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Diversity and Shared Team Mental Models in the Military

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Abstract

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McCafferty...turned the periscope in a complete circle. "I see no surface ships. No aircraft. Seas about five feet. Estimate the surface wind from the northwest at, oh, about twenty, twenty-five knots." He snapped up the handles and stepped back. "Down scope." The oiled steel tube was heading down before he'd spoken the second word. The captain nodded approval at his quartermaster, who held out a stopwatch. The scope had been up above the surface for a total of 5.9 seconds. After fifteen years in submarines, it still amazed him how so many people could do so much in six seconds.

--Tom Clancy, *Red Storm Rising*

The U.S. military is relying increasingly on closely coordinated teams for warfare and support activities, such as submarine crews, weapons teams, aircraft crews, and medical teams (Knouse, 1998). The recent incident off China where the Navy EP-3E intelligence plane was clipped by a Chinese F-8 is a relevant example (Thomas & Liu, 2001). After falling 8,000 feet, the plane's pilot, with the help of the crew, was able to gain control of the plane and make an emergency landing on China's Hainan Island, while the plane's crew disabled sensitive intelligence equipment and destroyed intelligence documents. This closely coordinated effort was accomplished by a crew of 24 composed of Navy, Marine, and Air Force officers and enlisted personnel, men and women, as well as people of differing ethnic backgrounds. In other words, this diverse team had a shared team mental model of what to do in such an emergency.

Into the 21st century, the U.S. military Services will have increasingly diverse members. At the same time, the direction of military operations appears to be towards smaller, highly coordinated teams (Salas, Cannon-Bowers, Payne, & Smith-Jentsch, 1998). Diversity can be an asset in a number of ways. Diverse teams should theoretically have more information and approaches to team problem solving, should have wider perspectives on problems, as well as "creative tensions," should be able to think divergently (look at differences rather than similarities in problems), and should have a greater skill mix for successful task completion. Diverse teams can also have greater cultural and language skills for deployment in international settings (Cox, 1993; Keller, 2001; Simons, Pelled, & Smith, 1999; Thompson & Gooler, 1996).

Diversity can also present disadvantages to teams. Closely coordinated teams should be cohesive, where team members pull together, help one another, and operate in a team mode in crises. Teams with diverse members, however, may have difficulty in finding common interests for building this crucial cohesion (Thompson & Gooler, 1996). In addition, the very advantage of team diversity – differing perspectives – can also be a serious problem. Team members with differing backgrounds may not see the world, and more specifically the team tasks at hand, the same way (Elsass & Graves, 1997). They may have difficulty understanding, communicating, and coordinating task performance without a common basis for action (Keller, 2001; Larkey,

1996). In short, diverse teams may have trouble acquiring a shared team mental model of their task situation.

The present report examines the concept of the shared team mental model within a military team diversity perspective. First, we look at defining basic terms – teams and diversity. Then we examine the concept of the shared team mental model – various definitions, purposes, properties, operation, and developmental aspects. The report presents research evidence supporting the operation and development of shared team mental models. We then analyze the role of team member diversity in shared team mental models. Based upon this theoretical and empirical work, the report presents a model of how diversity operates in shared team mental models. We briefly look at future directions. Finally, the report presents a number of recommendations for the military to enhance team shared mental models.

Diversity in Teams

Teams

The label of “group” may be used as a generic term for collections of individuals, including teams. Further, many use the two terms – “groups” and “teams” – interchangeably. We are focusing upon military teams here, however – combat teams, weapons teams, aircraft crews, medical teams, support teams. Therefore, we should begin by differentiating teams from groups. Theoretically, a group is a collection of individuals working toward common goals. They tend to work and be accountable more as individuals. Teams, on the other hand, are a more tightly bound collection of individuals, who are more closely coordinated in their task work. Accountability falls more toward team rather than upon individual performance (Lemons, 1997). Mohammed and Dumville (2001) see the group as working on less structured tasks, as less differentiated in its roles, and as experiencing less work interaction than teams. This appears to be particularly appropriate for military teams, which tend to engage in highly structured operations, have highly specific tasks, and experience intensive interpersonal interaction in accomplishing their tasks (Salas et al, 1998).

