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THE EFFECTS OF ACUTE STRESSORS ON TRANSACTIVE MEMORY AND SHARED MENTAL MODELS IN TEMPORARY PROJECT TEAMS: AN INFORMATION PROCESSING APPROACH

By

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ABSTRACT

THE EFFECTS OF ACUTE STRESSORS ON TRANSACTIVE MEMORY AND SHARED MENTAL MODELS IN TEMPORARY PROJECT TEAMS: AN INFORMATION PROCESSING APPROACH

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Aleksander P.J. Ellis

The purpose of this study was to develop and test a model of stress in team-based work structures. Based on information processing theory, stress was proposed to negatively impact team processes leading to decrements in team performance. Results indicated that stress was negatively related to the development of both transactive memory and shared mental models. Transactive memory and shared mental models were then shown to mediate the relationship between stress and team performance. A number of personal and situational characteristics were also proposed to affect the relationship between stress and team processes. Results indicated that cognitive ability and extraversion had little impact on team processes and failed to ameliorate the effects of stress on transactive memory and shared mental models. Results regarding the two situational characteristics, feedback and prior shared information, were mixed. The level of prior shared information was positively related to the level of retrieval coordination within the team, as well as shared mental model similarity and accuracy. Prior shared information also moderated the negative effects of stress on the level of retrieval coordination within teams. Providing negative feedback to the team as a whole rather than to an individual team member did not directly affect team processes, but it helped to moderate the negative effects of stress on the level of information allocation within teams. The theoretical and practical implications of these results are discussed.

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INTRODUCTION

Organizations have witnessed a number of drastic changes in the nature of the workplace over the last several decades (Cooper, 1998). In the 1980s, organizations were faced with an "enterprise culture," where privatization, mergers, joint ventures, and process reengineering became the norm. By the end of the 1980s and into the early 1990s, structures became flatter as organizations scrambled to eliminate unnecessary levels of management by "downsizing." This created a workforce composed of employees who had to do more work, while feeling more insecure about their jobs. The expansion of information technology only added to the problems by overloading employees with information and increasing the pace of work (Cooper, Dewe, & O'Driscoll, 2001).

As the changes began to take hold, employees became familiar with words such as "stress" and "strain." Between 1985 and 1990, the number of employees reporting "feeling highly stressed" more than doubled (Northwestern National Life, 1991). Employees under stress exhibited a number of somatic complaints, including migraines, tensions headaches, nausea, muscular discomfort, pain, burnout, anxiety, and emotional exhaustion (e.g., Burke, 1993; Hoiberg, 1982; Lee & Ashforth, 1993; Zander & Quinn, 1962). Stress was recognized as a potential problem not only for the employee, but also for the organization. In 1980, it was estimated that stress cost organizations approximately $75 to $90 billion annually nationally (Ivancevich & Matteson, 1980). By the end of the 1980s, the cost surpassed $100 billion (Niehouse, 1987).

To keep up with the changes within the workplace, research on stress has accumulated in an effort to better understand its causes and consequences. Researchers have identified numerous factors that contribute to stress levels among employees, including workload (e.g., Cooper & Roden, 1985; Kushmir & Melamed, 1991; Westman & Eden, 1992), role ambiguity (e.g., O'Driscoll & Beehr, 1994; Schaubroek, Cotton, & Jennings, 1989), role conflict (e.g., Jackson & Schuler, 1985; O'Driscoll & Beehr, 1994), and interpersonal conflict (e.g., Keenan & Newton, 1985). These factors tend to strain employees mentally and physically, leading to lower levels of productivity, increased absenteeism and turnover, and decreased health and well-being (e.g., Cooper & Payne, 1988; Kahn, Wolfe, Quinn, Snoek, & Rosenthal, 1964; Karasek & Theorell, 1990; Keita & Sauter, 1992; Levi, 1981; Matteson & Ivancevich, 1982; Perrewe, 1991; Quick, Murphy, & Hurrell, 1992). Researchers have also identified a number of moderators that may influence the stress process, such as the Type A behavior pattern (e.g., Davidson & Cooper, 1980; Lee, Ashford, & Bobko, 1990), negative affectivity (e.g., Parkes, 1990; Watson & Clark, 1984), and hardiness (e.g., Allred & Smith, 1989; Kobasa, 1982). To summarize the literature, several books and chapters have been published (e.g., Beehr, 1995; Beehr & Bhagat, 1985; Cooper, Dewe, & O'Driscoll, 2001; Ivancevich & Matteson, 1980; Jex, 1998; Jex & Beehr, 1991; Kahn & Byosiere, 1992).

Although much progress has been made toward understanding organizational stress, the nature of work continues to change as we move into the 21st century. A number of internal and external forces are impinging upon organizations, forcing them to shift to alternative work arrangements. New technologies such as computer-based communication systems are being developed and implemented at an exponential rate (Hesketh & Neal, 1999). Combined with the globalization of trade, the increase in technological capability has led to reductions in the size of many organizations. These changes demand that organizations remain flexible and adaptive, ready to expand or contract at a moment's notice while continually adopting innovation (Cooper, Dewe, & O'Driscoll, 2001). In such a fast-paced, ever-changing environment, employees are often faced with tasks that exceed their capabilities. In order to remain competitive, organizations have begun to assign tasks to groups or teams of employees (e.g., Cannon-Bowers, Oser, & Flanagan, 1992; Hackman & Morris, 1975; Salas, Dickenson, Converse, & Tannenbaum, 1992).

A "team" refers to a distinguishable set of two or more people who interact interdependently toward a common and valued goal/objective/mission, and who have each been assigned specific roles or functions to perform (e.g., Dyer, 1984; Ilgen, Major, Hollenbeck, & Sego, 1995; Salas et al., 1992). Teams have become prevalent in most organizations, including hospitals, the military, nuclear power plants, the airline industry, and the automobile industry. Although organizations often credit their success to the addition of team-based work structures (e.g., Hammer & Champy, 1993), employees working in team contexts are still susceptible to stress (e.g., Morgan & Bowers, 1995).

Unfortunately, stress researchers have been unable to keep up with the change from individual to team-based work structures. Little has been done to further our understanding of the effects of stress within teams (Boff & Lincoln, 1988; Driskell & Salas, 1991; Morgan & Bowers, 1995). This lack of research is surprising, considering that a number of scholars have suggested that studies of stress need to move beyond the individual to incorporate groups and teams (e.g., Bliese & Jex, 1999; Cox, 1997; Griffiths, 1994). Examining the stress process in team-based work environments is important for both practical and theoretical reasons.

Practically, stress within teams has been at least partly implicated in a number of tragic incidents. For example, in 1972, an Eastern Airlines flight crashed into the Florida Everglades, killing 99 passengers and crew members. During the flight, one of the landing gear lights burned out. While the entire crew focused their attention on fixing the problem, the autopilot became disengaged and the plane slowly began to descend into the ground (National Transportation Safety Board, 1972). A similar accident occurred in 1978, when a United Airlines flight ran out of fuel because the crew was trying to fix a problem with the landing gear. The first officer and flight engineer warned the captain about the problem on several occasions, yet the captain failed to listen (National Transportation Safety Board, 1979). In the military, anti-air warfare systems have become increasingly complex, forcing soldiers to process a large amount of information in a short period of time. The consequence of placing soldiers in such an intense team environment was exemplified in 1988, when a U.S. Navy Aegis cruiser mistakenly shot down an Airbus 300 Iranian commercial airliner (Salas, Driskell, & Hughes, 1996).

Theoretically, teams require employees to attend to additional responsibilities that may alter conceptualizations of the stress process. When individuals are placed in an interdependent team setting, tasks are often completed through the interaction of the team members. This social aspect of teams has recently received attention from scholars interested in socially shared cognition and information processing systems (e.g., Gruenfeld, Martorano, & Fan, 2000; Hinsz, Tindale, & Vollrath, 1997). Employees encode, store, and retrieve information as individuals, but teams process information between as well as within the minds of the team members (Ickes & Gonzales, 1994). In order for teams to be effective, there must be a coordinated exchange of information among the team members (Oser, McCallum, Salas, & Morgan, 1989). Social interaction has been identified as a critical factor in the stress process within teams (Hackman & Morris, 1975; Morgan & Bowers, 1995). Researchers have suggested that stressful environmental conditions may disrupt social interaction by focusing the attention of the team members away from the others and toward themselves (Driskell, Salas, & Johnston, 1999).

Despite the practical and theoretical importance surrounding the study of stress within teams, few researchers have attempted to empirically or conceptually tackle the issue. The purpose of this dissertation is to develop and test a theoretical model of stress in team-based work structures. The basic model is shown in Figure 1. The hypotheses derived from the model are summarized in Table 3. The model draws upon a number of different literatures. To begin the literature review, I discuss how researchers have conceptualized the stress process at the individual level. Then I introduce the literature on groups as information processors in order to show how team members may respond differently than individuals in stressful situations. In particular, when team members are faced with stressful environmental conditions, two social interaction processes may suffer: shared mental models and transactive memory. Next, a number of personal and situational characteristics are introduced as possible moderators of the negative relationship between the presence of stressful environmental conditions and team processes. More specifically, regarding personal characteristics, I examine the level of cognitive ability and the level of extraversion among the team members. Regarding situational characteristics, I examine the amount of prior shared information given to each team member and whether negative feedback is given to one team member or the team as a whole. Finally, team processes are linked to team performance. After introducing the model, a laboratory study is designed in order to test my hypotheses.

Before beginning the literature review, it is necessary to note several characteristics which limit the scope of this study. First, this study is primarily interested in examining acute stress, which Salas, Driskell, and Hughes (1996) define as "sudden, novel, intense, and of relatively short duration, disrupts goal oriented behavior, and requires a proximate response. Acute stress is illustrated by the prototypical 'emergency' situation, in which the scenario unfolds rapidly, the task must be dealt with in a short time period, and the consequences of poor performance are immediate" (p. 6). This study will not deal with chronic stress, which exacts its effects over a much longer period of time.

Second, this study focuses on the negative consequences of stressful situations that are acute in nature. Within the organizational stress literature, most researchers have concentrated on examining the effects of stressful situations on job performance. This has stimulated a longstanding debate regarding whether performance decreases or increases in stressful situations. Some have suggested that the relationship is negative (e.g., Jackson & Schuler, 1985), others have shown that it is positive (e.g., McGrath, 1976), and still others feel that it follows the Yerkes-Dodson law, which results in an inverted, U-shaped curve (e.g., Jamal, 1984). Unfortunately, most empirical research has found weak and inconsistent relationships between the presence of job stressors and performance (see Jex, 1998). As a result, Fried and Tiegs (1995) suggested that "the literature on stress and performance would benefit greatly if researchers concentrated on developing and evaluating theoretically derived linkages between specific job stressors and the specific duties and responsibilities of employees in a particular organizational position" (p. 282).

This study does not examine the direct relationship between acute stressors and job performance. Instead, I theoretically link the presence of acute stressors to the social behavior of project team members. Although I agree that acute stressors can benefit team members, I believe that the presence of acute stressors will negatively affect team members' social reactions. These reactions then are proposed to affect the team's level of performance, supporting researchers who suggest that performance is indirectly, not directly, affected by job stressors (e.g., Beehr & Bhagat, 1985).

Third, research on stress has undergone such a drastic expansion over the last fifty years that there are now at least four broad fields specializing in the study of stress, including medicine, clinical psychology, engineering psychology, and organizational psychology (Beehr & Franz, 1987). Although this study incorporates aspects of each discipline, the primary focus is on the organizational psychology literature. Attempting to summarize all four fields would be impossible and impractical, since many of the concepts do not transfer well across domains.

