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# Trust and cooperation as antecedents of team cognition: A temporal examination of the life cycle of team mental models

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TRUST AND COOPERATION AS ANTECEDENTS OF TEAM COGNITION:  
A TEMPORAL EXAMINATION OF THE LIFE CYCLE OF TEAM MENTAL  
MODELS

A Thesis

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## VITA

The author was born in Munich, Germany, on March 12, 1983. He graduated from University of Chicago Laboratory High School in 2001 and received his Bachelor of Arts degree in Psychology from The George Washington University in 2005.

## TABLE OF CONTENTS

Thesis Committee.....	ii
Acknowledgements.....	iii
Vita.....	iv
List of Tables.....	viii
List of Figures.....	ix
CHAPTER I. INTRODUCTION.....	1
Team Mental Models.....	2
Types of Team Mental Models.....	4
Operationalization of Team Mental Models.....	6
Antecedents of Team Mental Models.....	10
Team Processes and Mental Models.....	12
Personality and Teams.....	20
Rationale.....	28
Statement of Hypotheses.....	29
CHAPTER II. METHOD.....	30
Research Participants and Context.....	30
Measures.....	32
Control Variables.....	32
Personality Variables.....	34
Team Process of Planning.....	35
Team Process of Implicit Coordination.....	39
Mental Model Similarity.....	41

Team Performance.....	44
Procedure.....	44
CHAPTER III. RESULTS AND ANALYSES.....	49
Preliminary Analyses.....	49
Normality Assumption.....	49
Regression Assumptions.....	50
Hypothesis Testing.....	52
Hypothesis I.....	52
Hypothesis II.....	53
Hypothesis III.....	59
Hypothesis IV.....	59
Hypothesis V.....	60
Hypothesis VI.....	60
Hypothesis VII.....	61
CHAPTER IV. DISCUSSION.....	64
Mental Model Antecedents.....	64
Mental Model Consequences.....	66
Mental Model Changes Over Time.....	67
Study Limitations.....	68
Study Implications.....	71
CHAPTER V. SUMMARY.....	73
References.....	74
Appendix A. Demographic Information Questionnaire.....	84

Appendix B. Familiarity Check.....	86
Appendix C. Trust Scale.....	88
Appendix D. Cooperation Scale.....	90
Appendix E. Planning Scale.....	92
Appendix F. Additional Team Process Items.....	94
Appendix G. Implicit Coordination Scale.....	96
Appendix H. Teamwork Concepts used for Mental Model Elicitation.....	98



## LIST OF TABLES

Table 1.	Rotated Pattern Matrix for Principle Axis Factor Analysis (with Direct Oblimin Rotation) of Team Planning Scale.....	36
Table 2.	Descriptive Statistics and Correlations for All Study Variables.....	51
Table 3.	Summary of Hierarchical Regression Analysis of Planning as a Predictor of MM Similarity (post decision 4).....	53
Table 4.	Regression Analyses Examining Implicit Coordination as a Mediator of the MM Similarity and Team Performance Relationship.....	55
Table 5.	Summary of Hierarchical Regression Analysis of Trust as a Predictor of MM Similarity (post decision 2).....	61
Table 6.	Summary of Hierarchical Regression Analysis of Cooperation as a Predictor of MM Similarity (post decision 2).....	63

## LIST OF FIGURES

Figure 1. Integrated Model of Hypothesized Relationships.....	27
Figure 2. Hypotheses Related to Temporal Changes.....	27

## CHAPTER I

### INTRODUCTION

As teams have become more common in organizations, an increasing amount of research has focused on team effectiveness. In particular, the idea of cognitive similarity within a team has been given serious attention by many authors (e.g., Cannon-Bowers, Salas, & Converse, 1993; Klimoski & Mohammed, 1994). These authors have suggested that when the members of a team exhibit cognitive similarity, they interpret the team environment in a similar manner. The resulting shared situational understanding facilitates coordinated action and in turn increases team performance.

Cognitive similarity at the team level can be referred to as team cognition (Rentsch, Small, & Hanges, 2008). One common conceptualization of team cognition views the cognitive similarity between team members as organized knowledge structures, or mental models. When all team members have similar mental models, the team shares a situational understanding in the form of a team mental model. As suggested above, cognitive similarity in the form of a team mental model facilitates coordinated action and in turn increases team performance. However, despite recent interest in team cognition, relatively little is known about the development of team mental models.

Considering the importance of team cognition for effective team performance, an understanding of the antecedents of team mental model development is of particular relevance. If antecedent variables can be identified, these variables can be targeted in both the selection and training of teams, in order

to increase the likelihood of team mental model development. Accordingly, the present study explores potential antecedent variables and examines the temporal development of team mental models using a longitudinal design with teams that closely resemble top management teams. More specifically, an examination of team processes and the personality literature suggests that certain personality variables may facilitate the development of team mental models through the mediating role of specific team processes. Team mental models are subsequently related to team performance through the mediating role of additional team processes.

### Team Mental Models

The concept of a mental model (MM) as an organized mental representation is well established in cognitive psychology literature (Rouse & Morris, 1986). Mental models typically take the form of structured knowledge that represents an individual's understanding of some phenomenon or external system, whether it is an interpersonal relationship, a complex social network, or a larger organizational entity. Based on the idea that a given system can be conceptualized in different ways, it has also been suggested that there can be multiple MMs for the same system, all of which may be simultaneously correct (Rouse & Morris, 1986). Furthermore, MMs have several specific functions including (a) describing a system, (b) explaining a system, and (c) predicting system states. First, a MM can help an individual describe a system, for example why it exists (i.e., purpose) and what it looks like (i.e., form). Second, a MM can help an individual to understand and explain the system, for example how it

operates (i.e., function) or what it is currently doing (i.e., current state). Finally, a MM allows an individual to make future predications regarding the system (i.e., future state). Therefore, a MM can be defined as an organized mental representation of a system that allows an individual to describe the purpose and form of the system, explain the function and current state of the system, and make predictions about future states of the system (Rouse & Morris, 1986).

Individual team members in work teams use MMs, in which case the system of interest is the team environment (Cannon-Bowers et al., 1993). A work team can be defined as a group of two or more individuals that performs specific tasks, in which the individual members exhibit task interdependence, share one or more common goals, and interact socially (Kozlowski & Bell, 2003). Each team member has an organized mental representation of the team environment that allows the individual to describe, explain, and predict events that occur in that environment. However, this mental representation of the team environment is merely that of one team member, indicating an individual MM. It is only when this individual MM is similar to those of other team members that it becomes a team level phenomenon – a team mental model (TMM). Therefore, a TMM can be defined as a mental representation of the team environment that is shared by members of a team (Klimoski & Mohammed, 1994). Similar MMs among team members indicate that the individual team members have a similar conceptualization of the team environment, which allows them to coordinate their actions and perform more effectively as a team (Cannon-Bowers et al., 1993; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000).

### Types of Team Mental Models

Consistent with theorizing on individual MMs, there are also multiple types of MMs related to a team (Cannon-Bowers et al., 1993; Klimoski & Mohammed, 1994). Cannon-Bowers et al. (1993) originally suggested four distinct MMs in teams, including (a) equipment models, (b) task models, (c) team interaction models, and (d) team models. Equipment models refer to knowledge about the equipment used by the team, such as equipment functioning, operating procedures, equipment limitations, and likely failures of equipment. Task models refer to knowledge about the specific tasks that the team needs to complete, such as task procedures, likely contingencies, likely scenarios, task strategies, and environmental constraints. Team interaction models refer to knowledge about the way team members interact with one another, such as the roles and responsibilities of each member, which members are information sources, common interaction patterns, appropriate communication channels, and role interdependencies. Finally, team models refer to knowledge and specific information about other members of the team, such as the knowledge, skills, abilities, preferences, and tendencies of other members. Although these models are all distinct, they can coexist and are often not independent of each other (Cannon-Bowers et al., 1993).

Work on the evolution and maturation of teams suggests that teams separately develop both taskwork and teamwork competencies (Morgan, Salas, & Glickman, 1993). Based on this distinction, Mathieu et al. (2000) suggested the various TMM types can be subsumed by the two main content areas of taskwork

and teamwork. Taskwork MMs refer to knowledge about task-related features of the team environment. As such, taskwork MMs encompass both the equipment and task models mentioned above. Teamwork MMs, on the other hand, refer to knowledge about team-related characteristics. As such, teamwork MMs encompass both the team interaction and team models mentioned above. Both taskwork and teamwork MMs have been empirically linked to performance outcomes (Edwards, Day, Arthur, & Bell, 2006; Lim & Klein, 2006; Mathieu et al., 2000).

Whereas both taskwork and teamwork MMs appear to be essential for having a comprehensive understanding of the team environment, there has typically been a stronger relation between taskwork MMs and performance when direct within study comparisons are made (e.g., Lim & Klein, 2006; Mathieu et al., 2000; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005). This is not surprising when one considers that task performance is inherently related to an understanding of the task. However, in situations where the task or environment is novel and/or ambiguous, teamwork MMs may be especially relevant. In such situations, the ability to understand and anticipate the actions of one's teammates is likely to be very important. Marks, Zaccaro, and Mathieu (2000) found initial support for this idea by demonstrating that team interaction models were better predictors of team performance in novel situations, as compared to routine situations. Although team interaction models typically fall under the more general category of teamwork MMs, it is important to note that Marks et al. (2000) did include task information (e.g., build pillbox, lay mine) in their measure of team

interaction models. Despite this, the results suggest that knowledge of how team members interact can be important. Further, while taskwork mental models are inherently related to the individual tasks being performed by specific teams, teamwork mental models are likely to be more generalizable to various teams, as generic teamwork can occur in all teams (Rentsch & Klimoski, 2001). Accordingly, teamwork MMs will be examined in the present study.

#### Operationalization of Team Mental Models

Considering the nature of TMMs (i.e., a similar conceptualization of the team environment among members of a team), the most common operationalization is the amount of similarity between the MMs of all team members. Similarity can be assessed using some form of concept mapping, in which team members are given a set list of concepts, related either to the task or team, and are asked to fill in a predetermined structure using the list of concepts (Marks et al., 2000). A concept map generated by each team member can then be compared to the concept maps of other team members, with the overlap represented by a scoring algorithm. More commonly, however, structural assessment programs such as *Pathfinder* (Schvaneveldt, 1990) are used (e.g., Edwards et al., 2006; Lim & Klein, 2006; Marks, Sabella, Burke, & Zaccaro, 2002; Stout, Cannon-Bowers, Salas, & Milanovich, 1999). Members on a team are asked to make paired comparison ratings regarding the relatedness of various concepts relevant to either the task or team. *Pathfinder* uses the paired-comparisons to create concept maps for each team member, which represent their



MM. *Pathfinder* will then generate a similarity index used to assess the similarity of all team members' concept maps.

Empirical findings have shown a consistent positive relationship between MM similarity and team performance, for both taskwork MMs (e.g., Edwards et al., 2006; Lim & Klein, 2006; Mathieu et al., 2000) and teamwork MMs (e.g., Lim & Klein, 2006; Mathieu et al., 2000). Studies that have examined other more specific forms of TMMs, such as team interaction models, have also found a positive relationship between similarity and performance (e.g., Marks et al., 2000; Marks et al., 2002). Based on these findings, it appears as though similar MMs are important antecedents of team performance. However, it may be helpful to further consider the accuracy of MMs (Edwards et al., 2006; Marks et al., 2000). Just because a team agrees on a similar conceptualization of the team environment, this does not necessarily mean that it is a correct conceptualization of the team environment. Therefore, similarity may not always be the best way to operationalize TMMs.

Evidence concerning the benefit of either similar or accurate MMs (or both) does not provide a clear answer. For example, Edwards et al. (2006) found that MM accuracy was a better predictor of team performance than MM similarity for taskwork MMs. Contrary to this, Marks et al. (2000) found that MM similarity was a better predictor of team performance than MM accuracy for team interaction models (i.e., a specific MM type encompassed by the teamwork MM category). The reason for this inconsistency may lie in both the measurement of

accurate MMs and the fundamental differences between taskwork and teamwork MMs.

Although the methods for assessing the accuracy of MMs are very similar to the methods for assessing similarity, there are some additional difficulties when it comes to measuring accuracy (Edwards et al., 2006). For example, determining the accuracy of a MM requires comparing the MM to an expert (i.e., accurate) model rather than to other team members' models. In order to do this, it is first necessary to define the expert model by identifying what the objectively accurate conceptualization is. However, as mentioned above, there are often many correct ways to conceptualize a system. It follows that accurate MMs may be better predictors of performance in situations where there is one best performance strategy, rather than multiple.