Diversity

Several researchers have attempted to expand the definition of diversity beyond simple background variables, such as race, ethnicity, gender, and age. Milliken and Martins (1996) differentiate observable diversity (e.g., race and gender) from less observable aspects, such as work skills and personality. Harrison, Price, and Bell (1998) suggest surface level diversity (e.g., race and gender) and deep level diversity (e.g., attitudes, beliefs, and values). Building upon these typologies, Whaley (2001) proposes a three level classification: surface level (e.g., race and gender), working level (e.g., work skills, knowledge, and expectations of the group), and deep level (e.g., attitudes and values affecting group processes and performance). Apparently, deeper level diversity appears to operate at a cognitive level including beliefs, knowledge, and expectations, which affect group processes and performance.

Theories of Shared Team Mental Models

Definitions

An important cognitive concept influencing teamwork is the shared team mental model. Each individual team member has a separate cognitive model – an internal knowledge base - about how things should operate, how things should go together, and what should occur in his/her work environment. The shared team mental model is the extent to which these individual models overlap. Essentially, it is a means of organizing knowledge into meaningful patterns for the team (Blickensderfer, Cannon-Bowers, & Salas, 1997; Klimoski & Mohammed, 1994).

Another way of looking at it is as the process of sensemaking for the team – making sense of the environment, team member expectations, and the work they should be doing together. As a mutual sensemaking device, the shared team mental model should do three things: accurately describe the team's working environment, explain what is occurring, and predict what will happen next. This should result in shared understanding of the problem at hand, strategies, and team member roles and mutual expectations of team and task demands that will occur in the future (Blickensderfer, et al, 1997). More directly, the shared model should allow teams to coordinate performance without a lot of superfluous communication. It should allow team members to interpret task cues similarly, leading to compatible team decisions. In short, these shared models should guide team behavior (Cannon-Bowers & Salas, 2001).

Unfortunately, there are a large number of conceptual variations on the basic definition of the shared team mental model. Klimoski and his colleagues (Klimoski & Mohammed, 1994; Rentsch & Klimoski, 2001) see them as metaphors: group mind, transactional memories, internal knowledge bases, sociocognition, group prosocial behavior, shared understanding, group cognition, organizational consensus, group belief structure, negotiated belief structures, collective interpretations, shared meaning, collective frames of reference, shared internal frames of reference, teamthink, and team mind. Obviously, there is a great variety of approaches to understanding the concept of the shared team mental model. This can be an advantage in terms of the richness of the concept. It can also be a disadvantage, which as we will see later, in trying to measure this multifaceted concept.

Purposes of Shared Team Mental Models

Why are shared team mental models so important? Basically, they improve team performance. They allow team members to describe, explain, and predict team behaviors in order to do them better (Rouse & Morris, 1986). They allow for better group decisions and better adaptation to the changing demands of the task environment (Klimoski & Mohammed, 1994). Moreover, they tend to enhance team processes: coordination, communication, expectations, and decision making. In turn, enhanced team processes produce better team performance in terms of increased accuracy, efficiency, quality, and timeliness (Cannon-Bowers & Salas, 2001).

As an example, military researchers describe the effective operation of a Navy submarine. The submariners exchange relevant data by passing on information, seeking input

about the state of the environment, and summarizing progress on tasks. Their communication is vital to this exchange. They must use the right phrases, (e.g., “Sonar announced. Weapon in the water”), which are brief, clear, complete, and understood by other team members. Finally, they exhibit support behaviors such as correcting errors quickly, backing each other up, and providing assistance when a problem occurs (Smith-Jentsch, Campbell, Milanovich, & Reynolds, 2001).

Properties of Team Shared Mental Models

Several theorists have described various aspects of team shared mental models.

Content of the Models. Cannon-Bowers and Salas (2001) propose a hierarchy of content. The most narrow content is task specific knowledge that guides specific task performance. Then occurs task related knowledge, which is broader, and guides task processes that affect performance of a number of tasks. Broader still is team knowledge of team members (their strengths, weakness, and preferences), which helps team members work with one another and compensate for each others’ shortcomings. Finally, the broadest category is shared beliefs, which underlies all team work.

Mohammed and Dumville (2001), on the other hand, focus upon types of knowledge: declarative (knowledge of what), procedural (knowledge of how), and strategic (knowledge of content). In addition, they differentiate degrees of shared knowledge in the mental models. Identical knowledge (shared attitudes and values) requires highly similar team members, whose individual mental models overlap almost completely. Overlapping knowledge requires less similarity among team members, simply some common knowledge. Complementary knowledge occurs when each team member has unique knowledge, which is an important part of the whole (e.g., necessary for task completion). Obviously, team member diversity would appear to be highly detrimental in an identical knowledge situation, somewhat detrimental, but also somewhat advantageous, to an overlapping knowledge environment, and highly beneficial to a complementary knowledge situation.

