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How do teams learn? shared mental models and transactive memory systems as determinants of team learning and effectiveness

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HOW DO TEAMS LEARN? SHARED MENTAL MODELS AND TRANSACTIVE MEMORY SYSTEMS AS DETERMINANTS OF TEAM LEARNING AND EFFECTIVENESS

by

Amit Kumar Nandkeolyar

An Abstract

Of a thesis submitted in partial fulfillment
of the requirements for the Doctor of
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in the Graduate College of
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August 2008

Thesis Supervisor: Professor Greg L. Stewart

ABSTRACT

Shared mental models (SMM) and Transactive memory systems (TMS) have been advocated as the main team learning mechanisms. Despite multiple appeals for collaboration, research in both these fields has progressed in parallel and little effort has been made to integrate these theories. The purpose of this study was to test the relationship between SMM and TMS in a field setting and examine their influence on various team effectiveness outcomes such as team performance, team learning, team creativity, team members' satisfaction and team viability.

Contextual factors relevant to an organizational setting were tested and these included team size, tenure, country of origin, team reward and organizational support. Based on responses from 41 teams from 7 industries across two countries (US and India), results indicate that team size, country of origin and team tenure impact team performance and team learning. In addition, team reward and organizational support predicted team viability and satisfaction.

Results indicated that TMS components (specialization, coordination and credibility) were better predictors of team outcomes than the omnibus TMS construct. In particular, TMS credibility predicted team performance and creativity while TMS coordination predicted team viability and satisfaction. SMM was measured in two different ways: an average deviation index and a 6-item scale. Both methods resulted in a conceptually similar interpretation although average deviation indices provided slightly better results in predicting effectiveness outcomes.

TMS components moderated the relationship between SMM and team outcomes. Team performance was lowest when both SMM and TMS were low. However, contrary to expectations, high levels of SMM did not always result in effective team outcomes (performance, learning and creativity) especially when teams exhibited high TMS specialization and credibility. An interaction pattern was observed under conditions of low levels of SMM such that high TMS resulted in higher levels of team outcomes. The theoretical and practical implications of these results are discussed.

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CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

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Shared mental models (SMM) and Transactive memory systems (TMS) have been advocated as the main team learning mechanisms. Despite multiple appeals for collaboration, research in both these fields has progressed in parallel and little effort has been made to integrate these theories. The purpose of this study was to test the relationship between SMM and TMS in a field setting and examine their influence on various team effectiveness outcomes such as team performance, team learning, team creativity, team members' satisfaction and team viability.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

> Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it.
>
> - Samuel Johnson (In life of Samuel Johnson, 1791 by James Boswell)

Knowledge is of paramount importance nowadays since organizations are increasingly becoming service oriented and dependent on knowledge workers (Blackler, 1995; Davenport & Prusak, 1998). Organizations try to capture the benefits of collective knowledge assimilation by the formation of teams and task-forces (Edmondson, Bohmer, & Pisano, 2001; Katzenbach & Smith, 2003). Therefore, one of the primary challenges facing managers is to encourage knowledge sharing within a team so that team members can effectively combine their unique knowledge (Nonaka, 1994). Knowledge sharing takes place mostly through interaction with others and we often rely on others to augment our knowledge (Simon, 1997). A combination of individual and others' knowledge is an ideal means to obtain information, solve problems, and be creative in the workplace.

There has been a lot of research in the past decade on how groups engage in knowledge creation and sharing. For example, organizational researchers have demonstrated the importance of learning in groups and communities and its importance to team outcomes (Argote, Gruenfeld, & Naquin, 2001). Similarly, social psychologists have proposed that groups develop a shared understanding through a process of interaction, and the resulting knowledge is shared and distributed amongst group members (Thompson & Fine, 1999). Strategic Management researchers have proposed a knowledge-processing view of the firm that emphasizes the importance of social interaction as the process through which knowledge is created and transferred in organizations (Kogut & Zander, 1992; Nonaka, 1994). It can benefit all fields to integrate findings on group learning from these disciplines to better understand how group learning occurs.

I define team learning as the process by which team members seek to acquire, share, refine, or combine task-relevant knowledge through interaction with one another (Argote, Gruenfeld, & Naquin, 2001). Such a definition will include asking questions, challenging assumptions, seeking multiple perspectives and reflecting on past actions (Van der Vegt & Bunderson, 2005). The team learning literature has focused on how successful groups reach better decisions by assimilating the knowledge residing in individual members.

Team learning represents a process term under the Input-Process-Outcome (or I-P-O) framework (Hackman, 1987). These processes are mediating mechanisms linking input variables such as member, team, and organizational characteristics with output measures like team performance, team members' satisfaction and team viability. In addition to input variables, the team learning process is likely to be influenced by contextual factors (input variables) external to the team. Situational factors have been underappreciated in organizational research and need to be better documented to improve our understanding of the phenomenon (e.g. team learning) under study (Johns, 2006). I will incorporate contextual details to describe conditions under which teams engage in learning.

In some ways, team learning constructs also represent important emergent processes within an Input-Process-Output model (Marks, Mathieu, & Zaccaro, 2001). An emergent state is a dynamic construct that can define cognitive, affective or motivational aspects of team members and it affects team processes and the ultimate team outcome.

Since, team learning essentially represents a ‘theory-in-use’ (Argyris & Schon, 1978) it is an emergent state.

This definition of team learning is consistent with the notion of socially shared cognition which refers to how dyads, groups and large collectives create and utilize knowledge (Thompson & Fine, 1999). Thompson and Fine (1999) suggest that the word ‘shared’ in “shared cognition” could mean one of three possibilities. First, it could mean “held in common” that includes overlapping cognitive representations of task requirements and role responsibilities. Second, shared could mean “divided up into portions” as relating to dividing up responsibility for different information. The third possibility relates to the notion of consensus or acceptance as in viewing things and tasks from another person’s perspective. This paper focuses on clarifying the first two possibilities and hence will not explore the third concept of shared meaning. The two types of sharing represent two conceptualizations of collective learning in teams.

Shared mental models (SMM) are defined as a mental representation of knowledge regarding key components of a team’s environment that is shared amongst team members (Mohammed, Klimoski, & Rentsch, 2000). They represent a “held in common” type of knowledge sharing. A mental model is a cognitive structure or a network of associations between concepts in an individual’s mind. Thus, a degree of sharing exists amongst team members on knowledge or beliefs about the team’s environment (Klimoski & Mohammed, 1994). A general assumption underlying SMM is that team effectiveness will improve if the team members have an adequate shared understanding. This shared understanding could include understanding about the task and the equipment (task model), or awareness of team members characteristics including knowledge and beliefs about appropriate or effective processes (team model) (Cooke et al., 2003).

A transactive memory system (TMS) has been defined as a combination of an individual’s knowledge and a shared awareness of who knows what (Austin, 2003; Wegner, 1987). This represents a “divided up into portions” type of knowledge sharing. TMS was initially proposed to explain the knowledge residing amongst intimate couples and family members when they are able to bring together disparate knowledge to solve a problem. This means that even though the solution to any issue at hand may not be readily available, family members know how to come together and develop a response. Wegner (1987) explains how family members develop such a thought process.

> If we ask a question of a person who is a well-integrated part of a transactive memory network, this person often is able to answer (after consultation with other network members, of course) with information well beyond his or her own internal storage. Asking any member of a family a question about the family's summer vacation, for example, can prompt the retrieval of several members' accounts of the experience. The success we have in retrieving certain items depends on the degree to which the person we begin with has location information about the items we label. Even if we ask the person to retrieve an item with an obscure label, however, the person may be able to help us enter the storage system. Asking Bud how much the family paid for gasoline in Orlando, for instance, may lead him to quiz Dad-who generally knows about car-related items (p.190).

TMS has recently been extended to the work group level as it is a cooperative division of labor for learning, remembering and communicating relevant knowledge (Moreland & Myaskovsky, 2000). When team members correctly identify the experts and delegate tasks based on an individual member’s expertise, they perform better (Hollingshead, 2000). Hence, team performance may depend on whether the group can correctly recognize and utilize the knowledge of its members (Brandon & Hollingshead, 2004). The TMS definition includes two parts: a) a combination of individual knowledge and b) interpersonal awareness of others' knowledge.

Despite growing literature on SMM and TMS, there remains some confusion regarding the actual conceptualization of these constructs, with proponents of TMS and SMM suggesting that the other is a part of their construct (Austin, 2003; Mohammed, Klimoski, & Rentsch, 2000). Specifically, Austin (2003) defined TMS as "a team mental model about the distribution of knowledge within the group" (p. 867). Similarly, some researchers have suggested that TMS is a Shared Mental Model about importance of who knows what given the roles distribution in a team (Cooke, Salas, Cannon-Bowers, & Stout, 2000; Mohammed & Dumville, 2001). While the exact nature of the relationship between TMS and SMM is not very clear, it becomes important to clarify the unique contribution of these constructs in particular (Mohammed & Dumville, 2001). It appears that there is an obvious overlap between these two constructs even though they have been conceptualized differently. Not surprisingly, researchers have a hard time defining the term shared cognition and what is being shared (Cannon-Bowers & Salas, 2001; Mohammed, Klimoski, & Rentsch, 2000).

To the best of my knowledge, the constructs of TMS and SMM have not been studied together, except in a study by Ellis (2006) who indicated that lack of SMM and TMS helps explain why teams perform poorly under acute stress. In this paper, I expand on his conceptualization that SMM has an integrative function as it represents the common elements whereas TMS has a differentiating function as it emphasizes distribution of knowledge held by individual members. An integrative function captures the portion of the knowledge that is universally accepted while the differentiating function builds on the knowledge that is unique to each member in a team.

One way in which SMM and TMS are related can be understood via information processing theory as it focuses on the cognitive processes inside a group. According to this theory, information processing has been defined as the degree to which information, ideas, or cognitive processes are shared and how this sharing of information affects both individual and group-level outcomes (Hinsz, Tindale, & Vollrath, 1997). Every group member has separate, independent memory structures. Assuming group members engage in information sharing, they have access to one another's memory, effectively expanding the storage and retrieval capacity of any particular individual. Within this perspective, SMM seems helpful in explaining how the common information is shared amongst team members while TMS helps explain how teams collectively encode, store and retrieve unique differentiated information. Thus, studied together they may better elucidate how groups act as information processors and succeed in delivering results beyond any single individual's capacity.

My primary research questions in this dissertation are 1) *How are TMS and SMM related to each other?* I plan to investigate whether these concepts are indeed distinct. In addition, I ask 2) *How do TMS and SMM impact team performance?* Is one construct better than the other in explaining team performance? Or do they better explain team performance in combination with each other? This study is an extension of the previous work on group learning phenomena and contributes to the literature by contrasting two different group learning mechanisms.

CHAPTER 2: LITERATURE REVIEW

Theoretical framework

Learning happens at multiple levels. At times we learn independently, but most of the time we learn by interaction with others (Bandura, 1977). These interactions can happen at home, in the workplace, in our own network of peers and friends, and from routines embedded in organizations (Borgatti & Cross, 2003; Gersick & Hackman, 1990; Reagans & Zuckerman, 2001; Seger, 1994; Webb, 1982). One of the perspectives on team learning in recent years has focused largely on SMM or TMS (Edmondson, Dillon, & Roloff, 2008). Despite burgeoning literature on these topics, there has been only one study that explicitly included both these concepts and clarified the nature of their relationship (Ellis, 2006). This study used information processing theory as a framework to suggest that SMM is about integration of teammate's perceptions while TMS captured differences amongst team members' roles and responsibilities.

However, the study involved undergraduate students engaged in a computer-based simulation of defending enemy attacks, and this makes it difficult to generalize the results to an organizational setting. In this case, team members had clearly defined goals and distinct expertise. While the laboratory task of keeping simulated enemy aircrafts out of your home zone is not easy, in reality, many teams in organizational settings engage in tasks that are much more cognitively challenging. Moreover, team members often have overlapping expertise, lack a clearly defined role, a prior relationship with each other, and may be required to work in future together. The peculiarities of organizational teams make it useful to replicate in realistic settings. Additional study will help to uncover whether these two constructs are indeed unique and help increase the external validity of prior findings.

In the following sections, first, I expand on the nature of the relationship between TMS and SMM using the information processing framework. Second, I review the existing empirical research on SMM and TMS, as well as their impact on team performance. Finally, I highlight the potential impact of context on the present study.

Information Processing Theory

Information processing in teams has been defined as "the degree to which information, ideas, or cognitive processes are shared, and are being shared among group members and how this sharing of information affects both individual and group- level outcomes" (Hinsz, Tindale, & Vollrath, 1997, p. 53). As teams are performing increasingly cognitive tasks, team performance relies on team members' information processing capabilities. Team members must *attend* to information in order to process it. The information is then structured and interpreted by the process of *encoding*, followed by a *storage* process for *retrieval* from memory, when necessary.

The information processing framework has been helpful in explaining team performance in organizations. In a longitudinal study of 98 Research and Development groups, the fit between task technology's nonroutineness and the information processing needs of the team helped explain team performance as far out as one year later (Keller, 1994). According to Keller (1994), information processing theory explains top management team flexibility in strategic decision making in terms of the team's ability to better analyze and access information. In another cross level study, Thomas and McDaniel (1990) suggested that a better information processing structure (low formalization and high interaction between team members) allows top managers to better analyze environmental factors and provides a sense of control over the strategies to be followed. A CEO having lower information processing ability might evaluate a particular situation to be threatening while another CEO with a more accurate and well-developed information processing ability may scout for opportunities in a similar scenario. Thus, information processing helps in sense-making and better interpretation of the environment and could help extend our understanding of organizational learning and change (Huber, 1991; Thomas & McDaniel Jr, 1990). In summary, information processing theory highlights the cognitive processes by which top managers and teams engage in learning. Thompson and Fine (1999) came to a similar conclusion in their review of how groups develop shared meaning. According to them, groups develop shared meaning across three main dimensions: affect, behavior and cognition.

Affective experiences include identification with a group due to reduction of individuals' self-identity and creation of social identity by having group-level goals (Hogg & Terry, 2000; Tajfel & Turner, 1986). Such experiences enhance group cohesion and group norms. Behavioral consequences include coordination and creation of products and group decisions that are not identifiable to any individual level processes. The cognitive dimension takes the form of TMS and SMM.

According to Thompson and Fine (1999), both TMS and SMM are manifestations of an information-processing model. Consistent with the information-processing approach, group members have separate and independent memory structures located within each individual member. Moreover, group members have access to one another's memory if it is shared, thus effectively expanding storage and retrieval to any individual. The notion that SMM and TMS have a lot in common as they both are concerned with cognitive structures in teams has been reached by other researchers (cf.Mohammed &

Dumville, 2001). Hence, I explore the relationship between SMM and TMS using the information-processing framework.

Shared Mental Models

The term mental model refers to a symbolic representation of a system and its expected behavior (Johnson-Laird, 1983). According to Johnson-Laird (1983), human beings have an innate tendency to develop and use mental models because effective action requires an understanding of the system within which one is located. Thus people define and enact appropriate behavior by using their evolving knowledge of the system into a model that enables them to describe, explain and predict consequences of behavior (Rouse & Morris, 1986). This emphasis on prediction has led researchers to explore the usefulness of mental models primarily on performance.

Recently, the notion of a mental model was extended by researchers to account for performance differences between teams, and SMM has been defined as an organized understanding of relevant knowledge that is shared by team members (Klimoski & Mohammed, 1994). As the notion of SMM was developed to explain difference in team performance, there is an inherent assumption that SMM is an antecedent to effective team performance (Mohammed, Klimoski, & Rentsch, 2000). SMM could help explain how team members use similar knowledge to guide their (coordinated) behavior in effective teams. The predictive nature of the construct could help as an indicator of a team's 'readiness' to take on a particular task (Cannon-Bowers & Salas, 2001). This would lead managers to diagnose a team's problems and provide insight on how to solve them. Despite the potential usefulness of the construct, the empirical evidence to support the value of SMM is rather weak. As Cannon-Bowers and Salas (2001) note, "The problem seems to be that researchers have interpreted the shared cognition label to mean so many different things, that we are not sure that any two authors mean the same thing when they use it" (p.196). They further highlight that researchers have used over twenty labels to describe various types of shared cognition (e.g. collective cognition, team knowledge, team mental models, shared knowledge, transactive memory, shared mental models).

In an early attempt to clarify the confusion regarding what is meant by shared cognition, Cannon-Bowers, Salas and Converse (1993) proposed that there are conceptually four distinct types of SMM. The first includes knowledge about the equipment and tools used by the team. The second includes knowledge about task procedures, strategies and environmental cues that impact the task. Third includes knowledge about teammate characteristics such as preferences, habits and expertise. The fourth component includes knowledge about team roles and team interaction patterns. While researchers have theorized that multiple distinct types of mental models exist (Rouse, Cannon-Bowers, & Salas, 1992), few have actually investigated multiple SMMs and established the discriminant validity of this typology.

In some ways, the four types of models described above can be seen as reflecting two major domains: a) Task related aspects (e.g. knowledge of equipment/technology and job/task models) and b) Team related aspects (e.g. knowledge about team interaction and knowledge about teammates). Consequently, most researchers have re-classified SMM into two broad dimensions: Task-mental model and Team-mental model (Klimoski & Mohammed, 1994, p. 432; Rentsch & Hall, 1994). Mathieu, Goodwin, Heffner, Salas and Cannon-Bowers (2000) conceptually and empirically distinguished between task and team-based mental models using a sample of undergraduate dyads. Further, their results suggested that task mental models had no direct impact on team performance, whereas team mental models had a positive relationship with performance.

In this paper, I focus on *team-mental models* rather than task models as they are more likely to be relevant in teams that are engaged in a variety of tasks. The equipment and task mental models are context specific, and hence harder to study in teams engaged in different types of tasks that are not really comparable. The nature of teamwork and the team-mental model is expected to be universally relevant compared to the task-mental model as empirical results have been more supportive for studying team mental models over task mental models (Mathieu, Goodwin, Heffner, Salas, & Cannon-Bowers, 2000). Henceforth, I will use TMM to represent *team-mental model*. In addition, the content of task mental model as a representation of "who does what" is much closer to the concept of role differentiation, an issue better addressed by the TMS literature, and to be described later.

Further, TMM involves team members' knowledge of each other. In other words, conceptually TMM involves shared knowledge of each other's preferences, strengths, weaknesses and tendencies in order to maximize performance. TMM should benefit team performance by helping team members to compensate for each other, predict each other's action and provide information before being asked. Moreover, TMM is team specific and will only hold when team membership remains relatively stable. The above clarification responds to one of the questions posed by Cannon-Bowers and Salas (2001) that it is critical to clarify 'what is shared?'

Recently, Ellis (2006) examined the role of TMM and TMS in the relationship between acute stress and team performance in a study involving 97 teams running a PC based simulation task. Among other results, he found that both TMM similarity as well as accuracy was positively related to team performance. TMM similarity refers to common interpretation of their situation while accuracy refers to quality. The difference between similarity and accuracy is marked by Mathieu et al. (2000) comment, 'Similarity does not equal quality- and teammates may share a common vision of their situation yet be wrong about the circumstances that they are confronting' (p.281). Ellis (2006) operationalized TMM as the team interaction mental model, focusing on team-related aspects of a situation. Support for a positive relationship between TMM and team performance has also been reported by other researchers. For example, Marks, Zaccaro and Mathieu (2000) found in a study of 79 three-person student teams engaged in a computer based war simulation that TMM strongly predicted team performance under novel situations. Moreover, the similarity in TMM amongst the team members was responsible for more adaptive responses in novel situations.

Extending prior research, Smith-Jentsch, Mathieu and Kraiger (2005) used measures of both task and team mental models to predict safety and efficiency of 306 air traffic controllers across 47 airports. This appears to be the only published TMM study using intact work teams. Contrary to expectations, task and team mental models failed to demonstrate any linear effects on predicting air safety and efficiency (i.e. minimizing airport delays). However, there was an interaction between task and team mental models that better predicted air safety and efficiency. Their results suggested that the highest tower efficiency and safety rates were evident when Air Traffic Controllers exhibited high team and task mental models. Moreover, it was better to have low levels of both team and task mental models than to have a high team and a low task mental model. It appears that efforts to demonstrate linear effects of TMM on team performance have yielded mixed and somewhat equivocal results. Hence, there is a need to study more complex patterns of relationships to demonstrate the impact of TMM on team performance, especially in real work teams.

One reason for the mixed results obtained between TMM and team performance could be because of too much shared cognition. The resulting TMM might lead to 'groupthink', and the inability to incorporate external viewpoints might lead to failures (Janis, 1972). Groupthink refers to a deterioration of mental efficiency, reality testing, and moral judgment that results from in-group pressures. Groupthink has been blamed for such decision-making fiascoes as the Bay of Pigs invasion, the escalation of the Vietnam conflict, the Watergate cover-up, and the *Challenger* disaster as well as for flawed group problem solving in business and other organizations.

Although many aspects of groupthink have been questioned, it has been frequently invoked to explain group failures. One idea that has found support in groupthink research is that premature consensus has a negative effect on group decision making and leads to negative outcomes (Aldag & Fuller, 1993). When teams attempt to learn or solve problems, often team members have divergent solutions to problems that the team faces. Discussing these contrasting ideas is crucial to problem solving in groups and has been considered constructive (Tjosvold, 1985). Lack of alternative viewpoints might result in a failure to discuss critically relevant information that is not already shared (Stasser & Titus, 1987).

In fact, when groups are comprised of familiar members, they are less likely to bring out new or unshared information to solve a task that requires pooling of information

(Stasser & Titus, 1987). Such high TMM groups may already share a common frame of reference to interpret information. It is quite possible to have high degree of consensus on an apparently wrong way to attempt a task. As Ellis (2006) suggests, team members under stress may have high consensus on task requirement but this may result in a bad team performance. As Smith-Jentsch et al. (2005) observe in their study of air traffic controllers, teams that were simultaneously high on both the task and team mental models did not report high safety and efficiency. They speculate that a possible reason could be that teams may overgeneralize the actions they expected from their teammates – 'In other words, the same implicit coordination processes that enabled these teams to perform well under routine task conditions may have actually led to greater problems in emergency situations' (p.532).

Weick (1993) documented the story of fire-fighters who failed to drop their tools because they could not comprehend an unusual direction from their team leader. In the end, 13 fire-fighters lost their lives in the 'Mann-Gulch disaster'. This demonstrates that a high TMM does not necessarily result in increased performance. Another chilling disaster attributed to air crew's application of habitual routines resulted in the plunge of the Air Florida flight 90 into the Potomac River shortly after take-off from Washington D.C. (Gersick & Hackman, 1990). Thus, there are empirical and practical reasons as to why high TMM may not essentially be a good thing.

More team interaction could be beneficial as team members engage in frequent communication, build strong norms and increase team cohesiveness. Team members will be able to build a social identity by having an over-arching goal (Tajfel, 1982). Such activities will lead to a higher collective team identity that improves team performance

(Van der Vegt & Bunderson, 2005). A higher collective identity assumes that members will have higher expectations from their teammates as they will have a more accurate idea of teammate's beliefs, abilities and preferences. Such activities are likely to increase members' expectations from their teammates and also improve team performance as they come to know about each other's strengths. However, if there is too much time spent in understanding team members, the individual members may get too involved in maintaining social relationships and less in their own task related activities. This is especially true when team members have homogenous demographics and belong to a close-knit social network (Thomas-Hunt, Ogden, & Neale, 2003). Thus, a very high level of TMM will be undesirable as it could lead to disasters due to failure to engage in meaningful information processing. Thus, I propose that there is an optimum level of TMM for performance:

Hypothesis 1: The relationship between a team's TMM and team performance will be curvilinear (∩-shaped) such that both high and low agreement on TMM will exhibit low levels of team performance.

Transactive Memory Systems

A TMS focuses on who knows what and attempts to capture the uniqueness of information in a team. Based on their studies of learning in successful teams, Moreland and colleagues (Liang, Moreland, & Argote, 1995; Moreland & Myaskovsky, 2000) suggested that TMS has three distinct components – *Specialization*, *Credibility* and *Coordination*. People in an interpersonal relationship often develop a specialized division of labor with respect to encoding, storage and retrieval of information from different sources. Thus, each member in the relationship develops an expertise in some areas but not all. Other members expect members to be able to process and possess expertise in specific domains. This process leads to reduction in overlapping individual knowledge while improving information processing efficiency within teams. The Specialization component refers to the level of knowledge differentiation within the team. Credibility refers to team members' beliefs about the accuracy of other members' knowledge. Coordination refers to team members' ability to work together efficiently.

In one of the earliest studies indicative of TMS, Wegner, Erber and Raymond (1991) studied memory performance of 118 individuals who had been in close dating relationships for at least 3 months. For a memory task performed by pairs, some subjects were paired with their partners and some were paired with an opposite-sex partner from another couple. For some pairs, a memory structure was assigned (e.g., 1 partner should remember food items, another should remember history items, etc.), whereas for others no structure was mentioned. The pairs were asked to study together but not allowed to engage in verbal communication. Memory recall was tested subsequently in individuals. Memory performance of the natural pairs was better than that of impromptu pairs without assigned structure, whereas the performance of natural pairs was inferior to that of impromptu pairs when structure was assigned. This implies that dating pairs had developed their own implicit memory structure of how to divide the task. Adding external structure and directions resulted in interference with this TMS.

This result supports Wegner's (1987) assertion that people often try to improve their limited memories with external memory aids. These external aids may include either taking notes, maintaining diaries or reliance on other people. People often turn to each other for recalling information when they do not trust their own memory or have trouble recalling information. Hence, it appears that TMS develops in natural groups as an automatic process. This facet has spurred researchers to investigate whether teams engage in similar memory organization and retrieval as observed in intimate couples.

Liang, Moreland and Argote (1995) in an experimental setting studied students instructed to assemble radio kits in groups. Students trained together were better able to assemble radios than those trained individually. Groups whose members were trained together recalled more about how to assemble radios and made fewer assembly errors than did groups whose members were trained apart. Later, they investigated the videotapes of the students and coded behaviors suggesting the development of TMS. The measures of TMS were derived from judges' observations of videotaped teams who were assembling the radio kits. The researchers derived observation measures for member's knowledge (specialization), members' beliefs about the reliability of other's knowledge (credibility) and effective knowledge processing (coordination). Once these TMS behaviors were accounted for, there were no differences between groups who were trained together versus those trained individually. Hence, they inferred that TMS is responsible for improved team performance. However, there could be other reasons why these teams performed well apart from a well-developed TMS such as training and communication.

In order to rule out alternative reasons for improved performance, Hollingshead (1998) investigated TMS in a series of laboratory experiments. In the first experiment, intimate couples who worked face to face performed better on a knowledge-pooling task when compared to strangers who worked face to face or intimate couples who worked via a computer conferencing system. Additional analyses indicated that intimate couples when interacting face to face were better at determining when a partner's answers were correct even if only one member knew the answer prior to discussion. In the second experiment, intimate couples scored significantly better on a knowledge task when they had access to either nonverbal or paralinguistic communication cues than when they had access to neither. Taken together, the results indicate that communication could be important in the knowledge retrieval aspect of TMS.

In order to untangle communication from TMS, Hollingshead (2000) designed two experiments to test if communication could be responsible for better group performance, a result generally attributed to development of TMS. Sixty three, three-member teams were trained differently (e.g. individuals trained apart, individuals with feedback about others and individuals trained together) to perform the task of assembling radios. Groups whose members were trained apart with no chance to communicate with each other prior to the experiment performed equally well as the groups that trained together and whose group members were given feedback about the skills other members had. Both the above groups did much better than groups whose members were trained apart and had no knowledge of their members' skills. Training techniques did not explain differences in team performance. These set of studies clarified that TMS is distinct from communication and training and is responsible for improved team performance via knowledge of teammates' skills.

TMS coordination refers to team members' ability to work together efficiently and has been considered critical for team performance. Research on dating couples demonstrated that partners engage in coordinated action in response to tasks requiring an effective TMS (Moreland & Myaskovsky, 2000). Similar coordination was observed when a sample of clerical workers were asked to work with others in a laboratory setting

(Hollingshead, 2000). Participants were able to learn and recall more information when partners had different work-related expertise. The results were reversed when they worked with partners having similar expertise. These results suggest that coordination is a key part of TMS as members work on their own expertise area and rely on coordination from their partners to recall and combine information on areas different from their own.

TMS credibility refers to team members' beliefs about the accuracy of other members' knowledge and provides evidence that group members trust each other's expertise. This dimension has also been referred to as accuracy (Austin, 2003). In a study of student groups attempting to build AM radio-sets, groups who trained together developed more accurate TMS than those who were trained apart (Moreland & Myaskovsky, 2000). Researchers from other areas have also highlighted the importance of credible recognition of expertise within teams. In a study of loan officers asked to determine the bankruptcy chances for real estate firms, the person identified as the expert in the team performed as well as the entire group suggesting that accurate identification of expertise is a crucial measure of TMS (Libby, Trotman, & Zimmer, 1987). This is consistent with Wegner's original conceptualization that an individual can rely on other members with more confidence when he/she has a credible source of information.