Fourth, while there are a number of different types of teams that do work in organizations, this study concentrates on project teams. As noted earlier, organizations need to remain adaptive and flexible in order to remain competitive. One way to accomplish this goal is to make sure that the various subsystems within the organization are flexible and adaptive. Employees are now being asked to integrate into team environments as leaders or members, knowing full well that the team will disband in the near future (Allred, Snow, & Miles, 1996). These fast acting, temporary project teams have become the norm within many organizations (e.g., Cohen & Bailey, 1997; Herriot, 1993; Sundstrom, McIntyre, Halfhill, & Richards, 2000; Zemke, 1978). A recent national survey found that 30% of all teams are temporary project teams (Gordon, 1992). Members of project teams are expected to be self-managing, be able to handle novel tasks without prior training, and be willing to invest in a continuous learning process (Allred, Snow, & Miles, 1996). Project team members' day-to-day activities differ from those of other employees, requiring them to move from one task to another on a frequent basis. For example, an employee may be a member of an engineering team for six months and then a member of a production team for the next two months.

In sum, for this study, I am interested in examining team members' social responses to stressful environmental conditions that are time-limited, sudden, and often unexpected. In these types of situations that can occur in a variety of team settings, quick responses are critical to success and the consequences of failure are immediate. However, in this study I am focusing on teams that come together for short periods of time in order to perform a certain set of tasks together. Although this limits the generalizability of my results, acute stress in project teams is relevant to a number of applied settings such as aviation, military operations, the automotive industry, and other industrial occupations.

REVIEW OF THE LITERATURE

Although our knowledge of the stress process in individual employees has grown exponentially over the past fifty years, there is still much we do not know due to the complexity of the phenomenon under study (e.g., Beehr, 1995; Jex & Beehr, 1991; Spector, 1992). The problem has been compounded by researchers' inability to settle on one conceptualization, definition, and operationalization of organizational stress (e.g., Cooper, Dewe, & O'Driscoll, 2001; Mason, 1975; Seyle, 1975). Without a clear conceptualization of the concept, it becomes difficult to determine the nature and direction of research and limits the explanations that can be offered regarding any research findings (Newton, 1995). The difficulties in determining what is meant by organizational stress can be seen in the plethora of definitions offered by researchers. For example, Selye (1956) defined stress as a "nonspecific response to any demand." Caplan and his colleagues (1975) defined it as "any characteristic of the job environment which poses a threat to the individual." Cannon (1929) defined stress as "a condition at work interacting with worker characteristics to disrupt psychological or physiological homeostasis." Others define stress as "a transaction between the person and the environment [that] is evaluated by the person as a harm, threat, or challenge to that person's well-being" (Lazarus, 1991).

The variance in the definitions offered by researchers reflects the four different perspectives of the stress that have been identified in the literature: response-based, stimulus-based, interactional, and transactional. Researchers have often treated these perspectives as distinct, although they share a number of features with one another. In following few pages, I discuss the main thrust of each approach to organizational stress, include examples of the theories that they generated, and note any conceptual or operational problems that have been identified.

The Response-Based Perspective

A response-based approach views organizational stress as a dependent variable, or the employee's response to threatening stimuli. The lay person may find it easy to identify with this perspective, as most people have felt "stressed" at some point in their working lives. Responses usually consist of physical, psychological, and behavioral components, which combine to form a level of "strain" on an employee (Cooper, Dewe, & O'Driscoll, 2001). The origins of this approach to stress research can be linked to medicine. Wolf and Wolf (1943) were some of the first researchers to study stress as a response. Their patient, Tom, exhibited changes in stomach activity when faced with certain environmental conditions. Soon the response-based perspective became a powerful force in stress research, especially with the introduction of Hans Selye's general adaptation syndrome (Selye, 1956).

General Adaptation Syndrome (GAS). Selye (1956) suggested that stress was a nonspecific bodily response to any demand made upon it. An individual's response was invariant to the nature of the stressor, which meant that responses generally followed a universal three-stage pattern: alarm, resistance, and collapse. When faced with a stressor in the environment, the individual exhibits an initial alarm reaction, which is the initial psycho-physical response. At that point, the individual's resistance to the stressor is lowered. After the initial shock phase, the individual enters the counter-shock phase and resistance levels begin to increase. The reaction can be formed as either a "fight or flight response" (Cannon, 1935). The individual's body is ready to take action, as sympathetic activity increases with the release of catecholamines, the metabolism of fat and glucose, and the delivery of oxygen to muscle fibers. The initial alarm reaction is replaced with either the adaptation response or a return to equilibrium. If resistance continues for a long period of time, the individual could enter the last stage of collapse. Energy levels needed for adaptation have been depleted, which could result in exhaustion or even death (Selye, 1983).

The general adaptation syndrome was an influential theory at the time for a number of reasons. For one thing, Selye emphasized that stress reactions are not automatically detrimental. This explanation fits well with an evolutionary perspective, which views stress as a necessary component of developing societies. In the past, individuals had to either stand and confront an enemy or run away from a potentially dangerous situation. This is analogous to the “survival of the fittest” promoted by Darwinism. Everyone is faced with stress and those who react appropriately will carry on, while others will be eliminated. However, despite intuitive appeal, there were problems with applying GAS. In contemporary society, employees’ choices when faced when responding to stress are much more limited. In the workplace, there is little opportunity to physically fight to combat stress or run away from the situation. Employees, for the most part, lead sedentary lives and have no outlet for the psycho-physical response associated with stressful environmental conditions (Sutherland & Cooper, 2000). In addition to problems specific to the GAS, there were also a number of characteristics exhibited by response-based theories in general that reduced their applicability to the organizational stress process.

Problems with the Response-Based Perspective. The major difficulty in viewing stress from a response-based perspective lies in the assumption that the stimulus dimension of the stress experience can be ignored. Research has indicated that responses to different stimuli do not always follow the same pattern. Responses are, in fact, often stimulus-specific and depend on certain types of hormonal secretions. For example, the release of adrenaline seems to occur more frequently in anxiety-provoking situations, while noradrenaline is released in response to aggression-provoking events (Sutherland & Cooper, 2000). Response-based theories also tend to focus on the psycho-physical responses individuals exhibit in a stressful situation and ignore psychological responses, which reduces their applicability in situations that stimulate psychosocial stress (Christian & Lolas, 1985). Another problem with response-based theories is that they tend to disregard individual differences, which are considered important aspects of the stress process (e.g., Cox, 1990; Sutherland & Cooper, 1990). As a result, response-based theories are seen as representing only one component of the stress process (Cooper et al., 2001). In order to offer a more comprehensive conceptualization of the concept, researchers began to utilize different approaches to examining stress within organizational settings. This moved the study of stress away from response-based models to stimulus-based models.

The Stimulus-Based Perspective

Researchers examining stress from a stimulus-based perspective assume that there are certain forces that affect an individual in a disruptive fashion and are primarily interested in identifying such potential "stressors" for employees (Goodell, Wolf, & Rogers, 1986). This perspective is rooted in physics and engineering, where stress is viewed as a force exerted on a certain object. Objects possess certain tolerance levels protecting them against such external forces. When those tolerance levels are exceeded, the object is distorted in some fashion. Depending on the strength of the force, temporary or permanent damage could result (Sutherland & Cooper, 2000). Within organizations, employees confront external forces that arise primarily from certain aspects of their job. In an effort to better delineate some of the specific core characteristics of jobs that act as stressors, researchers developed the job characteristics model of stress (e.g., Beehr, 1985).

The Job Characteristics Model. The job characteristics model has identified a number of job characteristics that are considered to be stressors, including role ambiguity, role overload, role conflict, underutilization of skills, job insecurity or actual job loss, and lack of participation in organizational decision making (e.g., Beehr, 1976; Beehr, Walsh, & Taber, 1976; Caplan, Cobb, French, Van Harrison, & Pinneau, 1975; French & Kaplan, 1973). These job characteristics result in feelings of uncertainty among employees, and the longer the uncertainty continues, the more severe the levels of stress (Beehr, 1985; Ivancevich & Matteson, 1980). Although a number of studies support the idea that altering certain job characteristics can produce a more optimal work environment (see Hackman & Oldham, 1980), stimulus-based theories encounter the same problems as their response-based counterparts.

Problems with the Stimulus-Based Perspective. Like the job characteristics model, most stimulus-based theories of job stress subvert the importance of individual differences in the stress process. Despite the inclusion of a small subset of individual difference variables, such as growth need strength and experience in the job characteristics model, these theories generally assume that the environment plays the primary role. However, most researchers now agree that the situation and the person often play equal roles in the stress process. For example, variability in tolerance levels and expectations could explain why two individuals react differently when exposed to the same situation (Cooper et al., 2001). The stimulus-based perspective, like the response-based perspective, focuses too much on one end of the stimulus-response paradigm. Due to problems with both the stimulus and response-based approaches to organizational stress, researchers began to move toward those processes that link the individual with the environment. The result was an effort to examine stress as an interaction between person and situation.

The Interactive Perspective

The interactive model of stress embodies aspects of both the response-based and stimulus-based models of stress. In this combined model, the presence of certain working conditions is thought to be associated with a number of stress responses. Various organizational characteristics, situational factors, and individual differences then moderate this stimulus-response paradigm. Researchers have identified a number of interactive models of the stress process within the literature, including the job demands-control model, the cybernetic model, and the P-E fit approach (e.g., Cooper et al., 2001; Cummings & Cooper, 1979; Edwards & Cooper, 1988; Eulberg, Weekly, & Bhagat, 1988; Kahn & Byosiere, 1992).

The Job Demands-Control Model. The job demands-control model of stress was initially developed by Karasek (1979) who proposed that workers become stressed as a result of the interaction between job demands and job control. "Job demands are defined as psychological stressors, such as requirements for working fast and hard, having a great deal to do, not having enough time, and having conflicting demands . . . Job decision latitude [or control] comprises two components: the worker's authority to make decisions on the job (decision authority) and the variety of skills used by the worker on the job (skill discretion). Operationally these two components are combined into one measure of decision latitude, or control" (Ganster & Schaubroeck, 1991, pp. 241-242). Karasek felt that stress occurs primarily in "high-strain" jobs, which are high in demands and low in control. In "active jobs," where demands and control are both high, employee satisfaction, motivation, and healthful regeneration can result. "Job demands put the employee into an aroused or motivated state. If this aroused or motivated state is accompanied by low decision latitude or control over the job, this arousal will not be released in the normal execution of the job. It is this non-release, according to Karasek, which leads to negative psychological and physical consequences" (Jex & Beehr, 1991, p.322).

The job demands-control model of stress has garnered quite a bit of interest from researchers since its introduction and a number of its components have been empirically supported. Researchers have found that indices of strain and ill-health are positively related to the demands of the job and negatively related to the employee's level of control (e.g., Fletcher & Jones, 1993; Krasek, 1979; Landsbergis, 1988; Parkes, Mendham, & von Rabenau, 1994). The results regarding the hypothesized interactive effects of job demands and control, however, have been much more ambiguous. Although initial efforts supported the interaction effect (e.g., Karasek, 1979), the statistical techniques that were used were inadequate and possibly inflated the effect sizes (Edwards & Cooper, 1990;

Ganster & Fusilier, 1989). Subsequent efforts failed to confirm the predicted interaction effect (e.g., Carayon, 1993; Fletcher & Jones, 1993; Hurrel & McLaney, 1989; Landisbergis, 1988; Payne & Fletcher, 1983; Spector, 1987). Despite the presence of a few studies supporting the interaction (e.g., Dwyer & Ganster, 1991), researchers concluded that the model's "empirical validity has yet to be established" (Ganster & Fusilier, 1989, p. 254).