Operating Shared Team Mental Models

How do shared team mental models work, particularly with either homogeneous or diverse team members? Mohammed and Dumville (2001) differentiate three types of work modes where the models may work. Taskwork focuses upon task performance requiring information sharing and transactive memories (team memories of task situations). Homogeneous teams share common information; individual members of such teams help each other remember task performance sequences and possible problems. Diverse teams, on the other hand, pool the unique information each member possesses because of their diversity. Further, they may cue each other for unique rather than common transactive memories.

The second mode is teamwork, where the members act as a highly cohesive unit in carrying out tasks. Strong team cohesion is necessary, which unfortunately is a detriment for diverse teams. Thus, taskwork may be a better operating mode than teamwork for diverse teams.

The third mode is belief structure. One aspect of the structure is cognitive consensus – a close similarity in how key parts of the task are defined. Team diversity with its divergence of perspectives may make such consensus difficult to achieve, unless specific team training has occurred (Rentsch & Klimoski, 2001). On the other hand, team diversity fits well with the concept of cognitive diversity, which is bringing divergent perspectives to the problem in order to redefine or broaden the problem or generate a greater number of possible solutions. Mohammed and Dumville (2001) emphasize that extreme cognitive consensus (e.g., groupthink) or extreme cognitive diversity (conflict) is harmful to the team.

Development of Shared Team Mental Models

How do shared team mental models arise? Specifically, what are the antecedent variables that cause them to occur? Klimoski and Mohammed (1994) enumerate several variables important to the development of shared models. One factor is team composition. Similar team members already have similar knowledge and information bases (i.e., similar individual mental models), which can be easily subsumed into a shared team model. Diverse members, however, have dissimilar individual models, which makes the development of a shared team model more difficult.

A second factor involves stages of team development: forming, norming, storming, and performing. Norming is typically where individual team members share their expectations for how the team should operate, their role expectations, and their performance expectations (Keller, 2001). Again, similar team members should have similar expectations allowing the norming phase to occur fairly smoothly. Diverse team members with divergent expectations, on the other hand, may require a more lengthy norming stage. Indeed, they may quickly go into the storming phase in order to air their differences and try to negotiate some common ground.

A third factor is time team members spend together. Longer time together allows more interaction, which in turn allows more information to be shared upon which to build shared team models. Diverse team members, in particular, may require a longer time together in order to interact well. This, of course, has implications for team formation and training.

Training is the fourth factor. Training is a primary means of creating from the ground level similar individual mental models of how the group should operate and how task performance should occur. Training can produce a “level playing field” for diverse team members, from which shared team mental models can develop.

Once individuals are trained to do the task, they can perform the task as a team. Here a learning curve can develop as task work experience allows team members to learn what seems to work and what needs to be improved over time. Diverse members may require more task experience than similar team members, but eventually they can come “up to speed.”

A final antecedent factor is team cohesion. A highly cohesive team can communicate well and thus share more information, can coordinate activities well, and can operate closely together in crisis situations. Unfortunately, diverse team membership can work against cohesion in the sense of close interpersonal attraction among members developing. The problem may be,

however, in emphasizing cohesion as only social cohesion (i.e., everyone in the group has to at least be friends, if not love one another). Task cohesion may be an alternative solution (Knouse, 1998). The source of attraction here is the task rather than the social aspects of the team. Task cohesion requires selecting diverse members who have skill mixes complementing each other, training individual members in common knowledge necessary for successful task performance, focusing on task goals, and emphasizing a task orientation in leadership (Hackman, 1992).

The Limitations of Shared Team Mental Models

Although shared team models have many advantages, there are also limitations to them. Over-reliance on identical shared information and procedures can lead to tunnel vision about how to perform team tasks. Consequently, the team responds less effectively to changes in its situation. In the extreme, an exactly identical shared team member model for all team members can lead to groupthink, with its “we against the rest of the world” perspective, an artificial sense of what’s right (only what the group does is right), a lack of objective evaluation, and ultimately bizarre team decisions (Janis, 1982). Therefore, Klimoski and Mohammed (1994) indicate that team members must be able to disagree as well as agree on task performance. Diversity in team membership can provide differing perspectives on which to legitimately disagree in generating ideas, evaluating courses of action, and solving team problems.