When one considers the nature of both taskwork MMs and teamwork MMs, a similar distinction becomes apparent. For most well defined tasks, there is often a limited number of effective ways to complete the task, suggesting the importance of an accurate conceptualization. For coordinated teamwork, on the other hand, there are an infinite number of ways that team members can interact, but for coordination to occur a similar conceptualization is necessary. Therefore, accuracy may be more important for taskwork MMs, while similarity may be more important for teamwork MMs. This explanation is consistent with the conflicting findings discussed above, as Edwards et al. (2006) found accuracy to be a better predictor of performance for taskwork MMs, whereas Marks et al. (2000) found similarity to be a better predictor of performance for team

interaction models. Again, it is important to note that Marks et al. (2000) did include task information in their measure of team interaction models. However, Lim and Klein (2006) provide additional evidence to suggest that accuracy is less important for teamwork MMs. Despite having found a predictive advantage for accuracy of both taskwork and teamwork MMs, the predictive advantage was negligible for teamwork MMs (i.e., an effect size [ $r$ ] difference of .02), while the predictive advantage for taskwork MMs was much greater (i.e., an effect size [ $r$ ] difference of .13). In addition, Lim and Klein (2006) did not find an interaction between similarity and accuracy in predicting performance for either taskwork or teamwork MMs. This suggests that similar MMs, that also happen to converge on an expert model, are not necessarily better predictors of performance. Based on these findings, similarity will be used to operationalize TMMs in the present study, as teamwork MMs are the focus.

Team mental models, as described above, refer primarily to structured *declarative* knowledge, or the ability to describe, explain, and predict elements of a system. Yet there may be multiple types of knowledge captured by MMs (Cooke, Salas, Cannon-Bowers, & Stout, 2000). Banks and Millward (2007) found that while shared declarative knowledge generally had a positive impact on team performance, shared *procedural* knowledge, which refers to procedures necessary for task performance, was negatively related to team performance. However, in their study, Banks and Millward (2007) did not make a clear distinction between taskwork and teamwork MMs, nor did they clearly specify the team processes through which cognitive similarity was related to team

performance. It is conceivable that the differential impact of declarative and procedural knowledge is a function of whether or not there are multiple acceptable procedures, as is the case with accurate taskwork MMs. Until this possibility is fully explored, a complete understanding of the effects of shared procedural knowledge will remain elusive.

#### Antecedents of Team Mental Models

There has been some theoretical speculation as to how TMMs develop within a team (e.g., Klimoski & Mohammed, 1994; Rico, Sanchez-Manzanares, Gil, & Gibson, 2008), but relatively little is actually known about antecedents of TMMs. There are, nevertheless, a few exceptions that offer valuable insight and provide a starting point for further investigation. For example, Edwards et al. (2006) found that general mental ability was positively related to the development of taskwork MMs. In terms of teamwork MMs, other evidence seems to implicate the importance of some initial form of interaction between team members that allows them to calibrate their MMs to each other. For example, Rentsch and Klimoski (2001) found that team size was negatively related to MM similarity, which they refer to as team member schema agreement. One possible explanation for this finding, as suggested by the authors, is that teams with fewer members afford each individual member a greater opportunity to interact with the other members. Presumably, it is this interaction that facilitates the development of a similar conceptualization of the team environment (i.e. similar MMs).

Demographic similarity between team members has also been linked to the development of similar MMs. Demographic variables can serve as surrogates

for past experiences (Zenger & Lawrence, 1989). Similar life experiences should be related to the frequency and quality of interactions, and in turn to team member schema agreement (Rentsch & Klimoski, 2001). In their study, Rentsch and Klimoski (2001) demonstrated that similar education level and similar level in an organization predicted schema agreement. Further, recruitment into the team, as opposed to being assigned to a team, also predicted schema agreement, as teams typically recruit similar others. These findings further suggest the importance of team member interaction in the development of TMMs.

Additional evidence for the importance of interaction in the development of TMMs comes from the use of training in teams. Marks et al. (2000) found that team-interaction training was positively related to MM similarity within a team. The content of this training related to how to work better as a team, but did not address how to perform the specific task requirements. Essentially, this training taught team members how to effectively interact with one another. However, the training did specifically target knowledge organization, so it is unclear if the positive effect on TMM development was due to the training itself or the effect the training had on interaction within the team. Nonetheless, these findings imply the importance of interaction for the development of TMMs.

Related to the above findings, the process of planning may also be important to the development of TMMs. Conceivably, it is during the process of planning, which often occurs early in a performance episode (Marks, Mathieu, & Zaccaro, 2001; see below), that team members are afforded the initial interaction with one another that allows for a similar conceptualization of the team

environment. Stout et al. (1999) found that teams that engaged in better quality planning developed more similar MMs of one another's informational requirements. According to Stout et al. (1999), key components of planning include (a) creating an open environment, (b) setting goals and awareness of consequences of error, (c) exchanging preferences and expectation, (d) clarifying roles and information to be exchanged, (e) clarifying sequencing and timing, (f) considering unexpected events, (g) considering how high workload affects performance, (h) examining pre-prepared information, and (i) making provisions for self-correcting. Several of these key components, such as the determination of which team members have access to what information and clarification of the roles of all team members, represent important elements of teamwork MMs (Cannon-Bowers et al., 1993; Mathieu et al., 2000). Further, Marks et al. (2002) found that training aimed at improving team members' understanding of the roles and responsibilities of their teammates (i.e., cross-training) was also positively related to the development of similar MMs. Therefore, the process of planning appears to be positively related to the development of TMMs, insofar as it lays the groundwork for a similar conceptualization of the team environment among all team members.

### Team Processes and Mental Models

In order to advance a greater understanding of the development of TMMs in work teams, it is necessary to examine the general context in which they arise. Many authors have adopted an input-process-outcome (IPO) framework to team effectiveness (e.g. Marks et al., 2001; Marks et al., 2002; Mathieu et al., 2000).

According to this perspective, inputs refer to antecedent conditions that exist prior to performance and can include individual factors, team factors, or organizational factors (Mathieu et al., 2000). Processes refer to the interdependent activities that a team engages in with the purpose of transforming inputs into outcomes (Marks et al., 2001; Mathieu et al., 2000). Finally, outcomes refer to the performance criteria by which the effectiveness of the team is measured (e.g., profit), which result from the preceding inputs and team processes. However, the IPO framework, as described above, may no longer adequately capture the nature of teams in the increasing complex environment of modern-day organizations (Mathieu, Maynard, Rapp, & Gilson, 2008). One major criticism is the absence of a temporal component in the traditional IPO framework, as time undoubtedly plays a role in the functioning of teams. Fortunately, some authors have acknowledged this potential limitation and proposed a modified IPO framework that considers the temporal environment in which teams operate. Specifically, Marks et al. (2001) have proposed a temporally based framework of team processes that may be especially useful for understanding the context in which TMMs develop.

According to Marks et al. (2001), for every task that a team completes, the team engages in a performance episode, which consists of both transition and action phases. A performance episode is a distinct period of time usually identified by goals and goal completion. Action phases refer to times during a performance episode when the team is engaged in activities specifically directed towards goal completion. Transition phases refer to other times when the team is

either reflecting on past performance or, more importantly, planning future actions. Depending on the task, there may be multiple transition and action phases for a given performance episode. Each phase within a performance episode also consists of an IPO cycle, where the outcome of a transition phase may become the input for a subsequent action phase. In this framework, the ultimate or most distal outcome is analogous to the performance outcome in the traditional IPO framework. Other, more proximal outcomes may include emergent states, which refer to team member attitudes, values, cognitions, and motivations that result from preceding team processes. Emergent states are conceptually different from actual team processes, which refer to interdependent activities undertaken by the team that mediate the input-outcome relationship. However, as suggested above, an emergent state outcome can have an impact on performance by becoming an input in a subsequent IPO cycle. If one conceptualizes TMMs as an emergent state within a team, this framework provides a useful tool for examining the development of TMMs.

Marks et al. (2001) further outlined a specific set of team processes that commonly occur either in transition phases or action phases. Transition processes include (a) strategy formation and planning, (b) mission analysis, and (c) goal specification. Action phase processes, on the other hand, include (a) monitoring progress towards goals, (b) system monitoring, (c) team monitoring and backup behaviors, and (d) coordination. A recent meta-analysis suggests that these narrow team processes load onto two higher-order dimensions, represented by transition and action phase processes, respectively (LePine, Piccolo, Jackson, Mathieu, &



Saul, 2008). Team mental models should be especially important during action phases when team members need to anticipate each other's behaviors in order to facilitate coordination. Conversely, TMMs should be less important during transition phases when team members can openly communicate and strategize (Stout, Cannon-Bowers, & Salas, 1996; Mathieu et al., 2000). Furthermore, the activities undertaken during a transition phase, such as planning and strategizing, appear to be precisely the types of activities that facilitate the development of a shared situational understanding. Therefore, TMMs should emerge as outcomes from team processes during a transition phase, such as planning, and subsequently serve as inputs to later action phase processes, such as coordination.

Marks et al.'s (2001) framework suggests that TMMs emerge as outcomes from transition phase processes. The transition processes suggested by Marks et al. (2001) are conceptually similar to the planning process discussed by Stout et al. (1999). For example, both include discussion of the task, identification of environmental constraints, goal specification, and consideration of team members' roles and abilities. Therefore, these processes will be collectively referred to as planning and will be defined as the development and consideration of potential courses of action for goal accomplishment (Marks et al., 2001). It is through the process of planning that team members' roles and responsibilities are assigned or informally determined, information sources are identified, and everyone is given some initial insight into the knowledge and skills of their teammates, all of which represent the content of teamwork MMs (Cannon-Bowers et al., 1993; Marks et al., 2001; Stout et al., 1999). When all team members

actively engage in the planning process and collaboratively interact with one another, each team member should internalize information in a similar manner, indicating the development of similar MMs. The fact that Stout et al. (1999) found a positive relationship between the quality of planning and MM similarity provides support for the idea that TMMs develop through the process of planning. The present study aims to replicate the findings of Stout et al. (1999), as they represent an important link in the development of TMMs. Accordingly, it is hypothesized that the amount of planning that teams engage in will be positively related to MM similarity (Hypothesis I).

Based on Marks et al.'s (2001) framework, TMMs should further be related to performance via the mediating role of action phase processes, such as coordination. Coordination can be defined as the sequential orchestration and timing of goal-directed activities (Marks et al., 2001). This definition implies the importance of the appropriate sequencing and timing of goal-directed behaviors. In order to achieve synchronization, it is also important that team members exchange information and that individual actions are adjusted based on new information (Brannick, Roach, & Salas, 1993; Marks et al., 2001). Thus, communication and adaptability are also key components of effective coordination. Finally, related to the idea of adaptability, effective coordination requires that a team is able to identify when an individual team member needs help and provide assistance in the form of backup behaviors (Marks et al. 2001; Mathieu et al. 2000). It is worth noting that the occurrence of backup behaviors may depend on the perceived legitimacy of the need for help (Porter, Hollenbeck,

Ilgen, Ellis, West, & Moon, 2003). Further, backup behaviors may actually be counterproductive in that they may encourage loafing (Barnes, Hollenbeck, Wagner, DeRue, Nahrgang, & Shwind, 2008). However, it may be equally, if not more detrimental if a team is unable to identify and address a potential weak link. Therefore, key components of effective coordination include the sequencing and timing of activities, communication, adaptability, and the identification of team members who need assistance.

When actively engaging in goal-directed behavior, a similar conceptualization of the team environment should allow team members to anticipate each other's actions and coordinate their behavior, in turn increasing performance. Consistent with this, Marks et al. (2002) and Mathieu et al. (2000) found that coordination processes mediated the relationship between MM similarity and team performance. However, Marks et al. (2001) suggest that although coordination is primarily an action phase process, coordination can occur in transition phases as well. In order to clearly delineate the relationship between MM similarity and coordination, it is necessary to distinguish between the coordination that occurs in a transition phase and that which occurs in an action phase.

The process of coordination can be conceptually divided into explicit coordination and implicit coordination (Rico et al., 2008). Explicit coordination refers to activities undertaken with the specific intention of managing and organizing task-directed behavior. Planning is a traditional example of explicit coordination (Rico et al., 2008). Therefore, planning in the current study similarly

refers to explicit coordination. Implicit coordination, on the other hand, refers to a team's ability to act in fluid manner by adjusting behaviors in anticipation of actions of other members without the need for overt communication. Rico et al. (2008) suggest that key components of implicit coordination include (a) providing task-relevant information to other team members without an explicit request, (b) proactively sharing workload and helping other team members, (c) monitoring other team members' activities and performance, and (d) adapting behaviors in anticipation of others' actions. Whereas explicit coordination likely occurs during a transition phase, in the form of planning, implicit coordination likely occurs during action phases when team members need to act in a fluid manner to achieve effective performance. Therefore, it is hypothesized that MM similarity will be positively related to performance through the mediating role of effective *implicit* coordination (Hypothesis II).