Due to the inconsistent results, researchers have suggested that the job demands-control model may be deficient in some respect. Researchers feel that Karasek's model neglects to measure certain variables that could influence the interactive effects of job demands and employee control (e.g., Schaubroeck & Merritt, 1997). Some have focused their attention on the level of co-worker social support within the workplace and have found results that are generally supportive of a three-way interaction between job demands, control, and social support (e.g., Johnson & Hall, 1988; Parkes, Mendham, & Von Rabenau, 1994). The job demands-control interaction holds only when there is little social support within the workplace. Others have concentrated on the effects of domain-specific individual differences. Although Karasek's (1979) model is interactive, both variables are environmental in nature. The model, by neglecting the interaction between person and environment, assumes that the main propositions will remain applicable across all employees (Xie, 1996). Schaubroeck and Merritt (1997) found that the demands-control interaction holds for people who are high in self-efficacy because they feel confident in their ability to do their job. Although these results support the addition of individual difference variables to Karasek's model, other interactive stress theories, such as the cybernetic approach and P-E fit theory, do a better job of combining the person and the situation.

The Cybernetic Framework. Cybernetics involves the functioning of self-regulating systems and was developed by researchers in order to explain how individuals use information and feedback to control purposeful behavior (Weiner, 1948; Ashby, 1956). At the heart of the theory is the negative feedback loop, which operates through a number of distinct steps. First, an individual constructs a perception of the environment, which gets sent via an input function to the comparator. Then the comparator evaluates the perceived environment against a relevant reference criterion and, if there is a discrepency, an output function gets sent back in order to change the environment, thereby reducing or eliminating the discrepancy. The basic premise assumes that, when an individual realizes that he or she deviates from a certain goal state, they will be motivated to engage in certain behaviors to rectify the discrepancy (Edwards, 1992).

Initially, researchers in the biological and physical sciences used cybernetics to explain how systems adjust to disturbances (see Cummings & Cooper, 1979). However, the theory can easily be translated to fit into the organizational stress literature. Basically, "the theory defines stress a discrepancy between an employee's perceived state and desired state, provided that the presence of this discrepancy is considered important by the employee" (Edwards, 1992, p. 245). According to cybernetic theory, stress does not result from individual or environmental factors alone, but rather from an ongoing relationship between the two. Variables in the physical and social environment, the employee's personal characteristics, social information, and the employee's own construction of reality influence an employee's perceptions. These perceptions are then compared to the employee's own desires, which refer to any state or condition that the employee consciously wants. When the employee's perceptions and desires do not match, stress is often the result. This can affect the employee's psychological and physical health, as well as any efforts to cope with the problem (Edwards, 1992).

Although cybernetics offers a comprehensive, interactive view of the stress process, little has been done to empirically test the model. One reason may be that it is impossible to operationalize several of the more important concepts, such as the employee's perceived and desired states. Work stressors "frequently present employees with a myriad of subtle and contradictory signals, making it difficult to interpret what is real or imaginary. Direct knowledge of the states of these situations is also rarely available" (Cummings & Cooper, 1979, p. 404). There are both environmental and individual variables that make the assessment of actual work conditions difficult. Even if an employee is able to evaluate their perceived and desired states, it is not clear that they are comparable (Cummings & Cooper, 1979). Researchers have noted that there are a number of substantive and methodological problems with measuring the discrepancy between two variables (e.g., Cronbach & Furby, 1970; Johns, 1981). Difficulties in testing the cybernetic model of stress have reduced its practical and theoretical contribution to the literature. P-E fit theory has encountered similar problems, although there have been some initial attempts to test its validity.

<u>The P-E Fit Model</u>. The P-E fit model of organizational stress has been one of the most popular perspectives within the literature (e.g., Edwards, 1991, 1996; Edwards & Cooper, 1988; Edwards & Van Harrison, 1993). The theory rests on the assumption that employees feel a certain level of strain when they are out of equilibrium with the

environment, due to the presence of unmet needs and demands (Cooper et al., 2001). Two major versions of P-E fit have been identified: supplies-values (S-V) fit and demand-abilities (D-A) fit. S-V fit compares the employee's values with the aspects of the environment that have the potential to fulfill those values. Values can include a number of different internal characteristics, such as interests, motives, and goals (e.g., Cummings & Cooper, 1979; Edwards, 1992). When the environmental supplies cannot satisfy an employee's values, the employee will begin to feel more and more strained at work (e.g., Cummings & Cooper, 1979; Edwards, 1996; French, Caplan, & van Harrison, 1982). D-A fit, on the other hand, compares the knowledges, skills, and abilities of the employee with the demands of the job. Demands can be quantitative, qualitative, objective, or socially constructed. When the demands exceed the employee's ability level, strain can result (e.g., Edwards, 1996).

The P-E fit model of stress is intuitively simple. However, empirically testing the model has proven to be difficult, due to problems measuring relevant constructs (i.e., environmental supplies) and specifying the nature of person-environment misfit (Edwards & Cooper, 1988). Theoretically and methodologically, there are three forms of fit that can be examined. Researchers can calculate the discrepancy between P and E, the interaction between P and E, or the proportion of P that is fulfilled by E. Often these three interpretations are treated as interchangeable, despite recommendations to the contrary. Once researchers choose one form of fit, they still need to worry about the use of difference scores, the number of fit dimensions to include, and the measurement of the P and E components (Edwards & Cooper, 1990). Furthermore, although researchers have recently found some support for the P-E model of stress (Edwards & Van Harrison, 1993), there are a number of characteristics common to all interactive theories that the P-E model cannot avoid.

Problems with the Interactive Perspective. The interactive approach to stress research attempted to build upon previous theories, which focused solely on the stimulus or response side of the equation. However, the interactive approach is simply based upon the statistical interaction between the stimulus and the response. Although some theories (e.g., cybernetics) try to break out of this rather static mold, interactions generally ignore the process itself (Cooper et al., 2001). When restricted to simple cause and effect relationships, the complex stress process can only be further understood by adding additional moderator variables into the equation (e.g., Lazarus & Launier, 1978). Researchers have noted that "it is important now to move beyond the simple identification of potential moderator variables to more comprehensive theories that attempt to explain the mechanisms by which all relevant factors interact" (Cooper et al., 2001, p.11). Dissatisfaction with incomplete versions of the stress process led researchers to propose that the relation between environmental demands and the individual's response should be emphasized (McGrath, 1976). This more relational perspective led to the development of a transactional approach to the stress process.

The Transactional Perspective

The transactional approach represents a fundamental shift in how stress is conceptualized and research is conducted. Previous theories following response-based, stimulus-based, and interactive perspectives of the stress process viewed the causes and consequences of stress as conceptually distinct. However, the transactional perspective, as the name suggests, considers these constructs as "defined relationally and ultimately become inseparable from the context within which the stressful encounter takes place" (Cooper et al., 2001, p. 13). Researchers espousing this viewpoint believe that the cognitive appraisal and coping that underlie the stress process are critical for advancing our understanding of the concept of stress within the workplace.

According to the theory, employees engage in two forms of cognitive appraisal: primary appraisal and secondary appraisal during a stressful encounter. First, the employee determines, through primary appraisal, whether the situation they are encountering represents harm, threat, or challenge. If the situation is appraised as threat to the employee's well-being, the secondary appraisal process begins to search for the appropriate coping resources (e.g., Lazarus, 1966; Lazarus, 1991; Lazarus & Folkman, 1984, 1987). Lazarus (1995) defines coping as "the cognitive and behavioral efforts a person makes to manage demands that tax or exceed his or her personal resources" (p. 6). Like other theories (e.g., P-E fit theory), a stressful situation from a transactional perspective disrupts the employee's level of homeostasis, which must be rectified. However, the transactional approach sets itself apart from other theories by concentrating on the adaptive process of meaning, adjustment, and coping, instead of structural relationships between person and environment (Dewe, Cox, & Ferguson, 1993).

<u>Problems with the Transactional Perspective</u>. Although a number of researchers feel that the transactional approach represents a major advance in our thinking regarding the organizational stress process (e.g., Cooper et al., 2001; Harris, 1991; Salas, Driskell, & Hughes, 1996), it is not immune from criticism. A number of problems stem from the empirical approach researchers are forced to take when attempting to verify and test any transactional theory of stress. In essence, the transactional approach views stress as a

dynamic, ongoing relationship between person and environment. As a result, typical nomothetic research designs do not represent an adequate test of the model and must be dropped in favor of more ideographic designs. This may help researchers understand the stress process within one individual, but provide little insight into the cognitive processes or emotions of others. In fact, "the limited generalizability of ideographic findings present a chronic problem in the verification and testing of the transaction process approach" (Harris, 1995, p. 26).

By focusing on the individual, the transactional approach tends to neglect the environment. Although knowledge regarding specific stressful environmental conditions is helpful, transactional researchers believe that it has received adequate attention within the literature. If the study of stress is to move forward, researchers need to "generate knowledge about the kinds of persons who are more or less vulnerable to divergent sources of stress" (Lazarus, 1995, p. 10). However, by ignoring the situational part of the equation, the transactional approach leaves a number of questions unanswered. For example, what is it about the workplace that activates the stress and coping processes? Applied psychologists are particularly interested in the answer, as one of their duties is to inform organizations regarding potentially harmful working conditions. Brief and George (1995) note that "the challenge to organizational researchers is the development of theory to guide one to identify those conditions of employment likely to affect adversely the psychological well-being of most persons exposed to them" (p. 16). Transactional researchers, supporting an ideographic perspective, limit themselves to better understanding the cognitive processes of stress for single subjects while ignoring the environment (Harris, 1995).

Several problems also lie in the conceptualization of the coping process. Lazarus and Folkman (1987) suggest that individuals select different coping strategies for different situations based on their level of individual control. The coping strategies they select then act as mediating variables, altering the relationship between the person, the environment, and the emotional response. However, this perspective fails to recognize that individuals may possess a particular coping style that they tend to rely on across situations (e.g., Newton, 1989). If coping style is recognized as a variable, then the relationship becomes a moderated one. This would change the relationships among the variables included in the transaction and would modify the analytical strategies that could be used to test the model (Harris, 1995). Another conceptual difficulty involves the recursive nature of the theoretical arguments behind the coping process. Folkman and Lazarus (1988) note that "the relationship between emotion and coping in stressful encounters is bidirectional, with each affecting the other" (p. 466). However, this makes it difficult to determine whether stress affects coping or coping affects stress (Harris, 1995).

Summary.

Clearly there has been quite a bit of debate within the literature regarding the conceptualization of stress within the workplace. Some have viewed it as a response, others as a stimulus, others as an interaction, and still others as a transaction. Conceptual and operational difficulties abound, no matter which perspective is adopted by researchers. My intention in reviewing the four major perspectives of the stress process identified in the literature was not to denigrate their contribution to our understanding of occupational stress. Each has the potential to further our understanding of organizational stress, depending on the situation (Cooper et al., 2001).

In this study, the focus is on the effects of acute stressors within temporary project teams. Going back to the earlier definition of teams, team members must *interact* with one another in order to achieve their common goals and objectives because each team member depends on others to get the job done. The social interaction between team members has been shown to be an integral part of team decision making and problem solving (e.g., Gouran & Hirokawa, 1983; Hackman & Morris, 1975; Hirokawa & Scheerhorn, 1986), allowing team members to pool information and resources (e.g., Barnlund, 1959; Marquart, 1955; Zaleska, 1978), catch errors and reject inaccurate statements (e.g., Shaw, 1932; Taylor & Faust, 1952), and influence the decisions of others (e.g., Riecken, 1958). As group members interact, a certain chemistry is created through the synthesis of ideas and viewpoints that controls much of what the team does within the organization (Poole & Hirokawa, 1986). Although the chemistry can be faulty (e.g., Janis, 1972), social interaction is an essential component of any team. In fact, researchers consider interaction to be the key to understanding team behavior (Hackman & Morris, 1975).