Recently, TMS has been investigated in field settings and has been shown to explain superior team performance. Austin (2003) examined the relationships between TMS and performance amongst 27 teams in a large apparel and sporting goods company. Group TMS was measured as a combination of knowledge, knowledge specialization, transactive memory consensus and transactive memory accuracy. Eleven dimensions of skills were identified as relevant for the sample. Individuals were later asked to identify the expertise level of other group-mates on these eleven skills. The individual expertise scores were aggregated to a group score for calculating combination of knowledge. Transactive memory consensus was defined as the extent to which group members agree about who has the knowledge. Transactive memory accuracy involves the extent to which individuals identified by others in the group as possessing particular knowledge actually possessed it. According to Austin (2003), TMS is positively related to objective team performance, external evaluations, and internal evaluations. The results proved TMS could be applied in field settings but required direct observations and identification of skill sets in each team that can be cumbersome. When organizations have teams with widely different expertise it becomes increasingly difficult and time–consuming to apply this technique of measuring TMS.

While experimental settings did provide support for the conceptualization of TMS, it was hard to translate the measures to field settings. The measures developed for laboratory settings (e.g. assembling radio sets) were constructed for a setting where tasks are clear and do not differ across groups, a rarity in most organizational settings. Partly, this was responsible for fragmented research and lower interest in its application to organizational settings. This hurdle has been solved largely by the development of a survey instrument validated in the field (Lewis, 2003). Lewis developed and tested a 15 item measure in a field sample of 27 teams from technology companies. Her scale comprises the three sub-scales of specialization, credibility and coordination. The indirect method of knowledge observation based on surveys seems as valid as direct observations and seems to have provided a common method of measuring TMS.

Empirical evidence is broadly supportive of the notion that TMS impacts team performance. It is not clear whether each of the TMS components demonstrates a positive relationship with team performance. We need to extend the present theory by examining the relationship of TMS components with team performance. According to Lewis (2003), TMS is best represented as a second order factor indicated by three first order factors (specialization, credibility and coordination). She states that "when TMS exists, it causes specialized knowledge, mutual trust in others' knowledge, and smooth coordinated task processing" (p. 591). As the TMS literature is still in its nascent stage, we need to examine the impact of each first order latent construct (specialization, credibility and coordination) on team performance.

First, consider specialization and its impact on team performance. When team members with distinct roles have an overlapping knowledge amongst themselves, this causes redundancy of information. In organizational settings with clear team roles, team members need to decide who will share what information (Mohammed & Dumville, 2001). A TMS helps a group by reducing the redundant overlaps in knowledge and clarifying who will remember what information. This creates specialization within teams that aids in retrieval and accessibility of information later on. Increased specialization makes team members more efficient in cognitive processing, as only the individual assigned to a particular expertise attends to the relevant information and encodes it to one's memory. This frees up other individuals to concentrate on their tasks and improves information processing resulting in better team performance.

Coordination has been often considered critical for team performance and effective TMS will only come from effective coordination of teammates. In a study of 35 five-person teams across US and Japan, Montoya-Weiss, Massey and Song (2001) observed that coordination was responsible for smoother work flow, lowered negative conflict and improved team performance. Faraj and Sproull (2000) in a study of 69 software teams demonstrated that the mere presence of expertise is not enough, teams need to coordinate expertise in order to be effective. Entin and Serfaty (1999) in a study of teams comprising Navy officials found that adaptive coordination helps teams get over sudden events and leads to better team performance. In some ways coordination allows teams to engage in team learning. By effective coordination, a group is able to efficiently divide the process of acquiring information. Every member can concentrate on updating their memory, and when needed, on *retrieving* the correct information from the expert group members. In effect, TMS coordination helps in increasing the *storage* capacity of the group and makes *retrieval* more efficient (Hinsz, Tindale, & Vollrath, 1997).

Another crucial part of TMS deals with increasing the credibility of information. Once group members develop their expertise they will share it with their members and over a period of time are expected to be more accurate, by reducing errors. When group members need to find information, they are most likely to look up to the most credible person. Thomas-Hunt, Ogden and Neale (2003) found that individuals perceived as experts engage in more information-seeking behaviors than non-experts. They actively share their expertise as well as engage in seeking out unique information held by minority members. It is quite possible that credibility is in the eye of the beholder and the individual perceived as expert might engage in self-fulfilling prophecies and thereby raise his performance (Eden, 1984; Rosenthal, 1994). However, it is difficult to visualize the actual processes as to why individuals who are recognized as credible engage in more information sharing. Nevertheless, as long as the accuracy of team members is increased, credibility should result in better team performance as shown in another study by Fulmer and Stewart (2006) where a negative relationship was observed between the least accurate team members' perception of the leadership role and team performance. Formally stated, I expect that the TMS components will be positively related to team performance.

Hypothesis 2a: TMS specialization will be positively related to team performance.
Hypothesis 2b: TMS coordination will be positively related to team performance.
Hypothesis 2c: TMS credibility will be positively related to team performance.

Relationship between TMM and TMS

Many researchers have demonstrated that transactive memory systems predict team outcomes like accuracy on tasks (Austin, 2003), team viability and team performance (Lewis, 2004). We also know that team knowledge whether it is shared mental models, or transactive memory systems, has been shown to result in improved team performance (Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Lewis, 2004; Mohammed & Dumville, 2001). It is unclear whether TMS and TMM are conceptually distinct entities. If yes, how are they related? Are they compensatory or do they interact in different ways?

The lack of clarity between TMS and TMM can be seen in the way researchers have treated these two constructs in past studies. While the principal proponents of each of these constructs have tried to conceptually distinguish between the two constructs (Lewis, 2003; Mohammed, Klimoski, & Rentsch, 2000), some researchers have started calling for greater integration between the two constructs (Mohammed & Dumville, 2001). Researchers have implicitly described TMS as a type of shared knowledge (TMM) in groups about who knows what (Rulke & Rau, 2000). Similar assumptions have been made when TMS was defined as a form of TMM whereby team members store in memory who is aware of what information (Fiore, Salas, Cuevas, & Bowers, 2003). Still there are others who have equated TMM and TMS as a form of shared understanding within teams and investigated the impact of information distribution amongst team members on negotiation outcomes (Peterson & Thompson, 1997). It is important to investigate the nature of the overlap and the differences between these two constructs in order to better understand team processes and team performance.

Irrespective of conflicting viewpoints, one thing that is certain is that these concepts are related. One explanation behind the apparent confusion is the proliferation of similar sounding constructs of 'shared cognition' and the subsequent confusion regarding the ways to operationalize and measure them (Cannon-Bowers & Salas, 2001). According to Klimoski & Mohammed (1994), there are over thirty labels or variations of the term 'team mental models'. Some of these labels include terms like group cognition, cognitive maps of collectives, strategic consensus, collective cognitions, shared frames, shared meaning, collective mind and social cognition. It is quite likely that such labels have increased since 1994 creating more confusion for researchers and practitioners looking for guidance. In order to summarize and make sense of the empirical findings, we need to be parsimonious in labeling and provide more conceptual clarity behind what we mean by shared cognition. Once we do so it will be relatively easier to explain the relationship between TMM and TMS, two similar sounding dominant constructs.

Researchers have warned that it is important to clarify what we mean by ‘shared’. Generally, the advice is to clarify if shared means one of the following: overlapping, similar, compatible or complementary, or distributed (Cannon-Bowers & Salas, 2001; Mohammed & Dumville, 2001). While it is possible that some teams will be identical in every respect and some will be totally incompatible, most teams will fall somewhere between these extremes. In most real work teams, it is likely that some knowledge will be shared, some will be similar, and the rest will be distributed. Hence, the a priori definition of shared as one of the four categories will lead to a narrower definition than the reality.

I propose that we need to have an inclusive and more nuanced definition of shared cognition. In this study, I propose that we can meaningfully capture the idea of shared with ‘identical’ and ‘distributed’ as opposite ends on a continuum. Therefore, identical knowledge between members would be classified as overlapping. If members have unique knowledge, the team would be classified as distributed. This is consistent with the idea that the shared cognition literature has overemphasized the overlapping and underemphasized the distributed nature of sharing (Mohammed & Dumville, 2001). Obviously, this conceptualization assumes that TMM and TMS will overlap as evident by the coordination sub-dimension. Since both constructs, TMM and TMS, are assessed with indices of agreement and coordination, there is an indication that such an agreement has developed within teams.

One way to think about the relationship between TMM and TMS can be in terms of the distribution of knowledge in a team setting. A TMM forms when group members encode information collectively as a cognitive representation of related items (Cannon-Bowers, Salas, & Converse, 1993; Weick & Roberts, 1993). When these mental models reflect the accurate representation of team interaction, groups interact more efficiently and perform more effectively (Mathieu, Goodwin, Heffner, Salas, & Cannon-Bowers, 2000). Thus, TMM reflects similarity amongst team members. Overlapping knowledge amongst team members could be redundant and may result in less than optimal performance. In such situations with clear team roles, team members need to decide who will share what information (Mohammed & Dumville, 2001). A TMS helps a group by reducing the redundant overlaps in knowledge and clarifying who will remember or contribute what information. This creates specialization within teams that aids in retrieval and accessibility of information later. The process of *retrieving* the correct information from the expert group members helps in increasing the *storage* capacity of the group and makes *retrieval* more efficient (Hinsz, Tindale, & Vollrath, 1997).

In terms of their functions, TMM is about similarity amongst team members and suggests an *integrative* function amongst team members, TMS is more about specialization of knowledge and seems to highlight *differentiation* amongst the team member’s expertise (Ellis, 2006). In any team, it is quite likely that some tasks will need integration of knowledge while at the same time unique expertise needs to be identified, making differentiation also critical. To sum up, it appears that both TMM and TMS need to be present in order for effective information processing in groups.

TMS ensures that information will be held by at least one of the organizational members and lead to improved performance. In accordance with the information processing model, TMS highlights the necessary condition for collaborative recall: consensus, correctness and confidence (Hinsz, 1990). Despite strong theoretical support, empirical support has been equivocal for TMS. A higher TMS does not always translate into optimal team performance. This represents a process loss where team performance is not a simple multiple of individual performance (Steiner, 1972). TMS process loss is best captured in the following quote:

> The transactive memory concept is problematic because studies of ad hoc laboratory groups indicate that on most tasks, such as those requiring logic, judgment, or problem-solving, groups usually perform above the level of the average individual but rarely reach, let alone exceed, the level of the best member (Thompson & Fine, 1999, p. 287).

The results seem puzzling since TMS has been linked to improved performance but sometimes results in mediocre outcomes. The question arises as to why teams fail to leverage the expertise of all their members. However, given that TMS serves as a knowledge differentiator amongst teammates, comparison can be made from the results found in the literature on expertise diversity and performance. The empirical results between expertise diversity and performance have been positive in some cases and negative in others (Ancona & Caldwell, 1992; Pelled, 1996; Wiersema & Bantel, 1992). It appears that when diversity increases to a very high level, it becomes very difficult to coordinate between team members. It is possible that when expertise diversity increases, members may become alienated from each other and an even greater effort of coordination is required so that team members can leverage on the benefits of expertise diversity (Faraj & Sproull, 2000). Expertise diversity refers to "*differences in the knowledge* and skill domains in which *members* of a group *are specialized* as a result of their work experience and education" (Van der Vegt & Bunderson, 2005, p. 533, emphasis added). In some ways, the notion of expertise diversity is remarkably close to the concept of TMS as both focus on the distribution of knowledge in teams. So, we can apply this analogy in the present paper.

In her dissertation, Rau (2001) found that expertise diversity explained high team performance in the banking industry when team members develop TMS. However, her study looked at only the successful teams and overlooked the unsuccessful ones. This opens up the possibility that expertise diversity may have a different relationship with team performance when TMS is low or not so well developed. Fortunately, a study by Van der Vegt and Bunderson (2005) provides some clues to this puzzle. In their study, expertise diversity was linked as an antecedent to team learning in a study of multinational teams working in an oil and gas company. They examined the relationship of expertise diversity and team performance under varying levels of collective team identification. When team identification was low, expertise diversity was negatively related to team performance. Conversely, with high team identification expertise diversity was positively related to team performance.

Gruenfeld and colleagues (Gruenfeld, Mannix, Williams, & Neale, 1996; Gruenfeld, Martorana, & Fan, 2000) in their research suggest that familiar group members generally outperform groups of strangers when there is unique information with each member. However, groups of strangers outperform familiar groups only when they engage in information sharing. In some ways, TMS explains why group members do not share unique information with team mates and only share common information for the most part (Stasser, Taylor, & Hanna, 1989; Stasser & Titus, 1987). This may be because team members have no idea about the possession of unique information by other members, and they end up discussing what is collectively known. TMS will only expand and be beneficial for the team when teammates discuss unique information.

When strangers do engage in mutual communication and figure out mutual expertise, it often brings out unique knowledge. This is especially critical in tasks where a 'hidden profile' exists (Stasser & Stewart, 1992), a situation where team members possess knowledge differentially and all information must be shared in order to find the correct solution. An example includes solving a murder mystery in which the murder suspect is correctly identified only when all participants discuss the clues available to them. Since team members fail to share all the available information, unique information possessed by strangers often fails to come out in the open. This situation can be somewhat mitigated when members are motivated to complete the task and have been informed that a clear solution will exist only if they pool their knowledge together. It is clear that team diversity impacts how much team members will contribute to information sharing (Thomas-Hunt, Ogden, & Neale, 2003).

Sometimes teams get motivated, often for emotional reasons, to overcome these tendencies to avoid information sharing and engage in efforts to build a collective team identity. According to Van der Vegt and Bunderson (2005), collective team identification motivates team members to interact more with their teammates and re-categorize their goals. Consistent with self-categorization theory, it is assumed that re-categorization can mitigate the adverse effects of subgroups and create a supra-individual goal. Consequently, evaluations of other dissimilar group members become more positive and team members start counting others as in-group rather than out-group. When team members engage in an integration process, it builds the shared code and language necessary for teams to engage in knowledge creation (Nahapiet & Ghoshal, 1998). Integration is the "process of developing shared understanding among individuals and of taking coordinated action through mutual adjustment" (Crossan, Lane, & White, 1999, p. 525).

Faraj and Sproull (2000) observed that the mere presence of expertise diversity was not enough in high performing software teams. In fact when expertise diversity increased, team members had to engage in greater coordination so that they could leverage the benefits of expertise diversity. I expect that a fostering environment that creates collective identity will increase expectations of support from teammates resulting in an increased effect of TMM on teamwork. Hence, the best team performance is expected to occur when team members are able to balance their requirements for encoding knowledge amongst the various team mates by building a great TMS as well as by their ability to bring the required knowledge together through the commonality of TMM. Great teams should be able to distribute knowledge amongst team members by differentiating as well as integrating the collective knowledge.

On the other hand, when members are too specialized in their knowledge it may create an isolated environment for team members. There may not be any expectations from other team members to help, and it might result in a bunch of experts thrown together without any shared understanding of what is required of them. This seems like a sure recipe for disaster. Team members may stop asking for or offering information when it is most desired simply because they may not know whom to ask. A case in point is when the technicians building the mirror of the Hubble Telescope did not seek out the help of designers. Being under time pressure, the technicians and designers stopped working together, and it resulted in the production of a sub-optimal telescope. This was a financial as well as an image loss for both the Perkin-Elmer Corporation and NASA (see

Ellis, 2006). Consequently, among the Perkin-Elmer team members' TMM about team expectations declined and the resulting team performance was lower than expected. Thus, TMS alone may not help team performance if TMM is low.

Hypothesis 3: TMM moderates the relationship between TMS and team performance; the relationship is negative when TMM is low but positive when TMM is high.

Context

One way in which organizational work teams differ from typical undergraduate teams engaged in artificial tasks (e.g. playing computer games etc.) is by the presence of different contextual variables. Context is defined as "situational opportunities and constraints that affect the occurrence and meaning of organizational behavior as well as functional relationships between variables" (Johns, 2006, p. 386). As Johns (2006) argued, we as organizational researchers do not fully appreciate the impact of context in organizational settings. Ignoring contextual differences could be a reason why field research may not generalize across dissimilar settings. From a managerial perspective, we need to understand the conditions under which real work teams engage in team learning behaviors. This will be more meaningful as we understand the boundary conditions under which laboratory results could be applied in organizational work teams. Understanding these conditions will help practitioners prevent and diagnose potential problems in teams who are weak on TMM and TMS.

Context can be studied at two different levels – *omnibus* and *discrete* (Johns, 2006). Omnibus is a more broadly defined entity and can best be expressed in terms of capturing *who* (occupational and demographic characteristics), *what* (constitutes substantive content of the research), *when* (refers to the time at which research was conducted), *where* (location of the research site), and *why* (rationale for collection of research data).

In contrast, the discrete dimension of context is referred to by Johns (2006) as "the particular contextual variables or levers that shape behavior or attitudes" (p. 391). Discrete dimensions are expected to provide the explanatory link between the more descriptive omnibus context and specific organizational behavior like team learning. The various dimensions of discrete dimension include task, social and physical. Johns suggests task context would include autonomy, uncertainty, resources, etc. Similarly some examples of social context would be social density, social structure and direct social influence. Physical context includes temperature, light, the building environment and décor. For the purpose of this paper, I will limit my focus to elements capturing the task dimension of the discrete context apart from the omnibus indicators.

Research in individual job performance has sought to capture context in terms of situational constraints that make it difficult for employees to successfully accomplish their tasks (Peters & O'Connor, 1980). This link between situational variation and performance variation is implicit in several theories of performance that acknowledge how situational conditions can influence behaviors and outcomes (Campbell & Pritchard, 1976; Schneider, 1978). This notion is consistent with the interactional perspectives of psychology (Bandura, 1986; Schneider, 1978; Terborg, 1981) that suggest variation in context as an explanation for variance in performance outcomes. Researchers have generally found that performance is highest when situational opportunity exists adequately while lower performance results because of constrained settings (Blumberg &

Pringle, 1982; Peters, Fisher, & O'Connor, 1982; Peters & O'Connor, 1980; Steel & Mento, 1986; Stewart & Nandkeolyar, 2006; Stewart & Nandkeolyar, 2007).

While research supports the importance of context in individual performance, context in the form of constraints has also been found to impact team performance (Tesluk & Mathieu, 1999). In a study of the Pennsylvania Department of Transportation road crews, Tesluk and Mathieu (1999) observed that crew performance was hampered due to severe problems with their equipment, materials and work procedures. They further report that “Road crews who experienced more significant barriers to performance were rated by their managers as being less effective in meeting work deadlines, overcoming problems, maintaining effort, providing quality service, and working as a cohesive crew” (p. 210). It is crucial that teams effectively counter constraints and take pre-emptive measures to avoid lower team performance. As management researchers, we should be able to account for such contextual barriers to better account for team performance.

Organizational context is a significant source of influence on group processes. The existing research on context in teams can be reviewed by two distinct approaches (Mowday & Sutton, 1993). The first focuses on an organizations’ impact on teams (Hackman, 1987, 1990), the second examines the teams attempt to influence the larger organization (Ancona & Caldwell, 1992). According to Mowday and Sutton (1993), one way to study context is in terms of opportunities and constraints placed on the teams. Murnighan and Conlon (1991) in a study of British string quartets illustrated how context constrained behavior. In particular, the task of producing music influenced the resolution of paradoxes – leadership vs. democracy, confrontation vs. compromise – within the string quartets. Other examples of context influencing team processes abound (Gladstein, 1984; Katz, 1982).

Katz (1982) found that team longevity, measured as the time team members spent working together, affects group processes. In particular, the length of time for which 50 R&D teams worked together impacted teams' communication levels and team performance. Among newer teams, increased time working as a team was associated with better team performance. In contrast, amongst more mature teams increased time together correlated with decreased performance. Katz (1982) suggested that over time, groups become increasingly insulated from internal and external communication vital for their performance.

In yet another study involving 100 sales teams in the communication industry, Gladstein (1984) investigated the drivers of team member satisfaction, team members' self-reported effectiveness and sales performance. While the traditional theories of group effectiveness based on team inputs like task, structure and composition predicted team member satisfaction and self-reported effectiveness, it failed to account for the actual sales performance. She found that most of the variance in the team's sales performance was due to organizational contextual variables like rewards, supervisory leadership and industry growth rate. She suggested that there is a need to better understand how contextual factors like task demands and organizational level variables influence team outcomes.

In a study involving 51 surgical teams across multiple hospitals, Edmondson (1999) investigated the antecedents, processes and outcome variables associated with team learning. Edmondson found that contextual factors (e.g. organizational support and team leader coaching behavior) impact learning behaviors and team performance outcomes through psychological safety mechanisms. Psychological safety was described as the shared belief that the team is safe for interpersonal risk taking. Edmondson (1991) called for more integrative research by investigating task (e.g. team structures) and social (e.g. psychological safety) dimensions of contextual factors.

In one of the strongest evidence of contextual influence on team learning, Gibson and Vermeulen (2003) found that demographic characteristics (subgroups within team) fostered team learning behavior in a pharmaceutical firm. They found that a moderate 'subgroup strength' helped team learning. Subgroup strength was defined as the degree of overlap across multiple demographic characteristics among a subset of team members. Both very heterogeneous and very homogenous teams were not as effective in team learning compared to a team with moderate differences (subgroups). Further, in teams with moderate subgroups, other contextual factors (empowerment, knowledge management systems) accentuated team learning behavior.

Further support for studying contextual effects on team learning comes from the related field of team creativity and innovation. In a review article on team creativity and innovation implementation process, West (2002) articulated that task characteristics are an important antecedent on team creativity. He suggested that team autonomy and task requirements of completeness, opportunities for social interaction, opportunities for learning, and developmental possibilities lead to increased intrinsic motivation for team members and should be taken into account.

Now, I return to the original hypotheses and discuss the potential contextual impact on the hypothesized relationships. The first hypothesis proposes a curvilinear relationship between TMM and team performance. This relationship rests on the unstated assumption that very high agreement within team is detrimental. There are certain tasks in which instantaneous action is required from individuals. Any wrong action could lead to potential disaster and yet, we hardly hear of accidents in what have been called high-reliability organizations (Weick, 1987). According to Weick (1987), examples of such organizations would include air traffic control, nuclear power plants, naval air-craft carriers etc. In such a situation, we may fail to see the curvilinear relationship because the nature of the task requires a very high level of sensemaking to avoid accidents and consequently a very high level of TMM. The team performance will probably not lower if the teams have higher amount of TMM and everyone anticipates how their teammates will be reacting. In this case, the team performance may exhibit a more linear relationship with TMM.

In contrast, a manufacturing plant like Toyota Motors may like to avoid a very high TMM amongst its workforce. Toyota’s organizational culture requires people to suggest continuous improvements in production techniques, engage in reflection, continuous learning and knowledge sharing (Dyer & Nobeoka, 2000; Liker, 2004). It is quite likely that team performance will be best when teams display a moderate level of TMM. A moderate level of TMM allows for flexibility in teams to suggest continuous improvements (kaizen) which may not be possible with constrained routines expected due to a very high TMM. Moreover, employees are motivated to engage in knowledge sharing and deviate from expected norms as consequences of mistakes are generally not as serious in an automotive plant as compared to a nuclear power plant control room.

Hence, we should be mindful of the research setting encouraging high TMM versus those that don't.

Of course, the relationship may depend on other contextual factors like team interdependence. It is quite possible that teams engage in a sequential process where minimal coordination is required in terms of inputs from other team mates. Such a scenario will suggest that team interdependence will be much lower. Further, the team performance will be somewhat independent of the TMM and hence the proposed hypothesis may not be true. In this case, the relationship between TMM and team performance may not be linear but more likely to be horizontally flat, irrespective of TMM level. The preceding discussion highlights the importance of contextual effects to the study.

A similar case can be made for context influencing the relationship between TMS and team performance, as a function of task type. The nature of the task carried out by the team is quite important. If the task is relatively simple and routine, or an additive task, a team might be able to perform adequately even if the team members have not developed TMS. The relatively simple nature of the task may not require a substantial level of coordination and the expertise of different team members as part of a TMS. Hence, task complexity could be one contextual component which may weaken the association of TMS components with team performance. Of course, other contextual factors like a strong reward for team support could also influence the nature of relationships by motivating team members to work together. An external cue like a team based reward system could aid development of TMS in teams.

While I am not discussing the impact of different contextual variables on the third hypothesis which delves into the relationship between TMM and TMS, the previous examples suggest that research settings as well as discrete contextual variables focused on task can significantly alter results. After all, the need to really find the middle ground between commonalities (TMM) and the differences (TMS) does not have to be important in all teams. The proposed relationship between TMM, TMS, and team performance depends on the nature of the task and the type of the team. Though various typologies exist to classify teams, I will use the taxonomy developed by Sundstrom, de Meuse and Futrell (1990). They define team types based on the degree of internal differentiation (member heterogeneity) and external integration (linkage to organizational activities). The team types are advice/involvement, production/service, project/development and action/negotiation teams.

Advice/involvement teams are homogenous decision-making committees comprised of first-line employees whose actions were loosely coupled to the working of the organization. Production/Service teams are front-line employees that provide products or services and whose activities are highly integral to daily operation of the organization. Project/development teams are a homogenous group of white-collar professionals collaborating on one-of-a-kind projects whose operations are weakly aligned to the organizations' routine activities. Advice/Negotiation teams are groups of highly specialized individuals that engage in relatively brief real-time performance events requiring improvisation in unpredictable circumstances and whose activities are highly integrated with the rest of the organization.

It is clear from the above summary that context could be quite important for team learning and influence the relationships between group processes and team outcomes. I include both omnibus (team demographics) as well as discrete features (team identity, team interdependence, reward system and organizational support) of contextual features. Moreover, In order to detect and appreciate contextual effects, I include multiple dependent variables (Johns, 2006). Multiple dependent variables help uncover the impact of contextual effects as some variables are less sensitive to context than others. Hence, apart from measuring team performance as an outcome of TMM and TMS, I also include other theoretically relevant dependent variables. Such variables include performance related outcomes such as team member satisfaction and team viability (Hackman, 1987), team learning (Edmondson, 1999) and team creativity (Amabile, Conti, Coon, Lazenby, & Herron, 1996).

In summary, the contextual variables perform two important functions in this study. First, they add details that lead to a richer understanding of subjects and their work settings. This is consistent with the call by Johns (2006) mentioned above. Second, these contextual variables specify the boundary conditions of the proposed model. The importance of TMM and TMS is probably more relevant due to internal or external factors affecting the team. Internal factors include inherently complex tasks, interdependent team members etc. External cues include team rewards to motivate team members working together and teams engaged in repeated interactions (e.g. problem-solving project teams or production/service teams). Figure 1 summarizes the impact of contextual variables on the TMS, TMM and team effectiveness. Figure 2 depicts the hypothesized relationships as mentioned in the previous section.

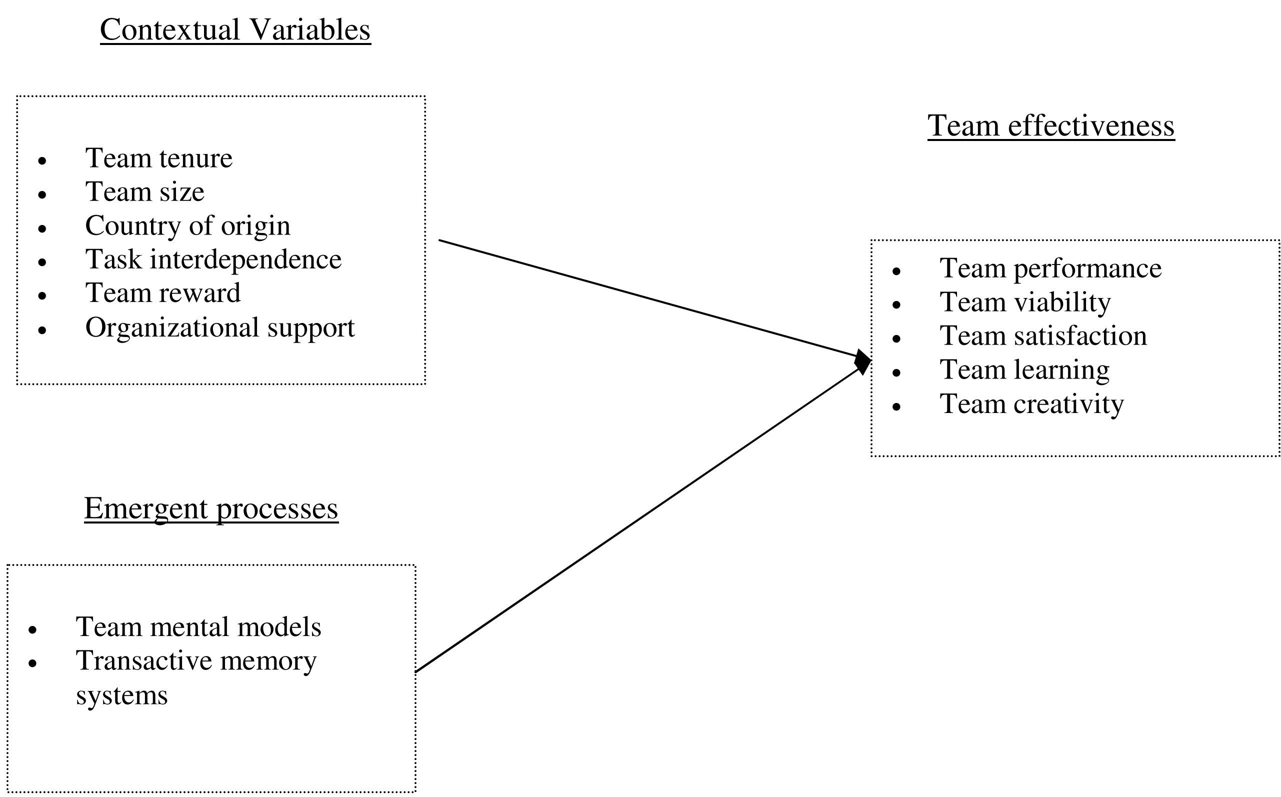

Figure 1. Team-level conceptual model describing relationships between processes, context and dependent variables.