In order to fully capture the temporal nature of TMM development suggested by the above framework of team processes, the present study will use a longitudinal design. Based on the idea that teams may engage in multiple planning and actions phases within a given performance episode, it is likely that with increased experience, the similarity of team members' MMs should increase over time (Mathieu et al., 2000). When a team first forms, team members have very little concrete information regarding the other team members or the task. As a result, team members will likely base their expectations and understanding of the team environment on their unique past experiences. As team members spend more time together, individual expectations and knowledge regarding the team

should become more similar, as these will be based on actual experiences with the current team. However, findings have consistently failed to support this proposition for both MM similarity and accuracy (Mathieu et al., 2000; Edwards et al., 2006). A possible explanation for this is that the time between MM measurements was inadequate to allow a significant change to occur (Edwards et al., 2006). For example, the protocol in Mathieu et al.'s (2000) study lasted approximately three hours, while the protocol in Edwards et al.'s (2006) study lasted two weeks. In the present study, teams will work together over a five-week period, which will include three separate data collection waves. This longer timeframe should allow for any temporal changes in MM similarity to be fully actualized. Accordingly, it is hypothesized that MM similarity will increase over time (Hypothesis III). With the increase in MM similarity over time, planning should become less important as team members rely more heavily on a shared situational understanding. Conversely, the effectiveness of implicit coordination should increase over time as a direct result of the increasingly similar situational understanding among team members. Therefore, it is further hypothesized that the amount of planning will decrease over time (Hypothesis IV), while the amount of implicit coordination will increase over time (Hypothesis V).

Past research has similarly attributed lack of significant findings to inadequate time for a proposed relationship to manifest. Like the present study, Neuschwander (2006) examined the relationship between planning and MM similarity. Contrary to the expected relationship, there was no main effect or interactive effect for either of two types of planning on MM similarity.

Neuenschwander (2006) suggested that the lack of significant findings might be the result of an inadequate amount of time for the hypothesized relationships to manifest. It is worth noting that there are other equally compelling explanations for the lack of findings in Neuenschwander's (2006) study, such as the use of planning approaches adapted from research on artificial intelligence, which may not be comparably applicable to human subjects. The longer timeframe of the present study should prevent the potential problem of inadequate time for the proposed relationships to manifest.

### Personality and Teams

Many authors have suggested the importance of deep-level composition variables for team outcomes (e.g. Bell, 2007; Harrison, Price, Gavin, & Florey, 2002; Hollenbeck, DeRue, & Guzzo, 2004), including the importance of personality (Driskell, Hogan, & Salas, 1987). A commonly used operationalization of personality is the five factor model (FFM). The FFM is a comprehensive model of personality traits organized in terms of five dimensions. Although there is some debate over the specific names of each dimension, they are commonly referred to as extraversion, neuroticism, conscientiousness, agreeableness, and openness to experience (openness). Extraverted individuals are driven by the need to seek social stimulation. Individuals with high levels of extraversion are often described as assertive, energetic, or outgoing (McCrae & John, 1992). Neurotic individuals are driven by a pervasive sensitivity to negative cues in the environment. Individuals with high levels of neuroticism are often described as anxious, tense, or unstable (McCrae & John, 1992). Conscientious

individuals are characterized by self-control, persistence, and attention to detail. Individuals with high levels of conscientiousness are often described as efficient, organized, or reliable (McCrae & John, 1992). Agreeable individuals are characterized by a tendency to be friendly and cooperative. People with high levels of agreeableness are often described as appreciative, kind, or accommodating (McCrae & John, 1992). Finally, openness is characterized by a healthy curiosity about the world and an interest in new experiences. People with high levels of openness are often described as curious, imaginative, or insightful (McCrae & John, 1992). Each of the dimensions exists on a bipolar scale, such that people can be either high or low on each of the five dimensions. For example, the dimension of neuroticism is sometimes referred to as emotional stability, which is the opposite of neurotic. Many researchers believe that the FFM represents the fundamental dimensions of personality (e.g., John, 1990; McCrae & John, 1992).

Support for the FFM comes from factor analyses that typically show a five-factor structure to be most appropriate in both natural language and theoretical based questionnaires. Furthermore, these findings have been consistent in both men and women, in people of different ages, and in different cultures (John, 1990). It is important to note that some have found that a six-factor structure may be more appropriate in some cases (e.g., Cellar, Miller, Doverspike, & Klawnsky, 1996), but this issue is beyond the scope of the present study. In general, there is consensus regarding the existence of the five factors.

A recent meta-analysis by Bell (2007) demonstrates the importance of personality for team performance. Of the five personality dimensions specified by the FMM, conscientiousness, agreeableness, extraversion, and openness were all related to team performance. In her analysis, Bell (2007) considered the moderating role of study setting. In general, there was a tendency for the relationship between personality traits and performance to be stronger in field settings than in laboratory settings. For example, conscientiousness and agreeableness were positively related to team performance in field settings, but there was no relationship for either in laboratory settings. Bell (2007) also found a significant moderating effect for the way personality was operationalized at the team level (e.g., team mean; minimum team value). For example, although emotional stability was not significantly related to performance in either field or laboratory settings, when team-level operationalization was considered a significant relationship was found when the team mean was used as the team level operationalization. Of all the effect sizes related to the FFM, agreeableness when operationalized as team-minimum agreeableness, exhibited the strongest relationship with team performance ( $\rho = .37$ ).

Considering the proposed importance of some form of initial interaction between team members for the development of TMMs, it may be prudent to examine personality as a factor that could impact interaction within a team. In particular, agreeableness should be especially important for interpersonal interaction. As mentioned above, individuals with high levels of agreeableness tend to be friendly, cooperative, and accommodating. These characteristics should



facilitate positive social relations and maintain social harmony. It follows that teams with agreeable members should exhibit positive interpersonal processes. Conversely, less agreeable individuals who are typically argumentative, inflexible, and uncompromising (Barrick, Mount, & Judge, 2001) should severely inhibit interpersonal processes. This may explain Bell's (2007) finding that the team-minimum operationalization of team-level agreeableness was the strongest predictor of team performance. It would appear that team performance is in part constrained by the extent to which team members are able to effectively interact, which in turn is directly constrained by the least agreeable member of the team.

Mount, Barrick, and Stewart (1998) examined the role of personality in jobs that involve interpersonal interaction. Agreeableness and emotional stability emerged as the best predictors of performance, specifically for jobs that involved interdependent interaction with co-workers. Supervisor ratings of how well employees interact with others were also examined as an additional criterion. Of all the FMM dimensions, agreeableness was the best predictor of interactions with others ( $\rho = .27$ ). These findings, in conjunction with the findings of Bell (2007) indicate the importance of agreeableness, not only for the performance of a team, but also for interaction within a team. Similarly, agreeableness is positively related to knowledge sharing (Matzler, Renzl, Muller, Herting, & Mooradian, 2008). Arguably, the more knowledge that a team shares during planning, the more likely individual team members will internalize information in a similar manner and develop a similar conceptualization of the team environment. This

further suggests the potential importance of agreeableness for interaction during planning processes, and in turn the development of TMMs.

Driskell, Goodwin, Salas, and O'Shea (2006) argue that in order to fully understand how personality is related to team processes and outcomes, a greater level of specificity than that provided by the broad FMM dimensions is necessary. This echoes the calls of other authors to link lower level personality facets to more specific criteria (e.g., Barrick et al., 2001; Barrick & Mount, 2005). Although the FMM dimensions effectively predict broad criteria, such as overall team performance, they are less likely to predict more specific criteria, such as planning. Driskell et al. (2006) identified two facets of agreeableness that they believe to be particularly important for teamwork: trust and cooperation.

Trust as an individual difference variable can be defined as a dispositional tendency to believe that others are honest and well intentioned (Driskell et al., 2006). Those who are low in trust are typically suspicious and doubt the motives, intentions, and sincerity of others. It is important to note that trust as conceptualized in the present study does not refer to the interpersonal process of trust between individuals, but rather an individual's stable capacity for trust across different situations. Dirks (1999) examined the importance of interpersonal trust in work groups and found that trust was necessary for groups to convert their efforts into effective team processes. Specifically, for high-trust groups, higher levels of motivation were associated with higher levels of coordination. In contrast, for low-trust groups, higher levels of motivation were associated with lower levels of coordination. Although the above study examined trust as an

interpersonal process, the findings suggest the importance of trust for effective team processes. Individuals with a low capacity for trust are likely to constrain the extent to which interpersonal trust is possible within a group. Similarly, low levels of the capacity for trust should prevent positive interpersonal processes during planning. If one does not trust the motives and intentions of other team members, productive interaction towards developing a similar conceptualization of the team environment is unlikely to occur. Conversely, high levels of trust should be associated with positive interpersonal processes during planning, in turn increasing MM similarity. Accordingly, it is hypothesized that trust will be positively related to MM similarity through the mediating role of planning (Hypothesis VI).

Cooperation as an individual difference variable can be defined as a tendency towards collaboration that maximizes outcomes for both the self and others, as opposed to competition in which outcomes are maximized for the self relative to others (Driskell et al., 2006; Van Lange, 1999). Again, it is important to note that cooperation as conceptualized in the present study does not refer to the interpersonal process of cooperation between individuals, but rather an individual's stable tendency to engage in cooperative behaviors, as opposed to competitive behaviors. The desire to maximize outcomes for the entire group, rather than just the self, represents a pro-social orientation in which a high value is placed on reciprocity (Van Lange, 1999). Thus, a pro-social orientation should be related to positive interpersonal processes. Similarly, a cooperative tendency should be related to positive interpersonal processes during planning, in turn

facilitating the development of a similar conceptualization of the team environment among team members. Competition, on the other hand, will likely be counterproductive as individual interests are considered to be more important than mutual team interests, in turn hindering interpersonal processes during planning and preventing the subsequent development of a shared situational understanding. Further, the presence of one competitive individual tends to elicit competitive behaviors in those who would otherwise be cooperative (Kelley & Stahelski, 1970). This suggests an additional disadvantage of competitiveness in a group. Not only is one person less likely to contribute to mutual team goals, but self-interest may also spread to compound the negative effects. This further explains Bell's (2007) finding that the team-minimum operationalization of team-level agreeableness was the strongest predictor of team performance. Therefore, cooperation should be positively related to team interaction during planning, and a subsequent increase in MM similarity. Accordingly, it is hypothesized that cooperation will be positively related to MM similarity through the mediating role of planning (Hypothesis VII).

Hypothesis I proposed that the amount of planning that teams engage in will be positively related to MM similarity. Hypothesis II proposed that MM similarity will be positively related to team performance through the mediating role of effective implicit coordination. Hypotheses VI and VII proposed that trust and cooperation would both be positively related to MM similarity through the mediating role of planning. Figure 1 depicts an integrated model of the hypothesized relationships in the present study, with the exception of hypotheses

related to temporal changes. With respect to temporal changes, Hypothesis III proposed that mental model similarity would increase over time. Hypothesis IV proposed that the amount of planning would decrease over time. Finally, Hypothesis V proposed that the amount of implicit coordination would increase over time. Figure 2 depicts the hypotheses related to changes over time.

FIGURE 1

Integrated Model of Hypothesized Relationships

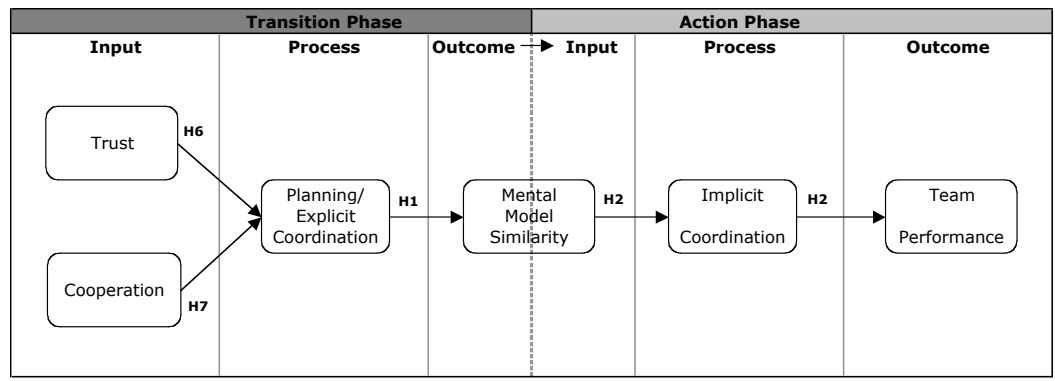
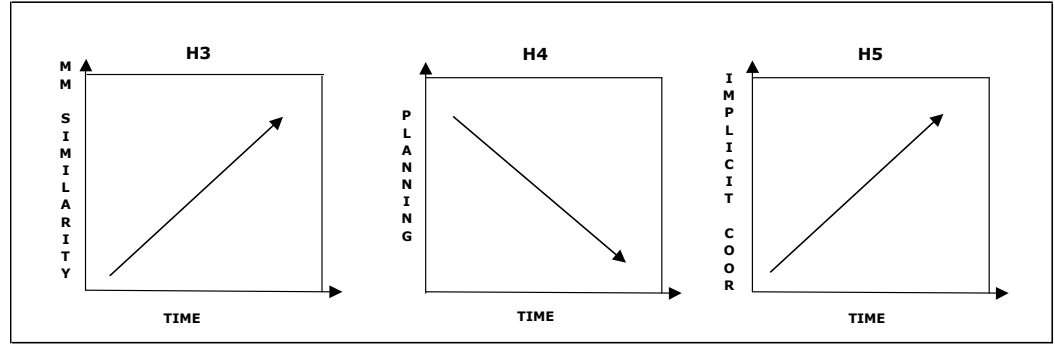


FIGURE 2

Hypotheses Related to Temporal Changes



### Rationale

The present study aims to make several contributions to the current understanding of TMMs. First, little is known about antecedents of the development of TMMs. Considering the positive relationship between TMMs and team performance, an understanding of team compositional variables and processes that facilitate the development of similar MMs is of great importance. With knowledge of the effects of compositional variables, organizations can easily manipulate team composition through selection and placement, in order to increase team effectiveness (Bell, 2007). Second, if it can be shown that similar MMs not only facilitate team processes, but also emerge as a result of them, the implicated antecedent processes can be targeted for training to increase the likelihood of TMMs. Marks et al. (2000; 2002) have already demonstrated the potential utility of training for TMMs. If this training can be more specifically targeted, the potential benefits to organizations that employ teams is considerable. Third, relatively little is known about the temporal nature of TMMs, as only a few studies have examined TMMs using a longitudinal design (e.g., Edwards et al., 2006; Mathieu et al., 2000). The five-week duration of the present study allows for a more complete examination of any changes in MM similarity over time, as any temporal changes have adequate time to actualize. Finally, TMMs have been predominantly studied in the context of military team training (Rentsch et al., 2008). The present study examines TMMs in the context of top management teams, which are characterized by a fundamental work cycle involving planning and subsequent decision-making (Devine, 2002). As top management teams

engage in complex problem solving in order to arrive at an appropriate decision, they should benefit from cognitive similarity in the form of a TMM. In using teams that closely resemble top management teams, any significant findings of the present study will generalize beyond the narrow focus of military team training and apply directly to real world top management teams.