However, little is known about how the social chemistry between team members reacts in stressful situations. In order to further our understanding of the stress process within teams, the interactive nature of teams needs to be taken into account (Cannon-Bowers & Salas, 1998; Morgan & Bowers, 1995). As a result, this dissertation focuses primarily on the social responses of team members to the presence of acute stressors. Given the situation, the conceptualization of the stress process that is most appropriate is the response-based perspective. Therefore, in Figure 1, the emphasis will be placed on team processes and how they change when acute stressors are introduced. Aspects of other perspectives of the stress process will be included, but will only play a secondary role.

In order to develop my response-based model of stress, I base the remainder of the literature review on the emerging view of groups as information processors. Researchers have suggested that this perspective is particularly useful model for understanding the social processes that occur within groups and holds promise as a meta-theoretical foundation for explaining many group phenomena (Hinsz et al., 1997). In the next section, I describe how groups and teams have been conceptualized as information processing systems within the literature. Then I explain how the collective information processing capabilities of team members can be disrupted by the introduction of acute stressors.

By utilizing information processing theory to examine the implications of team members' behavioral responses in stressful situations, I hope to better understand stress within teams, not team stress. I am not interested in developing an emergent theory of stress at the team level. Emergence occurs when individuals interact and create a collective construct that originates in their individual cognition, affect, behaviors, or other characteristics (e.g., Kozlowski & Klein, 2000). I do not suggest that stress exhibits emergent properties that alter the conceptualization of the construct at the team level. Team members feel stress just like other employees and respond similarly when faced with stressful environmental conditions. However, the implications of such responses may be much different in team situations, where employees are required to work interdependently with one another.

Teams as Information Processors.

Work groups and teams are facing tasks that are increasingly intellectual and cognitive in nature (Galegher, Kraut, & Egido, 1990; Salas, Dickenson, Converse, & Tannenbaum, 1992; Walsh & Ungson, 1991; Weick & Roberts, 1993). As a result, researchers have begun to extend methodological and theoretical developments in cognitive psychology that have traditionally been targeted toward individuals in order to better understand how groups and teams process relevant and available information in order to accomplish their goals (e.g., Bazerman, Mannix, & Thompson, 1988; Hastie, 1986; Hinsz et al., 1997; Hinsz, Vollrath, Nagao, & Davis, 1988; Ickes & Gonzales, 1994; McGrath & Hollingshead, 1994; Tindale, 1989).

For instance, among individuals, researchers define information processing as a sequence of operations within the human mind that takes in information, transforms it, and produces some sort of output. This sequence can take on a number of different forms, although researchers have suggested that there are certain elements that remain fairly consistent. These components are shown in Figure 2. An individual, when placed in a certain context, initially possesses a *processing objective* that directs his or her search of the environment. Individuals generally look for information that fulfills a certain objective, mission, goal, etc. While searching, individuals attempt to actually perceive the information in the *attention* phase. This information is then evaluated, interpreted and transformed through an *encoding* process that prepares it for *storage* within the mind. To get the information out again, the individual must *retrieve* it. The encoding, storage, and retrieval process follows certain rules that are contained in the individual's processing workspace. Based on the information that comes out of the processing workspace, the individual will likely make some sort of *response* that could involve making a decision or solving a problem.

The core elements that comprise an individual's information processing system have recently been transferred to groups and teams (Hinsz et al., 1997). However, that does not mean that the two systems are identical. In groups and teams, information processing occurs between as well as within the minds of the group members (Ickes & Gonzales, 1994). Information, ideas, and cognitive processes can all be potentially shared within the group or team through verbal or nonverbal interaction. Hinsz and his colleagues (1997) define information processing in groups as "the degree to which information, ideas, or cognitive processes are shared, and are being shared, among the group members and how this sharing of information affects both individual- and group-level outcomes" (p. 53). The social nature of teams changes the way that each component functions within the larger network as interactions and the interdependence between team members enter each phase of the process.

Processing objectives within teams still represent a targeted search of the environment. However, the team members need to have a common or shared frame of reference for the processing objective. If the search pattern is fragmented within the team, each team member could treat important information differently. For example, if a men's basketball team is playing defense and one team member thinks they are playing man-to-man while the rest of the team thinks they are playing a zone, that team member will be looking for different pieces of information. Instead of picking his spot on the floor, he will look for his man. By ignoring or misinterpreting certain pieces of information due to separate processing objectives, the system may break down and the other team may score a basket.

Like individuals, teams need to pay attention to information to process it. However, it is not necessary for all the team members to pay attention to all the information needed by the team. Through interaction, individuals can be assigned to perceive a certain set of information so that the team members are not overloaded. In addition, if one team member perceives an important piece of information, he or she can bring it to the team's collective attention. Only a small subset of team members need to perceive the information in order for the team to perceive it as a whole (e.g., Laughlin, 1980; Stasser & Titus, 1985, 1987). For instance, the basketball team, while playing defense, may encounter a point guard who is too quick for their players. When the point guard drives to the hoop, he always scores. So the team members playing defense on the perimeter yell "drive" whenever he drives to the hoop. At that point, their teammates converge under the basket, knowing that an opposing player is coming, although they did not perceive the initial move themselves.

The collective nature of the information processing system within teams continues in the encoding stage. At that point, team members' individual representations need to be combined into a representation for the entire team (Wilson & Canter, 1993). Sometimes team members may attach different meanings to the same information, so the team would not share a representation of the information. If encoding is allowed to occur with variance in team members' mental representations, problems could arise at a later point in time (Bettenhausen & Murnighan, 1991; Kim, 1993). To avoid such problems, and to facilitate the encoding process, any differences should be brought up within the team as soon as possible through open and direct communication. Going back to the basketball team, one team member could call a time-out if he feels that things are not going as well as they could be. When he yells "drive," one of his teammates does not move to the basket and instead sets up on the perimeter. By interacting, the team members can all converge on one interpretation of the word "drive" during the game.

Once the team has a shared representation of the information attended to by the separate team members, they need to store it in memory for later use. Researchers have noted that groups are often better than individuals at a number of memory tasks (e.g., Clark & Stephenson, 1989; Hartwick, Sheppard, & Davis, 1982; Stewart & Stasser, 1995; Yarmey, 1992) because their storage capacity is much larger (Hinsz, 1990). When faced with a complex task, team members do not have to remember all of the information that the team needs because they are able to interact with one another. Each team member can be given a set of information to store in memory. If the team needs the information, its members can ask for it and an individual team member can retrieve it from memory. In the basketball game, the team members do not all need to remember who goes to the basket and who goes to the perimeter when the point guard drives. When someone yells "drive," each team member has their own set of information in memory that tells them where to go on the floor.

By splitting up the storage duties, teams are better able to retrieve the information (Stasser, Stewart, & Wittenbaum, 1995). For one thing, teams draw on multiple memories, which helps them catch any retrieval errors made by one team member. In addition, if one team member remembers one set of information, it can stimulate other team members' retrieval processes (e.g., Martell & Borg, 1993; Meudell, Hitch, & Kirby, 1992). If one of the basketball players goes to the basket when he hears "drive," it may stimulate another player's memory so they are both there when the opposing player reaches the hoop.

The culmination of the processes described above is the collective response of the team members. When one team member yells "drive," two team members move to the basket, two team members converge on the ball, while the rest spread out around the perimeter to defend against any outside shot. The team will succeed in defending its basket as long as they have concentrated on sharing and disseminating information during each phase of the information processing system.

Summary. Utilizing an information processing framework to describe how groups and teams deal with cognitive and intellectual tasks has helped researchers understand the importance of social processes (Fiske & Goodwin, 1994; Hastie & Pennington, 1991; Ickes & Gonzales, 1994; Levine, Resnick, & Higgins, 1993; Neisser, 1982; Resnick, Levine, & Teasley, 1991; Wegner, 1987). The information processing system maps out the specific function of group interaction and communication at each phase of the process, beginning with the team's processing objectives and ending with the team's response. As noted earlier, researchers have always known that team members need to communicate with one another in order to accomplish their goals (e.g., Hackman & Morris, 1975). However, an information processing framework provides a window into the exact nature of those processes. It helps researchers understand when, why, and how information is shared and combined within the team. Disrupting the flow of communication could be potentially disastrous for the team. For example, going back to the basketball team, it is critical that someone yells "drive" when the point guard on the opposing team drives to the hoop. If one team member perceives an initial move to the hoop by the point guard, but is distracted by the sight of a celebrity in the crowd, he may delay his cry of "drive" for a couple of seconds. Those few seconds may allow the point guard to get through the defense for an easy lay-up. If the game is close, success or failure could depend on the timely communication of information within the team. Clearly the flow of information within the team needs to be unfettered if the team wishes to reach its goal. By better understanding how interaction operates within teams, researchers can more easily pinpoint possible obstacles to free and open communication. This study examines one potential obstacle, the presence of acute stressors, which may impair the team members' ability to interact with one another while attempting to reach their objective.

<u>The Effects of Acute Stressors on Information Processing within Teams</u>.

Researchers have long suggested that stress may be related to interaction processes within teams (Hackman & Morris, 1975). Although there has been some direct support for this proposition in the organizational literature, cognitive researchers interested in the scope of human attention have provided quite a bit of indirect support. When individuals are immersed in stressful situations, their breadth of attention narrows (Bacon, 1974; Baddeley, 1972; Bahrick, Fitts, & Rankin, 1952; Combs & Taylor, 1952; Easterbrook, 1959; Pennebaker, Czajka, Cropanzano, & Richards, 1990; Wachtel, 1968). For example, Bursill (1958) asked subjects to perform a primary pursuit tracking task while at the same time detecting intermittent visual signals provided by a number of lamps surrounding the tracking task. As he raised the temperature in the room, subjects' experienced began to perform more poorly on the secondary detection task, indicating that their attention span began to selectively deteriorate. Using a similar task environment, researchers have been able to successfully replicate Bursill's findings (e.g., Hockey, 1970a; Hamilton & Copeman, 1970).

Additional support for attentional narrowing in the presence of acute stressors has been provided by a number of other researchers. Hockey and Hamilton (1970) presented subjects with a series of words on eight separate slides in a noisy or a quiet environment. After a short break, the subjects were asked to recall what the words were. They were also required to indicate which corner of the slide the words appeared in: a task they were not aware of from the start. Subjects in the noisy environment ignored the secondary task. Hockey, Dornie, and Hamilton (1975) asked subjects to read through one of two interleaved passages. Subjects' recognition memory was then tested for words appearing in both passages. Under noisy conditions, subjects focused their attention on, and were better able to recall words from, the primary passage.

Although the results of Bursill and Hockey and his colleagues are intriguing, the performance decrement on the secondary task could have been partially due to the distracting nature of the environmental stressors that were manipulated. In an effort to remedy this potential confound, Weltman, Smith, and Egstrom (1971) compared two groups of divers on central and peripheral signal detection tasks. One group was told that they would experience conditions similar to a 60-foot dive, even though the pressure was kept constant across both groups. Divers who thought they were under extreme pressure concentrated much less on the peripheral signal detection task, supporting previous results.