Research Evidence for Shared Team Mental Models

There are a number of recent research studies describing how shared team mental models operate and develop.

Operation of Shared Team Mental Models

Several studies indicate that shared team mental models affect successful performance in teams. Effective cockpit crews better communicated their plans and strategies for action, including how to deal with difficulties, than did ineffective crews (Orasanu, 1990). Team members who understood each others’ internal frameworks better developed more accurate task expectations of each others’ behavior than did those who did not understand well. Further, team members with well-understood internal frameworks explained and predicted each others’ behavior well (Mitchell, 1986). Team concept maps (representation of team knowledge, how equipment operates, and task procedures) enhanced team performance on interdependent tasks (i.e., those requiring coordination) but not on independent tasks performed by individual team members (Minionis, Zaccaro, & Perez, 1995). Finally, more accurate schemas (knowledge structures) produced more accurate team performance, although not necessarily agreement among team members (Jenkins & Rentsch, 1995). In sum, aspects of team shared mental models (planning, expectations, concept maps, and schemas) can enhance team performance with some qualifiers, such as degree of task interdependence present.

Development of Shared Team Mental Models

Several studies supported and built upon the theoretical factors in the development of shared team mental models already discussed above. Team planning resulted in more efficient Navy

team communication and task coordination (Stout, Cannon-Bowers, Salas, & Milanovic, 1999). Using low workload periods to plan for task contingencies also enhanced Navy team performance (Cannon-Bowers & Salas, 1998). Performance monitoring (team members monitor each others' performance during task work and give feedback during task performance) enhanced shared models more than did performance feedback delivered after task performance (Rasker, Post, & Schraapen, 2000). Computer based training helped Navy team members develop mental models close to an established expert model for performance (Smith-Jentsch et al., 2001).

Among new venture entrepreneurs, social cohesion was related to affective conflict (conflict over feelings and perceptions) but not related to cognitive conflict (thinking about multiple ideas and the ensuing give-and-take in discussing them) (Ensley & Pearce, 2001). Further, task based schemas enhanced aircraft team performance in a flight simulator (Mathieu, Hefner, Goodwin, & Salas, 2000). Thus, there appears to be some evidence for the importance of task focus and task oriented cohesion in developing shared team models leading to successful team performance.

Finally, small DoD civilian teams with longer experience working together had more agreement on task schema than did larger, less experienced teams (Rentsch & Klimoski, 2001). In sum, there is empirical evidence that team planning, team performance monitoring during task performance, training, task focus, and task experience are important factors in developing successful shared team mental models.

Diversity and Shared Team Mental Models

Unfortunately, there is relatively little research reported on the effects of diverse team membership on shared team mental models. In one study, demographic diversity decreased strategy consensus in top management teams when interpersonal conflict was present and agreement seeking was strong. This seemingly negative finding may actually be somewhat supportive of diversity, because it appears to show that diversity, social cohesion, and the need for total agreement (consensus) are not all compatible or even desirable in team performance. Homogeneous DoD civilian teams in this study (similar age and GS rank) had more team schema agreement than heterogeneous teams (Rentsch & Klimoski, 2001). In another study, higher ranking Navy military personnel had more similar team mental models (Smith-Jentsch et al., 2001). In the latter two cases, a common factor underlying both age and rank may be task experience, which has already been identified as important to shared team mental models.

From these three studies, it appears that team diversity is not conducive to effective shared team mental models. This is not unexpected, since several theorists have already indicated that homogeneous groups develop shared mental models more easily than do diverse groups. The relevant point, however, is that shared mental models do enhance team performance. Thus, given that many military teams now and in the future will be increasingly diverse and given that this diversity can supply richness to team performance, there should be techniques available for developing shared mental models in order to improve performance of diverse teams, even if these models are difficult and time consuming to develop. The question is how to accomplish this, which we will examine in the next section.

Team Diversity and Shared Mental Models

First, this report summarizes theoretical and empirical work described above, including the role of diversity in influencing shared mental models. Then the report presents a model of how these models operate for diverse teams.

Effects of Diversity on Aspects of Shared Team Mental Models

Types of Diversity. Perhaps the best typology of diversity for our purposes is the Whaley (2001) framework. Surface level diversity (race, ethnicity, gender, age) may initially slow down shared model development. Working level diversity with its emphasis on task skills and knowledge may be the best focus for building shared team models in diverse teams. Deep level diversity (differences in attitudes, values, and beliefs) may be more personal and more important for developing social cohesion rather than the task cohesion necessary for shared task models. On the other hand, once shared team models are in place, differences in individual attitudes, values, and beliefs, may converge at least in task performance. In other words, diverse team members may still have deep level diversity in terms of personal preferences and dislikes about team members, but they may eventually agree on team beliefs about the task, role expectations, and team performance.