#### Statement of Hypotheses

Hypothesis I: The amount of planning that teams engage in will be positively related to mental model similarity.

Hypothesis II: Mental model similarity will be positively related to team performance through the mediating role of effective implicit coordination.

Hypothesis III: Mental model similarity will increase over time.

Hypothesis IV: The amount of planning will decrease over time.

Hypothesis V: The amount of implicit coordination will increase over time.

Hypothesis VI: Trust will be positively related to mental model similarity through the mediating role of planning.

Hypothesis VII: Cooperation will be positively related to MM similarity through the mediating role of planning.

## CHAPTER II

### METHOD

#### Research Participants and Context

Participants were 186 undergraduate- and graduate-level management students at a midsized Midwestern university that engaged in a team-based business simulation as part of a management capstone course. In terms of ethnicity, 50% of participants described themselves as Caucasian/White ( $N = 93$ ); 31.1% of participants described themselves as Asian/Pacific Islander ( $N = 56$ ); 9.7% of participants described themselves as Hispanic ( $N = 18$ ); 1.6% of participants described themselves as African American/Black ( $N = 3$ ); 1.6% of participants described themselves as Biracial/Multiracial ( $N = 3$ ); 0.5% of participants described themselves as American Indian/Alaska Native ( $N = 1$ ); and the remaining 6.5% described themselves as Other (3.8%;  $N = 7$ ) or did not provide any information (2.7%;  $N = 5$ ). With respect to gender, 47.8% of participants described themselves as female ( $N = 89$ ); 49.5% of participants described themselves as male ( $N = 92$ ); and the remaining 2.7% did not provide any information ( $N = 5$ ). Participants ranged in age from 20 years to 46 years, with a mean age of 24.15 ( $SD = 4.58$ ).

Participants were assigned to teams of two to eight individuals, comprising a total of 32 teams. Each team engaged in the business simulation as part of either one of two management capstone courses. One of the capstone courses was for undergraduate students, while the other capstone course was for graduate students. The study duration lasted for three academic quarters,



encompassing four sessions of the undergraduate-level course and two sessions of the graduate-level course, totaling six distinct sessions of the capstone courses. Although these sessions represent two distinct courses, several factors support combining the courses in the present study. First, the undergraduate- and graduate-level courses had similar content focusing on strategic decision-making in organizations. Second, the business simulation was identical across both courses. Finally, all six sessions were taught by the same professor. As the business simulation is a standard part of the course curricula, participants received both an individual and team grade for their participation in the simulation that was factored into their final grade in the course. Participants did not receive any additional incentives to participate in this research.

There were 162 participants across all four sessions of the undergraduate-level course and 24 participants across both sessions of the graduate-level course. Chi-square analyses suggest that there were no significant differences between the undergraduate- and graduate-level courses with respect to ethnicity of participants ( $\chi^2[7, N = 181] = 8.78, p = .27$ ) or gender of participants ( $\chi^2[2, N = 181] = 2.31, p = .32$ ). There were, however, significant differences between the undergraduate- and graduate-level courses with respect to the age of participants, as indicated by an independent samples t-test ( $t[179] = -6.23, p = .00$ ). This is not surprising as undergraduate-level students are likely to be younger than graduate-level students. In the undergraduate-level course, age in years ranged from 20 to 46, with a mean age of 23.40 years ( $SD = 4.11$ ). In the graduate-level course, age in years ranged from 24 to 45, with a mean age of 29.08 years ( $SD = 4.47$ ).

## Measures

### Control Variables

Data were collected on several control variables in order to ensure that such variables did not account for any statistically significant variance in the main study variables. Specifically, team demographic diversity, within-team familiarity, education-level, and team size were examined as potential control variables. In all analyses described below, control variables were only included if they exhibited a statistically significant relationship with the respective dependent variable of interest. For example, in examining the relationship between MM similarity (post decision 4) and implicit coordination, none of the control variables were significantly related to the dependent variable, implicit coordination. Accordingly, no control variables were included in the analysis. Conversely, in examining the relationship between planning and MM similarity, the control variable of ethnic diversity was significantly related to the dependent variable, MM similarity. Accordingly, ethnic diversity was used as a control variable in the analysis.

*Demographic Diversity.* Self-report demographic information was collected using a questionnaire requesting information on the ethnicity, gender, and age of participants. See Appendix A for the complete demographic information questionnaire. In order to operationalize ethnicity and gender diversity at the team level, Blau's (1977) index of heterogeneity was used (Harrison & Klein, 2007). According to this index, heterogeneity is defined by the following formula, where  $P_i$  is the proportion of each population in the group of

interest:

$$\text{Heterogeneity} = 1 - \sum P_i^2$$

In order to operationalize age diversity at the team level, the coefficient of variation was used (Allison, 1978; Harrison & Klein, 2007). The coefficient of variation was calculated by dividing the standard deviation of the variable of interest ( $D$ ) by the mean of that variable within each team, using the following formula:

$$\text{Coefficient of Variation} = [(D_i - D_{\text{mean}})^2/n]D_{\text{mean}}$$

*Familiarity.* In order to assess familiarity within a team, each team member was asked how familiar they were with the other members of their team. Participants rated how well they knew the other members of their team on a 5-point scale (1 = not at all; 5 = very well). The familiarity scale is included in Appendix B. In order to operationalize familiarity at the team level, the mean value of familiarity within teams was used.

*Education-Level.* Participants were students in one of two management capstone courses, either an undergraduate- or graduate-level course. Although it was deemed appropriate to combine both courses in the current study, as a precaution education-level (i.e., undergraduate, graduate) was examined as a potential control variable. A dummy-coded control variable was created to represent education-level, with zero representing the undergraduate-level and one representing the graduate-level.

*Team Size.* Much of the variability in team size can be accounted for by the education-level distinction. The graduate-level course typically had a much

smaller enrollment, necessitating smaller team sizes. However, in the current sample, there remained within-education-level variability in team size. In the undergraduate-level course, team size ranged from five to eight individuals with a mean team size of 6.75 individuals ( $SD = .68$ ), while in the graduate-level course team size ranged from two to four individuals with a mean team size of three individuals ( $SD = .54$ ).

### Personality Variables

Levels of participant trust and cooperation were operationalized using FFM facet scales from the International Personality Item Pool (Goldberg, 1999). These scales are commonly used measures for assessing FFM personality facets, with appropriate psychometric properties. Each facet was assessed with 10 items. The participants rated the degree to which they felt each item describes themselves on a 5-point scale (1 = extremely inaccurate; 5 = extremely accurate). See Appendices C and D for the complete trust and cooperation scales, respectively. Each scale included some positively keyed items (i.e., higher scores indicate greater levels of the facet) and some negatively keyed items (i.e., higher scores indicate lower levels of the facet). For all analyses, negatively keyed items were reverse-coded so that higher scores represent greater levels for both facets. The total score for each facet was the average of the ratings for each of the 10 items per scale. Internal consistency reliability for the trust and cooperation scales were  $\alpha = .87$  and  $\alpha = .73$ , respectively. Bell (2007) found that the team-minimum value was the best team-level operationalization of agreeableness when predicting team performance. This is consistent with the idea that team performance is

partially constrained by the extent to which team members are able to effectively interact, which is in turn directly constrained by the least agreeable member of the team. Therefore, team-minimum trust and team-minimum cooperation were used to represent team-level trust and cooperation.

### Team Process of Planning

The amount of planning that teams engaged in was assessed using a six-item scale developed by the author. The items on the scale were created to specifically reflect key elements of planning, as discussed by Stout et al. (1999) and Marks et al. (2001). Participants rated the degree to which they felt each item in the scale describes their team on a 5-point scale (1 = extremely inaccurate; 5 = extremely accurate). See Appendix E for the complete scale. A composite planning score was created for each participant by averaging the scores from all items in the scale, with higher scores representing a greater amount of planning. Internal consistency reliability for scores on the planning scale was  $\alpha = .83$ .

Given that the planning scale was developed for the current study, additional analyses were conducted to assess the psychometric properties of the scale and its construct validity. A factor analysis was conducted using principle axis factoring as an extraction method and direct oblimin rotation. Principle axis factoring was used because the goal was to identify an underlying latent construct (Preacher & MacCallum, 2003), while direct oblimin rotation was used because constructs in social and behavioral science are likely to be correlated (Fabrigar, Wegener, MacCallum, & Strahan, 1999). Two criteria were used to determine the number of factors captured by the planning scale. First, a scree plot of eigenvalues

**TABLE 1**

Rotated Pattern Matrix for Principle Axis Factor Analysis (with Direct Oblimin Rotation) of Team Planning Scale

	Factor	
	1	2
My team identifies which members can be turned to for specific types of information.	<b>.91</b>	-.06
My team clarifies the roles and responsibilities of all members.	<b>.74</b>	-.04
My team determines the strengths and weaknesses of all members.	<b>.73</b>	.11
My team sets goals for completing the task.	<b>.44</b>	<b>.42</b>
My team considers alternative courses of action for completing the task.	.12	<b>.75</b>
My team spends a lot of time discussing how to go about the task.	-.07	<b>.64</b>

*Note.*  $N = 179$

plotted against factors was examined (Cattell, 1966). The scree plot suggested the presence of two distinct factors. Second, the extracted eigenvalues were examined. Confirming the interpretation of the scree plot, there were two separate factors with eigenvalues greater than one (Tabachnick & Fidell, 2007). The rotated pattern matrix representing the two factors is presented in Table 1.

The first factor was most clearly interpretable, with three items loading onto the factor with values higher than .70. These same items had much lower loading on the second factor, ranging from as low as -.06 to .11. The items loading onto the first factor included (1) “My team clarifies the roles and responsibilities of all members”, (2) “My team identifies which members can be turned to for specific types of information”, and (3) “My team determines the strengths and weaknesses of all members”. Two items clearly loaded on the second factor, including (1) “My team spends a lot of time discussing how to go about the task”, and (2) “My team considers alternative courses of action for

completing the task”. A final item cross-loaded on both factors; namely, “My team set goals for completing the task”. A closer examination of the two factors reveals that the items comprising the first factor relate to components of planning that might impact interaction, or teamwork, within a team. The items in the second factor, on the other hand, more directly relate to components of planning that might impact task completion, or taskwork. Just as teams separately develop both teamwork and taskwork competencies (Morgan, Salas, & Glickman, 1993), it appears that there is a manifest distinction between planning that focuses on teamwork and planning that focuses on taskwork. The hypotheses put forth in the current study are grounded in the idea that team member interaction is a strong driver of TMM development. Accordingly, the items comprising the first factor were retained and subsequently used to operationalize planning. Internal consistency reliability for the updated planning scale was  $\alpha = .84$ . An additional factor analysis further resulted in the extraction of a single factor for the updated planning scale.

In order to demonstrate support for the construct validity of the updated planning scale, the scale was correlated with additional team process items that were independently developed by other researchers. Specifically, the additional items represent unpublished scales that were developed by John Mathieu and Michelle Marks to measure the team processes described by Marks et al. (2001). These items are included in Appendix F. Indeed, the updated planning scale was significantly correlated with additional items that were combined to represent the process of planning ( $r = .53, p = .00$ ). This correlation represents a large effect

size (Cohen, 1992) and provides support for the construct validity of the updated planning scale.