The rather consistent findings suggest that, despite the fact that a few studies have failed to find similar effects (e.g., Hockey, 1970b), an individual's scope of attention narrows in stressful situations as they prefer to pay attention to sources of information that are considered to be a priority (Hockey, 1979). Although individuals may occasionally benefit by ignoring secondary task information (Edland & Svenson, 1993), it may be extremely detrimental in a team setting.

In teams, attention can be focused on the situation, the task, the self, or the group (Hinsz et al., 1997). Researchers have suggested that, when a team member's scope of attention narrows in the presence of acute stressors, their level of interaction with other team members may be significantly reduced and they may become more self-focused and less team-focused (Driskell & Johnston, 1998; Driskell, Salas, & Johnston, 1999). This idea has been supported by Cohen (1978, 1980), who felt that individuals possess a certain level of attentional capacity. When acute stressors are introduced, an individual is forced to monitor potentially threatening stimuli, while at the same time inhibiting a natural response to the stimuli. Therefore, an individual must set priorities for his or her attention. The most common strategy is to focus attention on one's own goals while neglecting less important social cues. The threat rigidity thesis takes a similar perspective, suggesting that individuals, groups, and organizations tend to behave rigidly in threatening situations. In groups and teams, rigid behavior consists of narrowing fields of attention, simplifying information codes, and reducing the number of information channels used by each individual. This results in a system that is not sufficiently diversified or flexible, which can be maladaptive during radical environmental shifts (Staw, Sandelands, & Dutton, 1981).

This tendency for team members to become more self-focused and less team-focused when narrowing their attentional fields in stressful situations has been supported by a number of researchers. Gladstein and Reilly (1985) found that group members experiencing an external threat used fewer communication channels and exhibited less interaction than group members in a control group. Others have found that individuals reduce their level of prosocial behaviors. For instance, individuals are less likely to engage in altruistic behavior (Aderman, 1972; Cunningham, Steinberg, & Grev, 1980; Isen, Clark, & Schwartz, 1976; Isen & Levin, 1972; Rosenhan, Salovey, & Hargis, 1981) and are less likely to help others (Mathews & Canon, 1975) when acute stressors are present. These results may reflect on the research by Rotten, Olszewski, Charleton, and Soler (1978), who found that individuals in stressful situations have difficulty differentiating between people in different roles. As a result, "linkages between members may become confused and thus people do not have a clear perception of what they can expect from one another, with whom they can relate, [and] how they can relate to one another" (Torrence, 1954, p. 754).

Summary. The research described above indicates that acute stressors narrow the scope of attention within teams, forcing team members to focus on tasks that are considered to be a priority. Team members, as I have defined teams, are interdependent and need to divide their attention between completing their own tasks and coordinating with other team members through interaction and communication. When team members' attention narrows, they focus on their own tasks and neglect to interact with their teammates. I propose that this decreases the ability of teams to process information. In a collective information processing system, information needs to be processed within as well as among the minds of the team members (Ickes & Gonzales, 1994). When acute stressors are introduced, each team member is likely to focus on processing information in his or her own mind, while neglecting to process the information between the minds of his or her teammates. This weakens the interconnections between the team members and negatively affects the ability of the team as a whole to develop processing objectives, attend to important pieces of information, encode, store, and retrieve the information, and come up with an appropriate response. As a result, the definitions of stress offered earlier need to be extended to incorporate the collective information processing requirements of teams. I suggest that, from a response-based perspective, stress occurs when, in the presence of acute stressors, team members narrow their scope of attention and reduce their level of interaction, thereby disrupting the team's collective information processing capabilities. The implications of this disruption can be quite widespread. In particular, team processes, which are an inherent part of the team's collective information processing system, may suffer.

<u>Team Processes</u>

Team processes represent the mechanisms that determine whether team members are able to successfully combine their capabilities and behavior into some sort of functional output. If the team wishes to be effective, the processes working within the team must be running smoothly (McGrath, 1964). A variety of team processes have been identified within the organizational literature, including coordination, cooperation, cohesion, climate, collective efficacy, and team learning (see Kozlowski & Bell, 2001). For the most part, team processes require that team members communicate and interact with one another. However, this study focuses on two interaction-dependent team processes that fit particularly well into an information processing framework: shared mental models and transactive memory.

Shared Mental Models. When individuals interact with their environment, a psychological representation is created to explain the behavior of the world around them, recognize and remember how things are related to one another, and predict future events (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Rouse & Morris, 1986). These types of organized knowledge structures have been termed mental models in the organizational literature (e.g., Mathieu et al., 2000). As a general definition, a mental model is a "mechanism whereby humans generate descriptions of system purpose and form, explanations of system functioning, and observed system states, and predictions of future system states" (Rouse & Morris, 1986, p. 360). Mental models can help individuals process information in a rapid and flexible manner by providing them with a heuristic that connects and classifies different aspects of their environment (Cannon-Bowers, Salas, Converse, 1993; Rumelhart & Ortany, 1977).

Team members also utilize mental models in order to remain adaptive in environments that are constantly changing (Cannon-Bowers et al., 1993). However, in addition to understanding their own environment, team members must also understand how the characteristics, duties, and needs of their teammates fit in (Prince, Chidester, Bowers, & Cannon-Bowers, 1992). Researchers have suggested that, because they interact within a common environment, team members develop shared mental models (Cannon-Bowers, Salas, & Converse, 1990; Kleinman & Serfaty, 1989). According to Oransanu and Salas (1993), shared mental models represent organized knowledge structures that are mutually held by the team members. Team members do not have to possess identical knowledge structures, but they should be compatible and they should lead to common expectations. When confronted with a certain situation, most if not all of the team members should think about and interpret it the same way (Cannon-Bowers et al., 1993). Common expectations can help teams adapt to environmental shifts by coordinating the behavior of each team member (e.g., Cannon-Bowers & Salas, 1990; Cream, Eggemeier, & Klein, 1978; Gabarro, 1990).

Team mental models begin to develop during training, or at the "forming" stage (Tuckman, 1965), where team members begin to learn declarative and procedural knowledge regarding the task. As their knowledge base grows, team members may begin to share different ideas about how to work together. Occasionally, team members' perspectives may clash with one another (i.e., "storming"), but ultimately the team will reach some level of understanding of the nature of the team, the task, and the rules governing behavior (i.e., "norming"). However, the development process does not end there. Although shared mental models become more detailed through experience (McClure, 1990), they are constantly changing in reaction to the environment.

If team members' shared mental models do not adapt accordingly, team decision making and effectiveness will likely suffer (Cannon-Bowers & Salas, 1990; Cannon-Bowers et al., 1993; Oransanu & Salas, 1993). This is likely a result of the contribution of shared mental models to the collective information processing capabilities of teams. Teams need some sort of strategy, heuristic, procedure, or integration technique to organize and process information (Hinsz, 1995). In the team's information processing system, this relates to the encoding stage, where team members' individual representations need to be combined into a representation for the entire team. Team members need to share their mental representations of the information they are presented with if they want to avoid problems at a later point in time (Hinsz et al., 1997).

If teams utilize shared mental models to facilitate the collective encoding process, any disruption to the information processing system could have dire consequences. One such disruption, the presence of acute stressors, creates a shift in emphasis away from the team to the individual. Team members focus less on interacting with each other so that they can complete their own task-related duties. Consequently, the interconnections between the team members become weakened. This could negatively affect the encoding process by slowing the development of shared mental models. Researchers have suggested that shared mental models develop only if team members interact and communicate with one another (Donnellon, Gray, & Bougon, 1986; Innami, 1992). Once team members enter the "norming" stage, communication and interaction may not be as essential because team members' mental representations have reached maturity. Unfortunately, project teams, which form for short periods of time, still need communication and interaction because the majority of their time is spent in the "forming" and "storming" stages. When unusual task circumstances present themselves (i.e., acute stressors), teams often rely on the shared mental models that are already in place (Cannon-Bowers & Salas, 1997). This could be especially detrimental for project teams, who still need to develop their mental representations and common behavioral expectations. Therefore, I propose that, by reducing the amount of team-related interaction, acute stressors prevent the team from fully developing shared mental models.

However, certain shared mental models may be affected more by stress than others. A number of researchers have suggested that team members possess different types of shared mental models (e.g., Cannon-Bowers et al., 1993; Mathieu et al., 2000; Rentsch & Hall, 1994). Kilmoski and Muhammed (1994) note that "there can be (and probably would be) multiple mental models co-existing among team members at a given point in time. These would include models of task/technology, of response routines, of team work, etc." (p. 432). In an effort to bound the literature, Mathieu and his colleagues (2000) developed a typology of mental models that included four broad categories. First, team members can possess a mental model of the technology or equipment that they are using. Second, they can hold shared job or task models that deal with procedures, strategies, etc. that can be used to complete a task. Third, team members can collectively understand the flow of communication within the team. According to Mathieu and his colleagues, "these models describe the roles and responsibilities of team members, interaction patterns, information flow and communication channels, role interdependencies, and information sources" (p. 275). Fourth, team members can hold shared team member mental models. These types of models include "information that is specific to member's teammates- their knowledge, skills, attitudes, preferences, strengths, weaknesses, tendencies, and so forth" (Mathieu et al., 2000, p. 275). The last two mental models, the interaction and team member models, are considered to focus on team-related aspects of the situation, while the first two models focus on task-related aspects of the situation. The models that focus on team-related aspects of the situation develop primarily through communication between the team members. I expect the development of the latter two models to be particularly susceptible to the presence of acute stressors, which are likely to focus attention away from the team and toward the task. Therefore, I hypothesize the following:

Hypothesis 1. The presence of acute stressors will be negatively related to shared interaction and shared team member mental models in temporary project teams.

Transactive Memory. Another team process that may be affected by the presence of acute stressors is transactive memory. Transactive memory has been utilized by Wegner (e.g., 1987) to describe how couples in close relationships remember pieces of information. When couples have been together for a long period of time, they begin to learn things about each other's memories. For instance, one partner may not be able to find the bath towels, but he or she knows that their significant other has been in charge of laundry for the last year. By communicating, the appropriate information can be transmitted and the bath towels can be located. Each partner can therefore benefit from the collective memory of the pair by assuming responsibility for remembering certain items and simply attending to the other person's knowledge categories. When information is needed, it can be retrieved from the couple's transactive memory, which is greater than the memory capacity of either partner.

Transactive memory has been defined as a shared system for encoding, storing, and retrieving information (Wegner, 1987; Wegner, Erber, & Raymond, 1991; Wegner, Giuliano, & Hertel, 1985). Using the metaphor of a directory-sharing computer network, Wegner (1995) proposed that transactive memory systems consist of three dimensions: directory updating, information allocation, and retrieval coordination. As the directory updating phase begins, individuals begin to learn what others know by becoming more familiar with their domains of expertise. This can be accomplished through several different methods. First, individuals can assign certain domains of knowledge to each other. By agreeing to be responsible for a certain knowledge domain, an individual becomes the repository for all relevant items. Second, individuals can update their directories through perceptions of their own and their partner's relative expertise in different knowledge domains. This can occur through self-disclosure and shared experience, which are part of any relationship formation process (e.g., Hollingshead, 1998). Third, directory updating can come from knowing who has access to different pieces of information. If one partner has accessed information recently or has had to access information for a longer period of time, it may be inferred that he or she has more knowledge on the topic.

Once individuals become familiar with each other's domains of expertise, they can begin the second phase of information allocation, where new information is communicated to the person who possesses the relevant area of expertise, thereby facilitating the storage process. Normally, passing information from one person to another can be dangerous, as information quickly degrades with each transaction (e.g., Bartlett, 1932). However, according to Wegner (1995), if individuals in close relationships memorize every piece of information over a long period of time, their memory will become scattered and their directory will expand to the point where things become disorganized. In order to be more productive and reduce their cognitive load, partners should pass information to each other as quickly as possible without encoding anything into memory.

