ashleigh (2007) examined the impact of team training on the formation of transactive memory. The authors found that teams that received generic teamwork skills training had significantly higher transactive memory and performance than those that did not receive such training. Given
the support in this literature for both taskwork and teamwork training improving transactive memory, it seems likely that cross-training (which includes both types of information) would lead to higher levels of transactive memory than team coordination training. However, to the author’s knowledge no test of this hypothesis exists.

Contributions and Implications

Many contributions were made by the current study to the team training and team mental model literatures. The current study is the first to compare the mechanisms through which different types of team training impact team performance. A key finding was that cross-training and team coordination training do not have distinct effects on team cognition (i.e., the formation of different types of team mental models). The distinct effects of each type of team training on team cognition could not be determined from prior research due to the inclusion of only one type of team training strategy in experimental studies (e.g., Marks et al., 2000; 2002), or the collapse of all team training strategies together when examining specific outcomes or the collapse of all outcomes when examining specific training types in different meta-analyses (Salas et al., 2007; 2008). Even though no significant differences were found in the mean levels of team mental models across each type of team training, significant differences in team mental model formation were demonstrated within each type of training. These findings showed that either type of training is associated with the formation of more shared and accurate situation mental models than taskwork or teamwork mental models and more shared and accurate teamwork mental models than taskwork mental models. However, based on the fact that the results are based on dyads with specialized roles, short lifespans, and strong
task-based outcomes (i.e., dyad-structured action teams), these finding should be interpreted with caution.

Another interesting finding from the current study is that shared team mental models are not always a good thing! Increased shared taskwork mental models (indexed as distance ratings) among dyad members was actually harmful to the team by decreasing their level of performance. This finding is presented with the caveat that it may only be generalizable to teams with specialized roles. Similarly, shared situation mental models were found to decrease the positive effect of teamwork mental models (indexed through QAP correlations) on team performance and the positive effect of taskwork mental models (indexed through QAP correlations) on team performance. Both these finding run counter to several previous studies on team mental models that have shown that shared taskwork mental models lead to higher levels of performance (Banks & Millward, 2007; Lim & Salas, 2006; Mathieu et al., 2005; Smith-Jentsch et al., 2005) and higher levels of multiple types of mental team models are important to team effectiveness (Smith-Jentsch et al., 2005). A key implication from these findings is that different types (taskwork, teamwork, and situation mental models) and indices (distance ratings and QAP correlations) of team mental models can impact team outcomes in contradictory ways. It is therefore important for researchers to broaden their conceptualization and measurement of team mental models as much as possible through evaluating multiple types, properties, and indices of the construct.

A final contribution of the current study is the evaluation of situation mental models. Previous research on team mental models has focused on the assessment of taskwork and teamwork (e.g., Banks & Millward, 2007; Cooke et al., 2003; Edwards et
al., 2006; Kang et al., 2006; Lim & Salas, 2006; Mathieu et al., 2005; Smith-Jentsch et al., 2005). These evaluations overlook the situation/strategic knowledge component in Converse and Kahler’s (1992) three-factor typology of shared cognition. The current study helped to address this oversight through evaluating the measure and establishing its relationship with performance in relation to taskwork and teamwork mental models. The current study was also one of the first to evaluate situation mental models using paired similarity ratings. Serfaty and colleagues (1998) used a survey measure and Waller and colleagues (2004) used a qualitative measure to assess situation mental models, however paired similarity ratings more accurately capture both the content and the structure of the construct (Mohammed et al., 2000). The increased acuity in the measurement of situation mental models helped to demonstrate that more shared and accurate situation mental models lead to higher levels of performance than less shared and accurate situation mental models. The current study also demonstrated that high levels of shared situation mental models can conflict with high levels of shared taskwork mental models to actually decrease performance. A similar effect was found between highly shared situation mental models and teamwork mental models. This finding suggests that teams may fail because of unmanaged diverse perspectives between shared taskwork and situation, and shared teamwork and situation mental models.
References


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


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Appendix A: Training Guide for NeoCITIES Simulation (Information Manager)

WELCOME MESSAGE

Welcome to the NeoCITIES Basic Training Guide. This short briefing will give you a rundown of your role as a member of *either the Fire/EMS, Police, or Hazmat team is inserted here*, your partner’s role on the team, and additional information about the simulation in which you will be participating. If you have any questions at any time, please consult the experimenter.

NEOCITIES OBJECTIVES

You and your partner are tasked with maintaining the general safety and well-being of the NeoCITIES community by responding appropriately to events that require your team’s services. You will work in tandem with two other teams – *either the Fire/EMS, Police, or Hazmat teams are inserted here depending on which team is receiving the training* – towards this objective. At times, you may be required to collaborate with these other teams in order to properly respond to events. Your basic goal is to keep your team score and the city’s health as high as possible. Your score will diminish as a function of event time, therefore it is imperative that you respond quickly and appropriately.

TEAMS IN THE SIMULATION

Each of the three teams in the simulation addresses different events.
- The Fire team handles any fire-related activities and provides medical care for injured victims.
- The Police team handles any crime-related activities through maintaining and imposing order.
- The Hazmat team addresses any bomb-related activities and chemical and biological clean-ups.

YOUR ROLE: INFORMATION MANAGER

Your primary functions are to:
1. Receive event information as it occurs.
2. Interpret that information and decide if your team should ignore the event or respond to it.
3. Consult the information tab, if necessary, to make an assessment of the situation.
4. Pass relevant events on to your partner along with your assessment of the situation.

Additionally, you are responsible for handling all lines of communication between your team to the other teams via chat panels.
- You will be able to directly communicate with other teams’ Information Managers BUT not their Resource Managers.
- You will be able to directly communicate with your partner – however, your partner can only communicate with you and no one else.
NOTE: Not all events will require your team’s resources or assistance.
- You are responsible for correctly identifying which events involve your team.
- If you submit an event to your partner that does not require your team, and they allocate resources to the event, these resources may not be available for other events that DO require your team.
- However, if you misidentify an event, your partner can choose to ignore the event, thus saving your team’s resources for those events that do require your team.

USER INTERFACE

The following aspects of the interface are indicated on the above screenshot: team name, clock, role, team score bar, Department of Homeland Security (DHS) threat level, main map panel, zoom tool, move tools, mini map panel, event message tracker, chat panels, and information tab.

BASIC OPERATING PROCEDURE
1. During the simulation, you will receive new event notifications in two location on the interface:
   - The Event Tracker Table in the lower left-hand corner.
   - On the Main Map via an Active Alert Icon.
2. Clicking on either interface location will bring up additional information about the event, and present the options to either IGNORE the event or SUBMIT the event to your partner.
3. Clicking IGNORE will change the status of an event to IGNORED in the Event Tracker and replace the Active Alert Icon on the Main Map with the Ignored Alert icon.
   - Ignored events can be returned to at any time by clicking on the event in the Event Tracker Table or the Ignored Alert Icon on the Main Map.
4. Clicking SUBMIT will bring up a Submit Event Report window.
   - The Event Description is automatically transferred to the report.
   - You can attach a short detailed message to your partner via a text box beneath the Event Description. This space is present to allow you to provide a primary assessment of the event.
As Information Manager, you are required to assign an appropriate icon to an event before sending it to your partner. These icons are what your partner will see for the event and represent a quick form of assessment that can be critical to a speedy response on your partner’s part.

5. Your partner only receives those events that you SUBMIT to them.

ICON EXPLANATION

As Information Manager, you are required to assign an appropriate icon to an event before sending it to your partner. These icons are a quick form of assessment and can be critical to a speedy response, thus preserving your team score and the health of the city.

CONCLUSION

This concludes the basic training guide. At this time, please wait patiently at this screen for the experimenter to give you the signal to move on to the next portion of your training segment.

PLEASE WAIT AT THIS SCREEN FOR FURTHER INSTRUCTIONS.

THANK YOU.
Appendix B: Training Guide for NeoCITIES Simulation (Resource Manager)

WELCOME MESSAGE

Welcome to the NeoCITIES Basic Training Guide. This short briefing will give you a rundown of your role as a member of <either the Fire/EMS, Police, or Hazmat team is inserted here>, your partner’s role on the team, and additional information about the simulation in which you will be participating. If you have any questions at any time, please consult the experimenter.

NEOCITIES OBJECTIVES

You and your partner are tasked with maintaining the general safety and well-being of the NeoCITIES community by responding appropriately to events that require your team’s services. You will work in tandem with two other teams – <either the Fire/EMS, Police, or Hazmat teams are inserted here depending on which team is receiving the training> – towards this objective. At times, you may be required to collaborate with these other teams in order to properly respond to events. Your basic goal is to keep your team score and the city’s health as high as possible. Your score will diminish as a function of event time, therefore it is imperative that you respond quickly and appropriately.

TEAMS IN THE SIMULATION

Each of the three teams in the simulation addresses different events.
- The Fire team handles any fire-related activities and provides medical care for injured victims.
- The Police team handles any crime-related activities through maintaining and imposing order.
- The Hazmat team addresses any bomb-related activities and chemical and biological clean-ups.

YOUR ROLE: RESOURCE MANAGER

Your primary functions are to:
1. Receive information and assessments about events.
2. Interpret the information and decide if the team should ignore the event or respond to it.
3. Consult the Resource Monitoring tab, if necessary, to compare the situation to previous events.
4. Allocate the correct number and appropriate type of resources to events.
5. Monitor the resources as they respond to events and return to headquarters after events elapse.

REMEMBER: Not all events will require your team’s resources or assistance. You do not need to respond to every event during the course of an episode.
Appropriate resources will remain on-scene until an event reaches completion. Thus, it is essential that you keep track of your resources and do not over or under allocate.

USER INTERFACE

The following aspects of the interface are indicated on the above screenshot: team name, clock, role, team score bar, Department of Homeland Security (DHS) threat level, main map panel, zoom tool, move tools, mini map panel, event message tracker, chat panels, and information tab.

BASIC OPERATING PROCEDURE

1. During the simulation, you will receive new event notifications in two locations on the interface:
   - The Event Tracker Table in the lower left-hand corner.
   - On the Main Map via an Active Alert Icon.

2. Clicking on either interface location will bring up additional information about the event, and present the options to either IGNORE the event or ALLOCATE RESOURCES to the event.

3. Clicking IGNORE will change the status of an event to IGNORED in the Event Tracker and replace the Event Icon on the Main Map with the Ignored Alert icon. Ignored events can be returned to at any time by clicking on the event in the Event Tracker Table or the Ignored Alert Icon on the Main Map.

4. Clicking ALLOCATE RESOURCES will bring up a Send Resource window.
   - Click the arrows to increase or decrease the number of resources to send to the event.
   - Note that you have limited resources to send to events. Events typically only require a single unit type and sending too many resources may leave you unnecessarily shorthanded.
- Resources take time to reach the event on the map and return to headquarters after an event is completed.

5. Resources arrive on-scene and report their status. The map icon will change to reflect the new state. At that time, you may need to reallocate resources, send more of the same type, or your resources will automatically be recalled to headquarters if the event does not require your team.

RESOURCES
Below are the types of resources available to you, as the Resource Manager. The type of resources described will depend on whether the Fire, Police, or Hazmat team is receiving the information.

Information received by the Fire team:

<table>
<thead>
<tr>
<th>Resources</th>
<th>Functions</th>
</tr>
</thead>
</table>
| Fire Investigative Units | - Investigate fire-related activities  
                                      - Research the cause of fires
                                      - Perform safety inspections  
                                      - Maintain public and some private equipment such as hydrants, extinguishers, escape ladders, etc. |
| Fire Truck Units   | - Extinguish fires of various sizes  
                                      - Sometimes required at school talks and other safety events |
| Ambulance/EMT Units | - Provide medical care for injured victims or preventative care for individuals  
                                      - EMT units handle other maladies such as food poisoning in tandem with Hazmat officials |

Information received by the Police team:

<table>
<thead>
<tr>
<th>Resources</th>
<th>Functions</th>
</tr>
</thead>
</table>
| Squad Cars     | - Respond to a wide range of calls, such as domestic disturbances, breaking and entering, loitering, etc.  
                                      - Often present at public events in order to maintain peace and impose order  
                                      - Make arrests and take criminals into custody  
                                      - Handle small gatherings such as voter registrations and entertainment events  
                                      - Sent for crowd control when the threat of violence is low  
                                      - Make appearances at different high school and university speaking engagements |
| SWAT Units     | - Control riots and demonstrations involving large crowds  
                                      - Serve warrants or forcefully disarm violent and armed offenders  
                                      - Manage weapons collection and transport |
- Monitor buildings and perform raids as necessary
- Respond to hostage situations
- Handle any military related crime
- Escort higher officials

Police Investigative Units
- Investigate police-related activities through: questioning witnesses, receiving statements from victims, searching premises for crime scene evidence
- Retrieve evidence from crime scenes, conduct searches, serve warrants for unarmed suspects, investigate dead bodies or remains

Information received by the Hazmat team:

<table>
<thead>
<tr>
<th>Resources</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomb Squads</td>
<td>- Disarm, dispose of, detonate, and transport any explosives</td>
</tr>
<tr>
<td></td>
<td>Investigate bomb threats of any type</td>
</tr>
<tr>
<td></td>
<td>Occasionally visit schools for safety talks</td>
</tr>
<tr>
<td></td>
<td>Perform post-explosion clean-ups</td>
</tr>
<tr>
<td></td>
<td>Deal with heavy artillery, such as rockets, missiles, or grenades</td>
</tr>
<tr>
<td></td>
<td>Investigate events related to bombs and bomb-like materials</td>
</tr>
<tr>
<td>Chemical Trucks</td>
<td>- Clean-up, dispose, and transport all material of a chemical, biological, or radiological nature</td>
</tr>
<tr>
<td></td>
<td>- Decontaminate and secure the scene of a chemical spill Provide clean-up support for industrial and utility operations</td>
</tr>
<tr>
<td></td>
<td>- Deliver volatile products, secure old chemical inventories, and transport spent nuclear cores</td>
</tr>
<tr>
<td></td>
<td>- Occasionally lecture on chemical safety at a variety of venues</td>
</tr>
<tr>
<td>Hazmat Investigative Units</td>
<td>- Investigate hazardous material-related activities</td>
</tr>
<tr>
<td></td>
<td>- Search for possible threats, such as spills, gas leaks, or possible contamination</td>
</tr>
<tr>
<td></td>
<td>- Collect and analyze samples of a suspicious nature</td>
</tr>
<tr>
<td></td>
<td>- Perform inventories and inspections for businesses and schools in the community</td>
</tr>
</tbody>
</table>

CONCLUSION

This concludes the basic training guide. At this time, please wait patiently at this screen for the experimenter to give you the signal to move on to the next portion of your training segment.