The team process of planning reflects a team level property, but data were collected at the individual level. In order to justify aggregation, three indices were examined. First,  $r_{wg}$  was examined as a measure of within-group agreement. To determine within-team agreement, the observed variance of the updated planning measure between each member in a team was compared to the expected random variance of responses to the scale. The expected random variance refers to the variance that would be observed if responses from individual team members formed a uniform (i.e., rectangular) distribution (Bliese, 2000). An  $r_{wg}$  value was calculated for each team. As a direct result of the manner in which  $r_{wg}$  is calculated, it is conceivable for there to be negative  $r_{wg}$  values. LeBreton and Senter (2008) suggest that one possible solution is to change all negative  $r_{wg}$  values to zero. This was the method adopted in the current study. The average  $r_{wg}$  value across all teams for the updated planning measure was .61. Further, ICC(1) was examined to determine between group variability and ICC(2) was examined as a measure of within group consistency. Both forms of ICCs were calculated using a one-way analysis of variance (ANOVA), with group membership as the independent variable and the updated planning measure as the dependent variable (Bliese, 2000). Once the ANOVA was conducted, the following formulas were used to calculate ICC(1) and ICC(2):

$$ICC(1) = (MS_b - MS_w) / (MS_b + [K - 1] MS_w)$$

$$ICC(2) = (MS_b - MS_w) / MS_b$$



where  $MS_b$  is the mean squared variance between teams,  $MS_w$  is the mean squared variance within teams, and  $K$  refers to number of individuals within the teams. Because there were varying team sizes, the average team size across all teams was used to represent  $K$  (Bliese & Halverson, 1998). Based on the above formulas,  $ICC(1) = .06$  and  $ICC(2) = .29$ .

There are no universally accepted cutoff values to justify aggregation. Some authors have suggested that values of .70 and higher are appropriate for  $r_{wg}$  and  $ICC(2)$ , while  $ICC(1)$  should be viewed as an effect size with values of .01, .10, and .25 representing small, medium, and large effect sizes, respectively (LeBreton & Senter, 2008). It is worth noting that others have suggested typical values for  $r_{wg}$ ,  $ICC(1)$ , and  $ICC(2)$  in applied research are much lower (Bliese, 2000; Gevers & Peters, 2009). Regardless of any absolute criteria for appropriate justification, the values in the present case are not ideal. However, it was decided to proceed with aggregation as the  $r_{wg}$  value suggested moderate agreement and the  $ICC(1)$  value indicated a small grouping effect by team. Therefore, the team mean was used as the team-level operationalization of planning, using the updated planning measure. It is noteworthy, however, that the scant support for aggregation represents a limitation of the current study.

#### Team Process of Implicit Coordination

The amount of implicit coordination that teams engaged in was assessed using a five-item scale developed by the author. The items on the scale were created to specifically reflect key elements of coordination, as discussed by Rico et al. (2008), in addition to Brannick et al. (1993), Marks et al. (2001), and

Mathieu et al. (2000). Participants rated the degree to which they felt each item in the scale describes their team on a 5-point scale (1 = extremely inaccurate; 5 = extremely accurate). See Appendix G for the complete implicit coordination scale. A composite implicit coordination score was created for each participant by averaging the scores from all items in the scale, with higher scores representing a greater amount of implicit coordination. Internal consistency reliability for the scores on the implicit coordination scale was  $\alpha = .89$ .

Given that this scale was developed for the current study, additional analyses were conducted to assess the psychometric properties of the scale and its construct validity. A factor analysis was conducted using principle axis factoring as an extraction method and direct oblimin rotation. As with the planning scale, two criteria were used to determine the number of factors captured by the implicit coordination scale. First, a scree plot of eigenvalues plotted against factors suggested the presence of a single factor. Second, the extracted eigenvalues were examined and there was only one factor with an eigenvalue greater than one.

In order to demonstrate support for the construct validity of the implicit coordination scale, the scale was correlated with additional team process items that were independently developed by other researchers. As described above, the additional items represent unpublished scales that were developed by John Mathieu and Michelle Marks to measure the team processes described by Marks et al. (2001). These items are included in Appendix F. Indeed, the implicit coordination scale was significantly correlated with additional items that were combined to represent the process of coordination ( $r = .61, p = .00$ ). This

correlation represents a large effect size (Cohen, 1992) and provides support for the construct validity of the implicit coordination scale.

The team process of implicit coordination reflects a team level property, but data were collected at the individual level. In order to justify aggregation,  $r_{wg}$ , ICC(1), and ICC(2) values were examined and all three indices were used to triangulate on whether aggregation was appropriate. The average  $r_{wg}$  value across all teams was .74, while ICC(1) = .09 and ICC(2) = .37. As with the updated planning scale, the values in the present case are not ideal. However, it was decided to proceed with aggregation as the  $r_{wg}$  value suggested moderate agreement and the ICC(1) value indicated a small grouping effect by team. Therefore, the team mean was used as the team-level operationalization of implicit coordination. It is again noteworthy that the scant support for aggregation represents a limitation of the current study.

#### Mental Model Similarity

Mental model information was collected from participants in the form of paired-comparison ratings, by asking the participants to rate the degree of relatedness between pairs of teamwork concepts. Based on a review of measures used in previous studies to elicit teamwork mental models (e.g., Lim & Klein, 2006), ten key concepts related to teamwork were identified. These concepts include (a) team members work well together, (b) team members often disagree with each other on issues faced by the team, (c) team members trust each other, (d) team members communicate openly with each other, (e) team members agree on decisions made in the team, (f) team members back each other up in carrying

out team tasks, (g) team members are similar to each other, (h) team members are aware of other team members' abilities, (i) team members treat each other as friends, and (j) the team is highly effective. Pairing each of the above concepts with every other concept resulted in a total of 45 paired-comparisons. Appendix H includes all information provided to participants regarding the paired-comparisons.

Mental model similarity was operationalized using *Pathfinder* (www.interlinkinc.net), a structural assessment program that can generate concept maps, or networks, based on paired-comparison ratings. With the paired-comparisons, *Pathfinder* was used to generate networks for each team member, representing their MM. Networks are derived based on the proximities between concepts, as quantified by the paired-comparison ratings. In other words, the specific pattern of proximities between concepts determines whether or not certain concepts are linked within the network. Two parameters dictate how proximities are translated into concept links. First, the *q-parameter* constrains the number of possible indirect links (i.e., concepts that are connected to one another via a third concept) in the network. The *q-parameter* can vary from 2 to  $n-1$ , where  $n$  refers to the number of concepts used for the paired-comparisons. Second, the *r-parameter* defines the metric used to determine the distance of a link between concepts and can vary from one to infinity. For all networks, the *q-* and *r-parameters* were set to  $n-1$  and infinity, respectively, which constrained the networks to include the minimum number of possible links between concepts. Once all MM networks were created, *Pathfinder* was further used to generate a

similarity index between the networks of all members on a team. Specifically, *Pathfinder* calculates the similarity between two networks with the following formula:

$$CL / (TL - CL)$$

where CL refers to the number of common links between concepts across both networks (i.e., the number of instances in which the same two concepts are linked in both networks); and TL refers to the total number links between concepts across both networks. Mental model similarity within a team was operationalized by comparing each team member's network to the network of every other team member and averaging the similarity indices across all similarity comparisons.

Although traditional measures of reliability are not available for the networks derived by *Pathfinder*, the network index of coherence quantifies the extent to which an individual is consistent in their paired-comparison ratings. As an example, if a participant rates Concept A as strongly related to Concept B, but completely unrelated to Concept C, it follows that Concepts B and C should not be highly related. In other words, very low coherence values (coherence < .20) suggest that the participant did not, or possibly could not, take the rating task seriously (Schvaneveldt, 1990). In order to ensure that the rating task was taken seriously in the current study, coherence values for each network were averaged across all members of a team and then averages across all teams for each of the three data collection waves. The average coherence levels across all participants and teams after the first, second, and third data collection waves were .34, .31, and .29, respectively. Although these values suggest a progressive reduction in

average coherence, potentially the result of participant fatigue, none of the average coherence values was below .20. Accordingly, it appears as though participants took the rating task seriously.

### Team Performance

The business simulation provided several indices of performance for each team, which are generated at eight consecutive time points (corresponding to eight strategic decisions made by the teams) throughout the simulation. Only indices from the eighth time point were used to allow temporal precedence to all other variables in the study. The indices of stock price, return on assets, and return on sales were combined to generate a composite performance index for each team. These three indices were chosen because, in conjunction, they represent a holistic indication of overall organizational performance (Dierdorff, Bell, & Belohlav, 2010). Each individual index was standardized and then combined with the others using the mean value. Internal consistency for this composite was  $\alpha = .85$ .

### Procedure

The business simulation was implemented using computer software developed by Capsim Business Simulations, Inc ([www.capsim.com](http://www.capsim.com)). As part of the simulation, each team acted as a top management team in charge of an electronic sensor manufacturing company. The teams were responsible for developing a coordinated business strategy across all functional areas of their respective fictitious organization, including research and development, marketing, production, and finance. In doing so, each team was required to make strategic decisions with respect to the activities of their organization, with the ultimate goal

of maximizing organizational performance. For each course session, the entire simulation lasted five weeks in duration. This simulation has been used in past research and has been referred to as “an ongoing hands-on experience for [management] students” (Mathieu & Schulze, 2006; p. 609).

At the beginning of the simulation, each team was provided with detailed information regarding the business simulation in general and their organization in particular. This information included (1) how to interface with the Capsim simulation software, (2) how to interpret feedback from the simulation, (3) what factors to consider when making strategic-decisions, (4) an executive overview that described the history of their organization, (5) data regarding the electronics sensory industry, and (6) data regarding the operations of each functional area. Each team subsequently made eight management decisions based on the information given to them. Example decisions include the determination of production levels, product positioning, and product pricing. Teams received feedback from the simulation program regarding the effects of each decision in the form of reports that indexed the organization’s performance. Indices of organization performance include profit, stock price, return on assets, return on sales, asset turnover, and market share.

The business simulation lasted for five weeks in duration, during which time the teams made the eight strategic decisions. Prior to beginning the simulation, participants completed questionnaires to assess demographic information, within-team familiarity, and personality. In addition to pre-simulation data collection, data were collected at three additional times during the

simulation, namely after the second, fourth, and sixth strategic decision made by the teams. Initially, data on all team processes and MM similarity were collected at each of these additional data collection waves. However, after two academic quarters of data collection, feedback from the course instructor suggested that the inclusion of all measures at all time points was creating participant fatigue. This was further corroborated by a progressive reduction in response rates.

It was subsequently decided to drop Hypotheses IV and V, which required the repeated measurement of team processes. Accordingly, the data collection protocol was changed for the third and final academic quarter of data collection. This was deemed appropriate in order to collect more meaningful data for the primary focus of the study, MM similarity. Thus, the measurement of team processes was retained only for the time points necessary to examine their relation with MM similarity. After the second strategic decision made by the teams, data was collected on the team process of planning and MM similarity. Following the fourth strategic decision, data was collected exclusively on MM similarity. Following the sixth strategic decision, data was collected on the team process of implicit coordination and MM similarity. Finally, the reduction in measures afforded the inclusion of several additional items for the retained team process measurements. While these items were not included in any of the main analyses, they were used to provide evidence of construct validity for the team process measures that were created for the study, as discussed above.

In order to ensure that the change in protocol did not substantially impact any of the key variables in the study, independent sample t-tests were conducted



on each of the key study variables. Results suggested no significant differences between the simulations before and after the data collection change with respect to the team process of planning ( $t[30] = .48, p = .64$ ), the team process of implicit coordination ( $t[30] = .81, p = .42$ ), MM similarity after the second strategic decision ( $t[29] = -1.50, p = .14$ ), MM similarity after the fourth strategic decision ( $t[28] = .24, p = .81$ ), MM similarity after the sixth strategic decision ( $t[26] = .25, p = .80$ ), or team performance after the eighth strategic decision ( $t[30] = 1.33, p = .19$ ). These non-significant findings justify the combined analysis of data from both simulations before and after the data collection change.

All data were collected via self-report web-based survey. The links to all surveys were made available to participants either prior to the simulation for the pre-simulation data collection or after the completion of the respective strategic decision (i.e., second, fourth, sixth) for the remaining data collection waves. For all surveys, there was a five-day timeframe for completion. The response rate for the pre-simulation survey (i.e., demographic information, within-team familiarity, personality) was 97.3%. The response rate for the team process measure collected after the second strategic decision (i.e., team process of planning) was 94.6%. The response rate for the team process measure collected after the sixth strategic decision (i.e., team process of implicit coordination) was 85.5%. The response rates for the MM similarity measures collected after the second, fourth and sixth strategic decision were 85.5%, 75.0%, and 74.4%, respectively. This suggests a general trend toward a lower response rate throughout the five-week the simulation, with the lowest response rate occurring after the sixth strategic

decision for the MM similarity measure (i.e., 74.4%). Finally, given the practical constraints of acquiring a large sample size in team research, especially when the research is conducted outside of the laboratory, an a priori decision was made to test all hypotheses at the  $p < .10$  level of significance in order to increase statistical power.