Allocating information to the correct person can help retrieval coordination, which is the third phase in transactive memory process. Often individuals are faced with situations with which they are not familiar. If the individual is in a close relationship with another person, there is more than one directory that can be accessed. Retrieval coordination organizes the search process in order to maximize the speed and accuracy. Using a "directory of directories," an individual has a sense of who to look to first for a certain piece of information.

Researchers have suggested that the transactive memory system of encoding, storing, and retrieving information can also be applied to groups and teams (e.g., Hinsz et al., 1997; Moreland, 1999). Like couples, teams can split up different knowledge domains and develop a collective memory that is greater than the memory capacity of the team members by themselves. Hinsz and his colleagues (1997) note that "transactive memory allows different members of the group to process information, so they remember the information that is directly related to their area of expertise" (p. 48). Through directory updating, information allocation, and retrieval coordination, team members can learn about each other, plan work more easily, and assign tasks to those who are most qualified. In order for transactive memory to develop in teams, team members must communicate with one another (Hollingshead, 1998). In fact, "communication serves many beneficial functions in the encoding and storage of new information in transactive memory systems" (Hollingshead, 1998b, p. 427). Team members use communication as the medium for transferring knowledge between one another (Hinsz et al., 1997). Without verbal interaction, team members would find it much more difficult to learn about their teammates' knowledge, expertise, and relevant experience (Hollingshead, 1998). Communication also allows team members to delegate or assign responsibility for learning and storing new information to certain individuals (Wegner, 1987).

Because communication is an essential component of transactive memory, the presence of acute stressors could be particularly detrimental to directory updating, information allocation, and retrieval coordination in teams. Acute stressors, by focusing the attention of the team members away from the team and toward the task, could disrupt the team's shared system of encoding, storing, and retrieving information. If attention narrows and interaction is reduced, team members will not be able to efficiently and effectively update their directories, allocate information, or coordinate retrieval from their collective memory. Project teams must continually repeat the initial stages of directory updating, making them especially prone to the damaging effects of acute stressors, as they are not given the time to become familiar with the details of everyone's areas of expertise. Faced with information they are not familiar with in the presence of acute stressors, team members will not know who to allocate the information to and will not bother to try. Instead, team members will keep the information themselves, creating directories that are overflowing with useless information. By not communicating, project team members will not be able to develop a "directory of directories," which tells them who has the information they are looking for and retrieval coordination will suffer. Due to the damaging effects of acute stressors on the information processing capabilities of project teams, I hypothesize that:

Hypothesis 2. The presence of acute stressors will be negatively related to transactive memory in temporary project teams.

Summary

As hypothesized above, I expect the presence of acute stressors to negatively affect shared mental models and transactive memory systems within teams. Because the effects of acute stressors on shared mental models and transactive memory systems are proposed to be similar, one may question whether the two constructs are sufficiently different from one another to be considered distinct. Conceptually, researchers generally agree that the two should be treated separately (e.g., Hinsz et al., 1997; Kozlowski & Bell, 2001). Shared mental models represent an encoding system that is held by all the team members. Transactive memory, on the other hand, represents a much larger portion of the information processing system within teams, comprising the encoding, storage, and retrieval stages of the process. Although shared mental models may help teams develop a transactive memory system, there is not a one-to-one correspondence. Knowledge regarding the interaction patterns or areas of expertise within the team will develop into a transactive memory system only if team members are willing to engage in information allocation and retrieval coordination. If team members do not put forth the effort, they could share interaction and team member mental models without developing a collective system of storage and retrieval.

Despite their conceptual differences, empirically I expect that shared mental models will coincide with certain dimensions of transactive memory. In particular, shared mental models may arise from communications representative of the directory updating dimension of transactive memory systems. For example, if one team member asks another whether they know how to access an inventory file within the organization's intranet, he or she is developing a mental model of his or her teammate's area of expertise and is updating his or her directory. However, once team members share mental models regarding interaction patterns and expertise within the team, they may have trouble properly utilizing that information. In other words, they may be reluctant to ask their teammates for the information in their specific areas of expertise or they may neglect to send information to the appropriate person. The presence of shared mental models does not necessitate the presence of the information allocation or retrieval coordination dimensions of transactive memory. Therefore, I hypothesize that:

Hypothesis 3. The directory updating dimension of transactive memory systems will be positively related to shared interaction and shared team member mental models in temporary project teams.

Personal and Situational Characteristics

The detrimental effects of acute stressors on shared mental models and the three dimensions of transactive memory could be mitigated by a number of personal and situational characteristics. As noted earlier, stress researchers have identified numerous factors that moderate the effects of certain stressors on various outcomes, such as Type A behavior pattern, hardiness, locus of control, autonomy, control, and social support (see Cooper et al., 2001). Although these variables are important in the stress process, this study focuses on personal and situational characteristics that have been identified within the literature as potential influences on the team's collective information processing capabilities when faced with acute stressors. More specifically, regarding personal characteristics, I examine the level of cognitive ability and extraversion among the team members. Regarding situational characteristics, I am interested in the amount of shared information and the level of feedback provided within the team.

Cognitive Ability. Cognitive ability refers to individual differences in information processing capacity (e.g., Kanfer & Ackerman, 1989). The idea that there are limits on attentional resources and immediate memory capacity is one of the basic tenets of information processing theory and has been widely supported by cognitive psychologists (e.g., Dempster, 1981; Mandler, 1975; Shiffrin, 1976). Researchers have long suggested that individuals possess a certain attentional span, which determines the maximum number of elements that they can attend to at one time (e.g., Baldwin, 1894). Working memory, which is used to process incoming information and store the resulting products, is led by a central executive, a flexible workspace with severe restrictions on its capacity to handle large amounts of information (e.g., Baddeley, 1986; Baddeley & Hitch, 1974). The processing and storage of information must compete for the limited capacity in working memory (e.g., Daneman & Carpenter, 1980; 1983).

Organizational researchers have agreed, suggesting that an employee's attentional resources are "an undifferentiated pool representing the limited capacity of the human information-processing system" (Kanfer & Ackerman, 1989, p. 663). However, this general cognitive principle is not anchored exclusively at the individual level. Consistent with general systems theory, "the processing resources for any system are limited, and when several processes compete for the same resources, eventually there will be a deterioration in performance" (Norman & Bowbrow, 1975, p. 44). This could create problems in teams, where team members must attend to the situation, the task, the self, and the group (Hinsz et al., 1997). These competing task demands will dip into the team's collective pool of attentional resources. If team members decide to focus the majority of their attention on the task, the pool will be too shallow to adequately deal with the rest of their duties.

However, the depth of the team's pool of attentional resources and memory capacity can differ depending on the level of cognitive resources within the team. In the industrial and organizational psychology literatures, cognitive resources have been described in terms of general cognitive ability or g (e.g., Kanfer, 1987; Kanfer &

Ackerman, 1989). Support for the existence of g comes from research indicating that a single factor underlies performance on almost all tests that measure cognitive abilities (e.g., Hunter, 1986; Jensen, 1986; Ree & Earles, 1991). The link between g and cognitive resources has been supported by correlating scores on tests of memory span with scores on tests measuring g (e.g., Jensen, 1970). Additional support comes from research showing that there is a positive relationship between performance on tasks that require active information processing and scores on tests that measure g (e.g., Hartigan & Wigdor, 1989; Hunter & Hunter, 1984).

Teams that consist of employees who are high in general cognitive ability or g should have a deep pool of cognitive resources that can be distributed among the situation, the task, the self, and the group. Research has shown that task performance increases when team members are high in cognitive ability (LePine, Hollenbeck, Ilgen, & Hedlund, 1997; LePine, Colquitt, & Erez, 2000). But it is likely that the benefits of cognitive ability are not restricted solely to task performance. These teams should also be able to devote more cognitive resources to processing information both within and between the minds of the team members. Hollenbeck and his colleagues (1996) suggest that high cognitive ability allows team members to develop effective systems of interaction in order to effectively share and consider different pieces of information. By being able to pay more attention to both task-related and team-related duties, teams with members high in cognitive ability should be able to collectively encode, store, and retrieve information more efficiently and effectively.

Because the level of cognitive ability within teams affects collective information processing, it also has implications for shared mental models. It addition to expanding attentional resources and immediate memory capacity, cognitive ability has also been shown to determine learning speed (e.g. Hunter, 1986; LePine et al., 1997). This can be extremely helpful in the initial stages of shared mental model development, where team members begin to learn declarative and procedural knowledge about the task. The more quickly they learn the task, the more quickly they can begin to share different ideas about how to work together, and the more quickly they can begin to develop a shared representation of the task and the team. As a result, I suggest that:

Hypothesis 4. The level of cognitive ability will be positively related to shared interaction and shared team member mental models in temporary project teams.

Cognitive ability also has the potential to influence transactive memory within teams. Increased task and team resources may help in all three phases of transactive memory. In the directory updating phase, team members learn what others know by becoming more familiar with their domains of expertise. Team members high in cognitive ability should be better able to update their directories, helping them allocate information to the person with the correct area of expertise. By having a more complex and accurate "directory of directories," team members high in cognitive ability will be able to effectively coordinate retrieval when information in needed. The interaction needed at each step will not present a problem to team members high in cognitive ability, as they have plenty of resources to split among their different sub-tasks (LePine, 1998). Therefore, I propose that:

Hypothesis 5. The level of cognitive ability will be positively related to transactive memory in temporary project teams.

The positive effects of cognitive ability on shared mental models and transactive memory within teams could be particularly important when acute stressors are present. Researchers have shown that, when an unexpected change in the environment creates additional information processing demands, the level of cognitive ability within the team can determine whether the team will succeed or fail (LePine et al., 2000). As noted earlier, acute stressors increase information processing demands and narrow the attention span of team members. When acute stressors are present, team members tend to focus on their task-related duties and neglect their team-related duties. This shifts resources away from the team and toward individual team members, reducing the level of interaction within the team. However, shifting resources will not become problematic until the level of interaction falls below the level necessary for developing shared mental models and engaging in directory updating, information allocation, and retrieval coordination. Unfortunately, teams that are low in cognitive ability will likely be hovering at or near the minimum level. Therefore, any drop in resources would be particularly damaging to their ability to collectively process information. Teams high in cognitive ability, on the other hand, would likely have some amount of resources above the minimum level that could be spared. A drop in resources would not affect them as much. As a result, I hypothesize that:

Hypothesis 6. The relationship between the presence of acute stressors and shared mental models and transactive memory in temporary project teams will be more negative for teams that are low in cognitive ability.

Extraversion. Another personal characteristic that has the potential to impact the relationship between acute stressors and team processes is extraversion, which is one of the Big Five personality factors. For years, research has suffered from a lack of consensus regarding how personality should be defined and measured (e.g., Driskell, Hogan, & Salas, 1987). Researchers have developed a number of taxonomies in order to organize the wide array of personality variables identified in the literature. Some have suggested that personality consists of 16 primary and 8 second-order factors (Cattell, 1946), while others have proposed three primary factors (Eysenck, 1991), and still others have examined six primary factors (Hogan, 1986). However, the five factor model has received the most comprehensive and expansive empirical support (see Goldberg, 1993). Researchers have replicated the five-factor structure across cultures and rating scales and have found that the five factors are heritable and remain stable over time (Costa & McCrae, 1992). Although the argument is far from over (e.g., Block, 1995), "the development and validation of the five factor approach to personality offers a broad-based, empirically manageable, and demonstrably relevant avenue for examining personality in work organizations" (Barry & Stewart, 1997, p. 63). The five factors, or the Big Five, consist of agreeableness, conscientiousness, neuroticism, openness to experience, and extraversion. Agreeable individuals are flexible, trusting, good-natured, and cooperative. Conscientiousness is associated with responsibility, organization, meticulousness, and dependability. Neurotic individuals are anxious, depressed, angry, worried, and insecure. Openness to experience relates to being imaginative, curious, and open-minded. Extraversion is associated with being sociable, active, assertive, talkative, and gregarious (Barrick & Mount, 1991).