Team Development Stages. Shared team models begin to arise during the norming and storming phases of team development (Klimoski & Mohammed, 1994). For diverse teams, norming may have to be slowed down to allow discussion (cognitive diversity according to Mohammed and Dumville, 2001) of differing approaches, expectations, and beliefs. Storming may have to be extended to allow cognitive conflict (Ensley & Pearce, 2001) to negotiate differences in perspectives into a shared model of how the team is to proceed.

Training. Shared team mental models are emphasized in team training. Indeed, one of the primary purposes of team building is to produce common internal frames of reference among team members (Bettenhausen, 1991). With diverse team members, training in common procedures and expectations is particularly important for developing shared models (Klimoski & Mohammed, 1994). Individual self-paced computer based training (Smith-Jentsch et al., 2001) may help to generate common knowledge and expectations among diverse members initially. If team members learn some procedures individually at first, they may then be able to learn from group training subsequently, because they have common bases upon which to learn.

Task Experience. Research shows that as team members spend more time together working on tasks, they interact more and communicate more (Klimoski & Mohammed, 1994; Rentsch & Klimoski, 2001). In addition, planning task performance enhances that performance (Stout et al, 1999), and performance monitoring and feedback during team performance allows team members to learn knowledge and expectations important to shared mental models (Rasker et al, 2000).

Team Cohesion. Ideally, the team is homogeneous allowing very similar individual mental models easily to merge into a shared team mental model. In reality, many teams, particularly in the military, are diverse and becoming even more diverse. Diversity may well

hinder cohesion and interpersonal attraction from forming and thus, negatively affect shared models. Moreover, diversity can have a negative effect if the team focuses upon social factors in its shared models (Knight, Pearce, Smith, & Olian, 1999).

Instead, diverse teams should focus upon task cohesion (Knouse, 1998). Task based shared models can be effective (Mathieu et al, 2000). In addition, cognitive conflict from diverse views (exchanging and evaluating diverse information) can operate well in a task cohesive environment (Ensley & Pearce, 2001). Such cognitive conflict can provide richer information and allow greater perspectives to arise on how to perform well.

Content of Shared Team Mental Models. Team members from different backgrounds with a diversity of skills and knowledge may enhance task specific and task related knowledge in shared mental models (Cannon-Bowers & Salas, 2001). On the other hand, such diversity may prevent members from knowing one another closely, interacting closely, and developing closely held beliefs.

Degree of Sharing Team Mental Models. Diversity may hinder identical shared knowledge, which requires a high degree of similarity among team members (Mohammed & Dumville, 2001). Diversity, however, may enhance overlapping or complementary knowledge based shared models.

Operation of Shared Team Mental Models. In terms of information flow, diversity may hinder the sharing of common information, particularly if there is disagreement on what is common information everyone accepts. On the other hand, diversity may increase the pooling of unique information within the team as well as considering broader perspectives about how to carry out team tasks.

Diversity may hinder the development of team shared transactive memories (how the work was performed) but may cue unique team memories, which may be important for crystallizing shared mental models. Diversity may make cognitive consensus (Mohammed & Dumville, 2001) and other types of team agreement difficult, while diversity may increase cognitive diversity – exchanging and evaluating differing views.

Model of Diversity Effects on Team Shared Mental Models

Figure 1 presents a model of how diversity affects team shared mental models.

Antecedents. The starting point is type of diversity. Surface-level diversity (e.g., race and gender, Harrison et al, 1998) may initially hinder shared models from developing. Working-level diversity (skills and knowledge for task completion, Whaley, 2001) may be the core of shared mental model development for diverse teams. Deep-level diversity may pertain mainly to personal values and preferences (Harrison et al, 1998) and thus may not be so closely task related (i.e., of less relevance here).