PLEASE WAIT AT THIS SCREEN FOR FURTHER INSTRUCTIONS.

THANK YOU.
Appendix C: Script for Team Coordination Training Video

Welcome to the Team coordination Training module
In this training you will learn about the three core elements of team coordination

The three core elements of team coordination are:
1. Planning
2. Communicating, and
3. Assessing the situation

These elements will each be discussed in 4 steps:
Step 1: PowerPoint – Defines the construct
Step 2: Video – Shows how the strategies are used
Step 3: Quiz – Test your knowledge of the material
Step 4: Review – Check your answers to the quiz

Your training will now begin. Have fun!

Module 1: Planning
Effective Planning Involves:
1. Seeking out information
2. Making plans
3. Re-evaluating plans

More specifically, planning involves:
1. Seeking out information (this should be done before making a decision)
   a. the problem should be clearly defined,
   b. more than one option should be discussed on how to resolve the problem,
   c. the consequences of sticking to the proposed plan should also be discussed
2. Making plans
   a. these plans should be specific
   b. they should also focus on both short and long term strategies, and finally
3. Re-evaluating plans
   a. all plans should be flexible
   b. you and your teammate should be able to know when a plan is not working and develop an alternative solution to the problem

You will now watch a series of video clips on the 3 components of Planning.
NOTE: Even though the Information and Resource Managers are verbally communicating, All communication in the actual simulation should be written, NOT VERBAL.

The clip that you will view will highlight the Planning aspect of team coordination.
Planning Involves:
1) Seeking out information (this should be done before making a decision)
   - An example of ineffective information seeking was seen in this clip in the following clip:
     - <play clip: IM: “Things are piling up. We need to send resources now.”>
     - While the IM is trying to make a plan to deal with the accumulating resources, he has not gathered any information from the RM on why she is not sending resources. A better response to the RM saying “I’m gonna wait a while” would be for the IM to ask: “Are you running low on resources?”
   - The RM also fails to gather more information in the following clip
     - <play clip: RM: “Can we wait a while? We have to be picky about what we respond to.”>
     - Even though the RM is making an attempt at developing a plan she still has not consulted with the IM to gather more information on the pace of the events.
     - Remember relevant information needs to be gathered before making a decision.

2) Planning also involves making specific plans
   - An example of ineffective planning is seen in the following clip:
     - <play clip: IM: “I don’t think it’s best to wait. Let’s just do it! We don’t have time to strategize.”>
     - Not planning or strategizing is rarely the right option. If there is no time to strategize a brief short term plan should be developed.
   - An example of effective planning is seen in the following clip:
     - <play clip: RM: “If we don’t figure this out we could run low on resources.”>
     - This clip demonstrates that the RM is considering the consequences of the decision to simply send resources at all costs.
     - An increase in the severity of events may decrease the team’s resources.
     - Monitoring the team’s resources is a good way to identify changes in the environment and the need to adjust the team’s strategy.
   - Another example of effective planning was seen in the following clip:
     - <play clip: IM: “That’s true. Well right now the events aren’t coming that quickly so conserving resources seems to be less of an issue. I’ll let you know when things start to pile up on me and we can try to save resources for bigger events.”>
     - In this clip, the IM makes an attempt at building both a short and long term plan.

3) Finally, planning involves re-evaluating plans
   - An example of effective re-evaluation of plans is seen in the following clip:
To summarize, effective planning involves:

1. **Seeking out information** (this should be done before making a decision)
   a. the problem should be clearly defined,
   b. more than one option should be discussed on how to resolve the problem,
   c. the consequences of sticking to the proposed plan should also be discussed

2. **Making plans**
   a. these plans should be specific
   b. they should also focus on both short and long term strategies, and
   finally

3. **Re-evaluating plans**
   a. all plans should be flexible
   b. you and your teammate should be able to know when a plan is not working and develop an alternative solution to the problem

Please take a moment to answer the following question.

What are the three components of planning?

Please compare your response on the quiz to the following slide.

Effective planning involves:

1. **Seeking out information** (this should be done **before** making a decision)
   a. the problem should be clearly defined,
   b. more than one option should be discussed on how to resolve the problem, and
   c. the consequences of sticking to the proposed plan should also be discussed

2. **Making plans**
   a. these plans should be specific
   b. they should also focus on both short and long term strategies, and
   finally

3. **Re-evaluating plans**
   a. all plans should be flexible
   b. you and your teammate should be able to know when a plan is not working and develop an alternative solution to the problem

**Module 2: Communicating**

Effective Communicating Involves:

1. Providing information
2. Checking to make sure you understand each other
3. Ensuring that communication is clear and concise

More specifically, communicating involves:

1. Providing information involves
   a. stating information when asked or when needed,
   b. acknowledging comments made by your teammate, and
   c. giving feedback on the accomplishment of events

2. Checking to make sure you understand each other
   a. by more specifically, ensuring that you and your teammate are on the same page by asking questions and restating what you do not understand

3. Ensuring that communication is clear and concise
   a. this can be done by stating information in a specific and brief way, and
   b. asking for an explanation of unclear statements

You will now watch a series of video clips on the 3 components of Communicating. 
NOTE: Even though the Information and Resource Managers are verbally communicating, All communication in the actual simulation should be written, NOT VERBAL.

The clips that you will view will highlight the Communicating aspect of team coordination.

Communicating involves:

1) Providing information
   • An example of effectively providing information is seen in the following clip:
     o <play clip: RM: “The second event was completed.”>
     o In this clip the RM stated information when it was needed.
     o This information helped the Information Manager keep track of the resolution of events
   • Another example of the effective provision of information is seen in the following clip
     o <play clip: RM: … IM: “Got it.”>
     o In this clip, the IM acknowledged something said by his team member.
   • An example of the ineffective provision of information is seen here:
     o <play clip: IM: “What’s the status of the first event?” RM: “How should I know?”>
     o In this clip, the RM failed to provide feedback on the accomplishment of an event and ignored a request for information from the IM.
     o The IM then did not respond to the RM’s statement.
     o The fact that the IM did not explain why he needed the information also demonstrates ineffective communication.

2) Communicating also involves Checking to make sure you understand each other
   • An example of effectively asking for an explanation of unclear statements is seen in the following clip:
The IM asks for an explanation of what his team member said. He could have also restated what he did not understand. For example by asking: “The credentials were off?”

2) Finally, Communicating involves ensuring that sent messages are clear and concise

- An example of repeating information in a clearer way is seen in the following clip:
  - <play clip: RM: “The message said that the units arrived on-scene, but did not have the proper credentials to address the situation. They sent them back to us.”>.
  - Here the RM repeated the information stated previously as “the credentials being off” and rephrased it in a clearer manner.

To summarize effective communicating involves:

1. Providing information involves
   a. stating information when asked or when needed,
   b. acknowledging comments made by your teammate, and
   c. giving feedback on the accomplishment of events

2. Checking to make sure you understand each other
   a. by more specifically, ensuring that you and your teammate are on the same page by asking questions and restating what you do not understand, and finally

3. Ensuring that communication is clear and concise
   a. this can be done by stating information in a specific and brief way, and
   b. asking for an explanation of unclear statements

Please take a moment to answer the following question.
What are the three components of communicating?

Please compare your response on the quiz to the following slide.

Communicating involves:

1. Providing information involves
   a. stating information when asked or when needed,
   b. acknowledging comments made by your teammate, and
   c. giving feedback on the accomplishment of events

2. Checking to make sure you understand each other
   a. by more specifically, ensuring that you and your teammate are on the same page by asking questions and restating what you do not understand, and finally

3. Ensuring that communication is clear and concise
   a. this can be done by stating information in a specific and brief way, and
   b. asking for an explanation of unclear statements
Module 3: Assessing (the situation)

Effectively Assessing (the situation) involves:
1. Keeping team members informed about team-related or environmental changes
2. Showing that you are paying attention to what you and your team members are doing, and finally
3. Identifying current problems and anticipating future problems

Assessing (the situation) involves:
1. Keeping team members informed about team-related or environmental changes:
   a. An example of an environmental change is receiving an increasing number of events, also
   b. Information that is provided should be given just as it is needed (that’s not too early or not too late)
2. Showing that you are paying attention to what you and your team members are doing, by
   a. Closely monitoring your resources, and
   b. Asking questions about events you are uncertain about, and finally
3. Identifying current problems and anticipating future problems
   a. Look out for chained events or patterns in events

You will now watch a series of video clips on the 3 components of Assessing the situation.
NOTE: Even though the Information and Resource Managers are verbally communicating, all communication in the actual simulation should be written, NOT VERBAL.

The clips that you will view will highlight the Assessing aspect of Team Coordination.

Assessing involves:
1) Keeping team members informed about team-related or environmental changes
   a. An example of effective environmental awareness was seen in the following clip:
      i. <play clip: IM: “Things are getting a little crazy. I have a lot of events to sort through.”>
   b. Information is also provided in an timely manner in the following clip:
      i. <play clip: RM: “No problem. I’ve almost gotten through the events you sent.”>
2) Showing that you are paying attention to what you and your team members are doing
   a. An example of poor awareness of team functioning is seen in the following clip:
      i. <play clip: RM: “Oh no! Where did all my EMT units go?”>
      ii. In this clip, the RM was not closely monitoring her resources, which suggests that she was not paying close attention to what was occurring in the team.
b. An example of being aware of team functioning can be seen in the following clip
   ii. <play clip: RM: “I just got the events you just sent me. Are you sure about the first event? Is that us?”>
   iii. In this clip, the RM is uncertain about whether or not her team should respond to the event and is double-checking this information with the IM.
   iv. An inappropriate response to a situation like this in which you receive an event you are unsure about is to blindly allocate resources to events, finally effectively assessing the situation involves...

3) Identifying current problems and anticipating future problems
   a. An example of effectively anticipating problems can be seen in the following clip:
      i. <play clip: IM: “There was a report on food poisoning. They only need chemical samples for now but we should keep an eye on it because they may need our help later.”>
      ii. In this scene, the IM is using information or patterns in events to identify possible problems.

To summarize, effectively assessing the situation involves:
1. Keeping team members informed about team-related or environmental changes:
   a. an example of an environmental change is receiving an increasing number of events, also
   b. information that is provided should be given just as it is needed (that’s not too early or not too late)
2. Showing that you are paying attention to what you are doing and what your team members are doing, by
   a. closely monitoring your resources, and
   b. asking questions about events you are uncertain about, and finally
3. Identifying current problems and anticipating future problems
   a. look out for chained events or patterns in events

Please take a moment to answer the following question.
What are the three components of assessing the situation?

Please compare your response on the quiz to the following slide.
Effectively assessing the situation involves:
1. Keeping team members informed about team-related or environmental changes:
   a. an example of an environmental change is receiving an increasing number of events, also
   b. information that is provided should be given just as it is needed (that’s not too early or not too late)
2. Showing that you are paying attention to what you are doing and what your team members are doing, by
a. closely monitoring your resources, and
b. asking questions about events you are uncertain about, and finally

3. Identifying current problems and anticipating future problems.
   a. look out for chained events or patterns in events

Congratulations! You have completed all 3 Modules of the Team Coordination Training.

TOTAL DURATION: 15 minutes.
Welcome to the Team Cross-Training Module
In this training you will learn about the duties and responsibilities of the Information Manager and the Resource Manager.

This training will be divided into 4 steps:
Step 1: PowerPoint – which describes your teammate’s role
Step 2: Video – which will demonstrate and explain how the role is done
Step 3: Quiz – which will test your knowledge of your teammate’s role
Step 4: Review – in which you will check your answers to the quiz
Your training will now begin. Have fun!

THE INFORMATION MANAGER

The primary functions of the INFORMATION MANAGER are to:
1. Interpret event information and decide if your team should ignore the event or respond to it.
2. Pass relevant events on to the Resource Manager along with his assessment of the situation.
3. Communicate any concerns regarding other team’s events to other Information Managers.

The Information Manager is responsible for handling all lines of communication between your team and the other teams in the system.

ICON EXPLANATION

The Information Manager, is required to assign an appropriate icon to an event before sending it to his/her partner. These icons are a quick form of assessment and can be critical to a speedy response. Please take a moment to review these icons:

You will now watch a video clip on the 3 roles of the Information Manager.
NOTE: Even though the Information and Resource Managers are verbally communicating, all communication in the actual simulation should be written, not verbal.

**NARRATED VIDEO ON THE INFORMATION MANAGER**

<For the FIRE Team>

- As will be shown in this clip, the main responsibilities of the IM involve reading through all events and determining which ones relate to the Fire team. He also has the ability to communicate with other Information Managers and his Resource Manager.