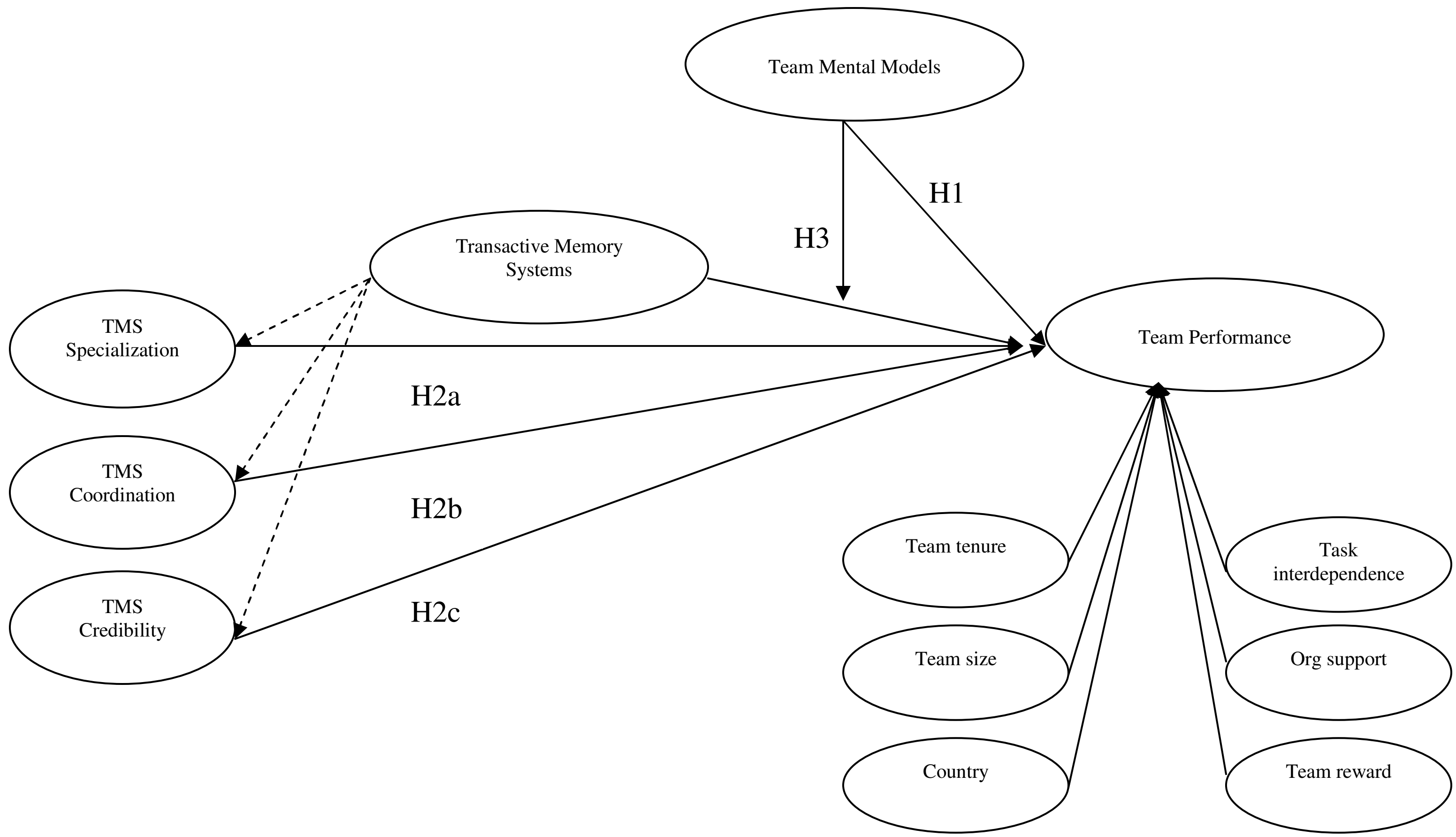

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Figure 2. Hypothesized relationship between TMM, TMS and team performance

CHAPTER 3: METHOD

Procedure

I administered an online version of the survey to team members and their team managers. The survey was expected to take no longer than 15 minutes for the team members and had a separate shorter section for the team managers. All the survey items are detailed in Appendix A. Team managers provided measures on team effectiveness dimensions (team performance, team learning and team creativity). Team members were asked to provide information on the rest of the variables including team learning measures (TMS and TMM). This helped minimize the common-method bias by having separate sources for independent variables and dependent variables. An informed consent document preceded the online survey and explained the purpose of the study to survey respondents (Appendix B).

I enlisted the help of sponsoring organization managers in administering the survey. Typically, senior managers in the sponsoring organizations forwarded my requests to their teams (team members and respective team managers); this way the anonymity and confidentiality of the survey respondents were maintained. Given that team based research requires a substantial number of teams to do a meaningful analysis (Stewart, 2006), I ended up surveying teams from multiple organizations as no one particular organization was sufficiently large in terms of team size. This process assured substantial variation between teams and was expected to result in a sample generalizable across multiple settings. I recorded organizational characteristics and team demographics to control for differences amongst teams from multiple organizations. I recruited teams who were working in the service industry from both the US and India, and which were part of project teams or ongoing work teams (Cohen & Bailey, 1997).

Sample

I approached organizations that were team-oriented and had teams working on clearly defined tasks or projects. Since organizations differ widely in their definition of teams, I prescreened the teams that agreed to participate in the study by employing the four criteria as described by Guzzo and Dickson (1996): 1) Teams must be part of an organization, 2) Teams have unique entity and clear boundaries, 3) Team members perform interdependent tasks, and 4) Tasks affects coworkers or customers.

In summary, 363 members from 46 teams participated in my survey. The team size ranged from 3 to 32 members and averaged 11 members. Of the 363 total team members surveyed, 290 provided usable responses. Of the usable response at the team level, the final response rate was 58% within teams. The actual number of respondents within a team ranged from a minimum of two (2) to a maximum of twenty-five (25). Team size was included in the team level analyses (Hypotheses 1-3). Ratings of individual teams by their respective team managers were available for only 41 out of the 46 teams surveyed. Hence, complete data from 41 teams were further analyzed.

Eighty-one percent of the team members had a bachelors' degree or higher. The average team member had been with the current organization for 6.27 years and current team for 2.91 years (S.D. = 2.16). Average team size was 11 members (SD = 7.4) and average number of respondents in a team was 5.50. Sixty-three percent of respondents were male. Slightly over forty-six percent (46.3%) of sample reported their ethnicity as Caucasian, 1.7% Hispanics, 51.7% Asians and 0.4% Hawaiian/others. The higher than expected sample of Asians is because of respondents from the Indian Information Technology (IT) industry.

My sample consists of teams from the US and India. The teams in the US were drawn from six organizations belonging to the Aeronautical, Healthcare, Education, Engineering, Information Technology (IT) and Retail industries. The teams from India were drawn from four organizations, three from the IT Industry and one from a finance company. More details about the teams, their country of origin and the industry are available in Table 1.

Aggregation Issues

Various methods of computing within group agreement exist and the exact statistic used to compute agreement depends on the underlying theoretical issue (Bliese, 2000). TMM fits the definition of a dispersion model of composition “because it refers to the variability within a group and a variance statistic is indexing an attribute of a group as opposed to an attribute of any individual-level response” (Chan, 1998, p.239). Statistics used to capture TMM, a team level agreement, could include r_{wg} (James, Demaree, & Wolf, 1993), ICC (Shrout & Fleiss, 1979), Average Deviation (Burke & Dunlap, 2002) or Standard deviation (Schmidt & Hunter, 1989).

Similar to the TMM, all constructs measured in the survey were conceptualized at the team level though the responses were measured at the individual level. To justify the aggregation to the team level, I calculated within-group agreement by computing interrater agreement on a uniform expected variance distribution commonly abbreviated as $r_{wg(j)}$ or r_{wg} (James, Demaree, & Wolf, 1984). The r_{wg} is calculated by comparing an observed group variance to an expected random variance - the latter usually refers to calculating a uniform distribution. The uniform distribution refers to the obtained distribution when all group members provide the same number of responses for each category i.e. if group members provided an equal number of 1s, 2s, 3s, 4s and 5s on a 5-point scale. This kind of distribution is seldom seen in groups as team members typically suffer from response bias e.g. team members are more likely to use 3, 4 and 5 instead of the full range. The presence of such response bias results in reduced observed variance and a high value for r_{wg}. Hence, the use of r_{wg} has been criticized (cf. Schmidt & Hunter, 1989). Inspite of the shortcomings, the magnitude of the r_{wg} provides a measure of within-group agreement on the variables of interest. The summary r_{wg} for the team-level variables are presented in Table 3. Average interrater agreement was above the 0.70 benchmark proposed by James et al. (1984) for all variables except TMS coordination.

As an alternative to r_{wg}, I also calculated two intraclass correlations – ICC(1) and ICC(2) and conducted an F-test for the ICC(1). ICC(1) indicates the extent of agreement among ratings from members of the same team whereas ICC(2) indicates whether teams can be differentiated on the variables of interest (Bliese, 2000). ICC(1) has been interpreted as an index of interrater reliability, the extent to which the raters are substitutable, and hence a suitable measure for aggregation (James, 1982). ICC(1) was calculated using the one-way random-effects ANOVA model:

ICC(1) = (MSB-MSW)/[MSB+[(k-1)*MSW].

MSB is the mean square between-group, MSW is the mean square within-group, and K is the average team size. ICC(2) provides an estimate of the reliability of the group means and is calculated by the following formula: ICC(2) = MSB-MSW/MSB. Details of ICC(1), ICC(2) and r_{wg} are reported in Table 2.

F-test for ICC(1) was significant for all the variables except for team satisfaction and team reward. However, I computed ICCs for all the variables and aggregated them anyway since the constructs are theorized at the team level of aggregation. As can be seen from the Table 2, ICC (1) and ICC(2) for TMS coordination was .10 and .40 (F=1.67, p=.01), task interdependence was .14 and .50 (F=2.00, p=0.00), Organizational support was .14 and .50 (F=2.00, p=0.00) and team viability was .14 and .49 (F=1.96, p=0.00). These ICC values indicate that we don't have reliable estimates of the group means and are on the lower side but are comparable with values obtained in field research conducted elsewhere (cf. Chen & Klimoski, 2003). Hence, these values of ICC should be acceptable in the present study.

Study Variables and Measures

Control variables

Heterogeneity measures including subgroups have been indicated to impact team learning (Gibson & Vermeulen, 2003). Hence, I recorded sex, age and ethnic background in the survey to control for the effects of heterogeneity in teams. Moreover, I recorded the type of task being done by the teams. The team task was classified as one of the four types- advice/involvement, production/service, project/development and action/negotiation teams based on the team managers' response (Sundstrom, de Meuse, & Futrell, 1990). Additionally, I controlled for the country of origin (0=India, 1= US). The sample was made up of twenty-six teams from the US and fifteen teams from India. In terms of industry, I had 14 teams from IT, 12 from Aerospace, 7 from Education, 5 from Healthcare, and one team each from Engineering, Retail and Finance. All teams from the IT industry were composed primarily of Indians or people of Indian origin working in the US. I also controlled for team tenure as teams with longer tenure might have a history of interaction amongst their team, so they may behave differently as they build up rituals and norms (Katz, 1982). Team size was also recorded as a control variable since coordinating a large number of teammates could be an important factor. These contextual features were expected to impact the hypotheses and I measured them accordingly (Johns, 2006).

Team Mental Model

Team-mental model refers to a shared understanding of knowledge about team interaction and team members (Mathieu, Goodwin, Heffner, Salas, & Cannon-Bowers, 2000). Stated otherwise, team-mental model involves shared knowledge of each other's strengths, weaknesses and preferences. Typically, TMM has focused on aspects of the team (e.g. teammates' knowledge, skills, attitudes and preferences) and team interaction (e.g. roles, communication channels, information flow and role interdependencies). One way to operationalize this shared team knowledge has been to measure the degree of convergence amongst teammates. The convergence can be assessed by asking team members to respond to a structured questionnaire about their teammates and team processes. A high degree of overlap amongst team members should suggest a high degree of TMM. Since this was an exploratory study in a field setting to studying team mental models, in the absence of prior research guidance I operationalized this construct in two different ways. The first uses an average deviation method and the other a 6-item five point Likert type scale I developed specifically for this study.

The use of agreement indices to capture mental models has been a common practice (Mohammed, Klimoski, & Rentsch, 2000). In particular, Mathieu and colleagues (Marks, Zaccaro, & Mathieu, 2000; Mathieu, Goodwin, Heffner, Salas, & Cannon-Bowers, 2000) have measured TMM by assessing the overlap in concepts selected by each of the team members. TMM was assessed by teammates' individual ratings of the relationship between various attributes. Mathieu and colleagues (Marks et al., 2000; Mathieu et al., 2000) asked undergraduate subjects to rate the relationship between team process on nine dimensions. In essence, each subject in every team filled up a 9X9 matrix on team processes. It was extremely difficult to sell this idea of filling up a 9X9 matrix to working professionals to collect a single measure. In the interest of economizing on the time taken to complete the survey, I used a slight variation on the basic process.

I selected six out of nine team processes from the one used by Mathieu et al. (2000) and asked the team members to rank order their relative importance. A high convergence in the rank-ordered pattern between various team members suggests a strong convergence on TMM. I selected the six team processes based on the existing literature (Marks, Mathieu, & Zaccaro, 2001).

Marks et al. (2001) suggest that teams have ten process dimensions nested within three superordinate categories: a) transition phase processes, b) action phase processes and c) interpersonal processes. Transition phases are periods of time when teams focus primarily on evaluation and/or planning activities to accomplish team objectives. During the action phase, teams conduct activities leading directly to goal accomplishment. Interpersonal processes are used to manage interpersonal relationships within teams. Transition phase processes include mission analysis, goal specification and strategy formulation processes and typically occur during the time period when teams reflect, evaluate and plan for future directions. Action processes refer to monitoring progress towards goals, systems monitoring, team monitoring and back-up behavior and coordination. Interpersonal processes include conflict management, motivation and confidence building and affect management.

Given that my approach was to make it easy to collect data from professionals working on teams, I selected the six most important and practical team processes likely to be generalizable across all teams. Transition processes such as goal specification and strategy formulation and action processes such as monitoring progress towards goals, team monitoring and backup behavior are crucial to understanding team outcomes. Moreover, since I focused on understanding team satisfaction and team viability outcomes, I included the interpersonal processes that occur throughout both transition and action processes – conflict management and motivation/confidence building.

First, consider the transition phase processes. It should be noted that mission analysis has not been included in this study since in most cases the teams' mission, resources and operating conditions are often dictated by senior executives and are beyond the jurisdiction of team members. This forces team members to engage in goal specification and strategy formulation to achieve the stated mission. Goal specification refers to identification and prioritization of goals and subgoals towards achievement of the teams' mission. Teams engage in goal specification to indicate what and how much must be accomplished within a specified time and within certain quality standards. Strategy formulation involves how team members go about achieving their missions, discussing expectations, relaying task-related information, prioritizing, role assignments, and communicating plans to all team members.

Second, I reflect on the relevant action phase processes. Monitoring progress toward goals is defined as tracking task and progress toward mission accomplishment, interpreting system information in terms of what needs to be accomplished for goal attainment, and transmitting progress to team members. Poor goal monitoring occurs when teams drift, procrastinate, or stray off task and are unable to provide appropriate performance feedback. Hence, it is vital that teams engage in periodic goal monitoring. Another important action process is team monitoring and backup behavior. Assisting team members happens by providing verbal feedback, task-related support and carrying out and completing tasks for their teammates. Team members observe their teammates' actions and watch for performance discrepancies. Whenever team members identify the need to provide help, backup behavior in terms of suggestive or corrective feedback is provided to get performance back on track.

Third, I expand on the two interpersonal processes – conflict management and motivating/confidence building. Conflict management refers to attempts to manage conflicts within the team. These can be preemptive or reactive. Preemptive techniques involve establishing conditions to prevent, control or guide team conflict before it occurs. Reactive techniques involve working through task, process and interpersonal disagreements among team members. Managing conflict is critical as it has been suggested to lower team performance (De Dreu & Weingart, 2003). The other critical interpersonal process is motivating/confidence building which involves encouraging team members to perform better or to maintain high levels of performance. Teams can enhance working relationships and performance by boosting their teammate's confidence levels. In contrast, team members can engage in negative comments that can lower team confidence and performance over time.

Participants were asked to rank order the importance of these six team processes in their team. Thus, each team member has his or her own rank orders.

Team Mental Model (Average Deviation)

I calculated Average Deviation (AD) indices for the level of TMM within each team (Burke & Dunlap, 2002; Dunlap, Burke, & Smith-Crowe, 2003). The resulting AD indices, from the rank ordered response on six team processes, were used as independent variables to capture TMM level in each team. Finally, I multiplied the resulting AD by (-1) to reflect the direction of the construct from disagreement to agreement within team.

Team Mental Model (alternative scale)

In addition to computing Average Deviation on the six team processes, I developed a 6-item scale to capture each of the six team processes as described in the previous section. Sample items include “We identified and prioritized goals for task accomplishment”, “We tracked our progress toward task accomplishment” and “We established rules to prevent, control, or guide team conflict before it occurred and worked out interpersonal disagreements among team members”. I averaged teammates response within each team and then averaged items to form a single scale. The coefficient alpha measured at the individual level was 0.83. The r_{wg} value was 0.82. ICC(1) and ICC(2) were 0.21 and 0.62 respectively suggesting the presence of substantial within-group agreement and allowing aggregation to the team level. I ran a confirmatory factor analyses to test whether the 6-item scale fits a one-factor model or not and the one-factor model showed a great fit to the data ($\chi 2 = 16.54$, $df = 9$, $p<.10$; SRMR = .05, NNFI = .99, IFI = .99, CFI = .99).

Transactive Memory Systems

Transactive Memory System focuses on who knows what and is influenced by knowledge about the memory system of another person (Wegner, 1987). Since each team member has a different way to store, encode and retrieve information, the knowledge held by individuals is often unique leading to *specialization* in information processing. The TMS develops when individuals develop accurate perception about their teammates and *credibility* develops as team members' form beliefs about the accuracy of other member's knowledge. However, just specialization and credibility can't help develop TMS unless they engage in transactions. These transactions often take the form of communication and interpersonal interactions, requiring a certain level of *coordination* between team members. Thus, any measure of TMS should be able to capture these three facets – specialization, credibility and coordination (Austin, 2003; Lewis, 2003). Therefore, absence of any of these three dimensions hampers the development of TMS and interferes with the efficient distribution of knowledge within teammates.

To assess TMS and its subcomponents, I adapted the 15-item questionnaire developed by Lewis (2003) for field studies. She developed and tested these items in a laboratory sample of 124 teams, 64 MBA consulting teams and 27 work teams from technology firms. Her scale has five questions for each of the three TMS facets - specialization, credibility and coordination. Based on results of confirmatory factor analyses, Lewis (2003) proposed that TMS is best represented as a second-order factor indicated by three first-order factors (specialization, credibility and coordination). This scale has an advantage of being task-independent and can be used to capture indirect measures of TMS with a high validity. TMS is conceptualized as a shared team level construct and hence teammates' responses were aggregated to the team level. This is because the survey items have a 'referent shift' since the items pertain to questions about the team and not the individuals themselves (Chan, 1998).

Consistent with Lewis (2003), I created one composite scale to measure TMS. However, I separately computed the three first order scales of TMS specialization, TMS credibility and TMS coordination. In order to examine the factor structure of the TMS variables (Specialization, Coordination and Credibility), I specified three measurement models using LISREL 8.71 (Jöreskog & Sörbom, 1996). A single factor to capture TMS provided a poor fit to the data ($\chi 2 = 213.03$, *df* =90, $p<.01$; SRMR = .08, NNFI = .83, IFI = .86, CFI = .86). Both the three-factor model with Specialization, Coordination and Credibility and second order factor with a single factor TMS indicated by three first order factors (TMS Specialization, Coordination and Credibility) were statistically equivalent and provided good fit to the data ($\chi 2 = 116.57$, *df* = 87, $p<.01$; SRMR = .08, NNFI = .96, IFI = .97, CFI = .97). Because the latter two models were better fitting than one based on a single TMS factor, I continued exploring the three-factor TMS construct in the subsequent analyses. I also analyzed the single factor TMS construct in keeping with prior research but expected the three-factor model to yield better insights. I have included multiple fit indices to report the results of the Confirmatory Factor Analyses. Table 3 details the result of the Confirmatory Factor Analyses on all study variables.

TMS Specialization

This construct was measured by the five-item scale developed by Lewis (2003). Sample items include "each team member has specialized knowledge of some aspect of our project", "Different team members are responsible for expertise in different areas" and “I know which team members have expertise in specific areas”. I averaged teammates response within each team and then averaged items to form a single scale. The coefficient alpha was 0.61. The r_{wg} value was 0.84. ICC(1) and ICC(2) were .28 and .70 respectively, suggesting the presence of substantial within-group agreement and allowing aggregation to the team level.

TMS Credibility

I measured TMS credibility using the five-item scale developed by Lewis (2003). Sample items include “In most cases, I trusted that other members’ knowledge about the project was credible”. I added the phrase “In most cases” in front of all the items. This was done to get a global sense of credibility and not let team members get distracted by isolated incidents. I averaged responses from teammates within each team and then averaged items to form a single scale. The coefficient alpha was 0.77. The r_{wg} value was 0.84. ICC(1) and ICC(2) were .42 and .81 respectively, suggesting the presence of substantial within-group agreement and allowing aggregation to the team level.

TMS Coordination

I measured TMS coordination using the five-item scale developed by Lewis (2003). Sample items include “We accomplished the task smoothly and efficiently” and “our team worked together in a well-coordinated fashion”. I averaged responses from teammates within each team and then averaged items to form a single scale. The coefficient alpha was 0.66. The r_{wg} value was 0.55. ICC(1) and ICC(2) were .10 and .40 respectively, suggesting lack of within-group agreement. However, in order to be consistent with similar measures (e.g. TMS specialization and TMS credibility), I aggregate the items into a team-level scale.

TMS

I measured the TMS construct by using the 15 items scale by Lewis (2003). This scale is a composite of the three subscales described earlier in the preceding paragraphs - TMS specialization, TMS credibility and TMS coordination. The coefficient alpha was 0.79. The r_{wg} value was 0.79. ICC(1) and ICC(2) were .28 and .70 respectively, suggesting presence of substantial within-group agreement and allowing aggregation to the team level. As noted earlier, based on the confirmatory factor analyses, the single-factor construct was a poor fit to the data ($\chi 2$ = 213.03, *df* =90, p<.01; SRMR = .08, NNFI = .83, IFI = .86, CFI = .86).

Team Viability

Team viability measures a teams' focus to maintain itself over time. Given that work teams work on multiple projects over a period of time, team viability can be a vital measure of effectiveness distinct from team performance. Team members rated their team using the seven-item measure developed by Hackman (1988). Sample items include "members of the team care a lot about it, and work together to make it one of the best", "working with team members is an energizing and uplifting experience" and "as a team, this work group shows signs of falling apart". Coefficient alpha was 0.86. The r_{wg} value was 0.88. ICC(1) and ICC(2) were relatively lower at .14 and .49 respectively, suggesting the presence of relatively low within-group agreement. I ran a confirmatory factor analyses to test whether the 7-item scale fits a one-factor model or not and the model showed an excellent fit to the data ($\chi 2$ = 69.46, *df* = 14, p<.01; SRMR = .07, NNFI = .95, IFI = .97, CFI = .97).

Team Satisfaction

Team satisfaction was measured by a three-item scale developed by Hackman (1988). Team members rated their agreement with sample items such as "Generally speaking I am very satisfied with the team", "I frequently wish I could quit the team (reverse coded)" and "I am generally satisfied with the work I do on the team". Coefficient alpha was acceptable at 0.73. The rwg value was 0.84. ICC(1) and ICC(2) were .03 and .16 respectively, suggesting lack of within-group agreement to allow aggregation to the team level. However, given that ICC(1) and ICC(2) were low while the rwg value was reasonably high at 0.84, it seems that most teams are relatively similar in response to team satisfaction. This might have lead to low within-group to between-group variance and substantially lower ICC values. In keeping with the rest of the variables, I aggregate the items into a team-level measure. The confirmatory factor model is not reported because the 3-item scale indicated a saturated model and demonstrated perfect fit.

Team Interdependence

I used a modified version of task interdependence items developed by Kiggundu (1983). The five-item scale was used to assess employees' task interdependence at an engineering company by Van der vegt et al. (Van der Vegt, Emans, & Van de Vliert, 2001). Sample items include "I have to obtain information and advice from my colleagues in order to complete my work", "I have a one person job; I rarely have to check or work with others" and "In order to complete their work, my colleagues have to obtain information and advice from me". The coefficient alpha for the scale was 0.74. The r_{wg} value was 0.74. ICC(1) and ICC(2) were .14 and .50 respectively, suggesting the presence of relatively low within-group agreement to allow aggregation to the team level. I ran a confirmatory factor analyses to test whether the 5-item scale fits a one-factor model or not and the model showed a great fit to the data ($\chi 2 = 13.50$, $df = 5$, $p<.01$; SRMR = .04, NNFI = .93, IFI = .97, CFI = .97).

Team Reward

I used the three-item scale developed by Denison, Hart and Kahn (1996). Sample items include “my performance review depends upon my performance as a member of the team, “my performance review depends upon the performance of the team and “effective work in support of teams is critical to my advancement within the organization.” The coefficient alpha for the scale was 0.58. The r_{wg} value was 0.68. ICC(1) and ICC(2) were .05 and .23 respectively, suggesting lack of within-group agreement. However given that ICC(1) and ICC(2) were low, it appears that most teams are relatively similar in response to team satisfaction. This might lead to lack of between-group variance and substantially lower ICC values. In keeping with the rest of the study variables, I aggregate the items into a team-level measure. The confirmatory factor model is not reported because the 3-item scale indicated a saturated model and demonstrated perfect fit.

Organizational Support

I used the five-item scale developed by Edmondson (1999). Sample items include “my team gets all the information it needs to do our work and plan our schedule”, “my team is kept in dark about current developments and future plans that may affect its work”. The coefficient alpha for the scale was 0.70. The r_{wg} value was 0.74. ICC(1) and ICC(2) were .14 and .50 respectively, suggesting lack of within-group agreement.

However given that ICC(1) and ICC(2) were low, it appears that most teams are relatively similar in response to team satisfaction. This might lead to lack of between-group variance and substantially lower ICC values. Finally, I ran a confirmatory factor analyses to test whether the 5-item scale fits a one-factor model or not and the and the model showed excellent fit to the data ($\chi 2 = 10.16$, *df* = 5, p<.10; SRMR = .09, NNFI = .96, IFI = .98, CFI = .98).

Team Performance

I adapted the six-item team performance measure developed by Kirkman and Rosen (1999) to capture ratings of team performance. Sample items include "the team meets or exceeds it goals", "team completes its tasks on time" and "team is a productive team". I asked the team managers to rate their team. The coefficient alpha for the scale was 0.83. I ran confirmatory factor analysis to test whether the 6-item scale fits a one-factor model. The model showed a reasonable fit to the data ($\chi 2 = 14.52$, *df* = 8, p<.10; SRMR = .08, NNFI = .91, IFI = .95, CFI = .95).

Team Learning

Team learning was adapted from the five-item scale developed by Edmondson (1999). Team managers rated their team using items such as the team "asks its internal customers for feedback on its performance", "relies on outdated information or ideas (reverse scored)", and "regularly takes time to figure out ways to improve its work performance". Coefficient alpha was 0.63 suggesting the scale reliability was marginal. I ran confirmatory factor analysis to test whether the 5-item scale fits a one-factor model or not and the model showed an acceptable fit to the data ($\chi 2 = 5.46$, *df* = 4, n.s.; SRMR = .12, NNFI = .90, IFI = .97, CFI = .96).

Team Creativity

Team creativity was measured by a four-item scale adapted from Gilson and Shalley (2004). Team leaders assessed the extent to which teams engaged in the creative process. Sample items include “my team links ideas that originate from multiple sources”, “my team searches for novel approaches not required at the time”, and “my team is good at coming up with new ways of doing things”. Coefficient alpha for the scale was 0.25 suggesting unacceptable reliability. I ran confirmatory factor analysis to test whether the original 6-item scale fits a one-factor model or not and the model showed a reasonable fit to the data ($\chi 2 = 13.51$, $df = 9$, n.s.; SRMR = .08, NNFI = .95, IFI = .97, CFI = .97). An inter-item intercorrelation suggested the presence of error covariances amongst the positive and negative worded items. Based on the results of confirmatory factor analyses, I dropped two reverse scored items from the original six-item scale. Coefficient alpha for the modified scale was 0.86. The final 4-item scale provided an excellent fit to the data ($\chi 2 = 2.08$, $df = 2$, n.s.; SRMR = .03, NNFI = 1.00, IFI = 1.00, CFI = 1.00).