## CHAPTER III

### RESULTS AND ANALYSES

#### Preliminary Analyses

##### Normality Assumption

Before testing the hypotheses, preliminary analyses were conducted to examine the extent to which basic assumptions were met. Specifically, outliers, skewness values, and kurtosis values were examined for each of the main study variables as operationalized above, including: (1) trust; (2) team cooperation; (3) planning; (4) implicit coordination; (5) mental model similarity for all three data collections; and (6) team performance. Any observations that were more than 3.29 standard deviations from the mean of their respective distributions were identified as outliers (Tabachnick & Fidell, 2007). Further, normality was statistically examined by comparing skewness and kurtosis against a standard z-distribution (Tabachnick & Fidell, 2007). This was done by dividing the skewness and kurtosis values by their respective standard errors. All resulting absolute values greater than 1.96 were considered to be significantly skewed or kurtotic. The above analyses suggested a potential problem with the distribution for implicit coordination. There was one outlier present in the distribution, which exhibited significant skewness ( $z = -4.57$ ) and kurtosis ( $z = 6.12$ ). As this variable served as a dependent variable in at least one of the analyses described below, a transformation was conducted by raising all values to the power of four. The value of four was chosen because it maximized the reduction in both skewness and kurtosis. Following the transformation, team implicit coordination did not

exhibit significant skew ( $z = 0.00$ ) and much less, albeit marginally significant kurtosis ( $z = 1.97$ ). The transformed implicit coordination variable was used for all further analyses. Descriptive statistics and correlations for all variables are included in Table 2.

### Regression Assumptions

Analyses were also conducted to ensure that the assumptions of regression were adequately met. Specifically, multicollinearity, influential observations, and heteroscedasticity were examined for all analyses. For multicollinearity, the tolerance values for all predictors were examined. If tolerance was lower than .10 for any predictors, the necessary predictors were dropped to reduce redundancy. For influential observations, Cook's distance was examined for all observations. Any values larger than  $4/(n-k-1)$  were considered influential observations. All influential observations were closely examined to ensure that they did not reflect a calculation or data entry error. For analyses where influential observations reflected valid data, results are reported both with and without the influential observations. To confirm homogeneity of variance, regression residuals were plotted against predicted scores on the criterion. If a visual inspection indicated a problem, a Goldfield-Quandt test was conducted to confirm the presence of heteroscedasticity (Goldfield & Quandt, 1965). Any violations of regression assumptions are discussed below following the respective analysis.

**TABLE 2**  
Descriptive Statistics and Correlations for all Study Variables

	N	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Ethnic Diversity	32	0.44	0.24														
2 Gender Diversity	32	0.37	0.18	0.47**													
3 Age Diversity	32	0.12	0.09	0.06	0.17												
4 Familiarity	32	1.75	0.56	0.15	0.03	-0.26											
5 Education-Level	32	0.25	0.44	-0.67**	-0.51**	-0.04	-0.21										
6 Team Size	32	5.81	1.77	0.70**	0.62**	0.01	0.27	-0.93**									
7 Trust	32	2.84	0.60	-0.27†	-0.31†	0.02	0.27	0.36*	-0.30†								
8 Cooperation Planning	32	2.78	0.43	-0.38*	-0.35	-0.01	-0.03	0.42*	-0.46**	0.52**							
9 (post decision 2)	32	3.35	0.48	0.21	0.02	-0.07	0.49**	-0.22	0.28	0.02	-0.03						
10 Implicit Coordination (post decision 6)	32	3.86	0.52	-0.02	-0.17	0.14	-0.01	-0.05	0.02	0.10	0.03	0.28					
11 Implicit Coordination (transformed)	32	241.26	95.87	-0.02	-0.10	0.07	0.07	-0.02	-0.01	0.10	0.11	0.28	0.94**				
12 MM Similarity (post decision 2)	31	0.31	0.06	0.25	0.13	0.16	0.16	-0.31†	0.28	0.01	-0.09	0.28	0.22	0.18			
13 MM Similarity (post decision 4)	30	0.32	0.05	-0.41*	-0.02	-0.13	0.01	-0.04	0.07	0.08	0.06	0.03	0.34†	0.30	0.35†		
14 MM Similarity (post decision 6)	28	0.34	0.08	-0.03	-0.07	-0.10	-0.11	0.34†	-0.32†	-0.18	-0.12	0.14	0.14	0.16	0.25	0.11	
15 Team Performance (Decision 8)	32	0.00	0.87	-0.15	-0.01	0.34†	0.05	0.11	-0.12	0.10	-0.07	0.17	0.34†	0.41*	0.07	0.06	0.13

\*\* Significant at the 0.01 level (2-tailed)

\* Significant at the 0.05 level (2-tailed)

† Significant at the 0.10 level (2-tailed)

## Hypothesis Testing

### Hypothesis I

The first hypothesis predicted that there would be a significant positive relationship between the amount of planning and MM similarity. Planning was not related to MM similarity after the second, fourth, or sixth strategic decision ( $r = .28, p = .12$ ;  $r = .03, p = .86$ ;  $r = .14, p = .49$ ; respectively). Although all correlations were in the expected direction, none reached significance at the  $p < .10$  level. To further test Hypothesis I, a hierarchical regression was conducted between planning and MM similarity (post decision 4) with ethnic diversity as a control variable, as ethnic diversity was significantly related to MM similarity (post decision 4;  $r = -.41; p = .03$ ). MM similarity after the fourth strategic decision was used as the dependant variable in order to provide temporal precedence to planning (collected after the second strategic decision), as planning was hypothesized to influence MM similarity as opposed to the converse. Ethnic diversity was entered in Step 1 of the regression, while planning was entered in Step 2. Listwise deletion of cases with missing variables was used, resulting in a sample size of  $N = 30$  for the analysis. The overall model was significant ( $F[2, 27] = 2.84, p = .08$ ), accounting for 17% of the variance in MM similarity (post decision 4). However, planning did not significantly predict MM similarity ( $\beta = 0.10, p = .61$ ), while ethnic diversity was significantly related to MM similarity ( $\beta = -.42, p = .03$ ). The results are presented in Table 3 and suggest teams that were more ethnically diverse exhibited less similarity in MMs.

An examination of the assumptions of regression suggested the presence

**TABLE 3**

Summary of Hierarchical Regression Analysis of Planning as a Predictor of MM Similarity  
(post decision 4)

	Coefficients			Model Statistics				
	<i>B</i>	<i>SE B</i>	$\beta$	<i>N</i>	<i>R</i> <sup>2</sup>	<i>F</i>	$\Delta R^2$	$\Delta F$
Step 1								
Ethnic Diversity	-0.09	0.04	-0.41*					
Step 2				30	0.17	2.84†	0.01	0.27
Ethnic Diversity	-0.09	0.04	-0.42*					
Planning	0.01	0.02	0.10					
<u>Reanalysis without Influential Observations</u>								
Step 1								
Ethnic Diversity	-0.07	0.03	-0.37*					
Step 2				28	0.18	2.71†	0.04	1.21
Ethnic Diversity	-0.08	0.03	-0.41*					
Planning	0.02	0.02	0.20					

\*\* Significant at the 0.01 level (2-tailed)

\* Significant at the 0.05 level (2-tailed)

† Significant at the 0.10 level (2-tailed)

of two influential observations. Despite their undue influence, an inspection of the data indicated no reason to believe these observations represented calculation or data collection errors as opposed to valid observations. The analysis was re-run without the influential observation, but the results did not substantively change. The results from the analysis without the influential observations are also presented in Table 3.

As a final test of Hypothesis I, the same analyses were conducted with MM similarity (post decision 6) as the dependent variable. This afforded additional examination of the hypothesis, while allowing planning to retain temporal precedence. However, planning did not significantly predict MM similarity. Accordingly, Hypothesis I was not supported.

### Hypothesis II

The second hypothesis predicted that implicit coordination would mediate

the positive relationship between MM similarity and performance. Baron and Kenny (1986) outline the necessary procedures to test a mediational hypothesis using a series of three multiple regressions. In the first regression analysis, the predictor must be shown to influence the mediator. Accordingly, implicit coordination was regressed onto MM similarity. No control variables were added to the analysis as none were significantly related to the dependent variable. MM similarity (post decision 4) was chosen as the predictor in order to allow temporal precedence over the mediator (i.e., implicit coordination), while simultaneously allowing the mediator to have temporal precedence over the criterion (i.e., team performance). Listwise deletion of cases with missing variables was used, resulting in a sample size of  $N = 30$  for the analysis. The overall model was marginally significant ( $F[1, 28] = 2.81, p = .105$ ), accounting for 9% of the variance in implicit coordination. Similarly, MM similarity (post decision 4) was a marginally significant predictor of implicit coordination ( $\beta = .30, p = .105$ ). The results are presented in Table 4 and suggest the more similar MMs were among team members, the more implicit coordination the team exhibited.

An examination of the assumptions of regression suggested the presence of two influential observations. The analysis was re-run without the influential observations. Without the influential observations, MM similarity (post decision 4) was no longer related to implicit coordination ( $\beta = .01, p = .975$ ), suggesting that these two observations were primarily responsible for the relationship between MM similarity and implicit coordination. Despite their undue influence, an inspection of the data indicated no reason to believe these observations



**TABLE 4**

Regression Analyses of Implicit Coordination as a Mediator of the MM Similarity and Team Performance Relationship

	Coefficients			Model Statistics				
	<i>B</i>	<i>SE B</i>	$\beta$	<i>N</i>	<i>R</i> <sup>2</sup>	<i>F</i>	$\Delta R^2$	$\Delta F$
Analysis 1: DV = Implicit Coordination								
MM Similarity (post decision 4)	603.3	360.2	0.30 <sup>A</sup>	30	0.09	2.81 <sup>A</sup>	--	--
Analysis 2: DV = Team Performance								
Step 1								
Age Diveristy	3.43	1.82	0.34†					
Step 2								
Age Diveristy	3.56	1.85	0.35†	30	0.12	1.89	0.01	0.30
MM Similarity (post decision 4)	1.85	3.36	0.10					
Analysis 3: DV = Team Performance								
Step 1								
Age Diveristy	3.43	1.82	0.34†					
Step 2								
Age Diveristy	3.22	1.75	0.32†	30	0.25	2.95*	0.14	2.46
Implicit Coordination	0.01	0.01	0.38*					
MM Similarity (post decision 4)	-0.36	3.32	-0.02					
<u>Reanalysis without Influential Observations</u>								
Analysis 1: DV = Implicit Coordination								
MM Similarity (post decision 4)	10.72	334.1	0.01	28	0.01	0.01	--	--
Analysis 3: DV = Team Performance								
Step 1								
Age Diveristy	3.43	1.87	0.33†					
Step 2								
Age Diveristy	3.66	1.79	0.36*	29	0.29	3.33*	0.18	3.07†
Implicit Coordination	0.01	0.01	0.41*					
MM Similarity (post decision 4)	1.21	3.61	0.06					

*Note.* All change statistics are between Step 1 and Step 2 within their respective model.

<sup>A</sup> These values are marginally significant at the 0.10 level (2-tailed);  $p = .105$

\*\* Significant at the 0.01 level (2-tailed)

\* Significant at the 0.05 level (2-tailed)

† Significant at the 0.10 level (2-tailed)

represented calculation or data collection errors as opposed to valid observations.

The results from the analysis without the influential observations are also

presented in Table 4.

In the second regression analysis, the predictor must be shown to influence

the criterion. Accordingly, a hierarchical regression analysis was conducted between MM similarity (post decision 4) and team performance with age diversity as a control variable, as age diversity was significantly related to team performance ( $r = .34$ ;  $p = .06$ ). Age diversity was entered in Step 1 and MM similarity (post decision 4) was entered in Step 2. Listwise deletion of cases with missing variables was used, resulting in a sample size of  $N = 30$  for the analysis. The overall model was not significant ( $F[2, 27] = 1.89$ ,  $p = .17$ ), accounting for 12% of the variance in team performance. MM similarity (post decision 4) did not significantly predict team performance ( $\beta = .10$ ,  $p = .59$ ), while age diversity was significantly related to team performance ( $\beta = .35$ ,  $p = .07$ ). The results are presented in Table 4 and suggest teams that were more diverse with respect to age exhibited better performance.

In the third regression analysis, both the mediator and predictor are entered into the analysis at the same time to demonstrate (1) that the mediator is related to the criterion and (2) that the relationship between the predictor and criterion is weaker when controlling for the effects of the mediator. Accordingly, a hierarchical regression analysis was conducted with team performance as the dependent variable. Age diversity was entered in Step 1 and both implicit coordination and MM similarity (post decision 4) were entered in Step 2. Listwise deletion of cases with missing variables was used, resulting in a sample size of  $N = 30$  for the analysis. The overall model was significant ( $F[3, 29] = 2.95$ ,  $p = .05$ ), accounting for 25% of the variance in team performance. MM similarity (post decision 4) did not significantly predict team performance ( $\beta = -.02$ ,  $p = .92$ ),

while both implicit coordination ( $\beta = .38, p = .04$ ) and age diversity ( $\beta = .32, p = .08$ ) were significantly related to team performance. The results are presented in Table 4 and suggest teams that exhibited more implicit coordination and were more diverse with respect to age performed at a higher level.