- **Event 5:**
  - In this scene, the Information Manager is reading through the events.
  - He has decided to respond to the current event, which is a report on individuals vomiting and collapsing. This is a medical issue that will require the use of medical emergency personnel.
  - The Information Manager sends the event to the Resource Manager with the “Medical Emergency” icon attached.
  - The Information Manager can also choose to send a message with the event.
    - **Video Clip Conversation**
      - Fire IM to Fire RM: “I think this might be ours but what do you think?” (show the IM attaching a “medical emergency” icon to the sent event)
      - Fire RM to Fire IM: “I believe you’re right. I’ll send EMS to check it out.”

- **Event 6:**
  - The Information Manager ignores the next event. This event is related to disorderly conduct and would therefore pertain to the responsibilities of the Police team as opposed to the Fire team.
  - The main purpose of the IM is to manage the events to which the FIRE team responds.

- **Event 7:**
  - The Information Manager is now reviewing the next event.
  - He realizes that it relates to his team. This is a fire that is spreading to other buildings and potentially getting out of control.
  - The Information Manager sends the event to the Resource Manager and comments on its urgency.
    - **Video Clip Conversation**
      - Fire IM to Fire RM: “This fire may get out of hand. You may need to send more than one truck to get this resolved quickly.” (show the IM attaching a “general fire incident” icon to the sent event)
      - Fire RM to Fire IM: “I’m on it.”

- **Event 8:**
  - The Information Manager ignores the next event. This event relates to a chemical incident, which is more suited to the Hazmat team.
Ignored events do not require any further attention and are not seen by the Resource Manager. Only events that are sent by the Information Manager are visible to the Resource Manager.

If ignored events are not managed by the other teams, the FIRE IM can send messages to the POLICE or HAZMAT IM reminding them to respond to their events, as demonstrated in the following scene:

- Video Clip Conversation
  - Fire IM to Hazmat IM: “I think the first event was yours. Don’t you handle bomb threats?”
  - Hazmat IM to Fire IM: “Thanks Fire! You’re right. I missed that one.”

<For the POLICE team>

- As will be shown in this clip, the main responsibilities of the IM involve reading through all events and determining which ones relate to the Police team. He also has the ability to communicate with other IMs and his RM.

  Event 3:
  - In this scene, the Information Manager is reading through the events.
  - He has decided to respond to the current event, which is a noise complaint. This event relates to criminal activity and will therefore require the use of police personnel.
  - The Information Manager sends the event to the Resource Manager with the “Criminal activity” icon attached.
  - The Information Manager can also choose to send a message with the event.
    - Video Clip Conversation
      - Police IM to Police RM: “I think this might be ours but what do you think?” (show the IM attaching a “criminal activity” icon to the sent event)
      - Police RM to Police IM: “I believe you’re right. I’ll send a squad car to check it out.”

  Event 4:
  - The Information Manager ignores the next event. This event relates to a bomb threat, which is more suited to the Hazmat team.
  - The main purpose of the IM is to manage the events to which the Police team responds.

  Event 5:
  - The Information Manager reviews the next event and also chooses to ignore it. This event relates to a medical emergency, which is more suited to the Fire team.
  - Ignored events do not require any further attention and are not seen by the Resource Manager. Only events that are sent by the Information Manager are visible to the Resource Manager.
  - If ignored events are not managed by the other teams, the Police IM can send messages to the FIRE or HAZMAT IM reminding them to respond to their events, as demonstrated in the following scene:
- Video Clip Conversation
  - Police IM to Hazmat IM: “I think the second event was yours. Don’t you handle bomb threats?”
  - Hazmat IM to Fire IM: “Thanks Police! You’re right. I missed that one.”

- Event 6:
  - The Information Manager is now reviewing the next event.
  - He realizes that it relates to his team. This is a large riot that could potentially get out of control.
  - The Information Manager sends the event to the Resource Manager and comments on its urgency.
    - Video Clip Conversation
      - Police IM to Police RM: “This riot may get out of hand. You may need to send more than one unit to get this resolved quickly.” (show the IM attaching a “civil unrest/rioting” icon to the sent event)
      - Police RM to Police IM: “I’m on it.”

<For the HAZMAT Team>
- As will be shown in this clip, the main responsibilities of the IM involve reading through all events and determining which ones relate to the Hazmat team. He also has the ability to communicate with other IMs and his RM.
- Event 2:
  - In this scene, the Information Manager is reading through the events.
  - He has decided to respond to the current event, which is related to suspicious material on the lawn. This event relates to a chemical incident and will therefore require the use of Hazmat personnel.
  - The Information Manager sends the event to the Resource Manager with the “Chemical incident” icon attached.
  - The Information Manager can also choose to send a message with the event.
    - Video Clip Conversation
      - Hazmat IM to Hazmat RM: “I think this might be ours but what do you think?” (show the IM attaching a “chemical incident” icon to the sent event)
      - Hazmat RM to Hazmat IM: “I believe you’re right. I’ll send an investigator to check it out.”

- Event 3:
  - The Information Manager ignores the next event. This event relates to a noise complaint, which is more suited to the Police team.
  - The main purpose of the IM is to manage the events to which the HAZMAT team responds.

- Event 4:
  - The Information Manager is now reviewing the next event.
  - He realizes that it relates to his team. This is a bomb threat that, based on the victim’s report, may be highly feasible.
The Information Manager sends the event to the Resource Manager and comments on its urgency.

- Video Clip Conversation
  - Hazmat IM to Hazmat RM: “This threat may actually be linked to a bomb. You may need to send more than one unit to get this resolved quickly.” (show the IM attaching a “bomb threat” icon to the sent event)
  - Hazmat RM to Hazmat IM: “I’m on it.”

- Event 5:
  - The Information Manager ignores the next event. This event relates to a medical emergency, which is more suited to the Fire team.
  - Ignored events do not require any further attention and are not seen by the Resource Manager. Only events that are sent by the Information Manager are visible to the Resource Manager.
  - If ignored events are not managed by the other teams, the HAZMAT IM can send messages to the FIRE or POLICE IM reminding them to respond to their events, as demonstrated in the following scene:
    - Video Clip Conversation
      - Hazmat IM to Police IM: “I think the second event was yours. Don’t you handle noise complaints?”
      - Police IM to Hazmat IM: “Thanks Hazmat! You’re right. I missed that one.”

To review, the primary responsibilities of the Information Manager are to:

1. Interpret event information and decide if your team should ignore the event or respond to it,
2. Pass relevant events on to the Resource Manager along with his assessment of the situation, and
3. Communicate any concerns regarding other team’s events to other Information Managers.

Please take a moment to answer the following question.
What are the three primary responsibilities of the Information Manager?

Please compare your response on the quiz to the following slide.

The primary responsibilities of the Information Manager are to:

1. Interpret event information and decide if your team should ignore the event or respond to it,
2. Pass relevant events on to the Resource Manager along with his assessment of the situation, and
3. Communicate any concerns regarding other team’s events to other Information Managers.

THE RESOURCE MANAGER

The primary functions of the RESOURCE MANAGER are to:
1. Interpret event information and decide if your team should ignore the event or respond to it.
2. Allocate the correct number and appropriate type of resources to events.
3. Monitor the resources that are allocated to events and communicate event feedback messages to the Information Manager.

RESOURCES
The following slides present the three types of resources available to the Resource Manager.
Please take a moment to review these slides.

Information received by the Fire team:

<table>
<thead>
<tr>
<th>Resources</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Investigative Units</td>
<td>- Investigate fire-related activities</td>
</tr>
<tr>
<td></td>
<td>- Research the cause of fires</td>
</tr>
<tr>
<td></td>
<td>- Perform safety inspections</td>
</tr>
<tr>
<td></td>
<td>- Maintain public and some private equipment such as hydrants, extinguishers, escape ladders, etc.</td>
</tr>
<tr>
<td>Fire Truck Units</td>
<td>- Extinguish fires of various sizes</td>
</tr>
<tr>
<td></td>
<td>- Sometimes required at school talks and other safety events</td>
</tr>
<tr>
<td>Ambulance/EMT Units</td>
<td>- Provide medical care for injured victims or preventative care for individuals</td>
</tr>
<tr>
<td></td>
<td>- EMT units handle other maladies such as food poisoning in tandem with Hazmat officials</td>
</tr>
</tbody>
</table>

Information received by the Police team:

<table>
<thead>
<tr>
<th>Resources</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squad Cars</td>
<td>- Respond to a wide range of calls, such as domestic disturbances, breaking and entering, loitering, etc.</td>
</tr>
<tr>
<td></td>
<td>- Often present at public events in order to maintain peace and impose order</td>
</tr>
<tr>
<td></td>
<td>- Make arrests and take criminals into custody</td>
</tr>
<tr>
<td></td>
<td>- Handle small gatherings such as voter registrations and entertainment events</td>
</tr>
<tr>
<td></td>
<td>- Sent for crowd control when the threat of violence is low</td>
</tr>
<tr>
<td></td>
<td>- Make appearances at different high school and university speaking engagements</td>
</tr>
<tr>
<td>SWAT Units</td>
<td>- Control riots and demonstrations involving large crowds</td>
</tr>
<tr>
<td></td>
<td>- Serve warrants or forcefully disarm violent and armed offenders</td>
</tr>
<tr>
<td></td>
<td>- Manage weapons collection and transport</td>
</tr>
<tr>
<td></td>
<td>- Monitor buildings and perform raids as necessary</td>
</tr>
<tr>
<td></td>
<td>- Respond to hostage situations</td>
</tr>
</tbody>
</table>
- Handle any military related crime
- Escort higher officials

Police Investigative Units
- Investigate police-related activities through: questioning witnesses, receiving statements from victims, searching premises for crime scene evidence
- Retrieve evidence from crime scenes, conduct searches, serve warrants for unarmed suspects, investigate dead bodies or remains

Information received by the Hazmat team:

<table>
<thead>
<tr>
<th>Resources</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomb Squads</td>
<td>- Disarm, dispose of, detonate, and transport any explosives</td>
</tr>
<tr>
<td></td>
<td>- Investigate bomb threats of any type</td>
</tr>
<tr>
<td></td>
<td>- Occasionally visit schools for safety talks</td>
</tr>
<tr>
<td></td>
<td>- Perform post-explosion clean-ups</td>
</tr>
<tr>
<td></td>
<td>- Deal with heavy artillery, such as rockets, missiles, or grenades</td>
</tr>
<tr>
<td></td>
<td>- Investigate events related to bombs and bomb-like materials</td>
</tr>
<tr>
<td>Chemical Trucks</td>
<td>- Clean-up, dispose, and transport all material of a chemical, biological,</td>
</tr>
<tr>
<td></td>
<td>or radiological nature</td>
</tr>
<tr>
<td></td>
<td>- Decontaminate and secure the scene of a chemical spill Provide</td>
</tr>
<tr>
<td></td>
<td>clean-up support for industrial and utility operations</td>
</tr>
<tr>
<td></td>
<td>- Deliver volatile products, secure old chemical inventories, and</td>
</tr>
<tr>
<td></td>
<td>transport spent nuclear cores</td>
</tr>
<tr>
<td></td>
<td>- Occasionally lecture on chemical safety at a variety of venues</td>
</tr>
<tr>
<td>Hazmat Investigative Units</td>
<td>- Investigate hazardous material-related activities</td>
</tr>
<tr>
<td></td>
<td>- Search for possible threats, such as spills, gas leaks, or possible</td>
</tr>
<tr>
<td></td>
<td>contamination</td>
</tr>
<tr>
<td></td>
<td>- Collect and analyze samples of a suspicious nature</td>
</tr>
<tr>
<td></td>
<td>- Perform inventories and inspections for businesses and schools in</td>
</tr>
<tr>
<td></td>
<td>the community</td>
</tr>
</tbody>
</table>

You will now watch a video clip on the 3 roles of the Resource Manager.

NOTE: Even though the Information and Resource Managers are verbally communicating, all communication in the actual simulation should be written, NOT VERBAL.

NARRATED VIDEO ON THE RESOURCE MANAGER

<For the FIRE Team>
- As will be shown in this clip, the main responsibilities of the RM involves trying to successfully resolve each event related to the Fire team and communicate any concerns she has to the IM.
- Event 5:
In this scene, the Resource Manager is reading the event she has received from the Information Manager.

Once an event is received by the RM, she can either choose to:

- 1) ignore the event or
- 2) allocate resources

The current event is a report on two individuals vomiting and collapsing. This is an emergency medical issue that will require the use of the Fire team personnel.

The RM therefore decides to allocate resources. In doing so, the RM will need to make two decisions:

- 1) What type of resources to send? and 2) How many resources to send?

- The current event is a medical emergency and will require the use of ambulance/EMT units as opposed to fire trucks or investigative units.
- There are also only a small number of injured victims. Therefore only one EMT unit will be sufficient to resolve this event.

The RM will receive feedback on the status of the event that she may communicate to the IM:

- Video Clip Conversation
  - Fire RM to Fire IM: “The EMT units are on-scene and working to resolve the situation.”
  - Fire IM to RM: “Got it.”

Event 6:

- The next event is ignored by the Information Manager and is therefore not seen by the Resource Manager. The event is related to disorderly conduct, which would pertain to the responsibilities of the Police team as opposed to the Fire team. However, if this event was relayed to the RM in error by the IM, the RM would have the option to ignore the event. As seen in the following scenario:
  - Video Clip Conversation
    - Fire RM to Fire IM: “I don’t think the disorderly conduct event is ours. This seems better suited to Police.”
    - Fire IM to RM: “Got it.”