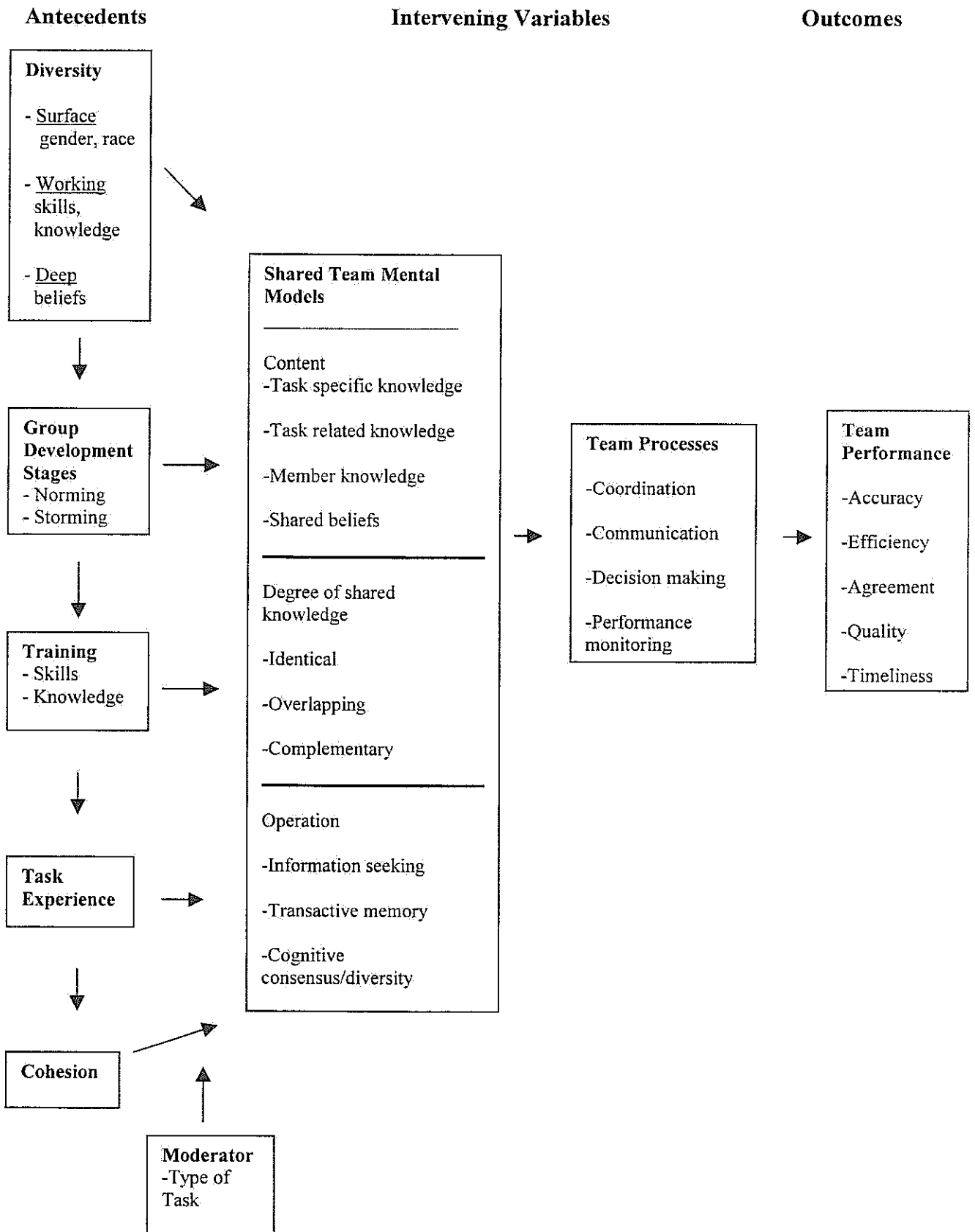


Figure 1

Effects of Diversity on Team Shared Mental Models

Diversity then influences the antecedent of team development. Team diversity may require a more extensive norming stage in order to develop common procedures and expectations for task performance (Keller, 2001). In addition, more extensive storming may be needed to negotiate these differences (Klimoski & Mohammed, 1994).

After the norming and storming stages are worked through, training usually takes place. Indeed, training is perhaps the fundamental means of creating common knowledge, expectations, and procedures for the team (Klimoski & Mohammed, 1994). Initial individualized training, such as self-paced computer training, may be first necessary to lay the foundation for a shared team model (Smith-Jentsch et al, 2001). Then, possessing a common basis, diverse members may be able to train together. In addition, cross training (Cannon-Bowers & Salas, 1998) of individual team members in each others' skills may strengthen the common perceptions of the team tasks as well as increase the flexibility of team response to unusual situations, such as new tasks or crises.