Out of the Big Five, conscientiousness has been found to be the most consistent predictor of performance across a wide variety of jobs (Barrick & Mount, 1991; Mount &

Barrick, 1995). However, Barrick and Mount (1991) do not suggest that the other four factors are irrelevant. Each of the five factors has the potential to explain variance in employee behavior in certain situations. Extraverts, because they are enthusiastic, outgoing, and friendly, should perform well when interpersonal skills and social interactions are required (McCrae & Costa, 1989). Research has supported this proposition, finding that employees high in extraversion tend to perform better in occupations where interactions with others are a significant part of the job (Barrick & Mount, 1991; Mount, Barrick, & Stewart, 1998). For example, Barrick and his colleagues (2001) examined the results of 15 prior meta-analytic studies correlating the Big Five and job performance and concluded that extraversion is highly related to sales performance, where there is a high degree of interaction between employees and customers.

Extraversion may also exert an influence in team settings. Team members high in extraversion are much more likely to participate in group discussions (Littlepage, Schmidt, Whisler, & Frost, 1995). They also feel confident that they can perform well in a team environment and prefer working in teams over working alone (Thoms, Moore, & Scott, 1996). Barry and Stewart (1997) note that extraverted team members "offer verbal contributions from the outset and are presumably apt to communicate easily and freely without fear of intimidation by their peers" (p. 66). This can create an atmosphere of open communication within the team that can persist through task completion.

The benefits of extraversion within teams have only been empirically examined in a small number of studies. Barry and Stewart (1997), utilizing 63 work groups consisting of graduate MBA students, found that group members high in extraversion were perceived as having a greater impact on group performance though their increased socioemotional and task inputs. According to Barry and Stewart, socioemotional inputs refer to the group members' ability to facilitate constructive intragroup relations. Interestingly, the proportion of extraverted group members was curvilinearly related to task focus and group performance. As the number of group members who were high on extraversion increased, task focus decreased and then plateaued. Group performance, on the other hand, increased and then leveled off.

However, the groups examined by Barry and Stewart completed a number of analytical exercises involving business case problems and team composition effects. To perform well, the group members simply had to turn in a written solution. There was no indication of the extent to which social interaction was required within the groups. In fact, each group member could be independently assigned one of the exercises without any input from the other group members. It is likely that teams, when performing an interdependent task requiring a high degree of interaction, would benefit from high levels of extraversion. That is exactly what Barrick and his colleagues (1998) found when they examined the behavior of 51 teams that assembled small appliances and electronic equipment. As the number of extraverted team members increased, so did team viability and team performance. These results seem to suggest that, when interaction is necessary, teams benefit from high levels of extraversion.

Because collective information processing within teams is highly dependent on team member interaction, the effects of extraversion on shared mental models and transactive memory should be even more powerful. Shared mental models develop when team members discuss different ways of working together and combine their individual representations into a combined representation for the entire team. By interacting with one another, team members can better understand the flow of communication within the team and they can discover each other's specific knowledges, skills, etc. Shared interaction and shared team member mental models enable team members to collectively encode incoming information more efficiently and effectively than if they were working separately. However, these shared mental models will be slow to emerge if team members are shy and prefer not to talk to each other. Any hesitation could lead to problems for project teams, where team members are not given a lot of time to develop shared mental models. In these situations, high levels of extraversion within the team could help to speed up the process. Therefore, I hypothesize the following:

Hypothesis 7. The level of extraversion will be positively related to shared interaction and shared team member mental models in temporary project teams.

Extraversion could also help with all three phases of transactive memory systems in teams. When updating their directories, team members have to learn who knows what. If team members feel reluctant to ask their teammates, or they neglect to divulge any important information, they will not be able to get a collective picture of the distribution of expertise within the team. During information allocation, information is verbally sent to the appropriate team member. If team members hesitate to communicate with each other and begin to concentrate on other tasks, they may forget important pieces of information and the transactive memory system will break down. Shy or non-talkative team members will also be reluctant to ask their teammates for any information that falls under their area of expertise, thereby handicapping retrieval coordination. Teams high in extraversion should be better able to handle the collective encoding, storage, and retrieval requirements of transactive memory systems. Consequently, I hypothesize that:

Hypothesis 8. The level of extraversion will be positively related to transactive memory in temporary project teams.

Extraversion could also mitigate the effects of acute stressors on shared mental models and transactive memory. Researchers have suggested that extraverted team members prefer team-related duties over task-related duties, seeking out opportunities to interact socially with their teammates (Barry & Stewart, 1997). As noted earlier, Barry and Stewart found that teams composed of highly extraverted team members focused significantly less on task-related duties. This could be particularly important when teams encounter stressful situations. When acute stressors are present, information processing demands increase and team members tend to reduce their level of interaction, focusing more on task-related duties and less on team-related duties. However, extraverted team members may be more resistant to any shift in resources away from the team. Because they enjoy interacting with their teammates, team members high in extraversion will find it difficult to eliminate that aspect of their job. Team members low on extraversion, on the other hand, may see the presence of acute stressors as the excuse they need to reduce their level of interaction with their teammates. Therefore, when choosing where to allocate attention in stressful situations, high levels of extraversion may enable teams to evidence less of a shift in resources away from team-related duties and toward task-related duties. As a result, I hypothesize that:

Hypothesis 9. The relationship between the presence of acute stressors and shared mental models and transactive memory in temporary project teams will be more negative for teams that are low in extraversion.

Prior Shared Information. Aside from team member personality and cognitive ability, there are a number of situational characteristics that can intrude upon the direct relationship between acute stressors and team processes by affecting the team's ability to collectively process information. One such characteristic is the level of prior shared information within the team. Prior shared information refers to information that is provided by the organization to more than one team member before the team begins its task. Unique or unshared information, on the other hand, is given to only one team member. When team members begin working on their task, they are unaware of which pieces of information are contained in each of their teammates' knowledge domains. Stasser and his colleagues (e.g., Stasser & Stewart, 1992) have used a similar approach in a number of their studies.

Although it has been suggested that unique information offers a number of benefits in team situations (Shiflett, 1979; Steiner, 1972), researchers have shown that decision-making groups are significantly more likely to discuss information that is shared rather than unshared (Larson, Christensen, Abbott, & Franz, 1998; Larson, Foster-Fishman, & Keys, 1994; Stasser, 1999; Stasser & Stewart, 1992; Stewart & Stasser, 1995; Wittenbaum, 1998). For example, Stasser and his colleagues (1989), using three and six person groups, distributed information regarding three candidates for student body president. Several pieces of information were given to all the group members and several pieces were only given to one group member. The three person groups mentioned 37% of the shared information and only 18% of the unshared information. The effects were even more pronounced in the six person groups, where 58% of the shared information got mentioned compared to only 18% of the unshared information. These effects seem to occur in most group situations, even when group members are aware that they each have specific domains of knowledge that contain a lot of unshared information (Stewart & Stasser, 1995).

Even if unique information is presented, it is less likely that group members will repeat it. For example, Larson and his colleagues (1994) had three-person groups study written profiles of three hypothetical faculty candidates. Each profile contained 18 items of information, 33% of which were shared, and 67% of which were unshared, among all the group members. When the group members brought up items of information, those that were shared were significantly more likely to be brought up again in the group's discussion. Other researchers have found similar results, supporting the idea that shared information holds a repetition advantage over unshared information (Stasser, Taylor, & Hanna, 1989).

Furthermore, when group members try to remember information, they have an easier time recalling prior shared information mentioned during group discussion. Stewart and Stasser (1995) found that, contrary to their hypotheses, assigning expertise to group members failed to eliminate the sampling advantage for prior shared information, especially during collective recall. The three person groups in the assigned expertise conditions were able to remember 56% of the shared information and only 42% of the unshared information.

Because prior shared information is discussed more frequently, repeated more often, and recalled more easily, the amount of prior shared information within groups has been associated with their ability to collectively process information. Hinsz and his colleagues (1997) note that "at the group level, information processing involves the degree to which information, ideas, or cognitive processes are shared, and are being shared, among the group members" (p. 43). They continue by suggesting that "the shared and sharing aspects of group information processing are interdependent of each other" (p. 44). Therefore, in order for a transmission of information to occur, there must be at least some level of prior shared information within the group. In project teams, the level of prior shared information needed may be even higher, because when individuals have little experience working together, they tend to focus even less on unshared items of information (Wittenbaum, 1998).

If the collective processing capabilities of project teams rely on a certain amount of prior shared information, excessive amounts of unshared information could disrupt the team's ability to construct shared mental models and a transactive memory system. As described earlier, shared mental models develop when team members hold mental representations that provide them with common expectations about the task and their behavior. Shared interaction models represent the network of communications within the team, including who needs to communicate with who and when. Shared team member models represent the various knowledges, skills, and abilities of each team member. If project teams wish to construct representations regarding each team member and the communication patterns that link them, all the team members must frequently talk to one another. However, talking is not enough. Team members also need to remember the information that gets presented if their collective representations are to fully develop. This process could be much more efficient and effective if team members share items of information with their teammates. Therefore, I hypothesize that:

Hypothesis 10. The level of prior shared information in project teams will be positively related to shared interaction and shared team member mental models.

Transactive memory could also be positively affected by the presence of a high degree of prior shared information. Directory updating requires team members to learn each person's area of expertise, even if it is unfamiliar. If team members hold information that is unshared, the team will be less likely to get a complete picture of each team member's specific skills. Even if the unshared information is distributed, team members still need to remember it and with whom it was associated. Recall becomes much more difficult when team members are faced with unshared information. This could also create problems for information allocation and retrieval coordination, both of which require knowledge of who needs what and who knows what. As a result, I hypothesize the following:

Hypothesis 11. The level of prior shared information will be positively related to transactive memory in temporary project teams.

Although prior shared information may directly affect team processes, things become more complicated in the presence of acute stressors. When team members perceive that they are under pressure from acute stressors, they initially restrict their interaction and choose to focus on themselves instead of the team as a whole, breaking the collective information processing cycle and negatively affecting their ability to develop shared mental models and transactive memory systems. If the remaining interaction within the team is restricted to prior shared information, the problems could become even worse, especially if the team members possess a lot of information that is unshared. Although there are few studies examining the effects of prior shared information on teams in stressful situations, there is some evidence suggesting that preferences for shared information become even more powerful when acute stressors are present.

When groups initially begin communicating, they tend to rapidly deplete the pool of shared information and neglect the unshared information. As the discussion progresses, the pool of unshared information becomes larger and larger in comparison to the pool of shared information. Eventually, there will be more opportunities to discuss unshared rather than shared information (e.g., Larson, Foster-Fishman, & Franz, 1998; Larson et al., 1994). However, when additional attentional demands such as time pressure are placed on group members, they are more likely to continue to focus on shared information (Stasser, 1999). This suggests that preferences for shared information are magnified in times of stress, which can affect how team members choose to allocate their attention. More specifically, because they prefer to discuss shared information in the presence of acute stressors, project team members could further shift their attention span away from their team-related duties when provided with a large amount of unshared information.