Event 7:

- The Resource Manager is now reviewing the next event that she has received from the Information Manager.
- She realizes that it relates to her team. This is a fire that is spreading to other buildings and potentially getting out of control.
- The Information Manager has also sent a message to the Resource Manager commenting on its urgency.
  - Video Clip Conversation
Fire IM to Fire RM: “This fire may get out of hand. You may need to send more than one truck to get this resolved quickly.”

Fire RM to Fire IM: “I’m on it.”

- The Resource Manager decides to send two fire trucks to the scene to extinguish the fire quickly.

- Note that the Resource Manager is only able to communicate with the Information Manager on her team and only sees events that are sent to her by the Information Manager.

<For the POLICE Team>

- As will be shown in this clip, the main responsibilities of the RM involves trying to successfully resolve each event related to the Police team and communicate any concerns she has to the IM.

Event 3:
- In this scene, the Resource Manager is reading the event she has received from the Information Manager.
- Once an event is received by the RM. She can either choose to:
  - 1) ignore the event or
  - 2) allocate resources
- The current event is a noise complaint. This event relates to criminal activity and will require the use of Police team personnel.
- The RM therefore decides to allocate resources. In doing so, the RM will need to make two decisions:
  - 1) What type of resources to send? and 2) How many resources to send?
  - The current event is a domestic disturbance, which requires the use of squad cars as opposed to SWAT or investigative units.
  - There is also the threat of “several noisy dogs” to deal with, which may require the use of more than one squad car. The RM therefore decides to send two squad cars to respond to the event.
  - (show the RM allocating 2 squad cars to the event)
- The RM will receive feedback on the status of the event that she may communicate to the IM:
  - Video Clip Conversation
    - Police RM to Police IM: “The squad cars are on-scene and working to resolve the situation.”
    - Police IM to Police RM: “Got it.”

Event 4:
- The next event is ignored by the Information Manager and is therefore not seen by the Resource Manager. The event is related to a bomb threat which would pertain to the responsibilities of the Hazmat team as opposed to the Police team. However, if this event was relayed to the RM in error by the IM, the RM would have the option to ignore the event. As seen in the following scenario:
  - Video Clip Conversation
• Police RM to Police IM: “I don’t think the bomb threat event is ours. This seems better suited to Hazmat.” (show the RM sending this message and selecting the ignore option for the event)

• Event 6:
  o The Resource Manager is now reviewing the next event that she has received from the Information Manager.
  o She realizes that it relates to her team. This is a large riot that could potentially get out of control.
  o The Information Manager has also sent a message to the Resource Manager commenting on its urgency.
    ▪ Video Clip Conversation
      • Police IM to Police RM: “This riot may get out of hand. You may need to send more than one unit to get this resolved quickly.” (show the IM attaching a “civil unrest/rioting” icon to the sent event)
      • Police RM to Police IM: “I’m on it.”
  o The Resource Manager decides to send two SWAT units to the scene to control the riot.

• Note that the Resource Manager is only able to communicate with the Information Manager on her team and only sees events that are sent to her by the Information Manager.

<For the HAZMAT Team>
• As will be shown in this clip, the main responsibilities of the RM involves trying to successfully resolve each event related to the Police team and communicate any concerns she has to the IM.

• Event 2:
  o The Resource Manager is reading the event she has received from the Information Manager.
  o Once an event is received by the RM. She can either choose to:
    ▪ 1) ignore the event or
    ▪ 2) allocate resources
  o The current event is a report of suspicious material on the lawn. This event relates to a chemical incident and will require the use of Hazmat team personnel.
  o The RM therefore decides to allocate resources. In doing so, the RM will need to make two decisions:
    ▪ 1) What type of resources to send? and 2) How many resources to send?
    ▪ The current event requires that units collect chemical samples from the lawn and interview residents. This is the job of investigative units, as opposed to bomb squads or chemical trucks.
    ▪ The report also states that the area that needs to be sampled is large. This indicates that more than one unit may be required. The
RM therefore decides to send two investigative units to the event.
(show the RM allocating 2 investigative units to the event)
- The RM will receive feedback on the status of the event that she may communicate to the IM:
  - Video Clip Conversation
    - Hazmat RM to Hazmat IM: “The investigative units are on-scene and working to resolve the situation.”
    - Hazmat IM to Hazmat RM: “Got it.”

- Event 3:
  - The next event is ignored by the Information Manager and is therefore not seen by the Resource Manager. The event is related to a noise complaint, which would pertain to the responsibilities of the Police team as opposed to the Hazmat team. However, if this event was relayed to the RM in error by the IM, the RM would have the option to ignore the event. As seen in the following scenario:
    - Video Clip Conversation
      - Hazmat RM to Hazmat IM: “I don’t think the noise complaint event is ours. This seems better suited to Police.”
        (show the RM sending this message and selecting the ignore option for the event)

- Event 4:
  - The Resource Manager is now reviewing the next event that she has received from the Information Manager.
  - She realizes that it relates to her team. This is a bomb threat that, based on the victim’s report, may be highly feasible.
  - The Information Manager has also sent a message to the Resource Manager commenting on its urgency.
    - Video Clip Conversation
      - Hazmat IM to Hazmat RM: “This threat may actually be linked to a bomb. You may need to send more than one unit to get this resolved quickly.”
        (show the IM attaching a “bomb threat” icon to the sent event)
      - Hazmat RM to Hazmat IM: “I’m on it.”
  - The Resource Manager decides to send two bomb squads to the scene to investigate the bomb-related event.

- Note that the Resource Manager is only able to communicate with the Information Manager on her team and only sees events that are sent to her by the Information Manager.

To review, the primary responsibilities of the Resource Manager are to:
1. Interpret event information and decide if your team should ignore the event or respond to it,
2. Allocate the correct number and appropriate type of resources to events, and
3. To monitor the resources that are allocated to events and communicate event feedback messages to the Information Manager.
Please take moment to answer the following question.
What are the three primary responsibilities of the Resource Manager?

Please compare your response on the quiz to the following slide.
The primary responsibilities of the Resource Manager are to:
1. Interpret event information and decide if your team should ignore the event or respond to it,
2. Allocate the correct number and appropriate type of resources to events, and
3. To monitor the resources that are allocated to events and communicate event feedback messages to the Information Manager.

Congratulations! You have completed the Team Cross-Training Module.

TOTAL DURATION: 14 minutes 53 seconds for each team video.
Appendix E: Team Coordination Training Quiz

QUIZ RESPONSES

Please use this sheet to record your responses to the quiz.

NOTE: DO NOT use this sheet to take notes during the video. Only use this sheet to write your ANSWERS to the quiz.

***You may PAUSE THE TIMER if you need more time to respond.***

What are the three components of planning?

QUIZ 1: RESPONSE

1. 

2. 

3. 

What are the three components of communicating?

QUIZ 2: RESPONSE

1. 

2. 

3. 

What are the three components of assessing the situation?

QUIZ 3: RESPONSE

1. 

2. 

3. 

Note. The italicized questions were not listed on quiz in the actual experiment.
Appendix F: Cross-Training Quiz

QUIZ RESPONSES

Please use this sheet to record your responses to the quiz.

NOTE: DO NOT use this sheet to take notes during the video. Only use this sheet to write your ANSWERS to the quiz.

***You may PAUSE THE TIMER if you need more time to respond.***

What are the three primary responsibilities of the Information Manager?

QUIZ 1: RESPONSE

1. ________________________________________________________________
   ________________________________________________________________

2. ________________________________________________________________
   ________________________________________________________________

3. ________________________________________________________________
   ________________________________________________________________

What are the three primary responsibilities of the Resource Manager?

QUIZ 2: RESPONSE

1. ________________________________________________________________
   ________________________________________________________________

2. ________________________________________________________________
   ________________________________________________________________

3. ________________________________________________________________
   ________________________________________________________________

Note. The italicized questions were not listed on the quiz in the actual experiment.
Appendix G: Team Coordination Training Reminder

Reminder:

Don’t forget to Implement what you Learned During Training!

Plan
1. Seek out information
2. Make plans
3. Re-evaluate plans

Communicate
1. Provide information to your partner
2. Check to make sure you understand each other
3. Ensure that communication between you and your partner is clear and concise

Assess the situation:
1. Keep team members informed about team-related or environmental changes
2. Show that you are paying attention to what you and your team members are doing
3. Identify current problems and anticipate future problems

In what area can you improve?

1. ____________________________________________________

2. ____________________________________________________

3. ____________________________________________________

Please keep these three areas in mind during the second round of training.
Appendix H: Cross-Training Reminder

Reminder:

Don’t forget to Implement what you Learned During Training!

The primary functions of the INFORMATION MANAGER are to:
1. Interpret event information and decide if your team should ignore the event or respond to it.
2. Pass relevant events on to the Resource Manager along with his assessment of the situation.
3. Communicate any concerns regarding other team’s events to other Information Managers.

The primary functions of the RESOURCE MANAGER are to:
1. Interpret event information and decide if your team should ignore the event or respond to it.
2. Allocate the correct number and appropriate type of resources to events.
3. Monitor the resources that are allocated to events and communicate event feedback messages to the Information Manager.

In what area can you improve?

1. ______________________________________________________
2. ______________________________________________________
3. ______________________________________________________

Please keep these in mind during the second round of training.
## Appendix I: Scenarios

### NeoCITIES Training Scenarios 1

<table>
<thead>
<tr>
<th>Order</th>
<th>Description</th>
<th>Team</th>
<th>Unit</th>
<th>Initial Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unit needed to supervise the towing of an illegally parked car. Towing company reports</td>
<td>Police</td>
<td>Squad Car</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>irate vehicle owner threatening representatives with a shotgun.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Bioengineering student reports a minor spill of waste resulted when he lost control of a container while transferring samples from laboratory. Send unit to assist with clean-up.</td>
<td>Hazmat</td>
<td>Chemical Truck</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>Resident reported seeing smoke pouring from neighbor's window. No alarms have sounded but units are advised to proceed with caution.</td>
<td>Fire</td>
<td>Fire Truck</td>
<td>1.25</td>
</tr>
<tr>
<td>4</td>
<td>Two fire extinguishers reported discharged and missing in Pollock Commons. Send unit to investigate and clean up.</td>
<td>Fire</td>
<td>Investigator</td>
<td>1.25</td>
</tr>
<tr>
<td>5</td>
<td>Small device found in maintenance closet is reportedly emitting a soft beeping noise and smells of gunpowder. Staff members suspect foul play by recently released janitor.</td>
<td>Hazmat</td>
<td>Bomb Squad</td>
<td>0.25</td>
</tr>
<tr>
<td>6</td>
<td>A statement is required from a criminally assaulted victim. Unit requested at victim's residence.</td>
<td>Police</td>
<td>Investigator</td>
<td>1.25</td>
</tr>
<tr>
<td>7</td>
<td>Suspicious smell reported wafting from sewer grate near the State College Municipal Building. Unit requested for further inspection.</td>
<td>Hazmat</td>
<td>Investigator</td>
<td>0.25</td>
</tr>
<tr>
<td>8</td>
<td>Resident in graduate housing complex requests immediate medical help. Reports experiencing sharp pains in chest and tingling sensation in his hand.</td>
<td>Fire</td>
<td>EMS</td>
<td>1.25</td>
</tr>
<tr>
<td>9</td>
<td>Officers needed to serve a warrant to a suspected violent sex offender. Suspect is believed to be armed and dangerous.</td>
<td>Police</td>
<td>SWAT</td>
<td>1.25</td>
</tr>
</tbody>
</table>

### NeoCITIES Training Scenarios 2

<table>
<thead>
<tr>
<th>Order</th>
<th>Description</th>
<th>Team</th>
<th>Unit</th>
<th>Initial Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small leaf fire reported by OPP on Old Main Lawn. Send unit to help extinguish.</td>
<td>Fire</td>
<td>Fire Truck</td>
<td>1.25</td>
</tr>
<tr>
<td>2</td>
<td>Deliver talk to community officials about chemicals and hazardous materials.</td>
<td>Hazmat</td>
<td>Investigative</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>Frantic parents called 911 to report their son falling out of a treehouse. Child's arm is suspected broken.</td>
<td>Fire</td>
<td>EMS</td>
<td>1.25</td>
</tr>
</tbody>
</table>
4 Unit needed to supervise the towing of an illegally parked car. Towing company reports irate vehicle owner threatening representatives with bodily harm.

5 Citizen reports finding an unexploded grenade in the basement of their grandfather's home. Send unit to reclaim and dispose of the explosives.