No	Characteristics		Number of teams	Number of people responding	Average team size
1	Country	USA	26	123	10.6
		India	15	126	12.9
2	Industry	Information Technology	14	124	13.6
		Aerospace	12	62	13.9
		Education	7	27	5.0
		Healthcare	5	29	11.8
		Engineering	1	2	5.0
		Retail	1	3	10.0
		Finance	1	2	2.0

Table 1. Sample details

Variable	ICC (1)	ICC(2)	F-test	p-value	Rwg (mean, SD)
TMS Specialization	0.28	0.70	3.31	0.00	0.84, 0.21
TMS Credibility	0.42	0.81	5.35	0.00	0.84, 0.30
TMS Coordination	0.10	0.40	1.67	0.01	0.55, 0.46
TMS	0.28	0.70	3.35	0.00	0.80, 0.19
TMM alternate scale	0.21	0.62	2.65	0.00	0.84, 0.20
Task Interdependence	0.14	0.50	2.00	0.00	0.74, 0.25
Team Reward	0.05	0.23	1.30	0.12	0.68, 0.34
Organizational Support	0.14	0.50	2.00	0.00	0.74, 0.21
Team viability	0.14	0.49	1.96	0.00	0.88, 0.15
Team satisfaction	0.03	0.16	1.19	0.22	0.84, 0.17

Table 2. Intraclass Coefficients (ICCs) and within-group agreement (Rwg) indices

Scale (items)	S-B χ^2 (df)	SRMR	NNFI	IFI	CFI
TMM – alternate scale (6)	16.54(9)	0.05	0.99	0.77	0.92
Task Interdependence (5)	13.50(5)*	0.04	0.93	0.97	0.97
Organizational Support (5)	10.16(5)	0.09	0.96	0.98	0.98
Team performance (6)	14.52(6)	0.08	0.91	0.95	0.95
Team learning (5)	5.46(4)	0.12	0.90	0.97	0.96
Team viability (7)	69.46(14)*	0.07	0.95	0.97	0.97
TMS					
TMS – single factor (15)	213.03(90)*	0.08	0.83	0.86	0.86
TMS – 3 first order factor (15)	116.57(87)*	0.08	0.96	0.97	0.97
TMS – 3 first order, one higher order factor (15)	116.57(87)*	0.08	0.96	0.97	0.97
Team creativity					
Team creativity, original scale, single factor (6)	13.51(9)	0.08	0.95	0.97	0.97
Team creativity– modified (4)	2.08(2)	0.03	1.00	1.00	1.00

Note. S-B χ^2 = Satorra-Bentler scaled chi square, df = degrees of freedom, SRMR =Standardized root mean squared residual, NNFI = Non-normed fit index, IFI= Incremental fit index, CFI = Comparative fit index.
*p<0.05

Table 3. Confirmatory factor analyses of the scales

CHAPTER 4: RESULTS

Descriptive statistics and zero-order intercorrelations for the variables are presented in Table 4. Several significant relationships involving control variables were observed. First, team tenure was positively related to high levels of TMS Specialization ($r = 0.32$, $p<0.05$) and TMS credibility ($r = 0.43$, $p<.05$), and teams with longer tenure reported a higher level of team performance ($r = 0.34$, $p<0.05$), team learning ($r = 0.42$, $p<0.05$) and team creativity ($r = 0.39$, $p<0.05$). Second, team size was negatively related to TMS specialization ($r = -0.44$, $p<0.05$), TMS credibility ($r = -0.41$, $p<0.05$), TMM Average Deviation ($r = -0.36$, $p<0.05$), team performance ($r = -0.33$, $p<0.05$) and team creativity ($r = -0.49$, $p<0.05$). Finally, country of origin affected the results. In addition, compared to teams from India, teams from the US had higher levels of TMS specialization ($r = 0.31$, $p<0.05$), TMS credibility ($r = 0.63$, $p<0.05$), engaged in more interdependent tasks ($r = 0.38$, $p<0.05$), and had higher levels of team performance ($r = 0.45$, $p<0.05$) and team creativity ($r=0.43$, $p<0.05$).

Teams high on TMS specialization demonstrated high performance ($r = 0.42$, $p<0.05$) and high team creativity ($r = 0.33$, $p<0.05$). Teams that exhibited high levels of TMS credibility were associated with high levels of team performance ($r = 0.46$, $p<0.05$) and team creativity ($r = 0.45$, $p<0.05$). In addition, TMS credibility was associated with team viability ($r = 0.29$, $p<0.05$) and team creativity ($r = 0.45$, $p<0.05$). Although the correlations were generally consistent with the proposed hypothesis, the relationships between (1) TMS coordination and team performance and (2) TMM and team performance, though in the expected direction, were not statistically significant.

As mentioned earlier, I operationalized TMM agreement in two different ways – 1) by computing an average deviation index and 2) by administering an equivalent 6-item scale – of six major team processes. Interestingly, these two measures showed little intercorrelation (r = -0.12, n.s.). Since both these methods were exploratory approaches, I proceeded to test my hypothesis by examining these two methods of computing TMM agreement. The rest of this chapter compares these two methods and describes the results.

Method 1: Team Mental Model (Average Deviation)

Relationship with Team Mental Model (TMM)

To test Hypothesis 1, I conducted a series of hierarchical regression analyses reported in Tables 5-10. Team tenure, team size and a dummy variable representing country were explored as control variables. Detailed results are presented in Table 5. First, I included control variables (team tenure, team size and country) found to have significant bivariate relationships with the dependent variables. Second, I tested whether TMM squared, hypothesized to have direct effects (entered in step 3), had predictive power over and above that of the TMM (entered in step 2) and the control variables (entered in step 1). A significant change in R^2 in step 3 indicates a curvilinear relationship.

I tested all the hypotheses at a p-value of 0.10. Increasing significance level (p values) to test the hypothesis generally increase the chance of "false positives" or Type I error reflecting the chance that the observed relationship is not true. On the flip side, type II error or "false negatives" reflecting the failure to detect relationships will decrease. It is necessary to balance the Type I and Type II errors in any statistical analysis.

Hypothesis 1 predicts a ∩-shaped relationship between TMM and team performance. This prediction was not supported ($\Delta R^2 = 0.00$, n.s.). No ∩-shaped relationship was observed between TMM and other dependent variables - team learning

($\Delta R^2 = 0.00$, n.s.), team creativity ($\Delta R^2 = 0.03$, n.s.), team viability ($\Delta R^2 = 0.00$, n.s.) or team satisfaction ($\Delta R^2 = 0.02$, n.s.). In addition, no linear relationship was observed between TMM with team performance, team learning or team creativity. However, a linear relationship was observed between TMM and team viability ($\Delta R^2 = 0.09$, $p<0.10$). A similar relationship was observed between TMM and team satisfaction ($\Delta R^2 = 0.08$, $p<0.10$). Relationships of TMM with team viability and team satisfaction should be considered tenuous because of using a higher significance level ($p<0.10$) to test the hypothesis.

In order to have adequate power to detect relationships between hypothesized variables, and to limit the number of independent variables in the regression analyses, I dropped these control variables (team tenure, team size and country of origin) from further analysis. In further regression analyses, I included contextual variables like task interdependence, team reward and organizational support as more theoretically meaningful control variables. Table 6 reports the results of hierarchical regression models by incorporating the changed control variables. Again, Hypothesis 1 predicting a ∩-shaped relationship between TMM and team performance was not supported ($\Delta R^2 = 0.00$, n.s.). No ∩-shaped relationship was observed between TMM and other dependent variables - team learning ($\Delta R^2 = 0.00$, n.s.), team creativity ($\Delta R^2 = 0.00$, n.s.), team viability ($\Delta R^2 = 0.01$, n.s.) or team satisfaction ($\Delta R^2 = 0.01$, n.s.). In addition, no linear relationship was observed for TMM with team performance, team learning, team creativity, team viability or team satisfaction. In summary, this set of results suggests lack of support for H1, predicting a curvilinear relationship between TMM and team performance.

Relationship with TMS

Tables 7-10 report a series of hierarchical regression models used to test Hypothesis 2. First, I included the control variables (task interdependence, team reward and organizational support) found to have significant bivariate relationships with the dependent variables. Second, I tested whether TMS or its components (entered in step 3) had predictive power over TMM (entered in step 2) and the control variables (entered in step 1). A significant change in R^2 in step 3 indicates a main effect. Hypothesis 2a-c predicts that TMS components (specialization, coordination and credibility) will be positively related to team performance. Before testing for TMS subcomponents, I examined the TMS construct first and its impact on team performance. Based on results from Step 3 of the model in Table 7, TMS had a weak positive relationship with team performance ($\Delta R^2 = 0.06$, $p<0.10$). There was an absence of relationships between TMS and team learning, team creativity, team viability and team satisfaction. Detailed results are presented in Table 7.

Next, I examined H2a that predicts that TMS specialization will be positively related to team performance. I tested whether TMS specialization (entered in step 3) had predictive power over TMM (entered in step 2) and control variables (entered in step 1). A significant change in R^2 in step 3 indicates a main effect. This prediction was not supported ($\Delta R^2 = 0.06$, n.s.). Further, based on results from step 3 of Table 8, no relationship was observed for TMS specialization with team learning ($\Delta R^2 = 0.01$, n.s.), team creativity ($\Delta R^2 = 0.02$, n.s.), team viability ($\Delta R^2 = 0.00$, n.s.) or team satisfaction ($\Delta R^2 = 0.02$, n.s.). Detailed results are presented in Table 8.

Next, I investigated H2b that predicts TMS coordination will be positively related to team performance. I tested whether TMS coordination (entered in step 3) had predictive power over TMM (entered in step 2) and the control variables (entered in step 1). A significant change in R^2 in step 3 indicates a main effect. This prediction was not supported ($\Delta R^2 = 0.00$, n.s.). Further, based on results from step 3, no relationship was observed for TMS coordination with team learning ($\Delta R^2 = 0.04$, n.s.) or team creativity ($\Delta R^2 = 0.02$, n.s.). A linear relationship was observed for TMS coordination with team viability ($\Delta R^2 = 0.05$, $p<0.05$) and team satisfaction ($\Delta R^2 = 0.04$, $p<0.10$). Detailed results are reported in Table 9.

Next, I investigated H2c that predicts TMS credibility will be positively related to team performance. I tested whether TMS credibility (entered in step 3) had predictive power over TMM (entered in step 2) and the control variables (entered in step 1). A significant change in R^2 in step 3 indicates a main effect. This prediction was supported ($\Delta R^2 = 0.07$, $p<0.10$). TMS credibility also predicted team creativity ($\Delta R^2 = 0.07$, $p<0.10$). Further, based on results from step 3, no relationship was observed for TMS credibility with team learning ($\Delta R^2 = 0.05$, n.s.), team viability ($\Delta R^2 = 0.00$, n.s.) or team satisfaction ($\Delta R^2 = 0.02$, n.s.). Detailed results are reported in Table 10. Overall, these sets of results provide partial support for Hypothesis 2c, but fail to support Hypothesis 2a and 2b.

Relationship between TMM and TMS

Table 7 also reports a series of hierarchical regression models used to test Hypothesis 3. First, I included the control variables (task interdependence, team reward, organizational support) found to have significant bivariate relationships with the dependent variables. Second, I tested whether the cross-product interaction term had direct effects (entered in step 4) and predictive power over and above that of TMS (entered in step 3), TMM (entered in step 2) and the control variables (entered in step 1). Third, I centered independent variables (TMM & TMS) to reduce multicollinearity during testing for interactions (Aiken & West, 1991). A significant change in R^2 in step 4 indicates a moderation effect. Hypothesis 3 predicts that TMM moderates the relationship between TMS and team performance such that the relationship is negative when TMM is low but positive when TMM is high. This prediction was not supported ($\Delta R^2 = 0.03$, n.s.).

Further, no moderation effect of TMM was detected for the TMS related to team learning ($\Delta R^2 = 0.05$, n.s.), team creativity ($\Delta R^2 = 0.08$, $p<0.10$), team viability ($\Delta R^2 = 0.01$, n.s.) or team satisfaction ($\Delta R^2 = 0.00$, n.s.). However, TMM moderated the relationship between TMS and team creativity ($\Delta R^2 = 0.08$, $p<0.10$). Contrary to expectations, TMM aided team creativity under conditions of low TMS, but hampered team creativity under high TMS conditions. Figure 3 graphically depicts this relationship. Team creativity was highest under conditions of high TMS and low TMM, and worst under conditions of low TMS and low TMM.

Post-hoc analyses: TMS Components

Although the previous set of results failed to support the moderating role of TMM on TMS and team performance, I explored the possibility that TMM might interact with TMS components (TMS specialization, TMS credibility and TMS coordination) and team effectiveness dimensions. This was indirectly supported by the initial evidence that a three-factor confirmatory factor analyses fit the data better than a single factor TMS, the presence of three distinct components (Table 3). More support for an exploratory approach came from the evidence that TMS components behaved differently with team performance as reported earlier in the bivariate correlation analyses (Table 4). Thus, I engaged in exploration of how these distinct components behave in relation to my proposed hypothesis. Engaging in post-hoc tests raises the possibility of alpha-inflation. In other words, the more tests I conduct at a given significance level (say $\alpha = .05$), the more likely the chance to claim a significant result when there isn't one (i.e., a Type I error increasingly exceeds the nominal level). Hence, care should be taken in interpreting these sets of results.

Similar to Hypothesis 1 that predicted curvilinear effect with TMM and team performance, I wondered about the possibility of a curvilinear relationship between TMS components and the dependent variables. To test these hypotheses, I ran a series of hierarchical regression analyses. This involved a three step process. First, I included the control variables (task interdependence, team reward and organizational support). Second, I entered TMS specialization. Third, I tested whether TMS specialization squared (entered in step 3) had predictive power over and above that of TMS specialization (entered in step 2) and control variables (entered in step 1). In addition, I centered the TMS specialization scale as suggested by Aiken and West (1991). A significant change in R^2 in step 3 indicates a curvilinear relationship. Detailed results from Table 11 suggests that a curvilinear relationship exists between TMS specialization and team creativity ($\Delta R^2 = 0.07$, $p<0.10$). No such relationship was observed between TMS specialization and the other dependent variables – team performance, team learning, team viability and team satisfaction. Figure 4 graphically depicts the curvilinear relationship between TMS specialization and team creativity. The effect was such that it takes a fairly high level of TMS specialization before teams experience increased team creativity. Even an average level of TMS specialization doesn't help team creativity. The level of TMS has to exceed a certain threshold level before it impacts creativity.

Next, I ran a similar series of hierarchical regression to test the relationship between TMS coordination and the dependent variables. In particular, I tested whether TMS coordination squared (entered in step 3) had predictive power over and above TMS coordination (entered in step 2) and the control variables (entered in step 1). I also centered the TMS coordination scale to minimize multicollinearity (Aiken & West, 1991). Detailed results are presented in Table 12. Curvilinear relationships were observed for TMS coordination with team viability ($\Delta R^2 = 0.09$, $p<0.01$) and team satisfaction ($\Delta R^2 = 0.04$, $p<0.10$). A high level of TMS coordination aided team viability. Figure 5 graphically depicts this relationship. The effect was such that it takes a fairly high level of TMS coordination before teams experience increased team viability. Even an average level of TMS coordination doesn't help team viability and the level of TMS coordination has to exceed a certain threshold level before it impacts viability. A similar pattern was observed between TMS coordination and team satisfaction. Team satisfaction increased beyond a certain threshold level of TMS coordination. Figure 6 graphically depicts this relationship.

Next, I ran a similar series of hierarchical regressions to test the relationship between TMS credibility and the dependent variables. In particular, I tested whether TMS credibility squared (entered in step 3) had predictive power over and above that of TMS credibility (entered in step 2) and the control variables (entered in step 1). I also centered the TMS credibility scale to minimize multicollinearity (Aiken & West, 1991). Detailed results are presented in Table 13. A nonlinear relationship was observed between TMS credibility and team performance ($\Delta R^2 = 0.08$, $p<0.05$). No curvilinear relationship was observed with other dependent variables. The non-linear effect was such that the increasing level of TMS credibility helps increase team performance. However, once TMS credibility goes past average level, there is no additional benefit in terms of team performance. Stated another way, teams perform badly under conditions of low TMS credibility. Team performance is not a problem under average or high levels of TMS credibility. Figure 7 graphically depicts this relationship.

Moderating impact of TMS Components

I explored the possibility of the moderating impact of TMM on the relationship between TMS components and the dependent variables. I investigated this possibility by running a series of hierarchical regression analyses as reported in Tables 8-10. Specifically, I entered the relevant interaction term (e.g. TMS Specialization X TMM) in step 4 of the regression equation of Table 8. No moderation effect was observed for TMM on TMS specialization and team performance. However, an interaction effect was observed between TMM and TMS specialization on team creativity ($\Delta R^2 = 0.08$, $p<.10$). Figure 8 graphically depicts this relationship.

According to figure 8, TMM generally resulted in higher levels of team creativity. As expected, team creativity was lowest when both TMM and TMS Specialization were low. The interaction was such that when TMS was low, TMM mattered. When TMS specialization was high, there was hardly any difference in team creativity. When TMS specialization was low, high TMM facilitated team creativity while low TMM lowered team creativity.

Similar analyses reported in figure 9 reveals an interaction between TMM and TMS coordination on team performance ($\Delta R^2 = 0.12$, $p<.05$). As expected, teams high on TMM demonstrated better than average performance under conditions of high TMS coordination. Team performance was equally good under conditions of low TMM coupled with low TMS coordination. This is puzzling and difficult to explain. However, team performance went down under conditions of low TMM and high TMS coordination. Again contrary to expectations, teams high on TMM demonstrated a lower than average team performance when coupled with high levels of TMS coordination, while teams low on TMM demonstrated a better than average performance when coupled with low levels of TMS coordination. TMS coordination and TMM thus demonstrated a compensatory relationship when predicting team performance.

Similar analyses reported in Table 10 reveal an interaction between TMM and TMS credibility with team performance ($\Delta R2 = 0.14$, $p<.01$), team learning ($\Delta R2 = 0.20$, $p<.01$), and team creativity ($\Delta R2 = 0.14$, $p<.01$). Figures 10-12 depict these relationships.

Figure 10 illustrates that teams high on TMS credibility generally demonstrated better team performance. Teams had their worst performance when they were low on both TMM and TMS credibility. However, teams demonstrated superior team performance under conditions of high levels of TMS credibility coupled with low levels of TMM. This result was counter-intuitive. Improvements in TMS credibility aided teams lowest on TMM levels. Overall, the interaction pattern was evident under conditions of low TMM. Teams high on TMM delivered average performance.

Figure 11 illustrates that teams high on TMS credibility engaged in more learning behaviors than the teams low on TMS credibility. Teams engaged in the least learning when they were low on both TMM and TMS credibility. However, teams engaged in more learning behaviors under conditions of high levels of TMS credibility coupled with low levels of TMM. This result was counter-intuitive. Improvements in TMS credibility aided teams lowest on TMM levels. Overall, the interaction pattern was evident under conditions of low TMM. Teams high on TMM engaged in an average level of team learning.

Figure 12 illustrates that teams high on TMS credibility engaged in more creativity than those teams low on TMS credibility. Teams were least creative when they were low on both TMM and TMS credibility. However, teams engaged in behaviors that are more creative when they experienced low levels of TMM and high levels of TMS credibility. This result was counter-intuitive. In other words, the interaction pattern was evident under conditions of low TMM. Teams high on TMM engaged in an average level of team learning. Overall, these sets of results indicate that TMS has its largest impact in predicting team performance, teams learning and team creativity on teams with low TMM.

Method 2: Team Mental Model (Alternate Scale)

Since this was an exploratory study of TMM in a field setting involving teams from multiple industries, I operationalized the TMM scale in two different ways – one using the average deviation of 6 rank-ordered team processes and the other a 6-item Likert type equivalent scale. I ran the entire analysis as described in the previous section using the alternate Likert scale developed for this study. The following section details the results.

Relationship with Team Mental Model (TMM)

To test Hypothesis 1, I conducted a series of hierarchical regression analyses as reported in Table 14. Team tenure, team size and a dummy variable representing country were explored as control variables. First, I included control variables (team tenure, team size and country) found to have significant bivariate relationships with the dependent variables. Second, I tested whether TMM squared hypothesized to have direct effects (entered in step 3) had predictive power over and above that of TMM (entered in step 2) and the control variables (entered in step 1). Third, I centered the TMM scale to reduce multicollinearity when testing for interactions (Aiken & West, 1991). A significant change in R^2 in step 3 indicates a curvilinear relationship.

Hypothesis 1 predicted a ∩-shaped relationship between TMM and team performance. This prediction was not supported ($\Delta R^2 = 0.01$, n.s.). No ∩-shaped relationship was observed between TMM and the other dependent variables - team learning ($\Delta R^2 = 0.00$, n.s.), team creativity ($\Delta R^2 = 0.01$, n.s.), team viability ($\Delta R^2 = 0.01$, n.s.) and team satisfaction ($\Delta R^2 = 0.00$, n.s.). However, there were linear relationships for TMM with team performance ($\Delta R^2 = 0.06$, $p<0.10$), team creativity ($\Delta R^2 = 0.08$, $p<0.05$), team viability ($\Delta R^2 = 0.42$, $p<0.01$) and team satisfaction ($\Delta R^2 = 0.40$, $p<0.01$). In addition, control variables (team tenure, team size and country of origin) as a block explained a sizeable proportion of variance in team performance ($\Delta R^2 = 0.32$, $p<0.01$), team learning ($\Delta R^2 = 0.27$, $p<0.01$) and team creativity ($\Delta R^2 = 0.38$, $p<0.01$). Specifically, team size was negatively related to team performance ($\beta = -.27$, $p<0.10$) and team creativity (β = -.27, $p<0.10$). Further, teams from the US were rated higher on team performance (β = .37, $p<0.10$) than those from India.

In order to have adequate power to detect relationships between hypothesized variables, and to limit the number of independent variables in the regression analyses, I dropped these control variables (team tenure, team size and country of origin) from further analysis. Dropping these control variables did not impact the substantial interpretation of results. In further regression analysis, I included contextual variables like task interdependence, team reward and organizational support as more theoretically meaningful control variables. Table 15 reports the results of hierarchical regression models by incorporating the changed control variables. Again, Hypothesis 1, predicting a ∩-shaped relationship between TMM and team performance, was not supported (ΔR^2 = 0.01, n.s.). No ∩-shaped relationship was observed between TMM and other dependent variables - team learning (ΔR^2 = 0.00, n.s.), team creativity (ΔR^2 = 0.02, n.s.), team viability (ΔR^2 = 0.01, n.s.) and team satisfaction (ΔR^2 = 0.01, n.s.). However, there was a linear relationship for TMM with team learning (ΔR^2 = 0.11, $p<0.05$), team viability (ΔR^2 = 0.07, $p<0.05$) and team satisfaction (ΔR^2 = 0.08, $p<0.05$). In addition, no linear relationship was observed for TMM with team performance or team creativity. In summary, this set of results suggests lack of support for H1 which predicted a curvilinear relationship between TMM and team performance.

Relationship with TMS

Tables 16-19 report a series of hierarchical regression models used to test Hypothesis 2. First, I included the control variables (task interdependence, team reward and organizational support) found to have significant bivariate relationships with the dependent variables. Second, I tested whether TMS or its components (entered in step 3) had predictive power over TMM (entered in step 2) and the control variables (entered in step 1). A significant change in R^2 in step 3 indicates a main effect. Hypotheses 2a-c predict that TMS components (specialization, coordination and credibility) will be positively related to team performance. Before testing for TMS subcomponents, I first examined the TMS construct and its impact on team performance. Based on results from Step 3 of the model in Table 16, TMS had weak positive relationships with team performance ($\Delta R^2 = 0.06$, $p<0.10$) and team creativity ($\Delta R^2 = 0.06$, $p<0.10$). There was no relationship for TMS with team learning, team viability or team satisfaction. Detailed results are presented in Table 16.

Next, I examined H2a that predicted TMS specialization to be positively related to team performance. I tested whether TMS specialization (entered in step 3) had predictive power over TMM (entered in step 2) and the control variables (entered in step 1). A significant change in R^2 in step 3 indicates a main effect. This prediction was not supported ($\Delta R^2 = 0.06$, n.s.). Further, based on results from step 3 of Table 17, no relationship was observed for TMS specialization with team learning ($\Delta R^2 = 0.01$, n.s.), team creativity ($\Delta R^2 = 0.02$, n.s.), team viability ($\Delta R^2 = 0.00$, n.s.) or team satisfaction ($\Delta R^2 = 0.00$, n.s.). Detailed results are presented in Table 17.

Next, I investigated H2b that predicted TMS coordination to be positively related to team performance. I tested whether TMS coordination (entered in step 3) had predictive power over TMM (entered in step 2) and the control variables (entered in step 1). A significant change in R^2 in step 3 indicates a main effect. This prediction was not supported ($\Delta R^2 = 0.00$, n.s.). Further, based on results from step 3, no relationship was observed for TMS coordination with team learning ($\Delta R^2 = 0.01$, n.s.), team creativity ($\Delta R^2 = 0.03$, n.s.), team viability ($\Delta R^2 = 0.01$, n.s.) or team satisfaction ($\Delta R^2 = 0.00$, n.s.). Detailed results are reported in Table 18.

Next, I investigated H2c that predicted TMS credibility to be positively related to team performance. I tested whether TMS credibility (entered in step 3) had predictive power over TMM (entered in step 2) and the control variables (entered in step 1). A significant change in R^2 in step 3 indicates a main effect. This prediction was supported ($\Delta R^2 = 0.05$, $p<0.05$). TMS credibility also predicts team creativity ($\Delta R^2 = 0.05$, $p<0.10$). Further, based on results from step 3, no relationships were observed for TMS credibility with team learning ($\Delta R^2 = 0.02$, n.s.), team viability ($\Delta R^2 = 0.01$, n.s.) or team satisfaction ($\Delta R^2 = 0.00$, n.s.). Detailed results are reported in Table 19. Overall, these sets of results partially support Hypothesis 2c, but fail to support Hypotheses 2a and 2b.

Relationship between TMM and TMS

Table 16 reports a series of hierarchical regression models used to test Hypothesis 3. First, I included the control variables (task interdependence, team reward, organizational support) found to have significant bivariate relationships with the dependent variables. Second, I tested whether the cross-product interaction term had direct effects (entered in step 4) and predictive power over and above that of TMS (entered in step 3), TMM (entered in step 2) and the control variables (entered in step 1). Third, I centered independent variables (TMM & TMS) to reduce multicollinearity during testing for interactions (Aiken & West, 1991). A significant change in R^2 in step 4 indicates a moderation effect. Hypothesis 3 predicts that TMM moderates the relationship between TMS and team performance such that the relationship is negative when TMM is low but positive when TMM is high. This prediction was not supported ($\Delta R^2 = 0.01$, n.s.).

Further, no moderation effect of TMM was detected for the relationships of TMS with team learning (ΔR2 = 0.00, n.s.), team viability (ΔR2 = 0.01, n.s.) or team satisfaction (ΔR2 = 0.01, n.s.). However, TMM moderated the relationship between TMS and team creativity (ΔR2 = 0.09, $p<0.05$). TMS generally aided team creativity irrespective of level of TMM. When TMS was low, team creativity was better under conditions of low TMM than under high TMM. Team creativity was worst under conditions of low TMS and high TMM. It appeared that TMM seemed to hamper team creativity especially under conditions of low TMS. Figure 13 graphically depicts this relationship.

Post-hoc analyses

Although the previous set of results failed to support the moderating role of TMM on the relationship between TMS and team performance, I explored the possibility that TMM might interact differently with TMS components (TMS Specialization, TMS Credibility and TMS Coordination) and team effectiveness dimensions. This possibility was supported by the initial evidence that a three-factor confirmatory factor analyses fit the data better than a single factor TMS with the presence of three distinct components (Table 2). More support for this exploratory approach came from the evidence that TMS components behaved differently with team performance as reported earlier in the bivariate correlation analyses (Table 3). Thus, I engaged in exploration of how these distinct components behave in relation to my proposed hypothesis.

Moderating impact of TMS components

I explored the possibility of the moderating impact of TMM on the relationship between TMS components and the dependent variables. I investigated this possibility by running a series of hierarchical regression analyses reported in Tables 17-19. Specifically, I entered the relevant interaction term (e.g., TMS Specialization X TMM) in step 4 of the regression equation of Table 17. TMM did not moderate the relationship between TMS specialization and team performance. However, an interaction effect was observed between TMM and TMS specialization on team creativity ($\Delta R^2 = 0.12$, $p<.05$). Figure 14 graphically depicts this relationship.

According to Figure 14, higher levels of TMS specialization resulted in higher levels of team creativity. Contrary to expectations, team creativity was lowest under conditions of high TMM. Moreover, teams demonstrated their lowest level of team creativity when TMM was high but TMS specialization was low. This result was puzzling in light of Hypothesis 3. It appears that high TMM has a detrimental impact on team creativity.

Similar analyses reported in Table 18 reveal an interaction between TMM and TMS coordination on team viability ($\Delta R^2 = 0.05$, $p<.05$). Figure 15 shows the relationship graphically. As expected, team viability increased under conditions of high TMM and high TMS coordination. Conversely, team viability was lowest under conditions of low TMM coupled with high levels of TMS coordination. High levels of TMM increased team viability, or their intention to maintain themselves. TMS coordination helped increase team viability under conditions of high TMM.