An examination of the assumptions of regression suggested the presence of one influential observation. The analysis was re-run without the influential observation. Without the influential observation, the relationship between age diversity and team performance became significant at the  $p < .05$  level ( $\beta = .36, p = .05$ ), as compared to the  $p < .10$  level. Despite its undue influence, an inspection of the data indicated no reason to believe the observation represented a calculation or data collection error as opposed to a valid observation. The results from the analysis without the influential observation are also presented in Table 4.

The first analysis demonstrated a marginally significant relationship between the predictor (i.e., MM similarity) and the mediator (i.e., implicit coordination;  $\beta = .30, p = .105$ ), assuming the inclusion of the influential observations. This marginally satisfies the first criterion for demonstrating mediation. The second analysis, on the other hand, demonstrated a non-significant relationship between the predictor (i.e., MM similarity) and the criterion (i.e., team performance;  $\beta = .10, p = .59$ ). Some authors have suggested relaxing the second criterion for demonstrating mediation in situations where the predictor is temporally removed from the criterion (Henderson, Wayne, Shore, Bommer, & Tetrick, 2008). The power to detect a relationship between a temporally removed distal predictor is relatively weak, as compared to via the mediated relationship

(Shrout & Bolger, 2002). Other authors have even suggested that showing a relationship between the predictor and the criterion is not necessary for demonstrating mediation, as the mediator may act as a suppressor variable (Kenny, Kashy, & Bolger, 1998). With respect to the third analysis, there was a significant relationship between the mediator (i.e., implicit coordination) and the criterion (i.e., team performance;  $\beta = .38, p = .04$ ). In comparing the beta-weights for MM similarity between the second and third analyses, the relationship between MM similarity and team performance was non-significant in both cases, but the magnitude was reduced in the third equation. These findings partially meet the requirements for mediation, as outlined by Baron and Kenny (1986). Namely, there was a marginally significant relationship between the predictor (i.e., MM similarity) and the mediator (i.e., implicit coordination), followed by a significant relationship between the mediator and the criterion (i.e., team performance). Preacher and Hayes (2008) provide a description of how to test the significance of an indirect effect for a mediational hypothesis with the inclusion of control variables. An examination of the indirect effect of MM similarity on team performance using the syntax provided by Preacher and Hayes (2008) suggested a non-significant effect.

The criterion (i.e., team performance) was operationalized as a composite of various performance indicators (i.e., stock price, return on assets, return on sales) after the eighth strategic decision, which gave temporal precedence to the predictor and mediator. However, there was additional information available on these indices after the seventh strategic decision. As a final test of Hypothesis II,

the analyses were re-run with a composite performance index after the seventh strategic decision, which still gave temporal precedence to the predictor and mediator within the analyses. All results were comparable; namely, there remained a marginally significant relationship between MM similarity and implicit coordination, in addition to a significant relationship between implicit coordination and team performance. Again, however, an examination of the indirect effect of MM similarity on team performance suggested a non-significant effect (Preacher & Hayes, 2008). Accordingly, Hypothesis II was not supported.

### Hypothesis III

The third hypothesis predicted that MM similarity would increase over time. To test this hypothesis, a repeated measures ANOVA was conducted to determine any significant mean differences in MM similarity between the three data collection waves. Listwise deletion of cases with missing variables was used in this analysis, resulting in a sample size of  $N = 26$ . The mean MM similarity values across all teams after the second, fourth, and sixth strategic decisions were 0.32, 0.32, and 0.34, respectively. Although there appears to be a slight increase in MM similarity at time 3, this difference is not significant ( $F[2, 50] = 1.88, p = .16$ ). Accordingly, Hypothesis III was not supported.

### Hypothesis IV

The fourth hypothesis predicted that the amount of planning that teams engaged in would decrease over time. As discussed above, this hypothesis was dropped due to participant fatigue that resulted from the additional measures required to test the hypothesis. Accordingly, this hypothesis was not tested.

### Hypothesis V

The fifth hypothesis predicted that the amount of implicit coordination that teams engaged in would increase over time. As discussed above, this hypothesis was dropped due to participant fatigue that resulted from the additional measures required to test the hypothesis. Accordingly, this hypothesis was not tested.

### Hypothesis VI

The sixth hypothesis predicted that trust would be positively related to MM similarity through the mediating role of planning. As discussed above, a series of three regression analyses can be used as criteria for demonstrating mediation. The results of Hypothesis I demonstrate a failure to meet one of the essential criteria for the current hypothesis. Namely, the mediator (i.e., planning) was not significantly related to the criterion (i.e. MM similarity). However, the direct effect of trust on MM similarity was still examined.

Trust was not related to MM similarity after the second, fourth, or sixth strategic decisions ( $r = .01, p = .97$ ;  $r = .08, p = .69$ ;  $r = -.18, p = .35$ ; respectively). To further test Hypothesis VI, a hierarchical regression was conducted between trust and MM similarity (post decision 2) with education-level as a control variable, as education-level was significantly related to MM similarity (post decision 2;  $r = -.31; p = .09$ ). MM similarity after the second strategic decision was used as the dependent variable because this data collection point was most proximal to the collection of trust data, while still providing temporal precedence to trust. Education-level was entered in Step 1 of the regression, while trust was entered in Step 2. Listwise deletion of cases with missing variables was

**TABLE 5**

Summary of Hierarchical Regression Analysis of Trust as a Predictor of MM Similarity  
(post decision 2)

	Coefficients			Model Statistics				
	<i>B</i>	<i>SE B</i>	$\beta$	<i>N</i>	$R^2$	<i>F</i>	$\Delta R^2$	$\Delta F$
Step 1								
Education-Level	-0.05	0.03	-0.31†					
Step 2				31	0.11	1.74	0.01	0.45
Education-Level	-0.05	0.03	-0.35†					
Trust	0.01	0.02	0.13					

\*\* Significant at the 0.01 level (2-tailed)

\* Significant at the 0.05 level (2-tailed)

† Significant at the 0.10 level (2-tailed)

used, resulting in a sample size of  $N = 31$  for the analysis. The overall model was not significant ( $F[2, 28] = 1.74, p = .19$ ), accounting for 11% of the variance in MM similarity (post decision 2). Trust did not significantly predict MM similarity ( $\beta = 0.13, p = .51$ ), while education-level was significantly related to MM similarity ( $\beta = -.35, p = .07$ ). The results are presented in Table 5 and suggest teams in the graduate-level course exhibited less similarity in MMs.

As a final test of Hypothesis VI, the same analyses were conducted with MM similarity (post decision 4) and MM similarity (post decision 6) as the dependent variables. This afforded additional examination of the hypothesis, while allowing trust to retain temporal precedence. Further, the analyses were re-run using the team mean as the team-level operationalization of trust. However, trust was not a significant predictor in any of the additional analyses.

Accordingly, Hypothesis VI was not supported.

### Hypothesis VII

The seventh hypothesis predicted that cooperation would be positively related to MM similarity through the mediating role of planning. The results of

Hypothesis I again demonstrate a failure to meet one of the essential criteria for the current hypothesis. Namely, the mediator (i.e., planning) was not significantly related to the criterion (i.e. MM similarity). However, the direct effect of cooperation on MM similarity was still examined.

Cooperation was not related to MM similarity after the second, fourth, or sixth strategic decisions ( $r = -.09, p = .62$ ;  $r = .06, p = .74$ ;  $r = -.12, p = .53$ ; respectively). To further test Hypothesis VII, a hierarchical regression was conducted between cooperation and MM similarity (post decision 2) with education-level as a control variable, as education-level was significantly related to MM similarity (post decision 2;  $r = -.31, p = .09$ ). MM similarity after the second strategic decision was used as the dependent variable because this data collection point was most proximal to the collection of cooperation data, while still providing temporal precedence to cooperation. Education-level was entered in Step 1 of the regression, while cooperation was entered in Step 2. Listwise deletion of cases with missing variables was used, resulting in a sample size of  $N = 31$  for the analysis. The overall model was not significant ( $F[2, 28] = 1.51, p = .24$ ), accounting for 10% of the variance in MM similarity (post decision 2). Cooperation did not significantly predict MM similarity ( $\beta = 0.03, p = .88$ ), nor did education-level ( $\beta = -.32, p = .11$ ). The results are presented in Table 6.

As a final test of Hypothesis VII, the same analyses were conducted with MM similarity (post decision 4) and MM similarity (post decision 6) as the dependent variables. This afforded additional examination of the hypothesis, while allowing cooperation to retain temporal precedence. Further, the analyses



were re-run using the team mean as the team-level operationalization of cooperation. However, cooperation was not a significant predictor in any of the additional analyses. Accordingly, Hypothesis VII was not supported.

**TABLE 6**

Summary of Hierarchical Regression Analysis of Cooperation as a Predictor of MM Similarity (post decision 2)

	Coefficients			Model Statistics				
	<i>B</i>	<i>SE B</i>	$\beta$	<i>N</i>	$R^2$	<i>F</i>	$\Delta R^2$	$\Delta F$
Step 1								
Education-Level	-0.05	0.03	-0.31†					
Step 2				31	0.10	1.51	0.01	0.02
Education-Level	-0.05	0.03	-0.32					
Cooperation	0.01	0.03	0.03					

\*\* Significant at the 0.01 level (2-tailed)

\* Significant at the 0.05 level (2-tailed)

† Significant at the 0.10 level (2-tailed)

## CHAPTER IV

### DISCUSSION

#### Mental Model Antecedents

With respect to the antecedents of MM similarity, Hypotheses I, VI, and VII collectively suggested that trust and cooperation would positively influence MM similarity through the mediating role of team planning. However, none of these hypotheses were supported. Specifically, planning was not significantly related to MM similarity (Hypothesis I), nor were there any direct or indirect effects of trust (Hypothesis VI) or cooperation (Hypothesis VII) on MM similarity. A potential explanation for the lack of findings is that teamwork MMs develop not only as a function of the current team, but also as a function of an individual's cumulative prior experience with teams. Indeed, researchers have suggested that team-relevant cognition is highly influenced by prior team experience (Rentsch, Delise, & Hutchison, 2009), a contention that has received empirical support (Rentsch, Heffner, & Duffy, 1994). Accordingly, characteristics of the current teams such as personality composition may exert minimal influence on team-relevant cognition compared to the accumulated characteristics of other teams that comprise team members' prior team experiences. Future research might explore the dual role of current team characteristics and past team experiences in the development of team-relevant cognitions.

The current study also focused on similarity with respect to teamwork MMs, as opposed to taskwork MMs. The updated planning scale that was ultimately used also retained only items that were deemed to be conceptually

linked to teamwork, as compared to taskwork. Despite this conceptual alignment, there was no significant effect of planning on MM similarity. Common conceptualizations of planning refer to the orchestration of team member activities to facilitate the completion of specific tasks (Marks et al., 2001) and make no distinction between taskwork and teamwork planning. Given that planning, regardless of its proximal focus, is ultimately a means of achieving team goals, it is conceivable that the process of planning exerts a stronger influence on shared cognitions related to taskwork, as opposed to teamwork. Future research should explore the differential relationship between team processes and various team-relevant content domains of shared cognition.

Interestingly, team-level diversity with respect to ethnicity was significantly related to MM similarity. Specifically, teams that were more ethnically diverse exhibited less similarity in MMs. Indeed, this is consistent with the idea that demographic variables can serve as surrogates for past experiences (Zenger & Lawrence, 1989) and that similar past experiences should be related to the frequency and quality of interactions, in turn facilitating shared cognitions (Rentsch & Klimoski, 2001). Further, Gibson and Zellmer-Bruhn (2001) found that mental conceptualization of teamwork in the form of metaphors systematically varied as a function of culture. To the extent that different ethnicities embody different cultures, members of different ethnicities might have disparate conceptualizations of teamwork as informed by their respective cultures, in turn resulting in reduced similarity of teamwork cognitions. Ethnic diversity was merely examined as a control variable in the current study. Future research

can more specifically examine the role of diversity in the development of shared cognition in teams. Given recent advancements in the conceptualization of diversity (Harrison & Klein, 2007) and the relationship between diversity variables and team performance (Bell, Villado, Lukasik, Belau, & Briggs, in press), this represents a fertile area for development.

#### Mental Model Consequences

With respect to the consequences of MM similarity, Hypothesis II suggested that MM similarity would positively influence team performance through the mediating role of implicit coordination. Although Hypothesis II was not supported, as indicated by a non-significant indirect effect of MM similarity on team performance, there were several positive indications. Indeed, given the often-ambiguous nature of the performance domain for top management teams (Devine, 2002), a shared understanding of team member interaction should be of particular relevance for coordinated action and subsequent performance. It is a positive indication that MM similarity had a positive, albeit marginally significant, impact on implicit coordination, which in turn had a positive impact on team performance. The absence of a significant indirect effect may well be a function of the temporal distance between the variables, which can serve to attenuate the strength of the relationships (Henderson, Wayne, Shore, Bommer, & Tetrick, 2008). Similarly, as discussed below, the sample size of the current study limited statistical power, which may have prevented the detection of otherwise detectible effects.