6 Warrant officers needed to present papers to suspected drug kingpin. Suspect is believed to be armed but alone.

7 Fire extinguisher discharged in West Halls dormitory. Investigate and replace or recharge unit if necessary.

8 Assault victim's statement required. Unit requested at victim's residence.

9 Supervise the draining of a wastewater treatment pond above North campus.

Performance Episode Scenarios 1 (Routine Context)

<table>
<thead>
<tr>
<th>Order</th>
<th>Description</th>
<th>Team</th>
<th>Unit</th>
<th>Initial Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Units needed for briefing on upcoming football weekend. Officials expect BOTH increased student rioting AND widespread injuries if we lose the game.</td>
<td>Police</td>
<td>Investigator</td>
<td>1.25</td>
</tr>
<tr>
<td>2</td>
<td>Send agents to Eisenhower to give training to campus security about bombs and bomb-making materials.</td>
<td>Hazmat</td>
<td>Investigator</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>Private citizen reports &quot;very loud music&quot; coming from a dorm. Party involving underage drinking is a possibility. Send unit to investigate.&quot;</td>
<td>Police</td>
<td>Squad Car</td>
<td>1.25</td>
</tr>
<tr>
<td>4</td>
<td>Director requests disposal of a large number of barrels containing expired chemicals found in the basement of Beaver Stadium. Some containers may be volatile. Units are advised to proceed with caution.</td>
<td>Hazmat</td>
<td>Chemical Truck</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>Investigate series of false alarms pulled in West Halls dormitory. Test and reset alarms.</td>
<td>Fire</td>
<td>Investigator</td>
<td>1.25</td>
</tr>
<tr>
<td>6</td>
<td>The front desk manager called to report a large group of intoxicated people lingering outside the Nittany Lion Inn. Send unit to disperse subjects.</td>
<td>Police</td>
<td>Squad Car</td>
<td>2.00</td>
</tr>
<tr>
<td>7</td>
<td>Fire extinguisher discharged in West Halls dormitory. Investigate and replace or recharge unit if necessary.</td>
<td>Fire</td>
<td>Investigator</td>
<td>1.25</td>
</tr>
</tbody>
</table>
8 Several intoxicated males seen fighting outside the University Club on College Ave and Atherton. No weapons are reported involved but a very large crowd has gathered around them that is obstructing traffic. Disperse crowd and arrest suspects.

9 Inventory the chemicals and hazardous materials at Beaver Stadium.

10 Open fire hydrant reported in front of dorm on Curtin Road. Send unit to repair.

11 Unit required to sweep and clear the Beaver Stadium area of any explosive materials.

12 Units needed to direct traffic at the intersection of College Ave and Atherton St.

13 Suspicious biological waste material found covering the sidewalk on College Ave. Send unit to collect sample and test.

14 A student called to report her friend vomiting and collapsing in the restroom at a local bar. Unit requested for treatment.

15 Young man reports his wallet and house keys stolen by an armed man. Send unit to interview victim and schedule a time for a visit with a sketch artist.

16 Caller reports falling asleep with a lit cigarette has led to a large fire in his residence. Resident is unable to contain the fire in the room and needs assistance.

17 Reported break-in at a small house on Allen St. Caller reports that he thought the owner was inside because it seems the burglar used keys to gain entry. Send unit to investigate.

18 Dispose of a small collection of fuel canisters from a mechanical engineering laboratory.

19 Employees report that an apartment has caught fire and spread to nearby store below. Units needed to suppress fire.

Performance Episode Scenarios 2 (Non-Routine Context)

<table>
<thead>
<tr>
<th>Order</th>
<th>Description</th>
<th>Team</th>
<th>Unit</th>
<th>Initial Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OPP has identified patches of dead grass on the football field. One anonymous caller reports seeing a couple of teenagers</td>
<td>Hazmat</td>
<td>Chemical Truck</td>
<td>0.25</td>
</tr>
</tbody>
</table>
spreading greenish liquid in the area two days prior.

2 Units needed to direct game day traffic at the intersection of Curtin Rd and University Dr.  
Police Squad Car 1.25

3 Pennsylvania’s Lt. Governor requires an escort from Nittany Lion Inn to Beaver Stadium. The Governor is very excited to watch the game and insists on making it to the stadium in time for kickoff.  
Police SWAT 1.25

4 Food poisoning reported at luncheon for visiting Governor. Units needed to investigate the source of chemicals that poisoned the food or water.  
Hazmat Investigator 0.25

5 The Governor has been reported as feeling ill from something he ate or drank at a luncheon. Send unit for treatment.  
Fire EMS 2.00

6 Group of students at the Creamery reported to be violently vomiting. Units requested to collect samples and investigate the case of possible food poisoning.  
Hazmat Investigator 0.25

7 Units requested at a massive infectious waste spill behind agricultural facility on campus grounds. Caller suspects that the chemicals may already be leaking into water supply. An immediate full-scale clean-up effort is necessary.  
Hazmat Chemical Truck 0.25

8 A series of pick-pockets have been reported from students along Curtin Rd. Send unit to investigate.  
Police Investigator 1.25

9 A student outside Beaver Stadium reports a strange smell coming from a barbeque grill. The caller suspects a possible gas leak. Unit needed to investigate.  
Fire Investigator 0.25

10 A tailgater along Park Ave reports that a small barbeque fire has started. Caller is concerned about it spreading to other grills next to him.  
Fire Fire Truck 1.25

11 Female student reports that a classmate has threatened to kill her by blowing her up "into little itty bitty pieces." Victim reports seeing the suspect sitting a few seats in front of her in the stands at Beaver Stadium."  
Hazmat Bomb Squad 0.25

12 A fire from a nearby grill has ignited a young woman’s blanket and tent. Units needed to extinguish the flames.  
Fire Fire Truck 2.00

13 Infuriated students have stormed the field at Beaver Stadium. Many fights have broken out between Penn State students and Ohio State fans. Units needed to disperse the crowd and arrest subjects.  
Police SWAT 2.00
14 A large group of VIPs require an escort from Beaver Stadium directly to the University Park Airport. Police SWAT 1.25
15 Units requested to treat young woman for very minor burns from barbeque fire. Fire EMS 1.25
16 Pennsylvania's Lt. Governor requires an escort from Beaver Stadium to the Nittany Lion Inn. The Governor is very unnerved by the student riots. Police SWAT 1.25
17 Student along Park Ave reports having slight difficulty breathing from smoke in the area. Student feels fine but is concerned about his asthma being triggered. Fire EMS 1.25
18 Dispose of small pipe bomb found at private residence. Hazmat Bomb Squad 0.25
19 Student caller twisted his leg running from Beaver Stadium. Unit requested for treatment. Fire EMS 1.25
20 Several groups of Penn State students reportedly beating on the vehicles of Ohio State fans and are blocking traffic. Units needed to disperse the crowd and arrest subjects. Police SWAT 3.00
21 Woman outside Beaver Stadium reports that her husband is complaining about increased chest pains and may be having a heart attack. She is concerned about the increased traffic in the area. Immediate treatment is requested. Fire EMS 3.00
22 Suspicious bag found in locker room at the football stadium. Caller is not sure whether or not the bag looks familiar. She is concerned that it may be a bomb. Hazmat Bomb Squad 0.25
23 A series of burglar alarm systems have gone off at College Ave. Units requested to investigate and to apprehend suspects. Police Investigator 1.25
24 Large group of students seen throwing rocks at several passing cars. Police Squad Car 3.00
25 A young woman reports being hit in the head with a small rock. She says she feels okay but would still like to be examined. Unit requested for treatment. Fire EMS 1.25
26 Several abandoned briefcases reportedly emitting audible ticking noises were found in the stands at Beaver Stadium. Units needed to sweep and clear the area. Hazmat Bomb Squad 0.25
27 Many calls have been received on several students being trampled at the Beaver Stadium. Several units needed for widespread treatment. Fire EMS 3.00
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Service</th>
<th>Type</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>Caller reports group of intoxicated males throwing rocks at students in a local sports bar on College Ave.</td>
<td>Police</td>
<td>Squad Car</td>
<td>2.00</td>
</tr>
<tr>
<td>29</td>
<td>Caller is concerned that there may be explosive materials in his neighbor’s backyard. Units are requested for the recovery of the material.</td>
<td>Hazmat</td>
<td>Bomb Squad</td>
<td>0.25</td>
</tr>
<tr>
<td>30</td>
<td>A series of fire alarms have gone off along College Ave. Send unit to investigate.</td>
<td>Fire</td>
<td>Investigator</td>
<td>1.25</td>
</tr>
</tbody>
</table>
Appendix J: Script Used to Guide Experiment

SPRING 2009 EXPERIMENT
TEAM TRAINING

DIAGRAM OF LAB

BEFORE THEY ARRIVE:

1. Place a wooden block at the bottom of the front door to allow participants access into the building.
2. Ask participants to wait in the lounge area right outside the lab or beside the door if they show up early and you’re still waiting for 4 people to arrive.

IN THE LAB

1. Place dividers between each computer.
   - The dividers are stored next to the Server computer in the left-hand corner of the lab.
   - There are 4 dividers. Place one between each computer as shown in the diagram above.
2. Get 12 copies of the consent form from the first shelf in the Black Cabinet.
   - Place 2 copies of each consent form on the keyboard in front of each computer.
3. Get 6 copies of Packet 1 (each copy should represent the different roles in the diagram) and 6 copies of Packet 2 from the Black Cabinet.
   - Place 1 copy of Packet 1 to the RIGHT of the monitor beside each computer.
4. The name of the Packet should correspond with the role displayed in the diagram.
5. Get 6 copies of the corresponding Quiz and Reminder sheet for the condition you are running. These are labeled and located in the 2nd draw in the Black Cabinet. **DO NOT give these to students yet.**
   - TCT condition: quiz has 3 responses; reminder relates to plan, communicate, and assess
   - CT condition: quiz has 2 responses; reminder relates to IM and RM roles.

**ON THE COMPUTER**
1. Log-in using your CLA user account and password.
2. Double-click “My Computer” then “labs on 'clafs01.cla.psu.edu\dept\psyc’”
   - Go to the following location on the L-drive:
     o L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment
   - To figure out which session to run click the file:
     o “Schedule for Spring 2009 experiment.xls”
   - Based on the Condition listed in the Schedule, double-click the corresponding folder:
     o TCT = TCT Condition
     o CT = CT Condition
   - Then open the corresponding team and role assignment based on the computer at which you are located (Note: Simply look at the cover of the packet located to the right of the screen for this information).
   - Open the PowerPoint slide and **PUT IT ON Slide Show**.

**ONCE AT LEAST 4 PEOPLE HAVE ARRIVED:**
1. Let students know they can now enter the lab.
2. Ask them to have a seat in front of the computers.
   - Fill the seats for the Fire (1 & 2) and Police (3 & 4) teams first.
   - The diagram on page 1 illustrates the order in which the seats should be filled.
     o e.g., if you have 3 people show up they would play the roles of the Fire IM (1), Fire RM (2), and Police IM (3).
     o e.g., if you have 4 people show up they would play the roles of the Fire IM (1), Fire RM (2), Police IM (3), and Police RM (4).
3. Announce the following:
   - “There are two copies of the consent form on the keyboard. Please sign and date one copy and return it to me and keep the second copy for your records.”
   - “Please write your name legibly so that we can assign you your research credit.”
4. Leave the lab for a second and remove the block from the front door.
   - **Note:** If you have students that are running late, during the first 30 minutes of the experiment, listen out for the phone in the lounge area. Late participants will call this number to gain access to the building. Once the phone rings simply open the front door. You do not need to answer the phone.
5. Collect the consent forms and check their names off on the Sign-up Sheet.
ONCE EVERYONE HAS ARRIVED (and you have collected all the consent forms) announce the following:

“Hi my name is <state name>. I’m going to be your experimenter for the evening.”

“Today you’ll be participating in a series of tasks. You’ll be completing an online survey and participating in the NeoCITIES experiment. You’ll learn a little more about that in a second. While completing these tasks please keep two things in mind:

1) The PowerPoint slides will guide you through the experiment therefore do not close them at any point in the study, also

2) A browser will open up with your online survey responses. Do not close this browser at any point in the study either.

If there are no questions for me <pause briefly> you may begin.”

STEPS IN EXPERIMENT: Fire & Police Teams

1. Complete Demographics Online
   - If you see people looking around like they have trouble figuring out there role, make a general announcement:
     “Your team and role are on the cover of the packets to the right of you.”
   - Problem: Student tells you that he/she doesn’t recall SAT scores
     - Solution: Ask if he/she can remember at least the overall score. If not let him/her then know they can type n/a in the fields. DO NOT ANNOUNCE THIS TO EVERYONE. Only tell the person that asked the question. Go to them directly and tell them softly (not a whisper but in a low voice).

2. NeoCITIES Training PowerPoints
   - After completing the online survey, participants will then view a series of PowerPoints on the NeoCITIES Training material.
   - Problem: You see a student rushing through the slides.
     - Solution: Make the following general announcement:
       “Once you get to the PowerPoint slides, DO NOT RUSH through them. You will need to know this information to participate in NeoCITIES.”

3. Team Training
   - Once you see students open the link for the VIDEO, place the quiz forms on the keyboard in front of them and say:
     “You’re going to need this for the quiz in the video.”
   - Problem: You see students looking around for their headphones for the video.
     - Solution: Go over to the student and point out where the headphones are.
     - NOTE: The headphones are located on the top of each person’s CPU. It doesn’t matter whether or not they flip the on/off switch. This turns on a noise cancelling feature on the headphones but they can still hear what’s going on when the switch is in the off position.
   - Problem: There is no sound or the sound is too low/high.
     - Solution: Go to Settings > Control Panel > Double-click “Sounds and Audio Devices”
- Increase the “Device Volume” to high and remove “Mute,” if checked.
- For computer 3 (Police IM), there is a separate controller for sound on the cord for the headphones.
  - If the sound is too low/high. There is a volume adjuster on the lower left-hand corner of the “QuickTime” video that pops up. The link takes a while to load DO NOT click it more than once.

4. Online Survey
   - NOTE: Some people accidentally skip the online survey by clicking the mouse button.
   - Keep an eye on them and let them know they can go back to the survey by pressing the WINDOWS key. It will be the Internet Explorer or Mozilla Firefox Browser that’s open on the taskbar.
   - Problem: Student is staring at the multiple choice questions on the screen and taking a while to answer them.
     - Solution: Let that person know:
       - “Just do your best to answer the questions.”