Similar analyses reported in Table 19 reveal an interaction between TMM and TMS credibility for team performance ($\Delta R2 = 0.14$, $p<.01$), team learning ($\Delta R2 = 0.20$, $p<.01$), and team creativity ($\Delta R2 = 0.14$, $p<.01$). Figure 16 depicts the relationship for creativity. The figure reveals that team creativity remains at a fairly high level under conditions of low TMM. Team creativity decreases when teams demonstrate low TMS credibility coupled with high TMM. TMS credibility generally helps improve team creativity except under conditions of low TMM. At high levels of TMS credibility, irrespective of TMM level, team creativity is quite high.

Table 20 details the key findings of all analyses, including similarities and differences, from analyses obtained by following two different methods of TMM operationalization – the average deviation method and the 6-item Likert scale. Support for the results has been marked by figures depicted previously in the manuscript.

Variable	Mean	SD	1	2	3	4	5	6	7	8	9
Control variables											
1. Team tenure	2.91	2.16	-								
2. Country[a]	0.68	0.47	0.53	-							
3. Team size	10.90	7.42	-0.16	-0.24	-						
Independent variables											
4. TMS specialization	4.16	0.47	0.32	0.31	-0.44	(.61)					
5. TMS credibility	4.00	0.54	0.43	0.63	-0.41	0.68	(.77)				
6. TMS coordination	3.91	0.43	0.17	-0.16	-0.12	0.06	0.20	(.66)			
7. TMS	4.02	0.36	0.43	0.39	-0.45	0.80	0.88	0.53	(.79)		
8. TMM (AD)	-1.04	0.29	-0.12	0.22	-0.36	0.21	0.14	-0.15	0.11	-	
9. TMM alt scale	3.88	0.52	-0.17	-0.50	0.09	0.17	0.00	0.64	0.33	-0.12	(.82)

Note. [a] Country (0=India, 1=US), N=41 teams. Scale reliabilities are on the diagonal in parentheses. The 95% confidence interval for correlations greater than or equal to 0.29 does not include 0 (.01<0.29<.57).[b] Reported by team managers, other measures obtained from team members.

Table 4. Means, Standard Deviations and Inter-correlations among study variables

Variable	Mean	SD	1	2	3	4	5	6	7	8	9
Contextual variables											
10. Task interdependence	3.45	0.61	0.32	0.38	-0.08	0.29	0.37	0.16	0.38	-0.05	0.04
11. Team reward	3.86	0.46	0.04	0.26	-0.21	0.51	0.54	0.25	0.59	0.10	0.38
12. Org support	3.52	0.53	0.15	-0.25	-0.06	0.20	0.24	0.63	0.45	-0.05	0.64
Dependent variables											
13. Team viability	3.98	0.56	-0.07	-0.14	-0.04	0.23	0.29	0.59	0.48	0.19	0.67
14. Team satisfaction	4.21	0.43	0.11	-0.09	-0.01	0.19	0.22	0.57	0.42	0.13	0.64
15. Team performance[b]	4.08	0.51	0.34	0.45	-0.33	0.42	0.46	0.17	0.48	0.06	0.09
16. Team learning[b]	3.95	0.72	0.42	0.43	-0.24	0.16	0.25	-0.05	0.18	0.11	-0.12
17. Team creativity[b]	4.03	0.78	0.39	0.43	-0.49	0.33	0.45	0.24	0.47	0.13	0.05

Note. [a] Country (0=India, 1=US), N=41 teams. Scale reliabilities are on the diagonal in parentheses. The 95% confidence interval for correlations greater than or equal to 0.29 does not include 0 (.01<0.29<.57).[b] Reported by team managers, other measures obtained from team members.

Table 4. Continued

Variable	10	11	12	13	14	15	16	17
Contextual variables								
10. Task interdependence	(.74)							
11. Team reward	0.44	(.58)						
12. Org support	0.02	0.29	(.70)					
Dependent variables								
13. Team viability	0.12	0.46	0.66	(.86)				
14. Team satisfaction	0.32	0.04	0.63	0.76	(.73)			
15. Team performance[b]	0.24	0.39	0.27	0.10	0.12	(.83)		
16. Team learning[b]	0.00	0.06	0.20	-0.06	0.00	0.73	(.63)	
17. Team creativity[b]	0.24	0.36	0.26	0.14	0.17	0.77	0.70	(.86)

Note. [a] Country (0=India, 1=US), N=41 teams. Scale reliabilities are on the diagonal in parentheses. The 95% confidence interval for correlations greater than or equal to 0.29 does not include 0 (.01<0.29<.57).[b] Reported by team managers, other measures obtained from team members.

Table 4. Continued

	Team performance			Team learning			Team creativity		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Team tenure	.11	.09	.09	.29†	.31†	.31†	.21	.20	.22
Team size	-.27†	-.29†	-.29†	-.13	-.12	-.11	-.41**	-.42**	-.39*
Country	.37*	.39*	.39*	.26	.24	.24	.23	.24	.25
TMM		-.07	-.06		.05	.04		-.04	-.15
TMM squared			-.01			.03			.19
R^2	.32**	.32**	.32**	.27*	.27*	.27*	.38**	.38**	.41**
ΔR^2		.00	.00		.00	.00		.00	.03

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 5. Results of Hierarchical Regression Analyses testing Hypothesis 1 with team tenure, team size and country of origin as control variables: TMM Average Deviation

	Team viability			Team satisfaction		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Team tenure	-.04	.07	.06	.17	.27	.25
Team size	-.12	-.01	-.02	-.07	.03	.01
Country	-.12	-.22	-.22	-.18	-.27	-.28
TMM		.34†	.39†		.32†	.42†
TMM squared			-.08			-.17
R^2	.03	.12	.12	.03	.11	.13
ΔR^2		.09†	.00		.08†	.02

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 5. Continued

	Team performance			Team learning			Team creativity		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	.11	.12	.11	.00	.02	.02	.12	.14	.15
Team reward	.28	.27	.30	-.01	-.03	-.02	.25	.23	.21
Organizational support	.19	.19	.19	.21	.22	.22	.18	.19	.20
TMM		.04	.12		.13	.16		.13	.07
TMM squared			-.13			-.05			.09
R^2	.19	.19	.20	.04	.06	.06	$.16^{\dagger}$	$.18^{\dagger}$	$.18^{\dagger}$
ΔR^2		.00	.01		.02	.00		.02	.00

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 6. Results of Hierarchical Regression Analyses testing Hypothesis 1 with task interdependence, team reward and organizational support as control variables: TMM Average Deviation

	Team viability			Team satisfaction		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	-.03	-.01	-.02	.26*	.29*	.27*
Team reward	.31*	.27*	.30*	.10	.07	.12
Organizational support	.57**	.59**	.58**	.59**	.61**	.60**
TMM		.19	.27†		.17	.30*
TMM squared			-.14			-.22
R^2	.51**	.55**	.56**	.50**	.52**	.55**
ΔR^2		.04	.01		.02	.03

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 6. Continued

	Team performance				Team learning				Team creativity			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	.11	.12	.05	.04	.00	.02	-.01	-.02	.12	.14	.07	.06
Team reward	.28	.27	.14	.15	-.01	-.03	-.09	-.07	.25	.23	.09	.11
Organizational support	.19	.19	.08	.11	.21	.22	.17	.22	.18	.19	.08	.13
TMM		.04	.01	.02		.13	.11	.13		.13	.10	.12
TMS			.34†	.37†			.15	.18			.34	.39†
TMM X TMS				-.16				-.25				-.29†
R^2	.19*	.19*	.25*	.28*	.04	.06	.07	.12	.16†	.18†	.24†	.32*
ΔR^2		.00	.06†	.03		.02	.01	.05		.02	.06	.08†

Note. N=41 teams, Regression coefficients are standardized betas.
**$p<0.01$, *$p<0.05$, $^{\dagger}p<0.10$

Table 7. Results of Hierarchical Regression Analyses examining impact of TMS on team outcomes: TMM Average Deviation

	Team viability				Team satisfaction			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	-.03	-.01	-.02	-.01	.26*	.29*	.30*	.30*
Team reward	.31*	.27*	.25	.24	.10	.07	.09	.09
Organizational support	.57**	.59**	.57**	.54**	.59**	.61**	.63**	.63**
TMM		.19	.18	.17		.17	.17	.17
TMS			.07	.05			-.05	-.05
TMM X TMS				.12				-.02
R^2	.51**	.55**	.55**	.56**	.50**	.52**	.53**	.53**
ΔR^2		.04	.00	.01		.02	.01	.00

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 7. Continued

	Team performance				Team learning				Team creativity			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	.11	.12	.09	.07	.00	.02	.00	-.01	.12	.14	.12	.10
Team reward	.28	.27	.15	.25	-.01	-.03	-.09	.00	.25	.23	.16	.28
Organizational support	.19	.19	.17	.18	.21	.22	.21	.22	.18	.19	.18	.20
TMM		.04	-.01	.06		.13	.10	.16		.13	.10	.18
TMS spec			.29	.31†			.15	.17			.16	.19
TMM X TMS spec				-.26				-.24				-.33†
R^2	.19*	.19*	.25*	.30*	.04	.06	.07	.11	.16†	.18†	.20†	.28*
ΔR^2		.00	.06	.05		.02	.01	.04		.02	.02	.08†

Note. N=41 teams, Regression coefficients are standardized betas, spec = specialization.
**p<0.01, *p<0.05, †p<0.10

Table 8. Results of Hierarchical Regression Analyses testing Hypothesis 2a and 3: TMM Average Deviation

	Team viability				Team satisfaction			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	-.03	-.01	.01	.02	.26*	.29*	.30*	.30*
Team reward	.31*	.27*	.31*	.25	.10	.07	.12	.12
Organizational support	.57**	.59**	.60**	.59**	.59**	.61**	.62**	.62**
TMM		.19	.21†	.16		.17	.19	.19
TMS specialization			-.09	-.11			-.13	-.13
TMM X TMS spec				.17				.00
R^2	.51**	.55**	.55**	.57**	.50**	.52**	.54**	.54**
ΔR^2		.04	.00	.02		.02	.02	.00

Note. N=41 teams, Regression coefficients are standardized betas, spec = specialization.
**p<0.01, *p<0.05, †p<0.10

Table 8. Continued

	Team performance				Team learning				Team creativity			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	.11	.12	.13	.09	.00	.02	.06	.03	.12	.14	.13	.12
Team reward	.28	.27	.28	.38*	-.01	-.03	-.02	.04	.25	.23	.22	.26
Organizational support	.19	.19	.23	.17	.21	.22	.39†	.35	.18	.19	.14	.12
TMM		.04	.04	.09		.13	.09	.13		.13	.14	.15
TMS coord			-.06	-.15			-.28	-.33			.10	.07
TMM X TMS coord				.38*				.25				.12
R^2	.19*	.19*	.19*	.31*	.04	.06	.10	.15	.16†	.18†	.18†	.20†
ΔR^2		.00	.00	.12*		.02	.04	.05		.02	.02	.02

Note. N=41 teams, Regression coefficients are standardized betas, coord = coordination.
**$p<0.01$, *$p<0.05$, $^{\dagger}p<0.10$

Table 9. Results of Hierarchical Regression Analyses testing Hypothesis 2b and 3: TMM Average Deviation

	Team viability				Team satisfaction			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	-.03	-.01	-.05	-.04	.26*	.29*	.25†	.25†
Team reward	.31*	.27*	.26*	.25†	.10	.07	.06	.06
Organizational support	.57**	.59**	.39**	.40**	.59**	.61**	.46**	.46**
TMM		.19	.23*	.22†		.17	.20†	.19
TMS coord			.32*	.34*			.25†	.25
TMM X TMS coord				-.07				-.01
R^2	.51**	.55**	.60**	.61**	.50**	.52**	.56**	.56**
ΔR^2		.04	.05*	.01		.02	.04†	.00

Note. N=41 teams, Regression coefficients are standardized betas, coord = coordination.
**p<0.01, *p<0.05, †p<0.10

Table 9. Continued

	Team performance				Team learning				Team creativity			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	.11	.12	.06	.02	.00	.02	-.04	-.09	.12	.14	.08	.03
Team reward	.28	.27	.14	.14	-.01	-.03	-.15	-.16	.25	.23	.09	.09
Organizational support	.19	.19	.15	.21	.21	.22	.19	.25	.18	.19	.16	.21
TMM		.04	.01	.01		.13	.09	.09		.13	.09	.09
TMS cred			$.32^{\dagger}$	.41*			.29	.39*			$.33^{\dagger}$	.41*
TMM X TMS cred				-.39**				-.46**				-.39**
R^2	.19*	.19*	.26*	.40**	.04	.06	.11	.31*	$.16^{\dagger}$	$.18^{\dagger}$	.25*	.39**
ΔR^2		.00	$.07^{\dagger}$	.14**		.02	.05	.20**		.02	$.07^{\dagger}$	.14**

Note. N=41 teams, Regression coefficients are standardized betas, cred = credibility.
**p<0.01, *p<0.05, †p<0.10

Table 10. Results of Hierarchical Regression Analyses testing Hypothesis 2c and 3: TMM Average Deviation

	Team viability				Team satisfaction			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	-.03	-.01	.00	.02	.26*	.29*	.31*	.31*
Team reward	.31*	.27*	.28†	.29†	.10	.07	.13	.13
Organizational support	.57**	.59**	.59**	.57**	.59**	.61**	.63**	.63**
TMM		.19	.19	.19		.17	.18	.18
TMS cred			-.03	-.06			-.14	-.13
TMM X TMS cred				.13				-.04
R^2	.51**	.55**	.55**	.56**	.50**	.52**	.54**	.54**
ΔR^2		.04	.00	.01		.02	.02	.00

Note. N=41 teams, Regression coefficients are standardized betas, cred = credibility.
**p<0.01, *p<0.05, †p<0.10

Table 10. Continued

	Team performance			Team learning			Team creativity		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	.11	.09	.09	.00	-.01	.00	.12	.11	.13
Team reward	.28	.15	.15	-.01	-.08	-.05	.25	.17	.23
Organizational support	.19	.17	.17	.21	.20	.23	.18	.17	.23
TMS spec		$.29^{\dagger}$	.29		.17	.22		.18	.28
TMS spec squared			.00			.18			$.32^{\dagger}$
R^2	.19*	.25*	$.25^{*}$	.04	.06	.09	$.16^{\dagger}$	$.19^{\dagger}$	$.26^{*}$
ΔR^2		$.06^{\dagger}$	.00		.02	.03		.03	$.07^{\dagger}$

Note. N=41 teams, Regression coefficients are standardized betas, spec = specialization.
**p<0.01, *p<0.05, †p<0.10

Table 11. Post-hoc Hierarchical Regression Analyses: TMS specialization and team outcomes

	Team viability			Team satisfaction		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	-.03	-.03	-.03	.26*	.27*	.27†
Team reward	.31*	.33*	.31	.10	.14	.12
Organizational support	.57**	.57**	.56**	.59**	.60**	.58**
TMS spec		-.05	-.07		-.08	-.10
TMS spec squared			-.07			-.08
R^2	.51**	.51**	.52**	.50**	.50**	.51**
ΔR^2		.00	.01		.00	.01

Note. N=41 teams, Regression coefficients are standardized betas, spec = specialization.
**p<0.01, *p<0.05, †p<0.10

Table 11. Continued

	Team performance			Team learning			Team Creativity		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	.11	.12	.11	.00	.05	.04	.12	.11	.10
Team reward	.28	.28	.24	-.01	-.01	-.02	.25	.25	.22
Organizational support	.19	.23	.27	.21	.39†	.41†	.18	.14	.16
TMS coord		-.07	-.10		-.29	-.31		.07	.05
TMS coord squared			.10			.05			.07
R^2	.19*	.19*	.20*	.04	.09	.09	.16†	.17†	.17†
ΔR^2		.00	.01		.05	.00		.01	.00

Note. N=41 teams, Regression coefficients are standardized betas, coord = coordination.
**p<0.01, *p<0.05, †p<0.10

Table 12. Post-hoc Hierarchical Regression Analyses: TMS coordination and team outcomes

	Team viability			Team satisfaction		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	-.03	-.07	-.12	.26*	.23†	.20
Team reward	.31*	.31*	.17	.10	.10	.01
Organizational support	.57**	.39*	.53**	.59**	.46**	.55**
TMS coord		.28†	.18		.22	.15
TMS coord squared			.35**			.23†
R^2	.51**	.56**	.65**	.50**	.52**	.56**
ΔR^2		.05†	.09**		.02	.04†

Note. N=41 teams, Regression coefficients are standardized betas, coord = coordination.
**p<0.01, *p<0.05, †p<0.10

Table 12. Continued

	Team performance			Team learning			Team creativity		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	.11	.06	.10	.00	-.05	-.01	.12	.06	.07
Team reward	.28	.14	.05	-.01	-.14	-.22	.25	.10	.09
Organizational support	.19	.15	.24	.21	.17	.25	.18	.14	.16
TMS cred		.32†	.25		.30	.24		.34†	.33†
TMS cred squared			-.32*			-.28			-.04
R^2	.19*	.26*	.34*	.04	.10	.17	.16†	.24*	.24*
ΔR^2		.07†	.08*		.06	.07		.08†	.00

Note. N=41 teams, Regression coefficients are standardized betas, cred = credibility.
**p<0.01,*p<0.05, †p<0.10

Table 13. Post-hoc Hierarchical Regression Analyses: TMS credibility and team outcomes

	Team viability			Team satisfaction		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	-.03	-.03	-.05	.26*	.28*	.29*
Team reward	.31*	.31*	.34*	.10	.15	.15
Organizational support	.57**	.57**	.53**	.59**	.61**	.61**
TMS cred		.00	.03		-.11	-.11
TMS cred squared			.12			-.01
R^2	.51**	.51**	.52**	.50**	.51**	.51**
ΔR^2		.00	.01		.01	.00

Note. N=41 teams, Regression coefficients are standardized betas, cred = credibility.
**p<0.01, *p<0.05, †p<0.10

Table 13. Continued

	Team performance			Team learning			Team creativity		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Team tenure	.11	.08	.08	.29†	.28	.28	.21	.18	.18
Team size	-.27†	-.24†	-.24†	-.13	-.12	-.12	-.41**	-.37**	-.38**
Country	.37*	.55**	.54**	.26	.31	.32	.23	.43*	.42*
TMM		.31†	.28		.10	.12		.34*	.31†
TMM squared			-.06			.05			.05
R^2	.32**	.38**	.39**	.27*	.28*	.28*	.38**	.46**	.47**
ΔR^2		.06†	.01		.01	.00		.08*	.01

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 14. Results of Hierarchical Regression Analyses testing Hypothesis 1 with team tenure, team size and country of origin as control variables: TMM Alternate scale

	Team viability			Team satisfaction		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Team tenure	-.04	-.10	-.10	.17	.11	.11
Team size	-.12	-.05	-.05	-.07	.00	.00
Country	-.12	.33†	.36†	-.18	.26	.27
TMM		.77**	.81**		.74**	.76**
TMM squared			.10			.04
R^2	.03	.45**	.46**	.03	.43**	.43**
ΔR^2		.42**	.01		.40**	.00

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 14. Continued

	Team performance			Team learning			Team creativity		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	.11	.09	.08	.00	-.03	-.05	.12	.10	.12
Team reward	.28	.35†	.31	-.01	.11	.08	.25	.33†	.38†
Organizational support	.19	.33†	.34†	.21	.46*	.46*	.18	.35†	.34†
TMM		-.26	-.30		-.44*	-.48*		-.30	-.23
TMM squared			-.09			-.08			.16
R^2	.19*	.22*	.23*	.04	.15	.15	.16†	.21†	.23†
ΔR^2		.03	.01		.11	.00		.05	.02

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 15. Results of Hierarchical Regression Analyses testing Hypothesis 1 with task interdependence, team reward and organizational support as controls: TMM Alternate scale

	Team viability			Team satisfaction		
Predictor	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Task interdependence	-.03	.00	.02	.26*	.30*	.31*
Team reward	.31*	.22	.26†	.10	.00	.04
Organizational support	.57**	.37*	.36*	.59**	.37*	.36*
TMM		.36*	.41*		.40*	.44*
TMM squared			.12			.10
R^2	.51**	.58**	.59**	.50**	.58**	.59**
ΔR^2		.07*	.01		.08*	.01

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 15. Continued

	Team performance				Team learning				Team creativity			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	.11*	.09	.03	.03	.00	-.03	-.06	-.06	.12	.10	.04	.02
Team reward	.28	.35	.21	.21	-.01	.11	.05	.06	.25	.33†	.18	.19
Organizational support	.19	.33	.21	.21	.21	.46*	.41†	.41†	.18	.35†	.23	.22
TMM		-.26	-.23	-.20		-.44*	-.43*	-.41†		-.30	-.27	-.19
TMS			.33	.34			.13	.14			.34†	.36†
TMM X TMS				.10				.09				.31*
R^2	.19*	.22*	.28*	.29*	.04	.15	.16	.16	.16†	.21†	.27*	.36*
ΔR^2		.03	.06†	.01		.11*	.01	.00		.05	.06†	.09*

Note. N=41 teams, Regression coefficients are standardized betas.
**p<0.01, *p<0.05, †p<0.10

Table 16. Results of Hierarchical Regression Analyses examining impact of TMS on team outcomes: TMM Alternate Scale

	Team viability				Team satisfaction			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	-.03	.00	-.02	-.03	.26*	.30*	.30*	.29*
Team reward	.31*	.22	.16	.17	.10	.00	.00	.00
Organizational support	.57**	.37*	.32*	.32*	.59**	.37*	.37*	.37*
TMM		.36*	.37*	.40*		.40*	.40*	.43**
TMS			.13	.14			.01	.02
TMM X TMS				.11				.12
R^2	.51**	.58**	.59**	.60**	.50**	.58**	.58**	.59**
ΔR^2		.07*	.01	.01		.08*	.00	.01

Note. N=41 teams, Regression coefficients are standardized betas.
$^{**}p<0.01$, $^{*}p<0.05$, $^{\dagger}p<0.10$

Table 16. Continued

	Team performance				Team learning				Team creativity			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	.11	.09	.07	.06	.00	-.03	-.04	-.06	.12	.10	.09	.06
Team reward	.28	.35†	.22	.16	-.01	.11	.04	-.02	.25	.33†	.25	.12
Organizational support	.19	.33†	.30	.31	.21	.46*	.44*	.44*	.18	.35†	.33†	.34†
TMM		-.26	-.24	-.17		-.44*	-.43*	-.36		-.30	-.29	-.14
TMS spec			.27	.40†			.14	.28			.17	.45*
TMM X TMS spec				.20				.22				.45*
R^2	.19	.22	.28	.30	.04	.15	.16	.19	.16†	.21†	.23†	.35*
ΔR^2		.03	.06	.02		.11*	.02	.03		.05†	.02	.12*

Note. N=41 teams, Regression coefficients are standardized betas, spec = specialization.
**$p<0.01$, *$p<0.05$, $^{\dagger}p<0.10$

Table 17. Results of Hierarchical Regression Analyses testing Hypothesis 2a and 3: TMM Alternate Scale

	Team viability				Team satisfaction			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	-.03	.00	.00	.00	.26*	.30*	.30*	.30*
Team reward	.31*	.22	.23	.21	.10	.00	.03	.00
Organizational support	.57**	.37*	.36*	.37*	.59**	.37*	.38*	.38*
TMM		.36*	.36*	.37*		.40*	.39*	.42*
TMS spec			-.03	.01			-.06	-.01
TMM X TMS spec				.06				.09
R^2	.51**	.58**	.58**	.58**	.50**	.58**	.58**	.59**
ΔR^2		.07*	.00	.00		.08*	.00	.01

Note. N=41 teams, Regression coefficients are standardized betas, spec = specialization.
**p<0.01, *p<0.05, †p<0.10

Table 17. Continued

	Team performance				Team learning				Team creativity			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	.11	.09	.09	.08	.00	-.03	-.01	-.04	.12	.10	.06	.05
Team reward	.28	.35†	.35	.35†	-.01	.11	.09	.08	.25	.33†	.35†	.35†
Organizational support	.19	.33†	.32	.31	.21	.46*	.51*	.46*	.18	.35†	.26	.25
TMM		-.26	-.28	-.30		-.44*	-.38	-.48†		-.30	-.41†	-.43†
TMS coord			.05	.07			.14	-.02			.24	.27
TMM X TMS coord				-.04				-.17				-.04
R^2	.19*	.22*	.22*	.23*	.04	.15	.16	.18	.16†	.21*	.24*	.24*
ΔR^2		.03	.00	.00		.11*	.01	.02		.05†	.03	.00

Note. N=41 teams, Regression coefficients are standardized betas, coord = coordination.
**$p<0.01$, *$p<0.05$, $^{\dagger}p<0.10$

Table 18. Results of Hierarchical Regression Analyses testing Hypothesis 2b and 3: TMM Alternate Scale

	Team viability				Team satisfaction			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	-.03	.00	-.03	.02	.26*	.30*	.28*	.32*
Team reward	.31*	.22	.23†	.25†	.10	.00	.01	.02
Organizational support	.57**	.37*	.31*	.38*	.59**	.37*	.35*	.41*
TMM		.36*	.29†	.44*		.40*	.37*	.48*
TMS coord			.16	-.03			.07	-.08
TMM X TMS coord				.27*				.20
R^2	.51**	.58**	.59**	.64**	.50**	.58**	.58**	.61**
ΔR^2		.07*	.01	.05*		.08*	.00	.03

Note. N=41 teams, Regression coefficients are standardized betas, coord = coordination.
**p<0.01, *p<0.05, †p<0.10

Table 18. Continued

	Team performance				Team learning				Team creativity			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	.11	.09	.05	.04	.00	-.03	-.06	-.07	.12	.10	.06	.02
Team reward	.28	.35†	.20	.23	-.01	.11	.01	.04	.25	.33†	.17	.23
Organizational support	.19	.33†	.24	.23	.21	.46*	.40†	.39†	.18	.35†	.25	.25
TMM		-.26	-.14	-.11		-.44*	-.37	-.34		-.30	-.18	-.12
TMS cred			.27	.26			.17	.16			.28	.26
TMM X TMS cred				.18				.17				.35*
R^2	.19*	.22*	.27*	.29*	.04	.15	.17	.19	.16†	.21†	.26*	.37*
ΔR^2		.03	.05*	.02		.11*	.02	.02		.05†	.05†	.11*

Note. N=41 teams, Regression coefficients are standardized betas, cred = credibility.
**p<0.01, *p<0.05, †p<0.10

Table 19. Results of Hierarchical Regression Analyses testing Hypothesis 2c and 3: TMM Alternate Scale

	Team viability				Team satisfaction			
Predictor	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Task interdependence	-.03	.00	-.02	-.03	.26*	.30*	.29*	.29*
Team reward	.31*	.22	.13	.14	.10	.00	-.02	-.01
Organizational support	.57**	.37*	.31*	.31*	.59**	.37*	.36*	.36*
TMM		.36*	.43*	.43*		.40*	.41*	.42*
TMS cred			.15	.15			.04	.03
TMM X TMS cred				.03				.07
R^2	.51**	.58**	.59**	.59**	.50**	.58**	.58**	.59**
ΔR^2		.07*	.01	.00		.08*	.00	.01

Note. N=41 teams, Regression coefficients are standardized betas, cred = credibility.
**p<0.01, *p<0.05, †p<0.10