### Mental Model Changes Over Time

With respect to temporal changes, Hypothesis III suggested that MM similarity would increase overtime. Hypothesis III was not supported, as there were no significant differences in MM similarity within teams across the three data collection waves. Although this is surprising given theoretical arguments in support of increased MM similarity over time (cf., Mathieu et al., 2000), this finding is actually consistent with empirical findings that have demonstrated temporal consistency in MMs (Mathieu et al., 2000; Edwards et al., 2006). One possible explanation for these findings was suggested above; namely that team-relevant cognition is highly influenced by prior team experience (Rentsch et al., 2009). As such, it is conceivable that the team members in the current study already had highly developed teamwork MMs upon entry into the current teams. These pre-existing MMs were ostensibly based on an accumulation of prior experiences with teams, in turn allowing little room for malleability based on a single additional team experience. Conversely, if there was initial adjustment or calibration of pre-existing MMs to fit the current teams, it is possible that this occurred relatively quickly, such that changes were already stabilized by the first MM measurement after the second strategic decision. Unfortunately, this could only be tested if a baseline MM measurement was taken prior to team formation, which was not done in the current study. Future research might examine changes in MM similarity that occur immediately after team formation, in order to isolate any team-specific adjustments that occur in MMs at the time of a team's inception.

### Study Limitations

In addition to the alternative explanations posited above, there were several limitations to the current study that might similarly explain the absence of statistically significant findings. First, the sample size in the current study limited the statistical power available to detect true effects. Indeed, a post-hoc power analysis was conducted using G\*Power 3.0 (Faul, Erdfelder, Lang, & Bucher, 2007) and indicated that the observed statistical power ranged from .50 to .90 across all analyses. Given that the conventional criterion for adequate power is .80 (Cohen, 1992), there may not have been adequate power for some of the analyses. Specifically, the lowest statistical power was observed for analyses related to trust and cooperation as predictors of MM similarity, as a result of the extremely small  $R^2$  values. A larger sample size would have afforded greater statistical power and allowed for more confidence in the results.

An additional limitation of the current study was missing data at the individual-level. As suggested above, response rates ranged from 74.4% to 97.3% across all surveys. In general, missing data at the individual-level is likely to influence results when data is aggregated and analyzed at the team-level (Allen, Stanley, Williams, & Ross, 2007; Timmerman, 2005). However, the impact of missing data is likely to vary depending on the type of variable under consideration (Kozlowski & Klein, 2000). For example, team processes strictly represent a team-level phenomenon, such that individual responses indicate ratings of the team-level property. In other words, individual team members can be viewed as raters of a target (i.e., the team), much like raters judge candidates or

employees in a performance appraisal context. The aggregation of such variables can be referred to as a composition process, in which variables at different levels of analysis are considered isomorphic, or identical (Bliese, 2000). In such situations, all members of a team would be expected to provide the same response, suggesting that the responses of team members should be interchangeable. Accordingly, missing data only means that there are fewer raters of the same target, rather than altering the meaning of the construct. Therefore, missing data should not have a detrimental affect on the interpretation of the team-level variable.

Mental models, on the other hand, cannot be considered isomorphic across different levels of analysis. At the individual-level, the MM represents a team member's structured understanding of a team-relevant content domain. When aggregated to the team-level, however, the construct of MM similarity no longer represents the concept of structured knowledge, but rather the *degree of similarity between* team members' structured knowledge. Aggregation in this case can be referred to as a compilation process, in which individual-level units are combined to form a qualitatively distinct construct or characteristic at a higher level of analysis (Bliese, 2000). In such cases, the meaning of the construct at the higher level of analysis inherently depends on all of the lower-level units, suggesting that missing data would influence the interpretation of the team-level variable. In the current study, the response rates for the three waves of MM data collection ranged from 74.4% to 85.5%, indicating the presence of missing data. It is conceivable

that the inclusion of this missing data in the operationalization of MM similarity would substantially alter the team-level variable.

Related to the above limitation, the construct of MM similarity refers to the degree of similarity between team members at a single point in time. In other words, although MM similarity was hypothesized to change over time, the individual measurements were meant to capture the degree of similarity at a discrete moment. However, the nature of the data collection protocol created some ambiguity with respect to this issue. Namely, all measures were made available to participants following the respective strategic decision, with a five-day timeframe for completion. As such, individual team members within the same team may have taken the measure as much as five days apart. This situation created the potential for a temporal disparity with the measurement of MM similarity, which could have attenuated the amount of similarity among team members' MMs.

A final limitation of the current study has to do with the aggregation of the team process variables. The aggregation of team process ratings requires justification via various metrics of agreement or consistency (Bliese, 2000), as all raters are presumed to be rating the same target (i.e., the team). As discussed above, three specific metrics were examined, including  $r_{wg}$ , ICC(1), and ICC(2). In each case, the values for these metrics were not ideal. Thus, although it was decided to proceed with aggregation due to moderate agreement and grouping within the level-2 units, the scant support for aggregation of team process ratings



represents a limitation. All findings of the current study should be viewed in light of this limitation, in addition to the other limitations mentioned above.

### Study Implications

The above limitations notwithstanding, the results regarding MM consequences have several important implications. Mental models have been predominantly studied in the context of military team training (Rentsch et al., 2008). The current study demonstrates the potential applicability of MMs to top management teams by partially replicating findings that suggest MM similarity influences team performance through the mediating role of coordination (Mathieu et al., 2000). Accordingly, this suggests that organizations might consider interventions aimed at ensuring members of top management teams are on the same page with respect to how they conceptualize teamwork. Specifically, organizations could employ training to induce MM similarity (Marks et al., 2000; Marks et al., 2002). Future research should continue to explore the relevance of shared cognition in top management teams, for example by examining other antecedent, additional consequence, and other content domains of shared cognition.

The current study also made a specific distinction between explicit and implicit coordination. Implicit coordination was defined as to a team's ability to act in fluid manner by adjusting behaviors in anticipation of actions of other members without the need for overt communication (Rico et al., 2008). This specific form of coordination is more conceptually aligned with the proposed outcomes of MM similarity in an action phase (Marks et al., 2001), as compared

to explicit coordination that requires overt communication, which is more indicative of planning in a transition phase. The distinction between explicit and implicit coordination is relatively recent, and thus little empirical work examining this construct has been conducted. The current study supports the importance of implicit coordination, both as a potential outcome of MM similarity and as a strong driver of team performance in top management teams. This suggests that organizations could assess the extent to which top management teams are able to achieve implicit coordination, as a means of assessing their performance potential. The implicit coordination scale developed in the current study, for example, could serve as a useful assessment tool.

## CHAPTER V

### SUMMARY

Despite recent interest in the concept of team cognition, relatively little is known about the development of MM similarity in teams. The current study examined several potential antecedents of MM similarity, in addition to their consequences and changes in similarity over time, using a longitudinal design with teams that closely resemble top management teams. Theory and research regarding team processes suggest that certain team processes may be especially relevant for the development of MM similarity. Certain personality facets may also be related to the development of MM similarity, through their influence on team processes. Specifically, it was hypothesized that the personality composition of teams with respect to both trust and cooperation would be positively related to MM similarity through the mediating role of planning. The hypotheses related to antecedents of MM similarity were not supported. It was further hypothesized that MM similarity would be positively related to team performance through the mediating role of implicit coordination. Indeed, MM similarity had a positive, albeit marginally significant, impact on implicit coordination, which in turn had a positive impact on team performance. However, the indirect effect of MM similarity on team performance was non-significant. Finally, it was hypothesized that MM similarity would increase overtime. However, there were no significant differences in MM similarity within teams across the multiple data collection waves.

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Appendix A  
Demographic Information Questionnaire

**1. How old are you? \_\_\_\_\_**

**2. What is your gender (check one)?**

- Female
- Male

**3. What is your ethnicity (check one)?**

- African American/Black
- American Indian/Alaska Native
- Asian/Pacific Islander
- Caucasian/White
- Hispanic
- Biracial/Multiracial
- Other

Appendix B  
Familiarity Check



**Overall, how well did you know your team members before this class?**

1	2	3	4	5
Not at All	Not Well	Somewhat Well	Well	Very Well

Appendix C

Trust Scale

**For each statement below, indicate how accurately the statement describes YOU. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly the same age. Please read each statement carefully and respond by filling in the appropriate bubble.**

1	2	3	4	5
Very Inaccurate	Inaccurate	Neither Inaccurate nor Accurate	Accurate	Very Accurate

1.    \_\_\_    I trust what people say.
2.    \_\_\_    I distrust people.
3.    \_\_\_    I believe that people are basically moral.
4.    \_\_\_    I believe that others have good intentions.
5.    \_\_\_    I suspect hidden motives in others.
6.    \_\_\_    I believe in human goodness.
7.    \_\_\_    I believe that people are essentially evil.
8.    \_\_\_    I trust others.
9.    \_\_\_    I am wary of others.
10. \_\_\_    I think that all will be well.

Appendix D  
Cooperation Scale

**For each statement below, indicate how accurately the statement describes YOU. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly the same age. Please read each statement carefully and respond by filling in the appropriate bubble.**

1	2	3	4	5
Very Inaccurate	Inaccurate	Neither Inaccurate nor Accurate	Accurate	Very Accurate

1.    \_\_\_    I contradict others.
2.    \_\_\_    I hate to seem pushy.
3.    \_\_\_    I insult people.
4.    \_\_\_    I love a good fight.
5.    \_\_\_    I am easy to satisfy.
6.    \_\_\_    I hold a grudge.
7.    \_\_\_    I have a sharp tongue.
8.    \_\_\_    I get back at others.
9.    \_\_\_    I yell at people.
10. \_\_\_    I can't stand confrontations.

Appendix E  
Planning Scale

**For each statement below, indicate how accurately the statement describes YOUR TEAM. Please read each statement carefully and respond by filling in the appropriate bubble.**

1	2	3	4	5
Very Inaccurate	Inaccurate	Neither Inaccurate nor Accurate	Accurate	Very Accurate

1.    \_\_\_    My team spends a lot of time discussing how to go about the task.
2.    \_\_\_    My team clarifies the roles and responsibilities of all members.
3.    \_\_\_    My team considers alternative courses of action for completing the task.
4.    \_\_\_    My team sets goals for completing the task.
5.    \_\_\_    My team identifies which members can be turned to for specific types of information.
6.    \_\_\_    My team determines the strengths and weaknesses of all members.

Appendix F  
Additional Team Process Items



**TO WHAT EXTENT DOES OUR TEAM ACTIVELY WORK TO...**

1	2	3	4	5
Not at All	Very Little	To Some Extent	To a Great Extent	To a Very Great Extent

Team Process of Planning

1. \_\_\_\_\_ Develop an overall strategy to guide our team activities?
2. \_\_\_\_\_ Specify the sequence in which work products should be accomplished?
3. \_\_\_\_\_ Prepare contingency ("if-then") plans to deal with uncertain situations?

Team Process of Coordination

1. \_\_\_\_\_ Communicate well with each other?
2. \_\_\_\_\_ Smoothly integrate our work efforts?
3. \_\_\_\_\_ Coordinate our activities with one another?

Appendix G  
Implicit Coordination Scale

**For each statement below, indicate how accurately the statement describes YOUR TEAM. Please read each statement carefully and respond by filling in the appropriate bubble.**

1	2	3	4	5
Very Inaccurate	Inaccurate	Neither Inaccurate nor Accurate	Accurate	Very Accurate

1.    \_\_\_    Members of my team provide task-related information to other members without being asked.
2.    \_\_\_    My team proactively helps individual members when they need assistance.
3.    \_\_\_    My team monitors the progress of all members' performance.
4.    \_\_\_    Members of my team effectively adapt their behavior to the actions of other members.
5.    \_\_\_    My team effectively coordinates the activities of all members when working to complete the task.

## Appendix H

### Teamwork Concepts used for Mental Model Elicitation

**On the following pages, you will be presented with pairs of concepts related to TEAMWORK. Your task is to rate how related the concepts in each pair are until all pairs have been rated. Please respond by entering how closely you deem the two concepts in each pair to be related using a 1-9 scale (1 = unrelated and 9 = related).**

1	2	3	4	5	6	7	8	9
Unrelated								Related

### Teamwork Concepts

1. Working well together.
2. Often disagreeing with each other on issues faced by the team.
3. Trusting each other.
4. Communicating openly with each other.
5. Agreeing on decisions made in the team.
6. Backing each other up in carrying out team tasks.
7. Being similar to each other (for example in personality and ability).
8. Being aware of other team members' abilities.
9. Treating each other as friends.
10. Being a highly effective team.