When the team has been together for a while, task performance experience will produce more task-oriented interaction, communication, and coordination (Klimoski & Mohammed, 1994), which in turn will produce more common knowledge and expectations within the developing shared team models. Team planning and performance monitoring can also enhance shared models (Rasker et al, 2000; Stout et al, 1999).

Diversity will most likely work against the development of social cohesion as a basis for shared mental models. Team building as well as task experience should focus upon task cohesion (Knouse, 1998) as the means of developing shared models. Again, working level diversity (skills and knowledge, Whaley, 2001) is perhaps the most effective type of diversity for building task cohesion.

Moderating Variables. One moderator may be the type of task facing the team. Shared mental models are more effective with highly interdependent team tasks rather than independent tasks that individual team members can accomplish largely on their own (Minionis et al, 1995).

Intervening Variables. The first intervening variable is the shared team mental model. Dimensions of the model include content, degree of sharing among team members, and operation. In terms of content, task specific and task related knowledge may be most beneficial in a team diversity environment (Cannon-Bowers & Salas, 2001). Diversity may enhance overlapping and complementary knowledge, but decrease identical knowledge (Mohammed & Dumville, 2001). Moreover, diversity may have several operational effects. It may hinder the sharing of common information while enhancing the pooling of unique information. It may hamper common transactive memories for task performance while enhancing unique memories. It may make cognitive consensus harder to achieve while fueling the creative process of cognitive diversity (Mohammed & Dumville, 2001).

The second set of intervening variables is team processes. Shared team mental models improve team processes, including coordination, adaptation, communication, decision making, and assisting one another (Cannon-Bowers & Salas, 2001). To the extent that diversity hinders shared models, diversity may hinder team processes. For example, diverse members may have

miscommunication problems through different word or phrase meanings (Smith-Jentsch et al, 2001). Further, diverse members may feel less at ease anticipating when team members need help or even asking for help when difficulties arise.

Outcomes. Team performance is the major outcome, which may be evaluated according to performance accuracy, efficiency, agreement, quality, and timeliness (Cannon-Bowers & Salas, 2001). To the extent that diversity enhances team mental models that in turn enhance team processes, team performance should then be more accurate, efficient, of higher quality, and more timely. On the other hand, diversity tends to hamper cognitive consistency, so agreement among all team members may not be an end result.

Future Directions

Measurement of Shared Team Mental Models

As we have seen, there are a large number of definitions of shared team mental models (Klimoski & Mohammed, 1994; Rentsch & Klimoski, 2001). With so many conceptual approaches to what shared team mental models involve, it is not surprising that the concept is difficult to measure. The literature review here has raised some issues. For example, what is the content of shared team mental models? Differing types of knowledge (Cannon-Bowers, 2001) provide one direction for measurement. The degree of sharing of knowledge is another factor. Moreover, teams can closely share knowledge, but it may be the wrong knowledge for getting the job done (Rentsch & Hall, 1994). Therefore, the accuracy of knowledge is another measurement concern.

There are some promising measurement techniques available. Map analysis is one approach, where a textual analysis of written material or of transcripts of team communication allows individual team member mental models to be extracted and combined according to similarities among individual models into a collective team model (Carley, 1997). Multidimensional scaling is another technique, which may be fruitful in identifying the dimensions of shared team mental models (Rentsch & Klimoski, 2001).

New Directions

Taskwork versus Teamwork. Several researchers are looking at the basic differences between teamwork and taskwork (McIntyre & Salas, 1995; Mohammed & Dumville, 2001). Ultimately, we may find that teamwork is the more appropriate concept for homogeneous teams where social cohesion can occur, while taskwork is the correct direction for diverse teams where task cohesion is more appropriate. A teamwork orientation may relate better to group learning and overlapping as the mode of shared team models, while a taskwork perspective may involve information sharing and distributed knowledge as the mode of shared team models (Mohammed & Dumville, 2001).

Training Needs Assessment. Shared team mental models may be useful for assessing the training needs of individuals in teams. They may identify what skills individuals need to possess in order to support the shared team model. They may indicate where cross training of skills

(Cannon-Bowers & Salas, 1998) may creatively enhance the complementary nature of skills and increase the flexibility of the team in situations of high uncertainty, such as a new task or a crisis. They may also show whether the knowledge being trained to the team is creating accurate shared models (Smith-Jentsch et al, 2001).