Table 19. Continued

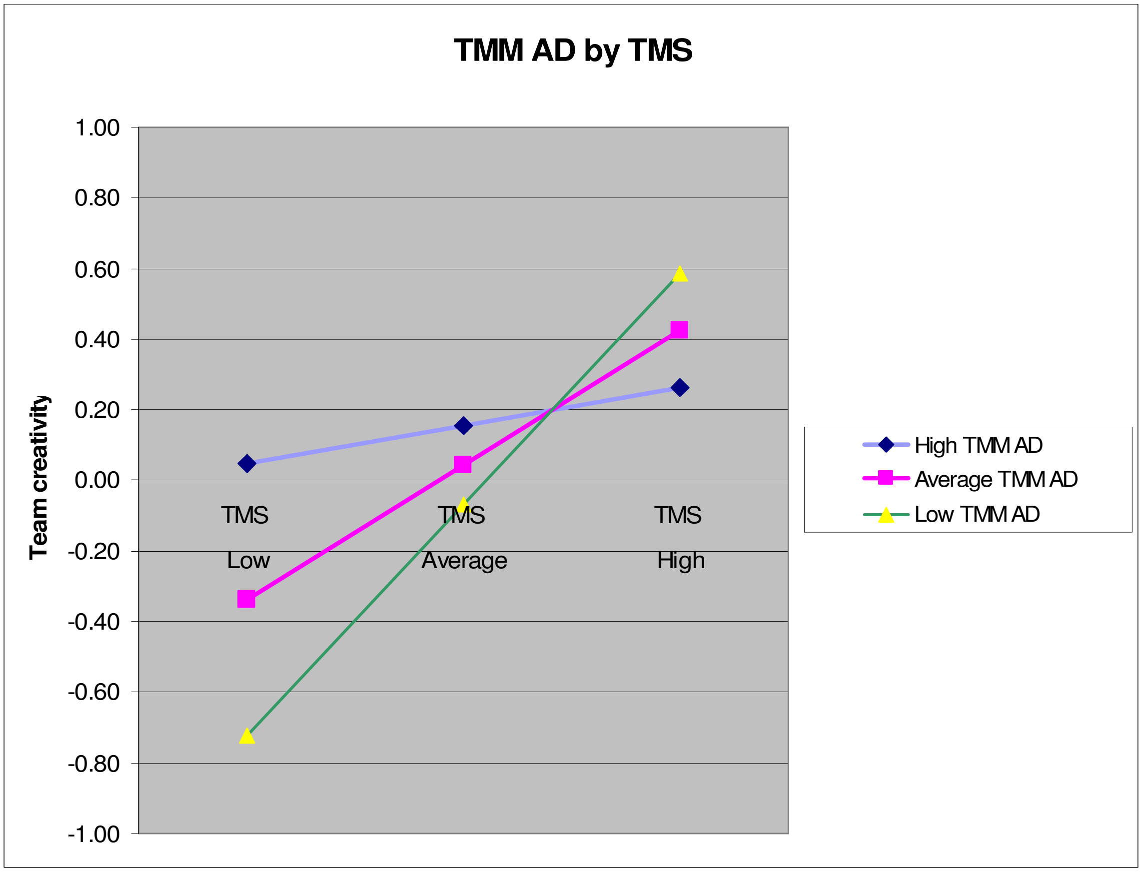

Figure 3. Interaction between TMM and TMS on team creativity

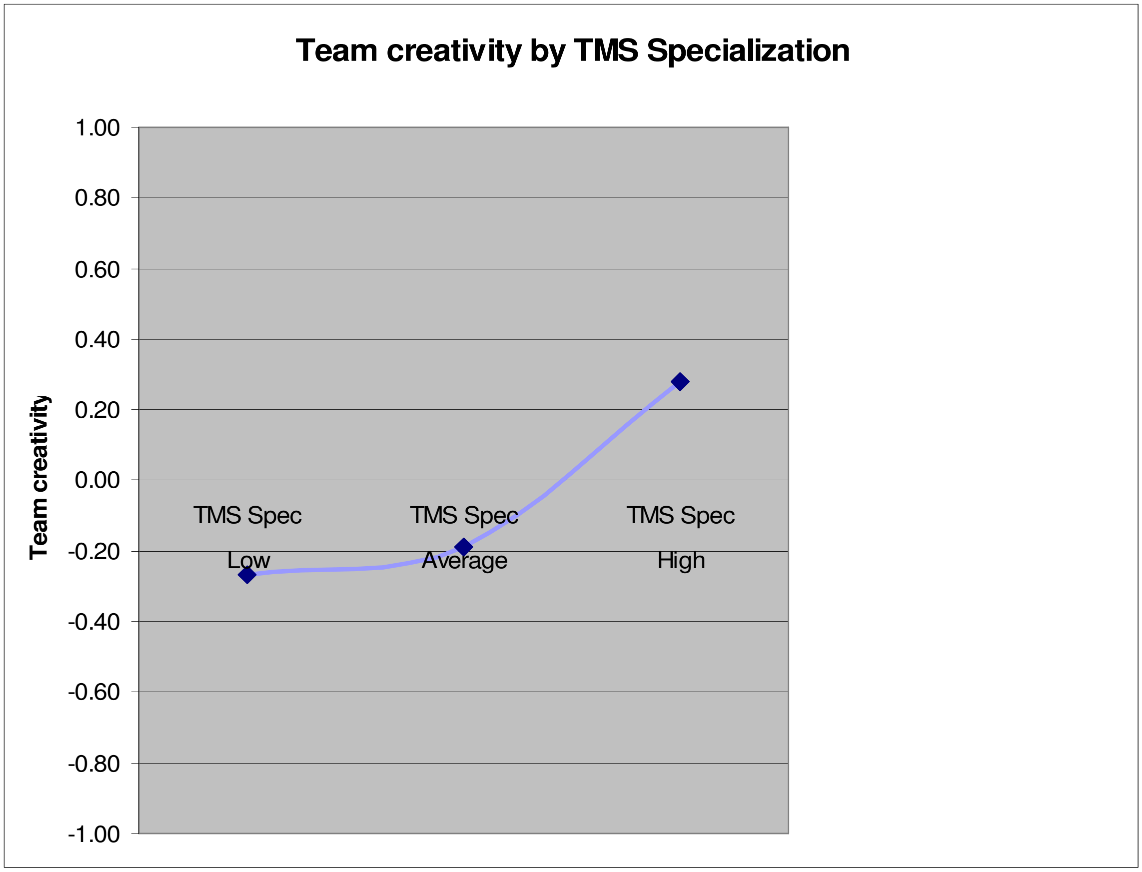

Figure 4. Curvilinear impact of TMS specialization on team creativity

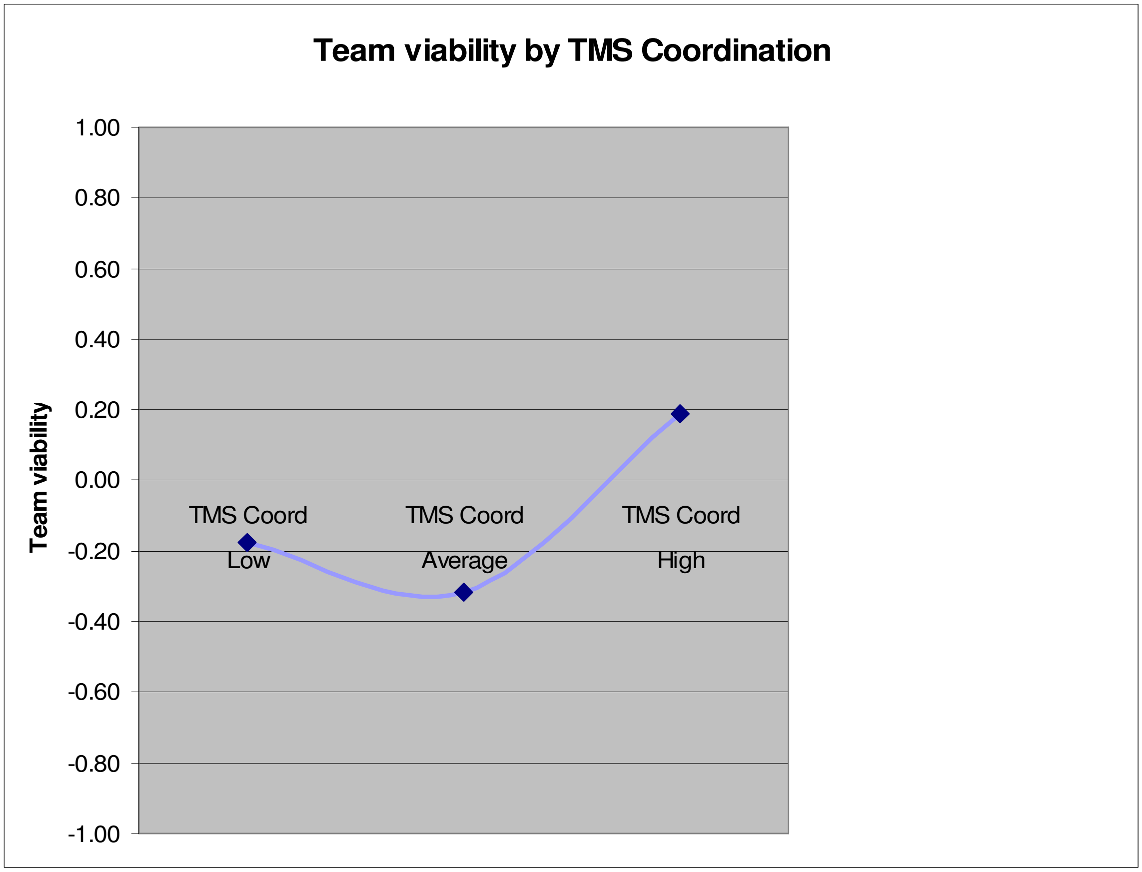

Figure 5. Curvilinear impact of TMS coordination on team viability

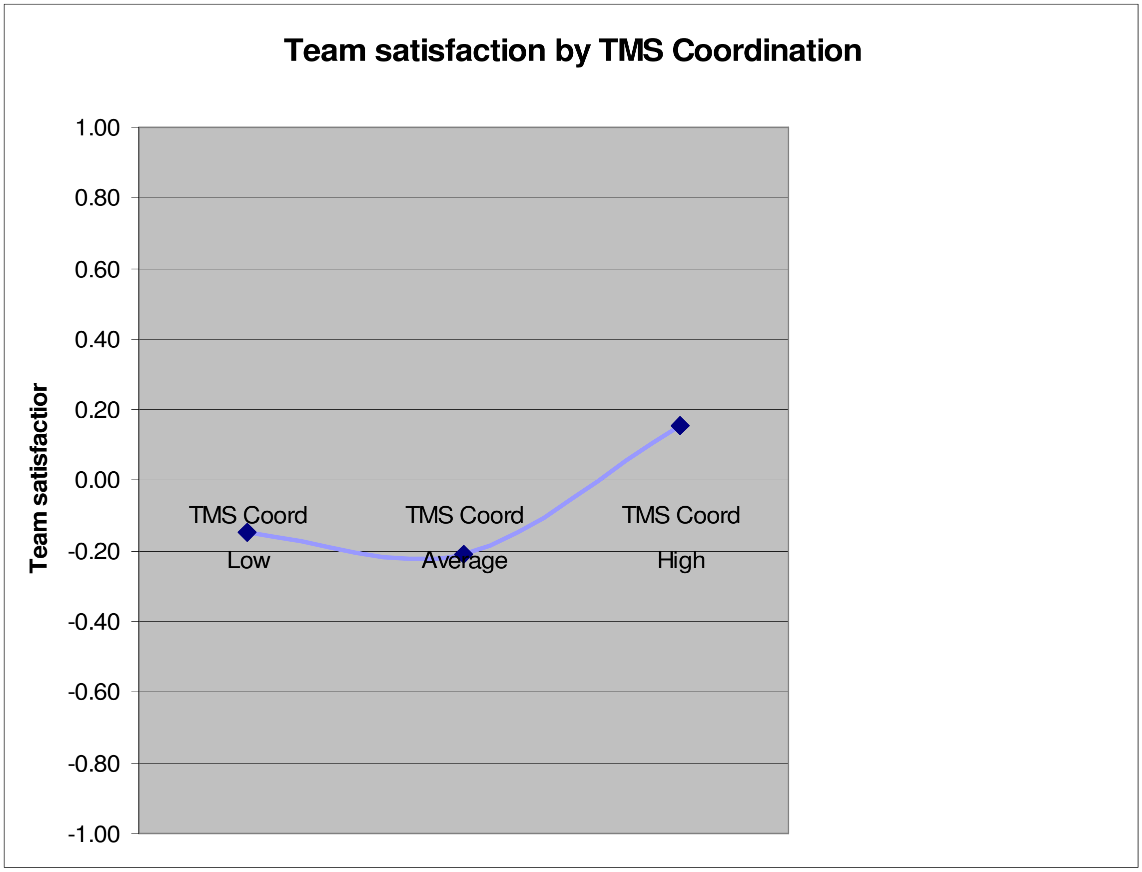

Figure 6. Curvilinear impact of TMS coordination on team satisfaction

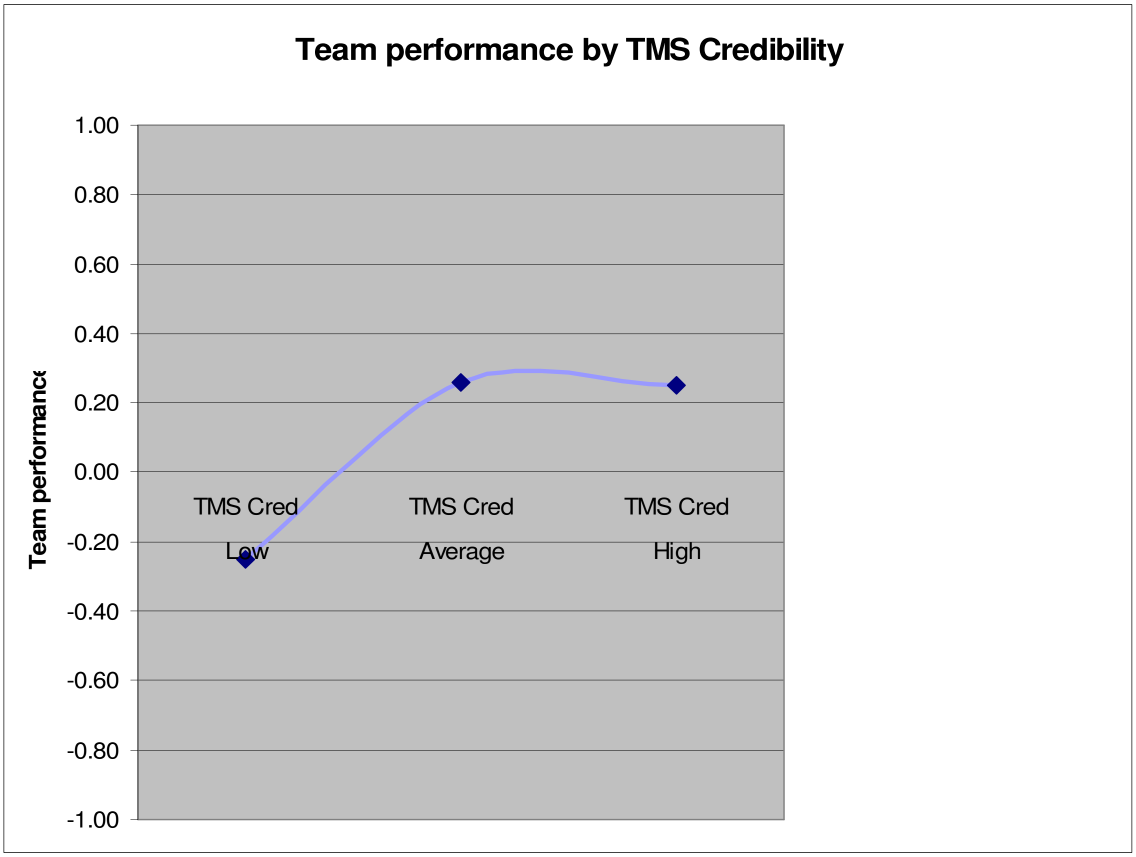

Figure 7. Curvilinear impact of TMS credibility on team performance

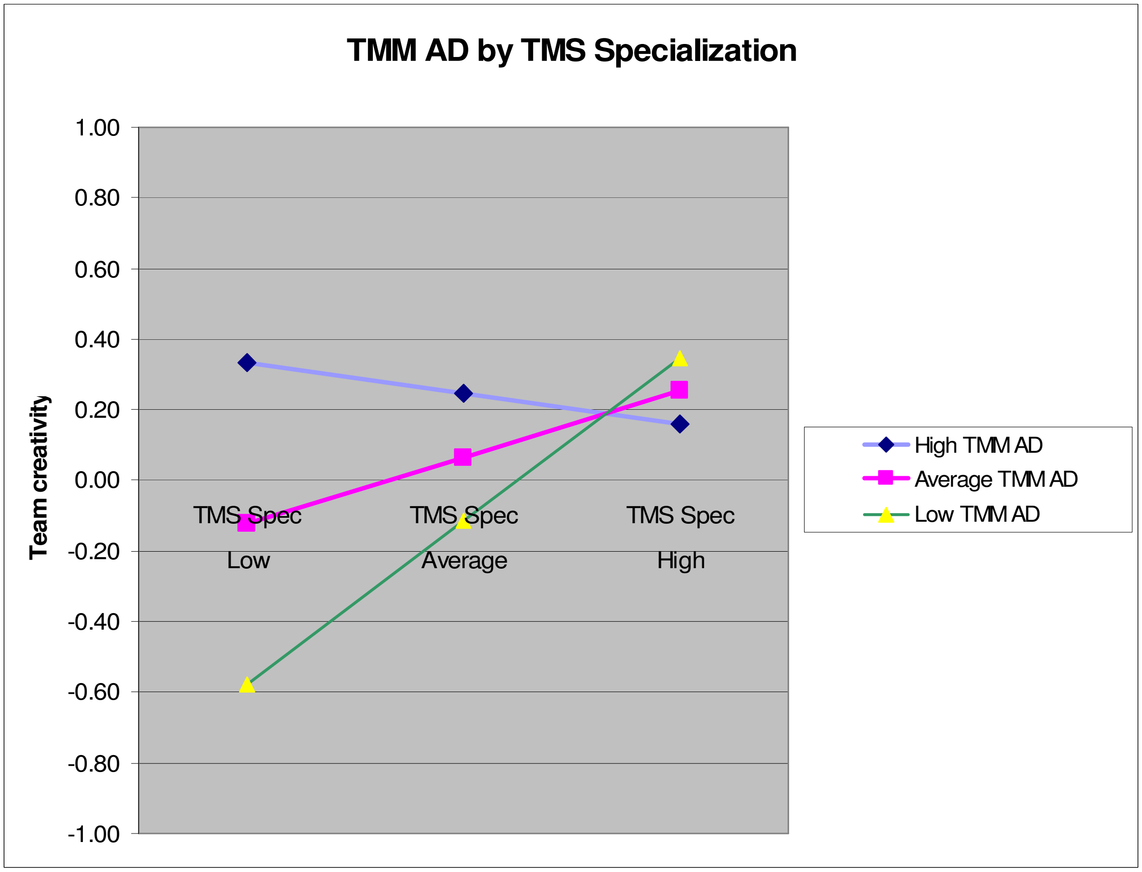

Figure 8. Interaction between TMM and TMS specialization on team creativity

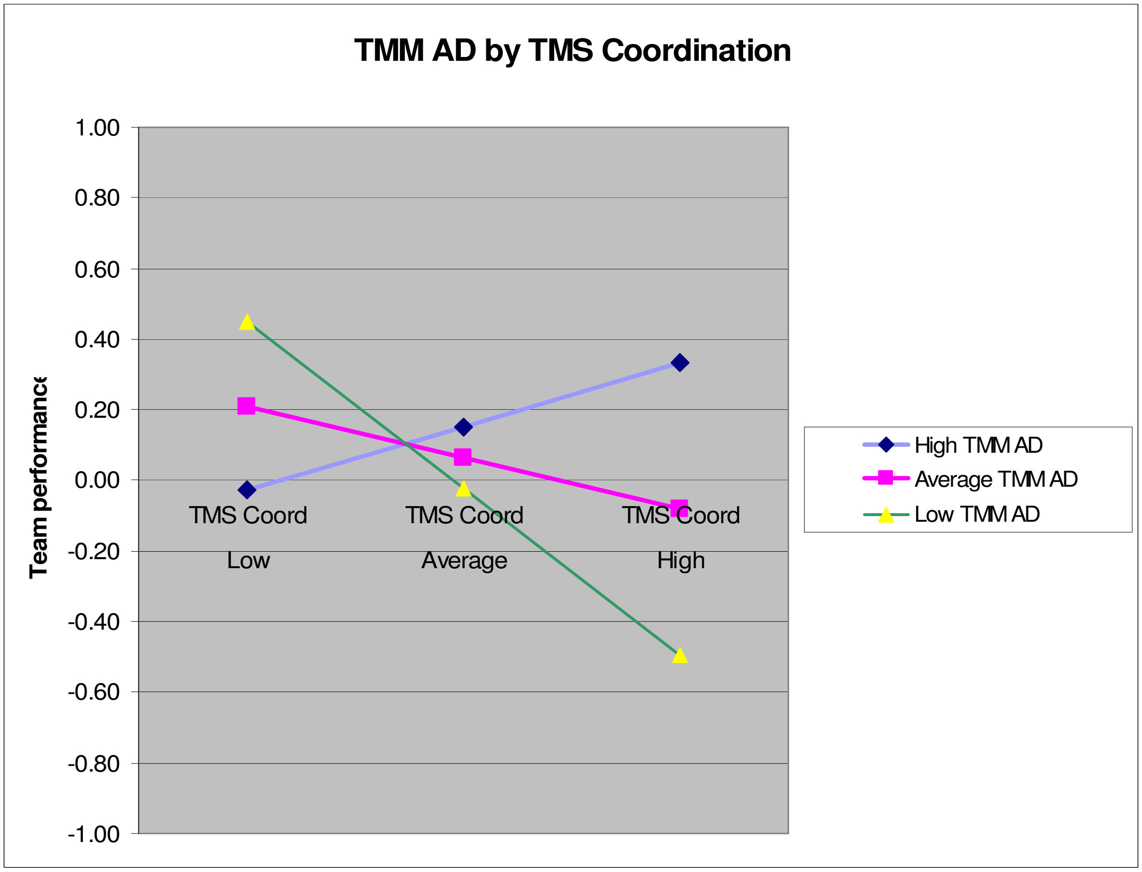

Figure 9. Interaction between TMM and TMS coordination on team performance

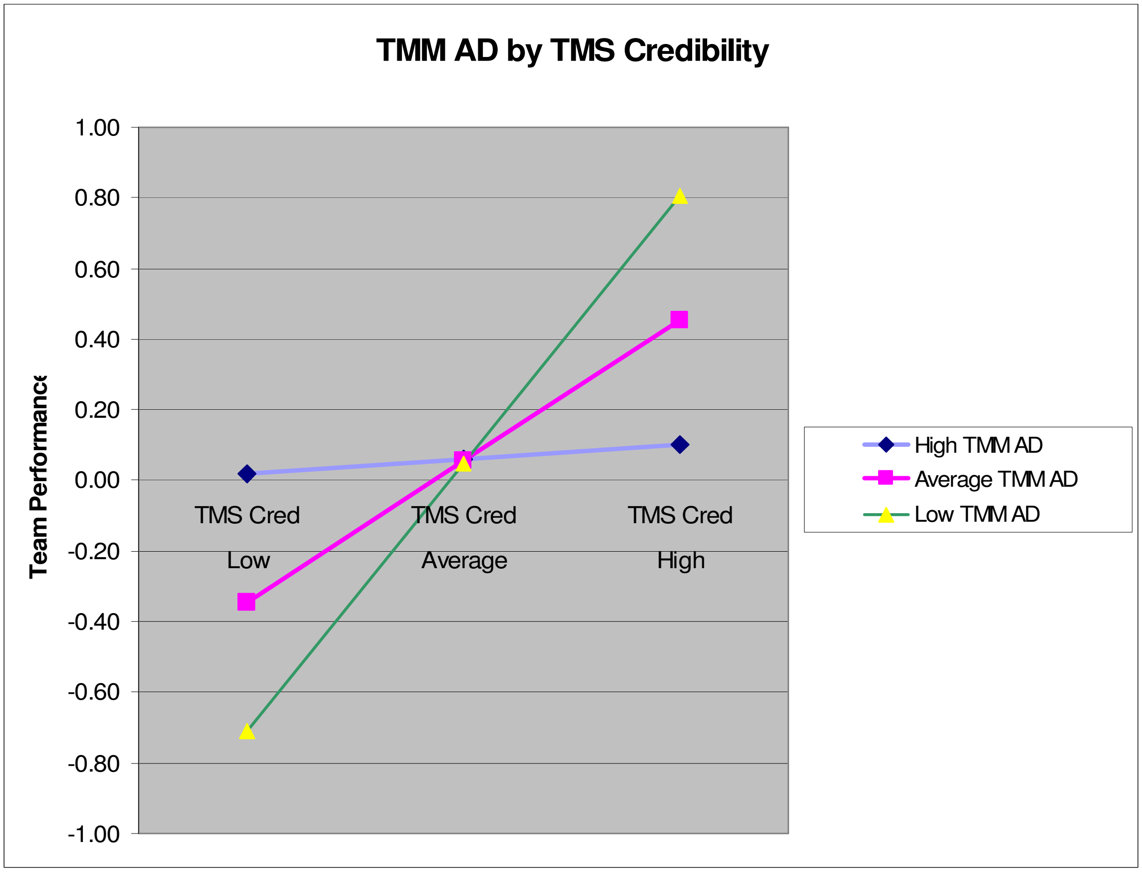

Figure 10. Interaction between TMM and TMS credibility on team performance

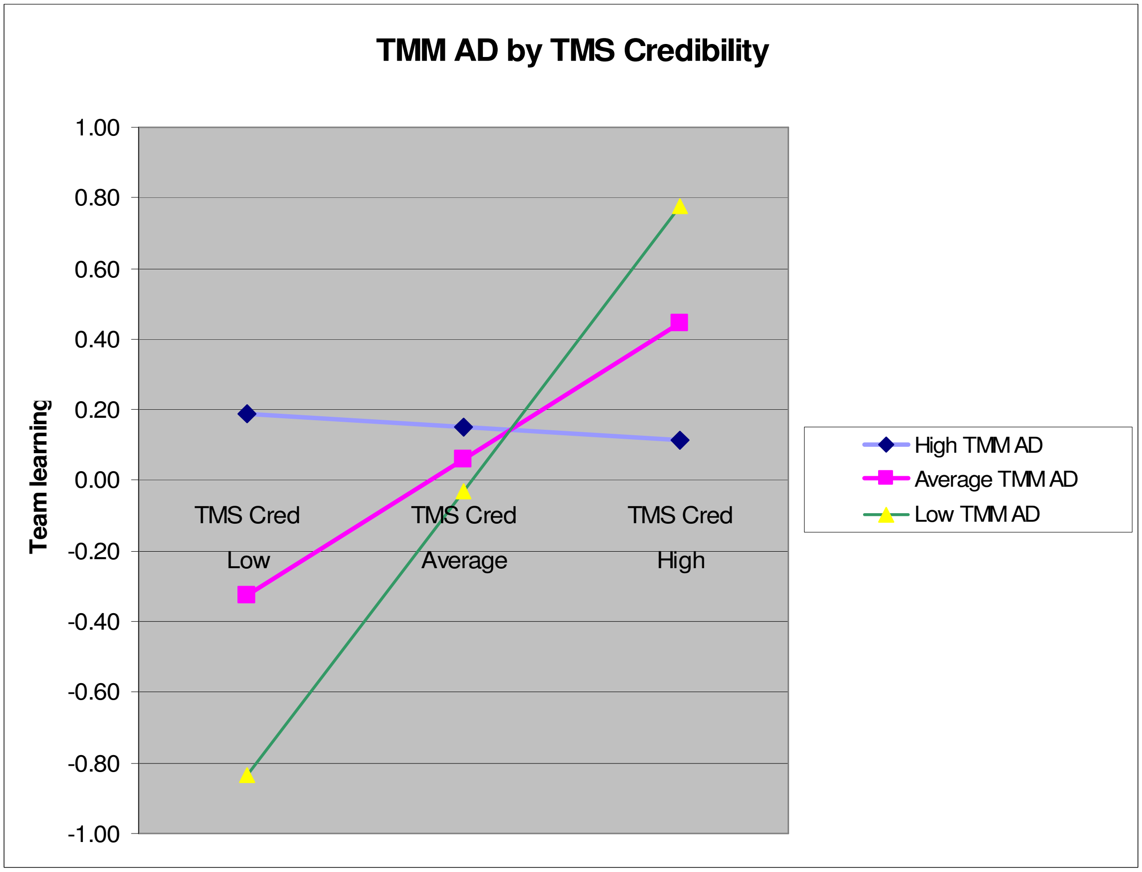

Figure 11. Interaction between TMM and TMS credibility on team learning

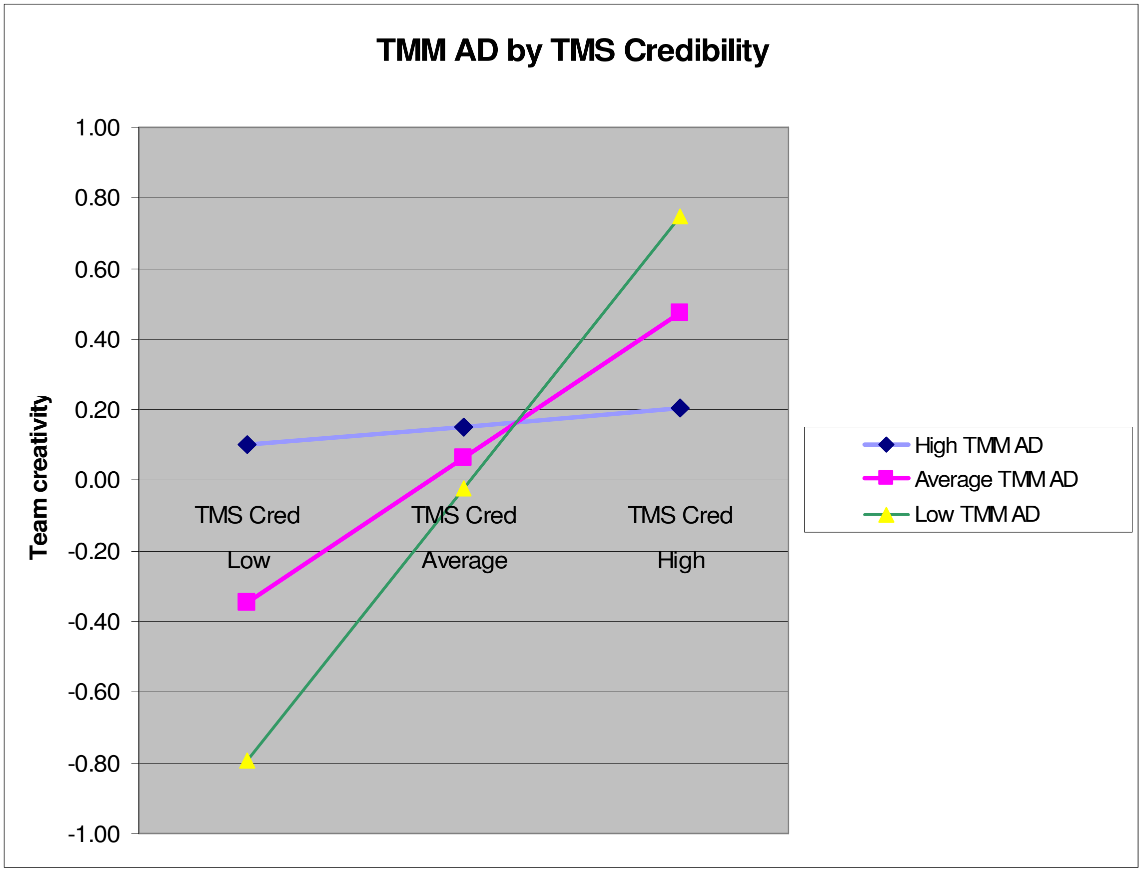

Figure 12. Interaction between TMM and TMS credibility on team creativity

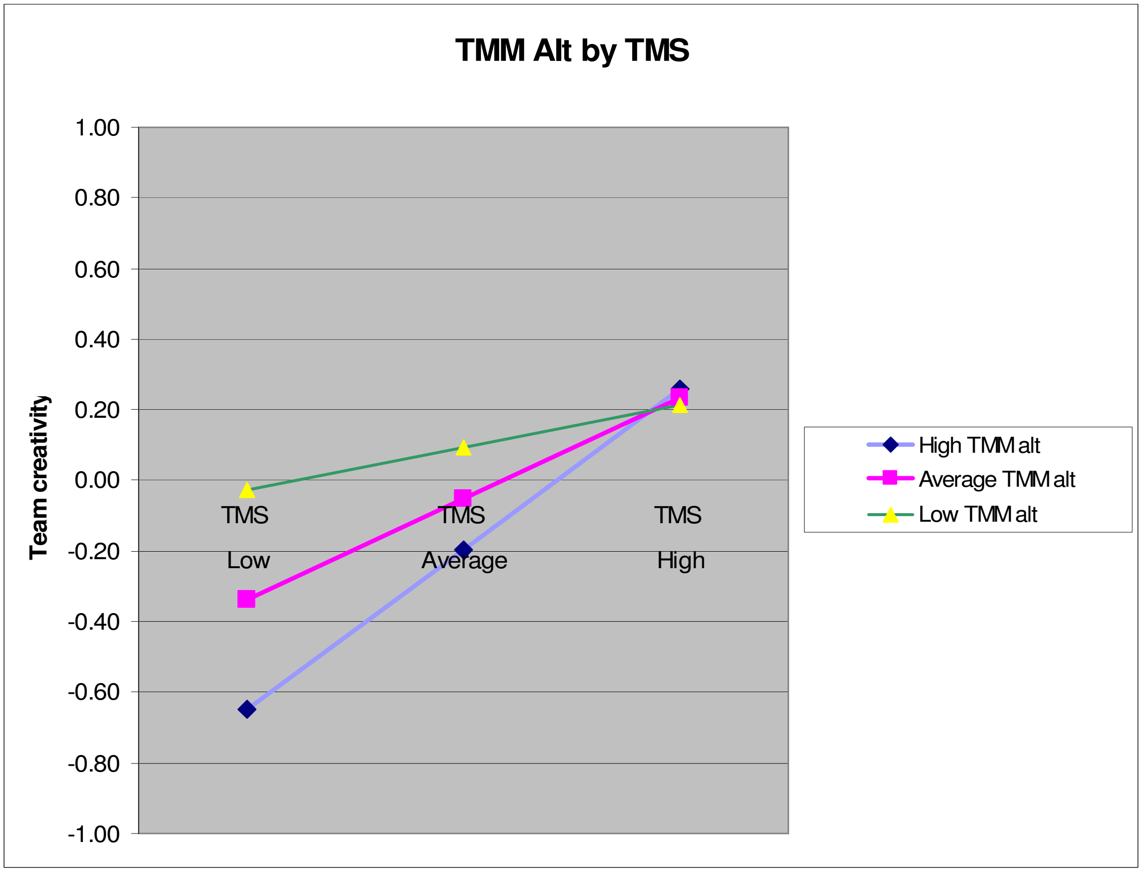

Figure 13. Interaction between TMM and TMS on team creativity

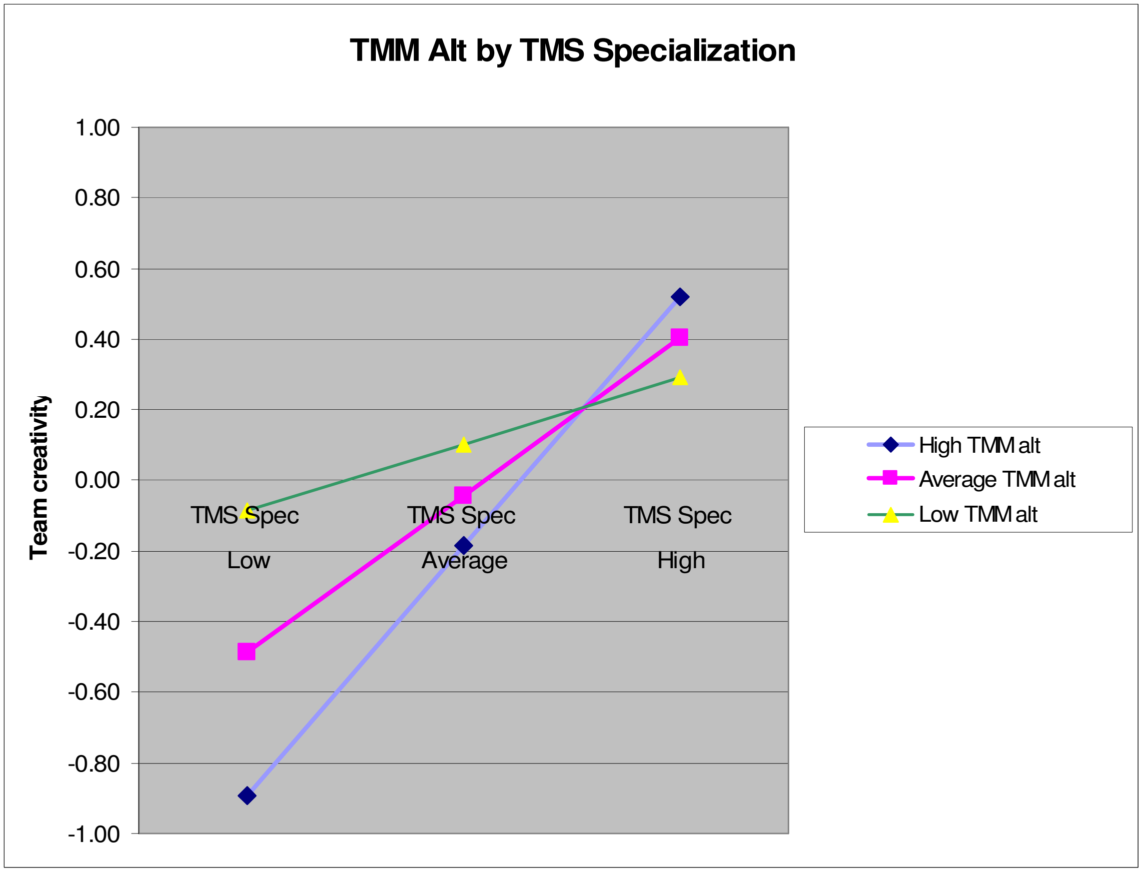

Figure 14. Interaction between TMM and TMS specialization on team creativity

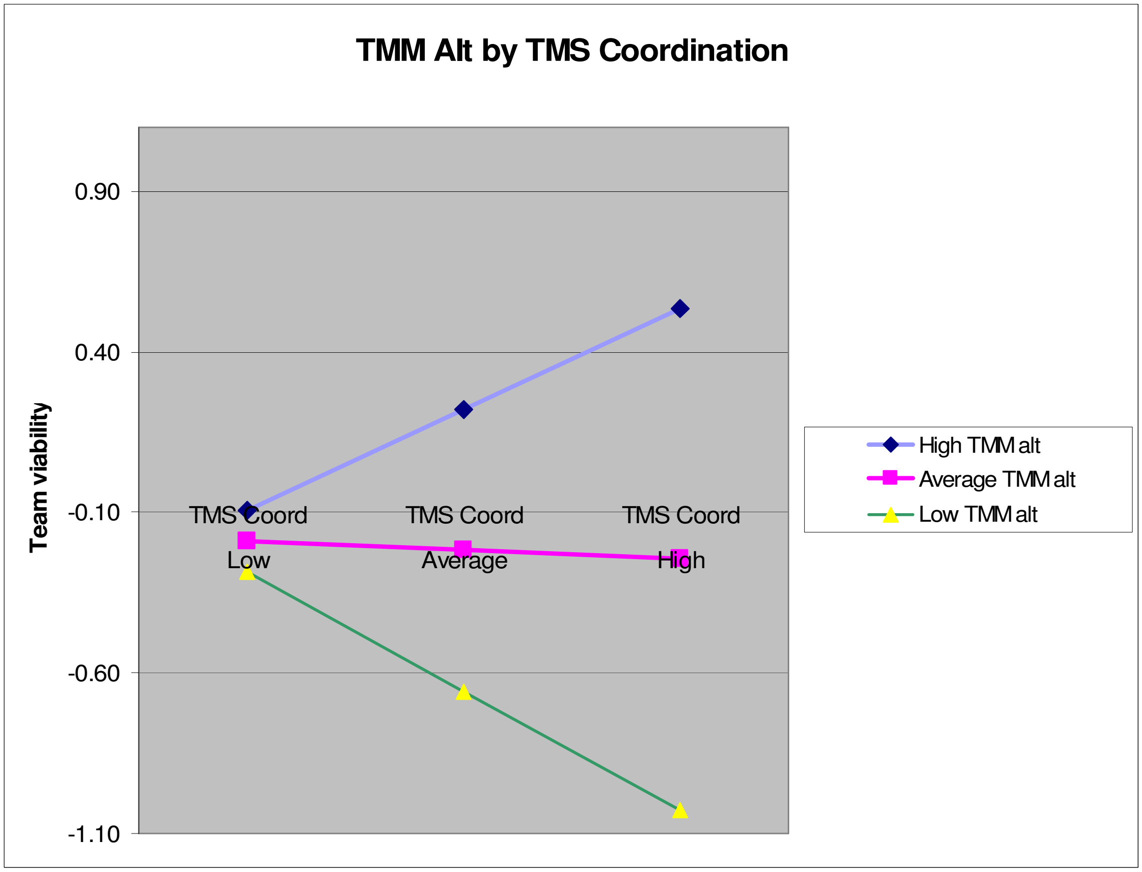

Figure 15. Interaction between TMM and TMS coordination on team viability

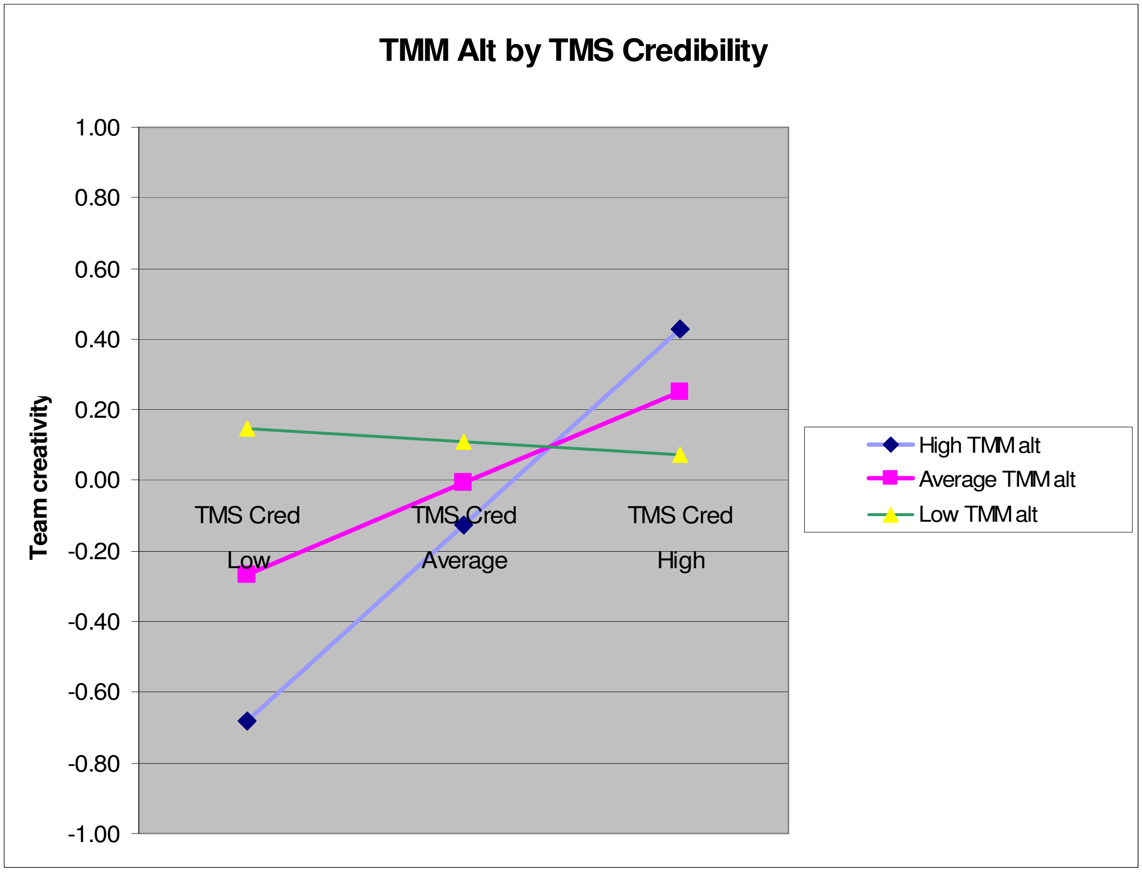

Figure 16. Interaction between TMM and TMS credibility on team creativity

Key findings	TMM (AD)	TMM (6-item scale)
Hypothesized relationships		
TMM has curvilinear relationship with team performance (H1).	Not supported	Not supported
TMS specialization is positively related to team performance (H2a).	Not supported	Not supported
TMS coordination is positively related to team performance (H2b).	Not supported	Not supported
TMS credibility is positively related to team performance (H2c).	Partially supported	Partially supported
TMM moderates relationship between TMS and team performance (H3).	Not supported	Not supported
Post-hoc Analysis		
TMS specialization exhibits curvilinear relationship with team creativity.	Figure 3[a]	
TMS coordination exhibits curvilinear relationship with team viability.	Figure 4[a]	
TMS coordination exhibits curvilinear relationship with team satisfaction.	Figure 5[a]	
TMS credibility exhibits curvilinear relationship with team performance.	Figure 6[a]	
TMM moderates TMS and team creativity	Supported (Figure 4)	Supported (Figure 13)
TMM moderates TMS specialization and team creativity	Supported (Figure 8)	Supported (Figure 14)
TMM moderates TMS coordination and team performance	Supported (Figure 9)	Not supported
TMM moderates TMS credibility and team performance	Supported (Figure 10)	Not supported
TMM moderates TMS credibility and team learning	Supported (Figure 11)	Not supported
TMM moderates TMS coordination and team viability	Not supported	Supported (Figure 15)
TMM moderates TMS credibility and team creativity	Supported (Figure 12)	Supported (Figure 16)

Note. [a] Relationships are independent of method of TMM operationalization.

Table 20. Summary of key findings.

CHAPTER 5: DISCUSSION

The purpose of the present study was to examine the contribution of two constructs – TMM and TMS, in predicting important team effectiveness dimensions (team performance, team learning, team creativity, team viability and team satisfaction) in field settings. Building on previous research, I was interested in examining the relationship between transactive memory systems (TMS) and team mental models (TMM). In addition, I explored the impact of TMS components (specialization, coordination and credibility) on team effectiveness dimensions. Further, I explored whether two different methods of operationalizing TMM (i.e. average deviation method vs. likert scale) would yield different results.

Key findings can be summarized under three broad headings: 1) TMM, 2) TMS and 3) Interaction between TMM and TMS. First, the relationship between TMM and team performance in a field setting appears to be more complex than a simple linear relationship observed in previous studies undertaken in laboratory settings. In addition, TMM failed to predict team learning or team creativity. Even the hypothesized curvilinear effects between TMM and team performance received no support. However, TMM had an impact on team viability and team satisfaction. In addition, the two very different and unrelated methods to compute TMM agreement (average deviation and the 6-item scale) led to similar patterns of relationships, suggesting both methods were capturing something similar even though they are virtually uncorrelated. Given that the average deviation indices performed as well as the alternative 6-item scale, this study provided initial support for using the average deviation technique as a conceptually and methodologically valid tool to measure TMM in a field setting. Hopefully, this may spur more studies on TMM using “real-life” organizational teams.

Second, TMS deserves to be treated as a multidimensional construct since the narrow specific dimensions are more helpful and predictive of team outcomes than the omnibus TMS construct. In particular, TMS specialization and TMS credibility were stronger indicators of the higher order TMS construct than TMS coordination. This is consistent with the findings that TMS specialization and TMS credibility are correlated, but neither correlates with TMS coordination, indicating that TMS coordination behaves differently than other components. Moreover, the hypothesized linear effect between the TMS components (specialization and coordination) and team performance was not supported. In particular, TMS credibility seemed to drive team performance and team creativity while TMS coordination was predictive of team viability and satisfaction. The results of post-hoc analyses suggested the presence of a non-linear relationship between the TMS components (specialization, coordination and credibility) and team effectiveness dimensions (e.g. team performance and creativity).

Third, no moderation effect of TMM was observed for the relationship between TMS and team performance. However, TMM was found to moderate the relationship between TMS and team creativity. Again, the interaction patterns of TMM on team effectiveness outcomes were stronger when specific TMS components were examined. Interestingly, the pattern of interaction between various TMS components and team effectiveness outcomes was strikingly similar. In general, the interaction pattern suggested a compensatory relationship between TMM and TMS components. Whenever a team experienced a low TMM, a high level of TMS component (say credibility) helped overcome the detrimental effects of low TMM to achieve high team performance. In contrast, a high level of TMM helped offset the downside of a low TMS component (e.g.

credibility) on team performance. Contrary to expectations, a high level of TMM and TMS component did not result in the most optimal team performance (or creativity).

Further, the results were mostly consistent across both methods of operationalizing TMM (average deviation vs. likert scale), although there were some minor differences. Specifically, TMM moderated the relationship between TMS credibility and team performance under the average deviation method but not under the Likert method. A similar result was observed with team learning under the average deviation index but not under the alternative method. Further details of the differences were discussed in the results section. Next, I discuss the theoretical and managerial implications of these results.

Theoretical Implications

Team learning

In a recently published article in The Academy of Management Annals, Edmondson, Dillon and Roloff (2008) commented that “team learning…is an useful rubric, an umbrella term encompassing a variety of loosely related theories and studies” (p.302). Consistent with information processing theory, the authors further suggest that terms such as *Shared Mental Models* and *Transactive Memory Systems* are conceptually similar since they are all team level cognitive systems that encode, store, retrieve and communicate knowledge, and are used to predict task performance. Yet surprisingly, there are few studies that investigate all of these similar sounding constructs. The present study is an early attempt to help bridge the research carried out in experimental settings (transactive memory systems, shared mental models) with those in field research (subsumed under group learning or team learning). This work addresses a key issue raised by many scholars who state the necessity to integrate existing findings (Argote, Gruenfeld, & Naquin, 2001; Mohammed & Dumville, 2001).

Extending on Ellis et al. (2006), I proposed that SMM and TMS are two mechanisms of team learning, and I examined the relationship between these two constructs. I attempted to conceptually clarify the construct of SMM as having an integrative function and the construct of TMS as having a differentiating function. In addition, I integrated the literature on information sampling (Stasser, Taylor, & Hanna, 1989; Stasser, Vaughan, & Stewart, 2000), information processing (Hinsz, Tindale, & Vollrath, 1997) and organizational team research (Argote, Gruenfeld, & Naquin, 2001) to extend the relationship between SMM and TMS. Table 21 reflects the conceptual overlap.

Perspective	TMM	TMS
Present study	Integrative	Differentiation
Group learning	Interpersonal focus	Task focus
Information sampling	Shared information	Unshared information
Information processing	Sharing	Storage and Retrieval

Table 21. Conceptual overlap across different literatures on team learning.

As seen in Table 21, the current study clarifies how TMM and TMS are conceptually similar to constructs discussed in various literatures related to team learning. First, the group learning literature stresses the importance to acquire, share, refine, or combine task-relevant knowledge through interaction with one another (Argote, Gruenfeld, & Naquin, 2001). It is clear that such a definition has two important components – a) interpersonal interaction and b) task-relevant knowledge. A TMM is a measure of interpersonal awareness and adequately captures the sharing of information across team members while TMS with its differentiation focus captures how task-relevant knowledge is distributed.

Second, small group researchers working mostly in experimental settings have developed an amazing literature on how groups work. This literature has been commonly referred to as the information sampling framework. A common result of their study is that groups work best when they combine all the relevant information, shared and unique, dispersed and available, to their members (Stasser, Vaughan, & Stewart, 2000; D. D. Stewart & Stasser, 1995). It has been suggested that groups are able to solve the most complex problems when they are able to incorporate unique information from out-group members or strangers (Gruenfeld, Mannix, Williams, & Neale, 1996; Thomas-Hunt, Ogden, & Neale, 2003). This is consistent with the present theoretical conceptualization that we need a match between TMM, focusing on common knowledge and interaction, and TMS, focusing on unique knowledge dispersed within the group.