5. Packet 1: Grids 1 & 2
   - Go over the instructions on how to complete team mental model measures.
   - Tell each person this information individually. If two people beside each other are more or less in the same spot, you can tell them at the same time.
     - i.) First give them a chance to read through the instructions.
     - ii.) Then ask: “Did you understand the example?”
   - Even if they say yes, go over the instructions (try to be friendly and personable not like a strict school teacher):
     “The idea here is that you’re relating each concept in the grid. <POINT THIS OUT ON THEIR SHEET> You’re only going to complete the white spaces. The scale is on 1 to 7 (so there are no 0’s or 10’s). In this example, the quarter-back and throw-pass is rated 7 because the quarter-back is the only one that can throw the ball. Huddle and throw and catch pass are rated 1 because you never throw or catch a pass in a huddle and Pass receiver and Huddle are rated 4 because the Pass receiver could be in the huddle or he couldn’t be. It’s likely that he’ll be there but it’s not necessary. <TURN PAGE>
     “When completing the grids, it’s best to read through all the definitions before you attempt to fill in any numbers just so you know what each of the columns mean. Once you know what the dimensions are, it’s best to fill in the extreme numbers first. So fill in the ones that you think are obviously not related (1) and extremely related (7). Then you can fill in the ones that are bit more fuzzy in the middle. Let me know if you have any questions.”
   - Once all members of the Fire and Police teams have completed Grids 1 and 2, let them know they can move to the next slide, i.e. the “Practice Session 1” Slide.

6. Training 1
   - Before you start the simulation, make the following announcement:
     “Before I start the simulation there are a couple ground rules I want to go over.
- Even though people were verbally communicating in the videos, all communication in the simulation should be written not verbal.
- Keep your eyes on your own screen. Do not look or reach across the dividers.
- The simulation will end abruptly so when it does it’s not because you did something wrong. That’s just how it ends.”

“Also, the Hazmat team will not be joining us today. Therefore please ignore any events you think would relate to Hazmat.”

“Keep these things in mind and I’ll start you up on your first Practice Session.”

- Make sure ALL the Clients for Police and Fire are open (i.e., you can see the interface on each of the 4 computers) before you start the Server.
  - **Problem:** The client on one of the computers fails to launch.
    - **Solution:** Close the black box and fire the link again. Usually, the second time is a charm 😊!
- Go to the following location on the L drive
  - L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment\The NeoCITIES Server Files\Batch_Files
  - Double-click “FIRE AND POLICE StartNCServer_Train1.bat”
- Once the simulation ends the interface will disappear and a black box will remain. Say:
  - “Don’t worry that’s just how it ends. You didn’t do anything wrong.”
  - “You can go ahead and close the black box on the screen and move to the next slide.”

7. Reminder
- Place the reminder on their keyboard or hand it to them.
- Let them take a MINUTE or so to read through this.
- Then say:
  - “Once you’ve had a chance to read through this sheet, please complete the bottom portion.”
- Once everyone has completed this sheet say:
  - “You can move to the next slide and click the link. This is round 2 of Practice.”

8. Training 2
- Make sure ALL the Clients for Police and Fire are open (i.e., you can see the interface on each of the 4 computers) before you start the Server.
- Go to the following location on the L drive
  - L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment\The NeoCITIES Server Files\Batch_Files
  - Double-click “FIRE AND POLICE StartNCServer_Train2.bat”
- Once the simulation ends the interface will disappear and a black box will remain. Say:
  - “Don’t worry that’s just how it ends. You didn’t do anything wrong.”
  - “You can go ahead and close the black box on the screen and move to the next slide.”

9. Performance 1
- “Go ahead and click the Performance 1 link, click RUN, then OK.”
Make sure ALL the Clients for Police and Fire are open (i.e., you can see the interface on each of the 4 computers) before you start the Server.

Go to the following location on the L drive
- L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment\The NeoCITIES Server Files\Batch_Files
- Double-click “FIRE AND POLICE StartNCServer_Perf1.bat”

Once the simulation ends the interface will disappear and a black box will remain. Say:
“You can go ahead and close the black box on the screen and follow the instructions on the next slide.”

10. Packet 1
   - After most people have completed the online survey, make the following announcement regarding Grid 3 in Packet 1.
     - “The grid that you’ll complete on this page is a little different. Instead of relating concepts, you’re relating the events that you just worked on. The idea here is to think about how interconnected or linked each event is to the others. Once again, it’s easier to fill in ones that you think are ‘extremely related’ (7) and ‘not related’ (1) first before you do the ones in the middle.”
     - “Please let me know if you have any questions on this.”
   - Collect Packet 1 (this includes their Quiz Responses and Reminder slide). Staple all the material together for each individual and place them on the Table.
   - After all Packet 1s have been collected, say:
     “Please move to the next slide and click the Performance 2 link, click RUN, then OK.”

11. Performance 2
   - Once again, make sure ALL the Clients for Police and Fire are open (i.e., you can see the interface on each of the 4 computers) before you start the Server.
   - Go to the following location on the L drive
     - L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment\The NeoCITIES Server Files\Batch_Files
     - Double-click “FIRE AND POLICE StartNCServer_Perf2.bat”
   - Once the simulation ends the interface will disappear and a black box will remain. Say:
     “You can go ahead and close the black box on the screen and follow the instructions on the next slide.”

12. Online Survey & Packet 2
   - As people get done with the online survey, distribute Packet 2. Say:
     - “Please complete all 3 Grids in Packet 2.”
     - Problem: You handed them the wrong Packet 2.
       - Solution: TRY NOT TO DO THIS, but if it happens don’t freak out.
         - The Police IM and RM can receive the same Packet 2.
         - The Fire IM or RM can also receive the same Packet 2.
         - Simply change the role (i.e., Information Manager or Resource Manager) on the cover of Packet 2, after you
collect it. You need to REMEMBER to do this or else the data will look screwy.

- **Problem:** Students see their peers leaving and rush through Packet 2.
  - **Solution:** Make a general announcement:
    “Please don’t feel rushed. You’ll have more than enough time to complete the experiment.”
  
  - NOTE: Make sure you collect Packet 1 before distributing Packet 2.
  - After students complete Packet 2 they will move to the next slide and finish the Online Survey.

13. Resume Online Survey
  - After students complete AND SUBMIT the online survey. Thank them for their participation and let them know they are free to go.

AFTER THE EXPERIMENT
2. Label the Packets with the Condition (e.g. CT or TCT), Date (e.g. 2/19/09), and Time Started (e.g. 5pm) in the top right hand corner of the document.
3. Staple Packet 1 and Packet 2 together and place them in the second drawer in the Black Cabinet.
4. Log off all the computers.
5. Replace dividers beside the Table next to the Server computer.

OTHER TROUBLE SHOOTING TIPS

**Problem: Participant Closes the Online Browser**
Solution: Go back to the second page of the PowerPoint, click the SurveyMonkey link, fill in their role, cut and paste “check previous” in any textboxes, click the extremes (all 1s) for the rating scale questions, and then you should have them caught up on where they should be. Don’t be too hard on them just make a general announcement saying “Remember to keep the online browser open.”

**Problem: Icons Do Not Appear (Only the Information Manager)**
Solution: Go up to them and let them know that whenever that occurs they can just run the mouse over the icons and they’ll appear. If they click one of the icons, the other buttons will appear. (Don’t announce this to everyone, just the tell the Information Manager this information when this problem occurs.)

**Problem: Participant wants to answer their phone**
Solution: Ask if it’s an emergency. If not, ask them nicely to wait a couple hours until the end of the experiment. If it is, let them take a quick break.

**Problem: You hear clicking when the participant should be waiting**
Solution: Walk around and look at the computer. If they are advancing through slides that they should take them back to where they are supposed to be and let them know they need to wait there for their teammates. (Try to say this in a polite way.)
**Problem:** Participant skips a section of the experiment.

Solution: This is a big issue. Let’s hope this doesn’t happen. The best solution to is to be aware of where all your participants are in the TIMELINE for the experiment and monitor whether or not they’ve completed each step. If they skip ahead, let them go back and complete what they skipped. Then make a note of it on their packet. This is most likely to occur with the online surveys and Packet 1.

<table>
<thead>
<tr>
<th>FIRE &amp; POLICE TIMELINE</th>
<th>HAZMAT TIMELINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demos: Online Survey</td>
<td>Demos: Online Survey</td>
</tr>
<tr>
<td>7 minutes</td>
<td>7 minutes</td>
</tr>
<tr>
<td>NC Training</td>
<td>NC Training</td>
</tr>
<tr>
<td>5 minutes</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Video</td>
<td>Practice 1</td>
</tr>
<tr>
<td>20 minutes</td>
<td>7 minutes</td>
</tr>
<tr>
<td>Reminder</td>
<td>Reminder</td>
</tr>
<tr>
<td>3 minutes</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Practice 2</td>
<td>Practice 2</td>
</tr>
<tr>
<td>7 minutes</td>
<td>7 minutes</td>
</tr>
<tr>
<td>Performance 1</td>
<td>Performance 1</td>
</tr>
<tr>
<td>10 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Online Survey</td>
<td>Online Survey</td>
</tr>
<tr>
<td>5 minutes</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Packet 1 (grids 1 &amp; 2)</td>
<td>Packet 1 (all 3 grids)</td>
</tr>
<tr>
<td>18 minutes</td>
<td>18 minutes</td>
</tr>
<tr>
<td>Practice 1</td>
<td>Video</td>
</tr>
<tr>
<td>7 minutes</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Reminder</td>
<td>Reminder</td>
</tr>
<tr>
<td>3 minutes</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Practice 2</td>
<td>Practice 2</td>
</tr>
<tr>
<td>7 minutes</td>
<td>7 minutes</td>
</tr>
<tr>
<td>Performance 1</td>
<td>Performance 1</td>
</tr>
<tr>
<td>10 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Online Survey</td>
<td>Online Survey</td>
</tr>
<tr>
<td>2 minutes</td>
<td>7 minutes</td>
</tr>
<tr>
<td>Packet 1 (grid 3)</td>
<td>Packet 2</td>
</tr>
<tr>
<td>7 minutes</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Performance 2</td>
<td>Online Survey</td>
</tr>
<tr>
<td>7 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Online Survey</td>
<td>Packet 2</td>
</tr>
<tr>
<td>10 minutes</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Packet 2</td>
<td>Online Survey</td>
</tr>
<tr>
<td>15 minutes</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Online Survey</td>
<td>3 minutes</td>
</tr>
</tbody>
</table>

**Blue sections need to be synchronized.**

**STEPS IN EXPERIMENT: Hazmat Teams**

**NOTE:** The Hazmat team will always be in the CT condition. Their reminder and quiz sheets should therefore always reflect that.

1. Complete Demographics Online
2. NeoCITIES Training PowerPoints
3. NeoCITIES Training 1
   - SYNCHRONIZATION: As soon as Fire and Police start their videos, Start Hazmat on Training 1.
   - Before you start the simulation, go to the Hazmat participants and softly tell them the following: “I’m going to start you on your first Practice session. Before I there are a couple ground rules I want to go over.
     - Keep your eyes on your own screen. Do not look or reach across the dividers.
     - The simulation will end abruptly so when it does it’s not because you did something wrong. That’s just how it ends.”
Make sure ALL the Clients for Hazmat are open (if there is only one Hazmat member then you only need to ensure that his or her interface is open) before you start the Server.

Go to the following location on the L drive

- L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment\The NeoCITIES Server Files\Batch_Files
- Double-click “HAZMAT StartNCServer_Train1.bat”

Once the simulation ends the interface will disappear and a black box will remain. Go to the Hazmat participant/s and softly tell them the following:
“Don’t worry that’s just how it ends. You didn’t do anything wrong.”
“You can go ahead and close the black box on the screen and move to the next slide.”

3. Reminder

- Place the reminder on their keyboard or hand it to them.
- Let them take a MINUTE or so to read through this.
- Then go to the Hazmat participant/s and softly tell them the following:
  “Once you’ve had a chance to read through this sheet, please complete the bottom portion.”
- Once they have completed this sheet let them know they can move to the next slide and click the link. This will be the second round of Practice.

4. Training 2

- Make sure ALL the Clients for Hazmat are open (if there is only one Hazmat member then you only need to ensure that his or her interface is open) before you start the Server.
- Go to the following location on the L drive
  - L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment\The NeoCITIES Server Files\Batch_Files
  - Double-click “HAZMAT StartNCServer_Train2.bat”
- Once the simulation ends the interface will disappear and a black box will remain. Softly say:
  “You can go ahead and close the black box on the screen and move to the next slide.”

5. Performance 1

- Softly say: “Go ahead and click the Performance 1 link, click RUN, then OK.”
- Make sure ALL the Clients for Hazmat are open (if there is only one Hazmat member then you only need to ensure that his or her interface is open) before you start the Server.
- Go to the following location on the L drive
  - L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment\The NeoCITIES Server Files\Batch_Files
  - Double-click “HAZMAT StartNCServer_Perf1.bat”
- Once the simulation ends the interface will disappear and a black box will remain. Softly say:
  “You can go ahead and close the black box on the screen and follow the instructions on the next slide.”

6. Online Survey
7. Packet 1
   o The Hazmat participant/s will complete the all 3 grids in Packet 1.
   o Remember to explain the instructions to them.

8. Video
   o Have the Hazmat participant/s wait at the BLUE SCREEN until the Fire and Police teams start their first Practice session. Then let Hazmat know they can move to the next screen and click the link. (Note: Hazmat should be watching the video DURING the Practice sessions and Performance 1 sessions for Fire and Police.)
   o Distribute the CT quiz sheet (it will ALWAYS be the CT quiz sheet) at this time to Hazmat.