Team Learning. As teams operate, they should learn from the environment (Mohammed & Dumville, 2001). In particular, performance monitoring and subsequent feedback (Rasker et al, 2000) can lead to improvement of team procedures and, eventually, refinement of team shared models. Guided team self-correction has merit, where the team leader requests feedback from team members after a task session for the purposes of improving procedures. Navy shipboard teams using guided team self-correction outperformed teams not using this technique (Cannon-Bowers & Salas, 1998).

One important factor in the feedback and improvement process is how the team handles failures (Cannon & Edmondson, 2001). Unfortunately, strongly shared team mental models may dictate certain team beliefs and procedures that are immune from change, regardless of their accuracy. In other words, strong team models can falsely dismiss failures as non-occurrences or explain them away as due to variables outside of the team. Ultimately, teams should learn from failures in order to improve procedures and processes in the future. Learning from failure should thus be a component of shared team models. Effective team leader coaching, clear direction, and an organizational culture of learning from failure are means of instilling learning and improvement into shared team models (Cannon & Edmondson, 2001).

Recommendations

Based upon the theory and research presented above, the report offers the following recommendations about creating and enhancing shared team mental models in the military.

1. *Select team members on background and skill diversity.*

Team members from diverse backgrounds may provide more diverse, unique information and perspectives for better team performance in a greater variety of situations. Such diversity, however, may slow down the development of shared team mental models, because initial common grounds are difficult to find. The subsequent recommendations given below may provide alternative common bases for building shared models in the absence of initial shared perspectives. Further, selecting members on complementary but diverse skills may fill gaps in team knowledge and skills and thus, strengthen team response to disparate situations (Cannon-Bowers & Salas, 2001).

2. *Allow sufficient storming to occur in team development.*

Storming allows diverse members to express the differing feelings and perspectives they bring to the team. Successfully working through storming may allow differing perspectives to be incorporated into common knowledge and expectations for the shared team mental model (Klimoski & Mohammed, 1994). Allow sufficient time

during storming for discussion of differences and negotiation of common role, task, and performance expectations (Keller, 2001).

3. *Train common aspects of shared team mental models.*

Training can provide a common knowledge base upon which team shared mental models can develop (Rentsch & Klimoski, 2001). Training can also develop team members complementary skills that are missing but are needed for shared team models. Cross training of individual team member skills can provide a common skills framework for enhancing shared models (Cannon-Bowers & Salas, 1998). Individualized training, such as computer based training (Smith-Jentsch et al, 2001), may be effective, especially when the alternative scenario of training team members together may be hampered by potential conflict, miscommunication, and misunderstandings among diverse members.

4. *Allow sufficient taskwork experience.*

Research shows that teams with more task experience have stronger shared team mental models (Mohammed & Dumville, 2001). Training exercises and simulations can perhaps provide some task experience. Keeping teams together for a longer period of time in order to accumulate task experience, rather than rotating individuals in and out of the team, may be effective (Klimoski & Mohammed, 1994; Rentsch & Klimoski, 2001).

5. *Involve team members in team task planning.*

Research shows that planning enhances shared team mental models (Stout et al, 1999). Coordinated planning requires the use of shared mental models. Moreover, the planning process can actively involve team members with diverse perspectives in the operation of the team, and thus enhance existing mental models.

6. *Focus on task rather than social cohesion.*

Diversity hinders social cohesion (interpersonal attraction of team members), because diverse members have difficulty finding commonalities upon which to build social cohesion. A focus on task cohesion, however, emphasizes taskwork, where team members can focus upon role expectations, task specific knowledge, and task performance without necessarily having to like one another (Knouse, 1998). Team building exercises might focus upon strengthening task cohesion, such as working with task knowledge or gaining experience with taskwork. In addition, task goal setting and task-oriented leadership can build task cohesion (Hackman, 1992).

Conclusion

We have established that shared team mental models are crucial to successful team performance. Ideally, teams would have homogeneous members where strong social cohesion develops, which in turn gives rise to identical shared mental models among team members. In reality, many teams, particularly military teams, are becoming increasingly diverse in team

member backgrounds as well as in skill mixes. These diverse teams must affect a transition from initial working level diversity of its members (different task beliefs and perceptions) toward a working level consensus in task-related beliefs, expectations, and knowledge. In other words, diverse teams must build upon their differing knowledge and perceptual bases in order to construct shared team mental models of the task situation. This report has identified several means of accomplishing this through selecting team members with complementary skill mixes, training common knowledge and required skills, allowing extensive task experience, and focusing upon developing task rather than social cohesion.

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