Third, the information sharing framework suggests that groups act as information processors when they efficiently share, store and retrieve information (Hinsz, Tindale, & Vollrath, 1997). Recently, Wilson et al. (2007) also characterized group learning as a three step process of sharing, storage and retrieval. I propose that TMM focuses on the sharing process while TMS captures the storage and retrieval part. Hence, the present conceptualization of the TMM and TMS constructs is consistent with those enumerated by the information-processing framework.

A major limitation of the previous work has been the lack of clarity about whether scholars are studying team learning as an outcome or as a process (Wilson, Goodman, & Cronin, 2007). I propose that team learning *processes* are explained by the constructs of SMM and TMS, while learning *outcomes* are better explained by team learning behaviors as observed by team managers. This is consistent with the argument that research focused on task mastery jobs (e.g. SMM and TMS) in experimental settings has been focusing on team learning *processes* while scholars investigating group processes have focused on team learning *outcomes* (Edmondson, Dillon, & Roloff, 2008).

A major contribution of this study is to integrate the research on team learning from multiple perspectives by making an explicit assumption that TMM and TMS are two emergent *learning processes* and are different from the construct of team learning as an *outcome*. I tested this assumption by explicitly measuring TMM, TMS and team learning. Another related contribution of this study is to extend the idea that TMM captures the integrative function while TMS focuses on the differentiation aspects within a team.

Finally, I delineated the team learning construct from team performance as Wilson et al. (2007) argue in the following statements that team learning is not equivalent to team performance as implicitly assumed (p.1043).

> We argue that learning may have occurred, even when there was no change in a group's overall performance. For example, the

> group may have learned something but may not have had an opportunity to apply the learning in a way that would change its performance. Conversely, performance can change without any learning actually taking place…... Finally, learning does not always result in positive outcomes. Research on group learning needs to account for the possibility of dysfunctional learning, as in the case of superstitious learning, where a group learns a false connection between its actions and some outcomes.

In the present study, team learning and team performance were highly correlated suggesting that learning was integral to better team performance. Yet, the results clearly suggest that team learning is quite distinct from team performance. It is important to understand that the predictors of team performance may not predict team learning. In addition, team learning and team creativity were quite distinct. Moreover, the present study highlights that the importance of explicitly considering the dependent variables of interest. The results suggest that team performance was contingent on TMS credibility but not on either TMS specialization or TMS coordination. In other words, the belief or trust in the accuracy of the teammates matters most for high team performance. Further, the actual distribution of knowledge amongst teammates, and the ability to work together, does not predict team performance. Similarly, team creativity was dependent on TMS credibility and TMS specialization, but not on TMS coordination. Thus, team creativity does not depend on team members' ability to work together.

Further, team coordination predicted team viability and team satisfaction. My study provides empirical support to the notion that team learning and team performance are not interchangeable, and are two distinct constructs with unique predictors. Hence, the idea that engagement in team learning will always lead to better team performance or vice-versa is not a tenable argument.

Context

As anticipated, contextual variables like team size, team tenure and country of origin were strong predictors of team effectiveness measures. It was interesting to observe that team tenure was related to increased team learning suggesting that team members may need to work together for a substantial time before they start engaging in team learning. This may be because team members need to know each others' preferences and skills/ beliefs before coming together to find common ground on how to change their established behaviors.

This is consistent with the findings of Gladstein (1984) that team performance in organizational settings is strongly dependent on organizational features. It is possible that there is an optimum team size beyond which team performance and team creativity suffer due to problems in managing coordination within the team.

In my study, teams from the US displayed higher team performance, engaged in more learning behaviors and team creativity compared to teams from India. It should be mentioned that almost all teams from India were from the IT industry, while the teams from the US were more diverse representing multiple industries. It is likely that teams from the IT industry behave differently compared to those in other industries. Hence, it is hard to pinpoint whether the observed differences were due to national or industry characteristics. The results underscore the importance of considering contextual factors like geography and organizational characteristics as boundary conditions for the applicability of theoretical models in team effectiveness (Johns, 2006).

Contextual variables like organizational support and team reward helped increase team viability. It appears that goals associated with team rewards help accentuate team members’ social identity with self and others into in-group and out-group. Self-categorization theory predicts that a superordinate goal applicable to everyone in the team (e.g. team rewards) will make the team work together for achieving the goal, resulting in relatively stable group structure and increased team viability (Hogg & Terry, 2000). Organizational support also helped increase team members’ satisfaction with each other.

These results reiterate the importance of considering contextual variables in order to predict team level outcomes. Laboratory experiments generally fail to capture the intricacies of teams in professional settings. In my sample comprising of teams from diverse backgrounds, contextual variables (e.g. team size, team tenure, country of origin, organizational support) were strong predictors of team effectiveness dimensions. Ignoring these important variables that are vital in any field study of “real-life” organizational teams will provide an incomplete picture of the actual team processes.

TMM

In particular, this study using the Average Deviation Index of TMM failed to support the notion that Mental Models had a linear effect on team performance, a result inconsistent with those obtained by Mathieu and colleagues (Mathieu, Goodwin, Heffner, Salas, & Cannon-Bowers, 2000; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005). However, the present research examined organizational work teams whereas Mathieu and colleagues have looked at mainly student samples. Also, the contextual variables provided a stronger effect on team performance and could be a reason why Team Mental Model (TMM) failed to predict team performance. However, the results are consistent with a rare field study conducted on TMM in a field setting which failed to observe linear relationships between TMM and team performance (Smith-Jentsch, Mathieu, & Kraiger, 2005).

Operationalizing TMM

The operationalization of TMM as a 6-item scale was supportive of the linear relationships between TMM and team performance. Since the proposed model was not validated by one of the two operationalizations of TMM, there is a need for further tests to investigate the inconsistent results obtained in this study in more field settings. It is clear that choosing the method to measure TMM has an impact on the results and implications for researchers working in this area.

The results from exploring average deviation indices (Burke & Dunlap, 2002) and using a six-item alternative likert scale (Appendix B) as indices of TMM were similar in one respect yet different in many ways. The results yielded similar results in relation to the three hypothesized relationships; yet, the post-hoc results yielded two different patterns and a slightly different explanation suggesting that computing agreement by rank ordering of the team processes by team members leads to an effective measure of TMM. The average deviation captures the agreement level in a team and hence seems to be an effective measurement method.

TMS and team effectiveness

TMS was more helpful than TMM in predicting team performance. Interestingly, the main component of TMS driving this relationship appears to be TMS credibility. In addition, TMS credibility also predicted team creativity. The results suggest that teams are more creative and better performers when members trust each other's expertise. This raises the suggestion that it is vital to develop recognition and credibility around the expertise available within teams.

The exploration of the curvilinear relationships between TMS components and the various team effectiveness dimensions led to some interesting results. It was important to highlight that different TMS components behaved differently with the dependent variables of interest. Specifically, TMS credibility exhibited an increasing hyperbolic relationship with team performance, TMS specialization exhibited a U-shaped relationship with creativity and TMS coordination exhibited the same with team viability and satisfaction. In general, team performance was best under the highest levels of TMS credibility, suggesting that it is important for team members to identify and trust the expertise available within teams. A high TMS credibility implies implicit trust about the accuracy of other members' knowledge. In contrast, a low TMS credibility suggests that members do not trust each other's expertise, and this may lead each member to waste time and effort by cross-checking the information received. In terms of information-processing theory, it is possible that when teammates have strong belief in each other, they will spend less time searching for information. This may lead to efficient retrieval of information, which should result in better team performance. When team members trust each other they are more likely to try out new ideas suggested by their members leading to higher team creativity.