9. Performance 2
   o SYNCHRONIZATION: As soon as Fire and Police are finish with Performance 1. Start Hazmat on Performance 2.
   o Make sure ALL the Clients for Hazmat are open (if there is only one Hazmat member then you only need to ensure that his or her interface is open) before you start the Server.
   o Go to the following location on the L drive
     - L:\Mohammedlab\Katherine's Dissertation Stuff\Spring 2009 Experiment\The NeoCITIES Server Files\Batch_Files
     - Double-click “HAZMAT StartNCServer_Perf2.bat”
   o Once the simulation ends the interface will disappear and a black box will remain. Softly say:
     “You can go ahead and close the black box on the screen and follow the instructions on the next slide.”
   o Collect all Packet 1 material and Distribute Packet 2.

10. Online Survey
    o The Hazmat participant/s will complete additional questions in the online survey.

11. Packet 2
    o The Hazmat participant/s will complete the all 3 grids in Packet 1.
    o Give them a brief reminder on the instructions.

10. Resume Online Survey
    o The Hazmat participant/s will them complete and SUBMIT the online survey.
    o Thank them for their participation and let them know they are free to go.
Appendix K: PowerPoint Slides Used to Guide Experiment

Welcome to the Experiment

These PowerPoint Slides will guide you through the study.

DO NOT Close this file at any point during the Experiment.

Please review the following slides on BASIC NeoCITIES Training...

DO NOT RUSH through these slides. You will need to know this information to participate in NeoCITIES.

- There are multiple TEAMS in the NeoCITIES system:
  - FIRE/EMS
  - Police
  - Hazmat

- Each of these three teams has two ROLES:
  - Information Manager & Resource Manager

- Your TEAM is Fire/EMS and your ROLE is the Information Manager.

Please complete the following online survey:

Welcome to the NeoCITIES Basic Training Guide!

This training will give you:
1) a rundown of your role as a member of the Fire/EMS team, and
2) additional information about the simulation in which you will be participating.

NOTE: If you have any questions at any time during the course of your participation, please consult the experimenter.

Fire/EMS Information Manager

The 3 MAIN functions of your role are to:

1. INTERPRET event information and decide if your team should ignore the event or respond to it.
2. PASS relevant events on to the Resource Manager along with your assessment of the situation.
3. COMMUNICATE any concerns regarding other teams’ (Police or Hazmat) events to other Information Managers.
The 3 MAIN functions of your role are to:

1. INTERPRET event information and decide if your team should ignore the event or respond to it:
   - You will receive new events in 2 locations:
     1. On the Main Map...
     2. In the Event Tracker Table...

Similar to 911 emergency calls, all teams in the system will receive the SAME list of events.

NEW EVENTS

- Only respond to the events that relate to your team.

The 3 MAIN functions of your role are to:

1. INTERPRET event information and decide if your team should ignore the event or respond to it:
   - You will receive new events in 2 locations:
     1. On the Main Map, and
     2. In the Event Tracker Table...
   - Double-clicking an event will open it.
   - New events can either be IGNORED or SUBMITTED to the Resource Manager.

NOTE: Ignored events can be returned to at a later time.
The 3 MAIN functions of your role are to:
1. INTERPRET event information and decide if your team should ignore the event or respond to it.
2. PASS relevant events on to the Resource Manager along with your assessment of the situation.
   - Only fire-related and medical emergency events should be sent to the Resource Manager.

The 3 MAIN functions of your role are to:
1. INTERPRET event information and decide if your team should ignore the event or respond to it.
2. PASS relevant events on to the Resource Manager along with your assessment of the situation.
   - Only fire-related and medical emergency events should be sent to the Resource Manager.
   - Sent events should include one of the following icons...

Only fire-related or medical emergency events should be sent to your Resource Manager. It is important to attach one of the following icons to each event that is sent.

The 3 MAIN functions of your role are to:
1. INTERPRET event information and decide if your team should ignore the event or respond to it.
2. PASS relevant events on to the Resource Manager along with your assessment of the situation.
3. COMMUNICATE any concerns regarding other teams’ (Police or Hazmat) events to other Information Managers.
   - Events that you ignore can be brought to the attention of other teams working in the NeoCITIES system by the chat panel...

Chat Panels
There are two tabs on the chat panel.
You may use this tab to talk to your Resource Manager...

Chat Panels
...and this tab to talk to all the other Information Managers.

The 3 MAIN functions of your role are to:
1. INTERPRET event information and decide if your team should ignore the event or respond to it.
2. PASS relevant events on to the Resource Manager along with your assessment of the situation.
3. COMMUNICATE any concerns regarding other teams’ (Police or Hazmat) events to other Information Managers.
   - Events that you ignore can be brought to the attention of other teams working in the NeoCITIES system by the chat panel.
   - Communicating with other Information Managers reduces the chance of events appearing as FAILED.
The NeoCITIES Interface

The following slides display key features of the NeoCITIES Interface.

You will now watch a brief 15-minute video clip on these and other concepts:

Please...
1. Turn on your headphones, and
2. Click the following link:

<Training Video>

NOTE: The video may take a while to load. Please ONLY click the link once.

This concludes the Basic Training Guide. Please proceed to the next step of the experiment:

1. First, Press the WINDOWS key to access and Resume the online survey.
2. Then, Complete GRID 1 and 2 in Packet 1.
CONGRATULATIONS!
You're now ready to Practice what you learned during training.

PLEASE WAIT AT THIS SLIDE
until you receive further instructions from the Experimenter.

PRACTICE SESSION 1
Click the link below to begin your 1st round of Practice...
<NC Training 1>
Select OK, then click RUN

NOTE: DO NOT be alarmed if the simulation ends abruptly.

REMEMBER...
Don't forget to use what you Learned in Training!
Please refer to the handout (from the experimenter) for a quick reminder.

PLEASE WAIT AT THIS SLIDE
until you receive further instructions from the Experimenter.

PRACTICE SESSION 2
Click the link below to begin your 2nd round of Practice...
<NC Training 2>
Select OK, then click RUN

NOTE: DO NOT be alarmed if the simulation ends abruptly.

GREAT JOB!
Hope you were able to implement what you learned during training.

Click the link below to begin your 1st Performance session...
<NC Performance 1>
Select OK, then click RUN

NOTE: DO NOT be alarmed if the simulation ends abruptly.

1. Press the WINDOWS key to access and Resume the online survey, then
2. Complete GRID 3 in Packet 1.
PLEASE WAIT AT THIS SLIDE until you receive further instructions from the Experimenter.

Click the link below to begin your 2nd Performance session...
<NC Performance 2>
Select OK, then click RUN

NOTE: DO NOT be alarmed if the simulation ends abruptly.

1. Press the WINDOWS key to access and Resume the online survey.
2. Complete all 3 grids in Packet 2.

3. Press the WINDOWS key to access and Finish the online survey.

THANK YOU FOR YOUR PARTICIPATION!

Please direct any questions on the study to Katherine Hamilton at klh365@psu.edu.
Appendix L: Control and Demographic Variables

CONTROL VARIABLES

Video Game Experience

In the past year, on average, how many hours per week (hrs/wk) have you spent playing each of the following games listed below. Please remember to list the name of the game/s played.

<table>
<thead>
<tr>
<th>Type of Game</th>
<th>Average number of hrs/wk</th>
<th>Name of Game/s Played</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer games</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online computer games</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Console games (e.g., X-Box, Playstation, Nintendo)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online console games</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Video/arcade games</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NeoCITIES (the current game)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Polychronicity

Please rate the extent to which you agree with each statement below on the scale provided.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Neither agree nor disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I like to juggle several activities at the same time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. I would rather complete an entire project everyday than complete parts of several projects.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. I believe people should try to do many things at once.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. I prefer to do one thing at a time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5. I believe it is best to complete one task before starting another.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Overall GPA: _____/4.0

SAT Scores:
Verbal: _____/800  Quantitative: _____/800  Overall: _____/1600
Training Satisfaction
Please rate the extent to which you agree with each statement below on the scale provided.
1 = strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = strongly agree

1. I am satisfied with the amount of training I received.
2. The training I received will be useful in playing the NeoCITIES simulation.
3. Overall, I am satisfied with the quality of the training program that I have just received.

Self-Efficacy
Please rate the extent to which you agree with each statement below on the scale provided.
1 = strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = strongly agree

1. I can meet the challenges of my role in this simulation.
2. I am confident in my understanding of how to make decisions.
3. I can deal with decisions under ambiguous conditions.
4. I am certain that I can manage the requirements of my position for this task.
5. I believe I will fare well in this task if the workload is increased.
6. I am confident that I can cope with my role if the simulation becomes more complex.
7. I believe I can develop methods to handle changing aspects of this task and my role.
8. I am certain I can cope with task components competing for my time.

DEMOGRAPHIC VARIABLES

Race:
1. Caucasian/White
2. African American/Black
3. Hispanic
4. Asian/Asian American
5. Indian
6. Other (Please specify)

Sex:
1. Male
2. Female

Academic year:
1. Freshman
2. Sophomore
3. Junior
4. Senior

Age:

Academic Major:

Work and Team Experience
1. How long have you:
   a. Worked in a full-time job _______ years _______ months
   b. Worked in a part-time job _______ years _______ months
   c. Worked in an emergency response unit _______ years _______ months

2. Please indicate on the scale provided below your level of comfort working in a virtual/distributed team.
   Extremely uncomfortable Moderately uncomfortable Neither comfortable nor uncomfortable Moderately comfortable Extremely comfortable
   1  2  3  4  5
Appendix M: Manipulation Check Items

TEAM TRAINING MANIPULATION CHECK ITEMS

OBJECTIVE ITEMS

Please complete the following questions, keeping the training you just received in mind.

Team Coordination Training Group

1. Which of the following strategies is NOT a core element of team coordination?
   A. Planning
   B. Trusting your teammate**
   C. Communicating
   D. Assessing the situation

2. Seeking out information BEFORE making a decision is used in which of the following strategies?
   A. Planning**
   B. Trusting your teammate
   C. Communicating
   D. Assessing the situation

3. Keeping team members informed about team-related or environmental changes is used in which of the following strategies?
   A. Planning
   B. Trusting your teammate
   C. Communicating
   D. Assessing the situation**

4. Identifying current problems and anticipating future problems is used in which of the following strategies?
   A. Planning
   B. Trusting your teammate
   C. Communicating
   D. Assessing the situation**

Cross-Training Condition

5. Which of the following is a key step in effective communication?
   A. Providing information.**
   B. Listening to what is said before responding.
   C. Repeating what your partner said.
   D. Seeking out information before making a decision.

6. The INFORMATION manager has the ability to communicate with which of the following people:
   A. all individuals in the Fire, Police, or Hazmat teams.
   B. only the resource manager on his/her specific team.
   C. all resource managers across all three teams.
   D. all information managers across all three teams.**
7. The RESOURCE manager has the ability to communicate with which of the following people:
   A. all individuals in the Fire, Police, or Hazmat teams.
   B. only the information manager on his/her specific team.**
   C. only the information managers across all three teams.
   D. only the resource managers across all three teams.

8. A key difference between the RESOURCE and INFORMATION managers roles is that the INFORMATION manager is responsible for:
   A. reviewing all events,**
   B. communicating information on the completion of events.
   C. monitoring the resources sent to events.
   D. communicating the feedback received on each event.

9. ____________ are attached to sent events to provide a quick visual description of each event.
   A. Icons**
   B. Symbols
   C. Images
   D. Identifiers

10. Your team has _____ types of resources to allocate to events. There are _____ units available of each type of resource.
   A. 2...5
   B. 3...5**
   C. 5...3
   D. 5...2

NOTE: ** Signifies the correct response.

SUBJECTIVE ITEMS

Please READ the instructions below carefully BEFORE moving to the next page.

INSTRUCTIONS
The questions on the next page relate to the material you learned IN THE VIDEO.
It is HIGHLY IMPORTANT that you complete these measures accurately.
Please AGREE ONLY if you received the material in the training VIDEO.
Please DISAGREE ONLY if you did not receive the material in the training VIDEO.
You may now click the "Next" button to continue.

REMEMBER...
For the following sets of questions:
AGREE ONLY if you received the material in the training VIDEO.
DISAGREE ONLY if you did not receive the material in the training VIDEO.
****Read the questions carefully.****
Please rate the extent to which you agree with each statement below on the scale provided.  
1 = strongly disagree  2 = disagree  3 = neither agree nor disagree  4 = agree  5 = strongly agree

**Team Coordination Training Group**

1. During training, the core elements of team coordination were EXPLICITLY discussed.
2. The training material explicitly discussed how to design plans and evaluate their effectiveness.
3. In training, I received details on how to evaluate environmental changes and identify current problems and anticipate future problems.
4. During training, I learned about the steps involved in developing different types of trust between me and my teammate. *

**Cross-Training Group**

1. During training, I received detailed descriptions on the primary functions of the Information Manager AND the Resource Manager.
2. The training helped me to understand the responsibilities of the Information Manager AND the Resource Manager.
3. Based on the knowledge I obtained in training, I would feel prepared to switch roles with the Information Manager or the Resource Manager on my team.
4. The training material taught me about the roles and SPECIFIC TYPES OF RESOURCES available to ALL teams in the system (i.e., all the resources of the Police, Fire, and Hazmat teams). *

*NOTE: * Indicates the distracter item for each scale.

**FORCED CHOICE ITEMS (SET 1)**

Please rate the extent to which you agree with each statement below on the scale provided. 
1 = strongly disagree  2 = disagree  3 = neither agree nor disagree  4 = agree  5 = strongly agree

1. The training material focused MORE ON describing the role of my teammate THAN on describing generic teamwork skills/coordination strategies.
2. The training focused MORE ON the steps involved in planning THAN on the specific roles of the Information and Resource Managers.
3. During training, I learned MORE about how to assess the situation THAN on the primary functions of the Information and Resource Managers' roles.
4. The training presented details on the responsibilities of the Information and Resource Managers' roles MORE SO THAN strategies on how to effectively coordinate as a team.

**FORCED CHOICE ITEMS (SET 2)**

1. The training material focused MORE on: (NOTE: Select only ONE) Describing details on the role of my teammate. Describing teamwork skills/coordination strategies.
2. The training material focused MORE on: (NOTE: Select only ONE) The specific roles of the Information and Resource Managers. The specific steps involved in effective planning.
3. The training material focused MORE on: (NOTE: Select only ONE) The primary functions of the Information and Resource Managers' roles.
The primary ways to assess the team and environmental situation.

4. The training material focused MORE on: (NOTE: Select only ONE)
   The responsibilities of the Information and Resource Managers’ roles.
   The strategies on how to effectively coordinate as a team.

ENVIRONMENTAL CONDITIONS MANIPULATION CHECK ITEMS

On the scale provided below, please rate how similar each of the following components of the work environment, you just experienced, were to the environment you worked in during the TRAINING PRACTICE sessions.

<table>
<thead>
<tr>
<th></th>
<th>completely new</th>
<th>somewhat new</th>
<th>neither new nor familiar</th>
<th>somewhat familiar</th>
<th>completely familiar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The speed at which events were received.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. The severity of the events.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. The speed at which events were resolved.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

The following open-ended question was also assessed after each performance episode:

How did you use the information learned in training in the NeoCITIES simulation YOU JUST COMPLETED?

1. _____________________________________________________
2. _____________________________________________________
3. _____________________________________________________
Appendix N: Task Mental Models

INSTRUCTIONS

In this packet you will be completing a series of grids.

It is **VERY IMPORTANT** that these grids are completed correctly.

Please follow the steps below, carefully.

1) Read through all the definitions of the dimensions listed on the left hand side before entering ANY information.

2) Insert a number only into the white boxes of the grid that ranges from 1 (Not Related) to 7 (Extremely Related).

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Related</td>
<td>Somewhat Related</td>
<td>Extremely Related</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3) It is easier to complete the boxes at the extreme ends of the scale FIRST (i.e., Extremely Related and Not Related), then complete those in the middle.

FOOTBALL EXAMPLE

(NOTE: This is a simplified example. The actual grids will have definitions of each dimension listed):

<table>
<thead>
<tr>
<th></th>
<th>Throw-pass</th>
<th>Catch pass</th>
<th>Huddle</th>
<th>Pass receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter-back</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Throw-pass</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Catch pass</td>
<td></td>
<td>1</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Huddle</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Pass receiver</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7 (Extremely Related): These events always occur together. In this example, the quarterback always throws passes therefore both are extremely related.

1 (Not Related): The two events are not dependent on each other, e.g., you would never catch a pass in the huddle.

4 (Somewhat Related): These events are likely to occur in the presence of the other but are not absolutely necessarily, e.g., the pass receiver is likely to be in a huddle but doesn’t necessarily have to be there.
Below are several descriptions of the technical aspects of completing events in NeoCITIES. Please rate how related each aspect is to all of the others. 

NOTE: Only complete the white squares. For example, the uppermost square asks you to rate how “Prioritize Events” is related to “Allocate Resources.” If you have any questions, please ask the experimenter.

<table>
<thead>
<tr>
<th>Prioritize Events: Assign a level of importance/value to the events received based on their severity.</th>
<th>Allocate Resources</th>
<th>Monitor Events</th>
<th>Classify Events</th>
<th>Filter Information</th>
<th>Relay Information</th>
<th>Re-evaluate Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocate Resources: Assign correct number and type of resources to events.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor Events: Evaluate the successful resolution of each event.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classify Events: Determine the type of team which should respond to the event.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter Information: Select which events to respond to and which ones to ignore.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relay Information: Pass event-related information on to your partner.</td>
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<tr>
<td>Re-evaluate Decisions: Revise a prior decision made on whether or not to respond to an event.</td>
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</tbody>
</table>
Appendix O: Teamwork Mental Models

<table>
<thead>
<tr>
<th></th>
<th>Develop Plans</th>
<th>Convey Information</th>
<th>Revise Strategy</th>
<th>Gather Details</th>
<th>Clarify Statements</th>
<th>Identify Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monitor Changes:</strong></td>
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<tr>
<td>Keep team members informed about team-related or environmental changes:</td>
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<tr>
<td><strong>Develop Plans:</strong></td>
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<tr>
<td>Develop specific plans on how to effectively resolve situations.</td>
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<tr>
<td><strong>Convey Information:</strong></td>
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<tr>
<td>Communicate information when asked or when needed.</td>
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<tr>
<td><strong>Revise Strategy:</strong></td>
<td></td>
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<tr>
<td>Revise existing plans and create an alternative solution to the problem.</td>
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<tr>
<td><strong>Gather Details:</strong></td>
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<tr>
<td>Request additional information on problems before making a decision.</td>
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<tr>
<td><strong>Clarify Statements:</strong></td>
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<tr>
<td>Ask questions and restate what you do not understand.</td>
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<tr>
<td><strong>Identify Problems:</strong></td>
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<tr>
<td>Anticipate problems that may arise during the simulation.</td>
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</tbody>
</table>
Appendix P: Situation Mental Models

<Performance Episode 1: FIRE situation mental model>

Below are several descriptions of the events in NeoCITIES. Please rate how LINKED, CHAINED, OR INTERCONNECTED each event is to the others.

NOTE: Only complete the white squares.

<table>
<thead>
<tr>
<th></th>
<th>Fire Extinguisher</th>
<th>Fire Hydrant</th>
<th>Vomiting in Bar</th>
<th>Apartment Fire</th>
<th>Store Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>7</td>
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</table>

Fire Alarms: Investigate series of false alarms pulled in West Halls dormitory. Test and reset alarms.

Fire Extinguisher: Fire extinguisher discharged in West Halls dormitory. Investigate and replace or recharge unit if necessary.

Fire Hydrant: Open fire hydrant reported in front of West Halls dorm. Send unit to repair.

Vomiting in Bar: A student called to report her friend vomiting and collapsing in the restroom at a local bar. Unit requested for treatment.

Apartment Fire: Caller reports falling asleep with a lit cigarette has led to a large fire in his residence. Resident is unable to contain the fire in the room and needs assistance.

Store Fire: Employees report that an apartment has caught fire and spread to nearby store below. Units needed to suppress fire.
Below are several descriptions of the events in NeoCITIES. Please rate how LINKED, CHAINED, OR INTERCONNECTED each event is to the others. **NOTE:** Only complete the white squares.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<tbody>
<tr>
<td>Not Related</td>
<td>Somewhat Related</td>
<td>Extremely Related</td>
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<tr>
<td><strong>Loud Music:</strong> Private citizen reports &quot;very loud music&quot; coming from a dorm. Party involving underage drinking is a possibility.</td>
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<td><strong>Lingering People:</strong> The front desk manager called to report a group of intoxicated people lingering outside the Nittany Lion Inn. Send unit to disperse subjects.</td>
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<tr>
<td><strong>Fighting Males:</strong> Several intoxicated males seen fighting outside the University Club on College Ave and Atherton. A very large crowd has gathered around them that is obstructing traffic.</td>
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<td><strong>Direct Traffic:</strong> Units needed to direct traffic at the intersection of College Ave and Atherton Street.</td>
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<td><strong>Stolen Wallet &amp; Keys:</strong> Young man reports his wallet and house keys stolen by an armed man. Send unit to interview victim and schedule a time for a visit with a sketch artist.</td>
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<tr>
<td><strong>House Break-in:</strong> Reported break-in at a small house on Allen St. Caller reports that he thought the owner was inside because it seems the burglar used keys to gain entry.</td>
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</table>
Below are several descriptions of the **events** in NeoCITIES. Please rate how **LINKED, CHAINED, OR INTERCONNECTED** each event is to the others.

**NOTE**: Only complete the white squares.

<table>
<thead>
<tr>
<th></th>
<th>Not Related</th>
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<th>Extremely Related</th>
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<td><strong>7</strong></td>
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</table>

**BBQ Fire**: A tailgater along Park Ave reports that a small barbeque fire has started. Caller is concerned about it spreading to other grills next to him.

**Tent Fire**: A fire from a nearby grill has ignited a young woman’s blanket and tent. Unit needed to extinguish the flames.

**Trouble Breathing**: Student along Park Ave reports having slight difficulty breathing from smoke in the area. Student is concerned about his asthma being triggered.

**Minor Burns**: Units requested to treat young woman for minor burns from barbeque fire.

**Twisted Leg**: Student caller twisted his leg running from Beaver Stadium. Unit requested for treatment.

**Chest Pains**: Woman outside Beaver Stadium reports that her husband is complaining about increased chest pains and may be having a heart attack. Immediate treatment is requested.

**Hit with Rock**: A young woman reports being hit in the head with a small rock. Unit requested for treatment.

**Trampled Students**: Many calls have been received on several students being trampled at the Beaver Stadium. Units needed for widespread treatment.
<Performance Episode 2: POLICE situation mental model>

Below are several descriptions of the events in NeoCITIES. Please rate how LINKED, CHAINED, OR INTERCONNECTED each event is to the others.

**NOTE:** Only complete the white squares.

<table>
<thead>
<tr>
<th></th>
<th>Escort VIPs</th>
<th>Student Riot</th>
<th>Escort Gov. Back</th>
<th>Beating Vehicles</th>
<th>Rocks at Cars</th>
<th>Rocks in Sports Bar</th>
<th>Burglar Alarms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escort Governor To:</td>
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<tr>
<td>Pennsylvania's Lt. Governor requires an escort from Nittany Lion Inn to Beaver Stadium. The Governor is very excited to watch the game.</td>
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<tr>
<td>Escort VIPs:</td>
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<tr>
<td>A large group of VIPs require an escort from the University Park Airport to the Beaver Stadium.</td>
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<tr>
<td>Student Riot:</td>
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<tr>
<td>Infuriated students have stormed the field at Beaver Stadium. Many fights have broken out between students and fans of the opposing team. Units needed to disperse the crowd.</td>
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<tr>
<td>Escort Governor Back:</td>
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<tr>
<td>Pennsylvania's Lt. Governor requires an escort back to the Nittany Lion Inn. The Governor is very terrified by the student riots.</td>
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<td>Beating Vehicles:</td>
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<tr>
<td>Several groups of students reportedly beating on the vehicles of visiting fans of the opposing team and are blocking traffic. Units needed to disperse the crowd.</td>
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<tr>
<td>Rocks at Cars:</td>
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<tr>
<td>Group of students seen throwing rocks at passing cars.</td>
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<tr>
<td>Rocks in Sports Bar:</td>
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<tr>
<td>Caller reports group of intoxicated males throwing rocks at students in a local sports bar on College Ave.</td>
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<tr>
<td>Burglar Alarms:</td>
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<tr>
<td>A series of burglar alarm systems have gone off at College Ave. Send units to investigate.</td>
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</table>
Appendix Q: Post-pilot Questionnaire and Oral Debrief

Post-pilot Questionnaire

Please rate the extent to which you agree with each statement below on the scale provided.

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
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</thead>
<tbody>
<tr>
<td>1. The training video I watched was too long.</td>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. The measures I completed were confusing.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I had difficulty comprehending the events in the simulation.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I found the NeoCITIES training material beneficial.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>5. I felt like I knew what other teams were doing during the simulation.</td>
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<tr>
<td>6. I was unsure about how to communicate with other teams.</td>
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<td>5</td>
</tr>
<tr>
<td>7. I felt like I needed more information to make correct decisions.</td>
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<td>5</td>
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<tr>
<td>8. I did not see any connections between events.</td>
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<tr>
<td>9. All of these events happened independently of each other.</td>
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<tr>
<td>10. I think there were connections between some of the events.</td>
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</tr>
<tr>
<td>11. I think each team had a part in resolving some related events.</td>
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<td>2</td>
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</tr>
</tbody>
</table>

List the top three (3) things that went well while working in the NeoCITIES simulation:
1. __________________________
2. __________________________
3. __________________________

List the top three (3) things that did not go well while working in the NeoCITIES simulation:
1. __________________________
2. __________________________
3. __________________________

Oral Debrief

1. What did you find confusing about the simulation?
2. Did you feel prepared to work in the NeoCITIES interface after receiving the training?
3. Did you find it difficult to complete the team mental model measures?
   i. If so, in what way? What could be done to make it clearer?
   ii. If not, what was particularly helpful for you to understand them?
Katherine L. Hamilton
Curriculum Vita

Department of Psychology, Pennsylvania State University
115C Moore Building, University Park, PA 16802
Email: klh365@psu.edu

EDUCATION

Pennsylvania State University, State College, PA
Ph.D., Industrial/Organizational Psychology (expected August 2009)
Major Advisor: Susan Mohammed, Associate Professor in Psychology
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Minor Advisor: Barbara Gray, Organizational Behavior, Director of the Center for Research in Conflict and Negotiation

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Advisor: Susan Mohammed, Associate Professor in Psychology

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B.A., Psychology (August 2004; Summa Cum Laude); Minor: Business

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A.A., Psychology (August 2002; Highest Honors with Distinction)

HONORS

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2003: APA PRIME Research Fellowship, Florida International University, FL
2001: APA PRIME Research Fellowship, Miami-Dade College, FL

PUBLICATIONS


MANUSCRIPTS IN PREPARATION


CHAIRMED CONFERENCE SESSIONS