Similarly, results suggest that teams high on TMS specialization engage in more creative behavior. This is likely because teams high on specialization will be comprised of individuals with a high level of knowledge differentiation. A team with different viewpoints is more likely to engage in new ways to do things and be creative. Another set of results that TMS coordination predicts team viability and team satisfaction has a simple explanation. TMS coordination refers to team members' ability to work together efficiently. Thus, teams are more likely to continue working together in the future and engage in behaviors essential to maintaining itself for future tasks or be viable. In addition, team members are more likely to be satisfied with each other when they can work together efficiently.

TMS and TMM interaction

When I examined the interactions between TMM and TMS, the two different operationalizations of TMM led to different results. The one clear pattern from examining the results was that measuring TMM in terms of average deviation led to superior results in terms of the observed interactions amongst TMM and TMS. This suggests that it is important to measure agreement amongst team members about their teammates and team processes. I'll first discuss the results obtained when TMM was operationalized as an average deviation index.

Contrary to expectations, TMM and TMS did not have an additive effect on team performance and team learning but more of a compensatory effect. High TMM made up for low TMS. As expected, TMM moderated the relationship between TMS and team creativity but in an unexpected way. As expected, teams had the lowest creativity when both TMS and TMM were lowest. Surprisingly, results revealed that team creativity was highest under conditions of low TMM and high TMS. The results suggest lack of TMM frees team members from a rigid mindset of doing things, unleashing more options and fostering the climate for innovation and creativity. In addition, my results suggest a consistent pattern of moderation between TMS credibility and TMM on team performance, team learning and team creativity. A similar pattern of results was also observed between TMS specialization and team creativity.

One reason why we observe the compensatory effect of TMM and TMS in predicting team performance and team learning could be that a high degree of TMM coupled with high trust levels regarding expertise in a team (TMS credibility) builds a sense of complacency within the team. It is also possible that in such situations, project teams are expected to bring their different expertise and viewpoints towards completion of organizational tasks. However, teammates look toward their "experts" and fail to engage in an open ended constructive dialogue critical for effective team performance (Tjosvold, 1985). This may result in the building of unusually high trust within teams, which may lead to stifled creativity as a potential downside (Wicks, Berman, & Jones, 1999). Thus, high TMM and TMS credibility lead to a situation where teams engage in less idea-generation, a negative consequence of both high TMM and high TMS credibility. This may be partially responsible for the absence of team learning behaviors because the team has a mental model that suggests a dysfunctional level of agreement.

The results were slightly different when measured with a 6-item scale to measure TMM. TMM moderated the relationship between TMS specialization and team creativity as observed before, but the pattern of interaction was slightly different (Figure 14) than that observed when TMM was measured as an average deviation index (Figure 8). Teams displayed the highest creativity levels when they demonstrated both high TMS specialization and high levels of TMM. Conversely, teams exhibited the lowest creativity under conditions of high TMM and low TMS specialization. It appears that high levels of TMM are unhelpful and lead team members to behave in an established way of doing things. This condition of high TMM seems especially problematic when there is low TMS specialization, or a lack of specialists. A team with a high level of shared knowledge, low TMS specialization, is hardly going to be creative when they all share a high TMM. On the contrary, TMM is most helpful when team members focus on their own task and engage in sharing the unique knowledge dispersed among team members.

The pattern of interaction observed between TMS credibility and TMM on team creativity is similar. Under conditions of low TMS credibility when team members have very little trust in each other, a high level of TMM was particularly disruptive. Naturally, team creativity was lowest when teammates trusted each other the least and were under a situation of high TMM. Teams did best when they had high TMM and a strong belief in each other, as evident by high TMS credibility.

As expected, team viability was highest under conditions of high TMM and high TMM coordination. Stated another way, when teammates have an ability to work together efficiently, as captured by the notion of high TMS coordination and high knowledge about teammate's characteristics and their interpersonal interaction patterns, captured by high TMM, they express interest in continuing to work together. In contrast when TMM is low, teammates are wary of their teammate's reaction to a particularly novel situation that may arise in due course. Teams exhibit low willingness to continue together when they have teammates who have the ability to work together but don't do so. This might create an impression that it is better to dissolve the existing team than continue working together.

It was interesting to observe a moderate correlation between TMS coordination and the alternative 6-item TMM scale. It appears that there is a similar reaction towards

TMS coordination as towards TMM. This is expected, as per the definition of these two constructs. If there is substantial agreement amongst team members, it is quite likely that they will have a high TMM as well as believe in their ability to work together efficiently leading to high TMS coordination. In some ways, TMS coordination has the closest linkages to TMM, suggesting that these two constructs may be capturing the same underlying phenomenon. However, the lack of a similar relationship with the average deviation method does weaken the argument.

Managerial Implications

The results provide helpful tips for practitioners interested in team learning. While many practitioner oriented books have suggested that team learning is very important, it has been rather difficult to implement the suggestions in practice. I hypothesized that TMM and TMS are important antecedents to team performance. The results illustrate that contextual factors like team size, team tenure and country are strong predictors of team performance and team learning. Managers should consider the impact of increasing team size in organizations. While more people in a team helps bring multiple and often varied expertise to a team, managing divergent viewpoints and conflict becomes an important drawback resulting in lower than expected team performance (Haleblian & Finkelstein, 1993). This is especially important as organizational work teams have been increasing in team size over the years. The fact that increased team tenure helps increase team learning is critical for organizations that are promoting intellectual capital. The fact that team learning is an added benefit of retention will be of interest to human resource executives. The cross-cultural study also highlights the importance of considering the influence of national work cultures. A majority of the teams were from organizations with a substantial multinational presence, and yet the results suggested that teams from the US had better team performance than those from India.

Results suggest that TMS credibility plays a key role in improved team performance and team creativity. The results are consistent with prior findings that team processes are more important for team effectiveness than individual members' competence when teams work together for a long time (Watson, Michaelsen, & Sharp, 1991). This study supports the conventional wisdom that it is important to build trust in team members' knowledge rather than staffing a team with individual star performers (Gladwell, 2002).

Organizations can help teams achieve high TMS credibility by identifying experts and encouraging team members to believe in each other by assigning tasks that build trust and reliance on each other. Additionally, results demonstrate that it is important to determine team objectives before engaging in any team-building activities. Managers must decide whether they want to focus primarily on team performance, team creativity or team viability. The choice of the specific objective must be matched with corresponding TMS components. In my study, high performance teams were high on TMS credibility, while the most satisfied teams were high on TMS coordination. This implies that different mechanisms are at play in achieving desired team effectiveness dimension.

Senior executives and organizations should also realize that spending time and effort on improving TMM is not always a good thing (Senge, 1990) because teams in my sample did perform well despite low levels of TMM. Managers should consider the alternative approach of improving TMS credibility to achieve high team performance.

More importantly, managers must take into account the contingency approach between balancing TMS and TMM. High team performance can be obtained by being high on one construct and low on the other. Practitioners should take into account the match between TMM and TMS before deciding on how teams should achieve the desired objectives. If the team has high TMM, managers may not benefit from trying to improve TMS mechanisms. On the other hand, if the team exhibits low TMM, efforts to improve TMS mechanisms can be helpful. All of the preceding suggestions can be facilitated by managers surveying team members in order to find out initial levels of TMM and TMS.

Limitations

The relatively small sample size in this study limited the statistical power to detect significant relationships. The sample for the present study comprised of 41 teams, and is similar to those in many other team level studies like a 45 team study reported by Stewart and Barrick (2000) as well, average project teams studies reported by Cohen and Bailey (1997). However, some strong results were observed between team performance, team size and country. The presence of the interactive relationship between TMM and TMS credibility suggests the presence of strong effects irrespective of the small sample size. Thus, it is important to further explore these constructs to better understand team performance and learning.

Second, the present sample may not be generalizable to all types of organizations. However, the study sample consisted of 41 teams from 11 organizations across 7 industries from two countries. The multi-industry, multi-organization sample resulted in increased variance in the sample. Hence, the results are expected to be conservative estimates and should generalize better than prior studies focused on a particular industry or an organization.

Third, the cross-sectional nature of the data limits the findings. Teams may have been at different stages in their life-cycle, some newly formed, others mature and yet others working on their last project together when the data were collected. The average team tenure was 2.9 years, suggesting most teams had been working together for a substantial length of time and the lack of supportive findings are not due to the survey timing. It would have been beneficial if all the teams were at the same level of formation, and the data collection was done longitudinally to better understand the team learning processes. Hence, any inference of causality should not be deduced because of the correlational nature of data.

Fourth, although many measures were collected from team managers, some results may have been influenced by common method bias. In particular, common method bias could have influenced the relationship between team viability and satisfaction and TMM and/or TMS. The team processes (TMM and TMS), team viability, and team satisfaction measures were collected from team members rather than external observers.

Fifth, although I had a reasonably high response rate, 58% response within each team, for a field study done remotely by online surveys, team level constructs such as TMM and TMS are more representative when complete information from every team member is available. However, it took multiple reminders to achieve the present response rate and researchers should be mindful of the low response rate in field settings.

Sixth, I operationalized TMM as an average deviation index, a type of difference score, following scholars studying the mental model literature (cf. Smith-Jentsch, Mathieu, & Kraiger, 2005). The use of difference scores has been criticized by researchers as this may not capture the agreement constructs like TMM effectively. Edwards (Edwards, 1995; Edwards & Parry, 1993) has recommended that researchers use other techniques like polynomial regression techniques to operationalize the agreement constructs like TMM.

Seventh, many of the findings were of marginal significance ($p \leq .10$). This increases the probability of finding results by chance, a direct result of Type I error. Hence, these results should be interpreted with caution. Replication studies are needed to support these results.

Finally, I chose to aggregate constructs to team level even when some agreement indices were lower than the conventionally accepted cut-off norms. This may have affected the results. It is possible that my sample represents a lower level of agreement amongst team members than has been observed in the published research. This may reflect team members having significant within-group differences. Future researchers should carefully model agreement in future research differences, as well the similarities amongst team members, by using a multilevel procedure (Kozlowski & Klein, 2000). Fortunately, the chi-square tests under confirmatory factor analyses were significant despite the small sample size, which provides a conservative estimate that items do represent the underlying constructs.

Future Research

Future researchers could pursue many different avenues. First, it is important to investigate the conditions under which teams engage in learning behaviors. In this study, I did find that contextual variables play an important role in predicting team-level outcomes, but was unable to pinpoint the impact of industry and the country of origin on team effectiveness. Due to the paucity of field studies involving TMM and TMS, there is a need to engage in more field studies to replicate the findings of this study. Scholars should investigate multiple industries, and countries to examine their impact on team-level dimensions. It is also important to examine more proximal organizational design features that may affect team performance and team learning.

Second, TMS and TMM are conceptualized as emergent processes that emerge over a period of time. The current study was a cross-sectional study and included teams at all levels of maturity. It will be helpful in future studies if teams are tracked from their time of formation to the time of disbanding, and regular measurements at equal intervals are done to track the development of TMS and TMM. Hence, it is important to do a longitudinal study of the teams to get a better sense of how TMS and TMM develop, as well as resulting impact on the team level outcomes like team performance, team learning and creativity.

Third, there is an urgent need to clarify both conceptually and methodologically the nature of the TMM construct (Mohammed, Klimoski, & Rentsch, 2000). Ironically, unless there is an agreement amongst researchers working on the mental model construct, the research is likely to remain fragmented and of little use to researchers and practitioners alike. I conceptualized two different ways to capture TMM, and the similar pattern across both methods suggests that the TMM construct can be meaningfully captured using an average deviation index in field settings. This is an initial effort to measure TMM in “real-life” teams and needs to be replicated in other settings.

Fourth, the finding that the TMS construct is better represented as a three-factor structure under an umbrella construct deserves more investigation. The evidence that the narrow dimensions (e.g. specialization, coordination and credibility) predict team outcomes (e.g. team performance and team creativity) better than a broader construct is helpful. In the future, researchers should include these three factors as stand-alone predictors of variables such as team performance.

Fifth, the results suggest an extremely strong relationship between TMS, TMM and team creativity. Team creativity turned out to be more strongly related to the TMS components than team learning. This unexpected relationship can be utilized by researchers focused on creativity, as TMS specialization and TMS credibility turned out to be important predictors of team creativity.

Sixth, in order to integrate findings across similar sounding labels, it is important that researchers take a broader perspective when they continue working in this field and adopt a cross-fertilization approach to assimilate the existing findings and clarify the meaning underlying the term team learning. The confusion regarding the construct is quite evident by recent summaries of literature around this topic, and it is no wonder that the existing research is so fragmented that researchers hope for more integration (Edmondson, Dillon, & Roloff, 2008; Wilson, Goodman, & Cronin, 2007).

Seventh, it could help the team learning literature if researchers engage in a systematic, objective review of existing studies and conduct a meta-analysis. A meta-analysis might highlight the major findings and settle confusion in the existing literature. It is important that we do not engage in the minor replication of existing studies, but rather identify specific areas which can help advance the team learning and related literature.

Finally, researchers working in this area should not only investigate the inter-relationship between TMS and TMM but they should also incorporate related cognitive constructs that are most likely related to the concept of team learning. Such terms might include information sharing, cognitive consensus and group learning amongst other similar sounding labels.

Conclusion

Despite multiple calls for integrating the research on various team learning related constructs, there is little empirical research especially in field settings. In this study, I tested the relationship between team mental models (TMM) and transactive memory systems (TMS) and their impact on team outcomes in the field. Although the results generally advance our understanding of these team learning mechanisms, the results generally failed to support the existence of a positive relationship between TMM and team performance. In addition, TMM failed to moderate the relationship between TMS and team performance. On further evaluation of TMS components, the results were more promising. TMS credibility was positively related to team performance and team creativity. I found that TMM moderated the relationship between TMS credibility and team outcomes. Additionally, high levels of TMM were found to be less than optimal for effective team performance, especially when teams demonstrated high TMS. I hope that my study will provide a stimulus for future research investigating team learning.

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APPENDIX A: SURVEY

1. Please enter your team identification number __________

(To be determined in consultation with the sponsoring organization, used for linking your response with those of your teammates)

2. Please select your role

a. Team manager
b. Team manager

Note: If you selected team manager, please go to question number 14. If you are a team member, please respond to the next question.

<u>To be completed by the team members</u>

Transactive Memory Systems (TMS)

3. For the following statements, please refer to the *last completed project* involving your team. Please rate the following actions/behaviors in terms of *your agreement with the following statements* on a scale of 1-5 (where 1 = strongly disagree 3 = neutral and 5= strongly agree)

1	2	3	4	5
Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree

(Specialization)
1. Each team member has specialized knowledge of some aspect of our project.
2. I have knowledge about an aspect of the project that no other team member has.
3. Different team members are responsible for expertise in different areas.
4. The specialized knowledge of several different team members was needed to complete the project deliverables.
5. I know which team members have expertise in specific areas.

(Credibility)

6. In most cases, I was comfortable accepting procedural suggestions from other team members.
7. In most cases, I trusted that other members' knowledge about the project was credible.
8. In most cases, I was confident relying on the information that other team members brought to the discussion.
9. In most cases, when other members gave information, I wanted to double-check it for myself. (reversed)
10. I did not have much faith in other members' "expertise." (reversed)

(Coordination)

11. Our team worked together in a well-coordinated fashion.
12. Our team had very few misunderstandings about what to do.
13. Our team needed to backtrack and start over a lot. (reversed)
14. We accomplished the task smoothly and efficiently.

15. There was much confusion about how we would accomplish the task. (reversed)

Team Mental Models (TMM)

Instructions: Below are some adjectives that could describe working in teams.

Operational Definitions:

1. **Conflict Management:** Establishing conditions to prevent team conflict and working out interpersonal disagreements among team members.

2. **Goal specification:** Identification and prioritization of goals for task accomplishment.

3. **Monitoring progress toward goals:** Tracking progress toward task accomplishment.

4. **Motivation and confidence building:** Generating a sense of collective confidence and motivation with regard to task accomplishment.

5. **Strategy formulation:** Developing alternative courses of action and choosing the best course of action.

6. **Team monitoring and backup behavior:** Assisting team members in performing their tasks by providing verbal feedback, helping or completing a task for them.

4. Think about the processes that were decided/established by your team/teammates during the execution of the project. Now**,** based on your experience in the last completed team project, please rank order the importance of the following team processes. Please rank order them from 1-6 where 1= most important, 2 = second most important and so on, 6 = least important.

_______ Conflict Management
_______ Goal specification
_______ Monitoring progress toward goal
_______ Motivation and confidence building
_______ Strategy formulation
_______ Team monitoring and backup behavior

Alternative TMM

5. For the following statements, please refer to the *last completed project* involving your team. Please rate the following actions/behaviors in terms of *your agreement with the following statements* on a scale of 1-5 (where 1 = strongly disagree 3 = neutral and 5= strongly agree)

1	2	3	4	5
Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree

1. We established rules to prevent, control, or guide team conflict before it occurred and worked out interpersonal disagreements among team members.
2. We identified and prioritized goals for task accomplishment.
3. We tracked our progress toward task accomplishment.
4. We generated and worked on creating a sense of collective confidence and engaged in motivating each other by building team cohesion.
5. We developed alternative courses of action for task accomplishment and chose the best course of action.
6. We assisted team members to perform their tasks by providing verbal feedback or coaching, helped others in carrying out actions, or completed a task for a teammate.

6. For the following statements, please refer to the *last completed project* involving your team. Please rate the following actions/behaviors in terms of *your agreement with the following statements* on a scale of 1-5 (where 1 = strongly disagree 3 = neutral and 5= strongly agree)

1	2	3	4	5
Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree

Task Interdependence

1. I have to obtain information and advice from my colleagues in order to complete my work.
2. I depend on my colleagues for the completion of my work.
3. I have a one person job; I rarely have to check or work with others.
4. I have to work closely with my colleagues to do my work properly.
5. In order to complete their work, my colleagues have to obtain information and advice from me.

Reward for team performance

1. My performance review depends upon my performance as a member of the team.
2. My performance review depends upon the performance of the team.
3. Supporting my team is critical to advancement within the organization.

Organizational support

1. My team gets all the information it needs to do our work and plan our schedule.
2. It is easy for my team to obtain expert assistance when something comes up that we don't know how to handle.
3. My team is kept in the dark about current developments and future plans that may affect its work.
4. My team lacks access to useful training on the job.
5. Excellent work pays off in this company.

7. For the following statements, please refer to the *last completed project* involving your team. Please rate the following actions/behaviors in terms of *your agreement with the following statements* on a scale of 1-5 (where 1 = strongly disagree 3 = neutral and 5= strongly agree)

1	2	3	4	5
Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree

Team viability

1. Members of my team care a lot about it, and work together to make it one of the best.
2. Working with team members is an energizing and uplifting experience.
3. There is a lot of unpleasantness among members in the team. (reverse-coded)
4. Some members in the team do not carry their fair share of the overall workload. (reverse-coded)
5. Sometimes, one of us refuses to help another team member out. (reverse-coded)
6. As a team, this work group shows signs of falling apart. (reverse-coded)
7. Every time we attempt to straighten out a member of the team, whose behavior is not acceptable, things seem to get worse rather than better. (reverse-coded)

Team satisfaction

1. Generally speaking I am very satisfied with the team.
2. I frequently wish I could quit the team. (reverse coded)
3. I am generally satisfied with the work I do on the team.

Team Identity

8. I belong to:
   a. only one work group (scored 3);
   b. one primary work group, but also some secondary work groups (scored 2);
   c. or more than one work group (scored 1). (Single team membership)

9. My primary work group:

a. consists mostly of members who are relatively permanent members of the group (scored 3)
b. consists of some members who are relatively permanent and some members who change frequently (scored 2)
c. consists of members who frequently change (scored 1). (Team member permanence)

10. I would describe my primary work group as:
    a. a group of members all working together as a single team (scored 3)
    b. two or more subgroup of co-workers (scored 2)
    c. or a collection of individual employees doing their own work (scored 1). (Single-team functioning)

Team demographics

11. Now, please tell us a little bit about yourself.
    1. Your age in years __________
    2. No. of years with the present team __________
    3. Number of years with the present organization __________
    4. Number of members in your team __________
    5. Your functional specialization (expertise) __________

12. Please select your gender _________ Male _________ Female

13. Please select the highest level of education you have completed.
    1. Some high school (including high school graduate)
    2. Some college coursework (including 2-year degrees)
    3. 4-year college degree (e.g., BA/BS)
    4. Some graduate coursework
    5. Completed graduate degree (e.g., MA, MBA, MD, Ph.D., etc.)

14. Please select your industry.

    1. Manufacturing
    2. Banking/Finance/Accounting
    3. Insurance / Real Estate / Legal
    4. Federal (Including Military)/State / Local Government
    5. Communications
    6. Transportation / Utilities
    7. Construction / Architecture / Engineering
    8. Wholesale / Resale / Distribution

9. Education

10. Marketing / Advertising / Entertainment

11. Research / Development Lab

12. Computer/IT related

13. Business Consulting

THANK YOU FOR COMPLETING THE SURVEY!!

To be completed by the team managers

15. For the following statements, please refer to the *last completed project* involving your team. Please rate the following actions/behaviors in terms of *your agreement with the following statements* on a scale of 1-5 (where 1=somewhat below requirements 3= neutral and 5 = consistently exceeds requirements).

1	2	3	4	5
Somewhat below Requirements	Slightly below Requirements	Neutral	Slightly above Requirements	Consistently exceeds Requirements

Team performance

1. This team meets or exceeds its goals.
2. This team completes its tasks on time.
3. This team makes sure that products and services meets or exceeds quality or service standards.
4. This team responds quickly when problems come up.
5. This team successfully solves problems that slow down its work.
6. This team is a productive team.

Team learning

16. For the following statements, please refer to the *last completed project* involving your team. Please rate the following actions/behaviors in terms of *your agreement with the following statements* on a scale of 1-5 (where 1 = strongly disagree 3 = neutral and 5= strongly agree)

1	2	3	4	5
Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree

1. This team asks its internal customers (those who receive or use its work) for feedback on its performance.
2. This team relies on outdated information or ideas. (reverse coded)
3. This team actually reviews its own progress and performance.

4. This team does its work without stopping to consider all the information team members have. (reverse coded)
5. This team ignores feedback from others in the company when some tough situation arises.

Team creativity

17. For the following statements, please refer to the *last completed project* involving your team. Please rate the following actions/behaviors in terms of *your agreement with the following statements* on a scale of 1-5 (where 1 = strongly disagree 3 = neutral and 5= strongly agree)

1	2	3	4	5
Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree

1. This team is methodical and consistent in the way it tackles problems. (reverse coded)
2. This team is open to the implementation of new ideas and methods.
3. This team links ideas that originate from multiple sources.
4. This team is persistent in solving a problem even in novel situations.
5. This team searches for novel approaches not required at the time.
6. This team pays strict regard to the sequences and steps needed to complete a job. (reverse coded)

Task type

18. This team is comprised of members who are mostly:
 a) Homogenous
 b) Heterogeneous
 c) Neither of the above

19. The work done by this team is highly integral to the daily operations of the organization.
 a) Yes
 b) No
 c) Can't say

20. This team can best be classified as:
 a) A homogenous team engaged in production or service activities that are highly integral to the daily operation of the organization e.g. Sales team, assembly team.
 b) A homogenous team engaged in decision making activities that are loosely connected to the daily operation of the organization e.g. Employee involvement groups, Quality control circles.
 c) A heterogeneous team of specialized individuals working in an unpredictable environment and engaged in activities highly integral to the daily operation of the organization e.g. surgery team, flight crew.

d) A heterogeneous team comprised of specialized professionals assigned to a project and not directly involved in the daily operation of the organization e.g. R&D, New product development team.
e) Other (please specify).

If you selected other, please specify: ___________________________________

21. Please describe the nature of task last completed by your team in a sentence or two.
____
____

THANK YOU FOR COMPLETING THE SURVEY!!

APPENDIX B: INFORMED CONSENT DOCUMENT

Project Title: **How do teams learn? Shared Mental Models and Transactive Memory Systems as determinants of team effectiveness**
Research Team: **Amit Nandkeolyar, MBA**

This consent form describes the research study to help you decide if you want to participate. This form provides important information about what you will be asked to do during the study, about the risks and benefits of the study, and about your rights as a research subject.

- If you have any questions about or do not understand something in this form, you should ask the research team for more information.
- You should discuss your participation with anyone you choose such as family or friends.
- Do not agree to participate in this study unless the research team has answered your questions and you decide that you want to be part of this study.

<u>WHAT IS THE PURPOSE OF THIS STUDY?</u>

This is a research study towards the completion of a PhD dissertation. I am inviting you to participate in this research study because you are employed in a commercial organization and routinely work in teams.

The purpose of this research study is to gain an understanding of team effectiveness in real world settings. Further, I seek to examine if team learning explains a team's ability to perform successfully.

<u>HOW MANY PEOPLE WILL PARTICIPATE?</u>

Approximately 250-300 people will take part in this study conducted by researchers at the University of Iowa.

<u>HOW LONG WILL I BE IN THIS STUDY?</u>

If you agree to take part in this study, your involvement will last for 15 minutes.

<u>WHAT WILL HAPPEN DURING THIS STUDY?</u>

You will be asked to complete a survey either online or in a paper-pencil format. You will be asked to enter the team identification number which will be provided to you by the researcher in the e-mail inviting you to participate in the survey. You will then select your role as a team member or a team manager.

The survey will ask you to answer certain questions about your experience in working with teams. Team members will also be asked to provide our age, sex, number of years with the team and organization, number of members in your team, highest educational degree obtained, and your specialization/expertise. You are free to skip any questions that you would prefer not to answer.

WHAT ARE THE RISKS OF THIS STUDY?

There are no foreseeable risks to participating in this study.

WHAT ARE THE BENEFITS OF THIS STUDY?

We don't know if you will benefit from being in this study. However, we hope that, in the future, other people might benefit from this study because we will learn about team processes in commercial settings.

WILL IT COST ME ANYTHING TO BE IN THIS STUDY?

You will not have any costs for being in this research study.

WILL I BE PAID FOR PARTICIPATING?

You will not be paid for being in this research study.

WHO IS FUNDING THIS STUDY?

The University and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

WHAT ABOUT CONFIDENTIALITY?

We will keep your participation in this research study confidential to the extent permitted by law. However, it is possible that other people such as those indicated below may become aware of your participation in this study and may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

- federal government regulatory agencies,
- auditing departments of the University of Iowa, and
- the University of Iowa Institutional Review Board (a committee that reviews and approves research studies)

To help protect your confidentiality, we will not put your name on any part of the questionnaire. Your responses will be available only to members of research team. The hard copy, if any, of data will be stored in locked file cabinets in locked offices. Any research information stored on computers will be stored in password protected computer files. The team ID Code assigned to your team will be linked to identifying information about your organization and team. The list linking the team identification code and your organization/team will be stored in a separate location that is accessible only to the researchers.

The overall results of the study will be provided to your organization. If we write a report or article about this study or share the study data set with others, we will do so in such a way that you cannot be directly identified.

IS BEING IN THIS STUDY VOLUNTARY?

Taking part in this research study is completely voluntary. You may choose not to take part at all. If you decide to be in this study, you may stop participating at any time. If you decide not to be in this study, or if you stop participating at any time, you won't be penalized or lose any benefits for which you otherwise qualify.

WHAT IF I HAVE QUESTIONS?

We encourage you to ask questions. If you have any questions about the research study itself, please contact: Amit Nandkeolyar, 319-335-1504 (O), 319-354-8161 (H). Alternatively, you may contact Dr. Greg Stewart at 319-335-1947 (O) who is the chair of the dissertation committee. If you experience a research-related injury, please contact: Amit Nandkeolyar at 319-335-1504 (O), 319-354-8161 (H).

If you have questions, concerns, or complaints about your rights as a research subject or about research related injury, please contact the Human Subjects Office, 340 College of Medicine Administration Building, The University of Iowa, Iowa City, Iowa, 52242, (319) 335-6564, or e-mail irb@uiowa.edu. General information about being a research subject can be found by clicking "Info for Public" on the Human Subjects Office web site, http://research.uiowa.edu/hso. To offer input about your experiences as a research subject or to speak to someone other than the research staff, call the Human Subjects Office at the number above.

By completing and submitting the surveys, you are consenting to the use of your responses in our research study. To begin the survey, please GO TO THE NEXT PAGE. You may stop your participation at any time by closing the browser window.

APPENDIX C: GLOSSARY

Information processing: Information processing in teams has been defined as the degree to which information, ideas, or cognitive processes are shared, and are shared among group members and how this sharing of information affects both individual and group level outcomes.

Shared mental models (SMM): Organized understanding of relevant knowledge that is shared amongst team members

Task (Shared) Mental Model: SMM typology focusing on the knowledge about equipment and tools & task procedure, strategies and environmental cues impacting task.

Team (Shared) Mental Model (TMM): SMM typology focusing on the knowledge about teammate characteristics, team roles and team interaction patterns.

Team learning: Process by which team members seek to acquire, share, refine, or combine task relevant knowledge through interaction with one another.

Transactive Memory Systems (TMS): A combination of an individual's knowledge and a shared awareness of who knows what.

TMS Coordination: Team members' ability to work together efficiently.

TMS Credibility: Team members' beliefs about the accuracy of each member's knowledge and provides evidence that team members trust each other.

TMS Specialization: Team members' level of knowledge differentiation