The potential buffering effect of prior shared information on the relationship between acute stressors and team processes is also indirectly supported by research examining social support. In the organizational stress literature, social support has been inconsistently and vaguely defined (Beehr, 1995). As noted by Vaux (1988), "people assist each other in an astonishing variety of ways" (p. 17). One of the most popular conceptualizations of social support has been offered by House (1981), who differentiates between four kinds of support. Emotional support involves showing interest in, or sympathy for, an individual's difficulties. Appraisal support gives feedback about an individual's functioning that may help to bolster his or her self-esteem. Informational support supplies the individual with information that may help him or her deal with problems. Instrumental support refers to providing help that is direct and of a practical nature.

Social support can exert influence on the stress process in a number of ways. First, there may be a main effect of social support, whereby strains are reduced irrespective of the stressors that are encountered. Second, social support may mediate the effects of stressors on psychological and physiological strains. Third, in what is referred to as the stress-buffering model, social support may moderate the relationship between stressors and strains. That is, when confronted with aversive events, individuals who receive social support will be shielded or protected from any potentially harmful consequences. Although support for each model varies, in this situation I am particularly interested in research examining the stress-buffering hypothesis.

Because organizational psychologists believe that other people can exert an influence on the stress process, there has been a "quick, widespread acceptance of the buffering hypothesis in regard to social support and work-related stress" (Beehr, 1995, p. 182). However, the results from a number of studies conducted over the years have been much more inconclusive (Cooper et al., 2001). Cohen and Wills (1985), in their review of the literature, concluded that there was considerable support for the buffering effects of social support in the occupational literature. Despite their positive conclusions, they only managed to review three studies. In a more comprehensive review, Beehr (1985) found that results are mixed, with some studies finding a buffering effect, others finding a reverse-buffering effect, and some finding no buffering effects whatsoever. Since Beehr's review, there have been a number of additional studies examining the stress-buffering effects of social support (see Cooper et al., 2001; Beehr, 1995). Although several studies have found support for the buffering hypothesis (e.g., Iwata & Suzuki, 1997; Moyle & Parkes, 1999), only a small set of the interactions they examined reached significance. For example, across six studies (Beehr, King, & King, 1990; Etzion, 1984; Ganster, Fusilier, & Mays, 1986; Kaufmann & Beehr, 1986, 1989; Seers, McGee, Serey, & Graen, 1983), researchers found 26 significant interactions across 153 tests (Beehr, 1995).

Although the buffering effects of social support have been fairly weak within the organizational literature, the support provided by shared information within project teams could be much more powerful. Researchers have noted that research on social support suffers from a lack of specificity. In order for social support to be effective, the source of support should be consistent with the nature of the outcome and the source of the stressor (Beehr, 1985, 1995; Cooper et al., 2001; Ganster et al., 1986; Russell, Altmaier, & Van Velzen, 1987). In addition, social support represents a meta-construct and should be broken down into its components if researchers hope to find any significant interactions. Shared information represents a specific form of social support that matches up with the relationship between acute stressors and team processes examined in this study. Specifically, shared information gives informational and instrumental support that can help to maintain the collective information processing capabilities of project teams faced with a combination of acute stressors. Team members who share information understand what each other are experiencing, which could offer solace in stressful situations, providing an easy way to maintain their team-related duties. Because the degree of prior shared information within project teams may have a greater influence on team processes when acute stressors are present, I hypothesize that:

Hypothesis 12. The relationship between the presence of acute stressors and shared mental models and transactive memory in temporary project teams will be more negative for teams that possess high levels of prior unshared information.

Feedback. Another situational characteristic that has the potential to affect the information processing capabilities of teams in the presence of acute stressors is the provision of performance feedback. Feedback can be generally defined as the process of communicating information regarding the results and outcomes of actions or behaviors (Taylor, Fisher, & Ilgen, 1984). Because of its informational and motivational components (Ilgen, Fisher, & Taylor, 1979), organizations have recognized feedback as an integral tool that can be used to effectively manage human resources (Earley, Northcraft, Lee, & Lituchy, 1990). Due to its popularity, a number of studies have been conducted within the organizational literature examining the effects of feedback on the performance of individual employees (e.g., Atwater, Waldman, Atwater, & Cartier, 2000; Earley, Northcraft, Lee, & Lituchy, 1990). Although there has been some debate regarding the effectiveness of feedback interventions (Kluger & DeNisi, 1996), researchers have generally agreed that feedback represents an important component of an individual's information processing system (e.g., Carver & Scheier, 1981; Kanfer & Ackerman, 1989; Naylor, Pritchard, & Ilgen, 1980).

Feedback has also been associated with the collective information processing capabilities of groups and teams (Hinsz et al., 1997; Tinsdale, 1989). However, providing feedback to teams of employees differs from providing feedback to individuals. Because team members operate in an interactive, social setting, organizations have two feedback options. Feedback can be given to one team member regarding his or her behavior or it can be given to the entire team regarding their collective behavior (e.g., Conlon & Barr, 1989). Although empirical evidence is lacking, researchers have suggested that feedback provided to one team member could be particularly damaging to the team's information processing system (Hinsz et al., 1997). When feedback is given to one team member, the team may begin to focus less on team-related duties in favor of individual task-related duties (Smither, 1998). This is supported by theories of vicarious reinforcement (Bandura, 1977, 1986), where observers are aware that someone is getting punished or rewarded for a specific set of behaviors. Positive or negative feedback can signal to the observers what behaviors should be matched or avoided to produce particular outcomes. If the correct behavior is unclear, the observer will develop hypotheses about the types of responses that are required to obtain rewards and avoid punishment.

The effects of providing feedback to individual team members or the team as a whole will be especially powerful if the feedback is negative. Taylor and his colleagues (1984) propose that negative feedback forces individuals to look for more effective alternative behaviors, while positive feedback is less likely to lead to behavioral change. Kluger and DeNisi (1996) agree, citing evidence indicating that individuals reduce or maintain their effort when receiving positive feedback and increase their effort when receiving negative feedback.

Despite the paucity of empirical evidence, the literature suggests that providing negative feedback to one team member could focus the attention of all the team members on their own task-related duties, damaging the team's collective information processing capabilities. This could have repercussions for shared mental models and transactive memory among the team members. Shared team-member and interaction models require that team members focus not only on what they are doing, but also on what the their teammates are doing, in order to work together efficiently and effectively. If team members are successful in building these types of shared representations, it could help them with the encoding stage of information processing (Hinsz et al., 1997). However, if team members are focused on their own behavior, they will have problems encoding the communication networks within the team and the skill domains of their teammates. Giving one team member feedback about his or her behavior could be one factor that contributes to the self-focused attention of all the team members. As a result, I hypothesize that:

Hypothesis 13. Providing negative feedback to one team member, rather than the team as a whole, will be negatively related to shared interaction and shared team member mental models in temporary project teams.

In addition, it is likely that the attention team members pay to their own task duties relates to transactive memory. If team members wish to update their directories, they need to find out what their team members know. When negative feedback is given to one team member, the most important tasks become those that have the potential to avoid punishment (i.e., each team member's individual responsibilities). This may make it more difficult to learn each team member's area of expertise. Negative feedback given to one team member could also have an influence on information allocation. Team members will not know who to send important pieces of information to, and distributing information will not become a priority. Retrieval coordination could also suffer due to team members' inability to remember who has what piece of information in their knowledge domain. Because negative feedback has the potential to affect all three phases of transactive memory, I hypothesize the following:

Hypothesis 14. Providing negative feedback to one team member, rather than the team as a whole, will be negatively related to transactive memory in temporary project teams.

The benefits of providing negative feedback to the team as a whole could also help to insulate teams against the debilitating consequences of acute stressors by stimulating proactive coping behaviors. Proactive coping "involves the accumulation of resources and the acquisition of skills that are not designed to address any particular stressor but to prepare in general, given the recognition that stressors do occur and that to be forearmed is to be well prepared" (Aspinwall & Taylor, 1997). By accumulating resources, which act as moderators, team members can minimize the negative effects of a stressful encounter (Hobfoll, 1988, 1989). When acute stressors are present, teams with the correct resources will continue to interact and collectively process information, thereby experiencing less damage to their shared mental models and their ability to engage in directory updating, information allocation, and retrieval coordination.

One resource that the team could use when faced with acute stressors is feedback. Perhaps the most important characteristic of feedback is its informational value, which refers to the extent to which feedback provides meaningful information about the "correctness, accuracy, or adequacy of the response" (Ilgen et al., 1979). Earley (1988) suggests that specific feedback activates planning by directing an individual's attention to specific domains. After receiving feedback, an individual focuses his or her attention on job relevant behaviors and away from irrelevant or inappropriate ones (Earley, Northcraft, Lee, & Lituchy, 1990). Individuals tend to match their attention and behavior to the dimensions of performance feedback that are provided (Ilgen & Moore, 1987). If team members match their behavior to the feedback that is provided, then negative feedback that is given to the team as a collective unit should serve to concentrate their efforts on their team-related duties, which they should see as more job-relevant. When acute stressors are introduced, the team should have the correct set of resources that they need to remain resilient in the face of difficult circumstances. On the other hand, if individual team members receive negative feedback, the team as whole could cue on the wrong set of behaviors. When the team enters a stressful situation, they will not have the resources they need to proactively cope with the situation. This could further shift the concentration of the team members away from their team-related duties and toward their task-related duties. Because the negative effects of acute stressors on team process may be exacerbated when feedback is given to only one team member, I hypothesize that:

Hypothesis 15. The relationship between the presence of acute stressors and shared mental models and transactive memory in temporary project teams will be more negative when negative feedback is provided to one team member rather than the team as a whole.

<u>Summary</u>.

A number of characteristics have been examined as moderators of the stress process at the individual level, such as Type A behavior pattern and hardiness. Often these characteristics are included without much theoretical rationale. As a result, firm conclusions regarding the exact nature of their effects have been lacking (Cooper et al., 2001). In this study, I introduce several personal and situational characteristics that can be directly linked to the collective information processing capabilities of temporary project teams, including cognitive ability, extraversion, shared information, and feedback. Theoretically, these characteristics have the potential to influence the deterioration of shared mental models and transactive memory in stressful situations. The purpose of this study is to empirically examine the issue. These results have important implications because, as discussed in the next section, shared mental models and transactive memory can be linked to team performance.

The Effects of Shared Mental Models and Transactive Memory on Team Performance

McGrath (1964), in his input-process-outcome model, suggested that team processes exhibit a direct link with team outcomes. Although shared mental models and transactive memory could have implications for a number of important team outcomes, I am interested in investigating their effects on team performance.

Shared Mental Models. Empirically, researchers have, for the most part, only been able to establish an indirect link between team mental models and performance (e.g., Hammond, 1965; Kleinman & Serfaty, 1989). For example, Oser and his colleagues (1990) found that team members who offered information to teammates before they requested it performed better. Foushee and his colleagues (1986) discovered that teams performed better under difficult circumstances when team members possessed a number of shared experiences. Researchers also found that team members worked together better when they shared internal frames of reference (Mitchell, 1986) and schema representations (Rentsch, Heffner, & Duffy, 1993).

To more directly test the relationship between team mental models and performance, Mathieu and his colleagues (2000) ran 56 two-person teams through a flight simulator task. They found that team mental models had a positive influence on team performance by increasing the communication between the team members. These results were recently supported by Marks and her colleagues (2000), who found that leader briefings and team interaction training led to shared mental models, which subsequently led to increased team performance.

Despite a few detractors (e.g., Adelman, Zirk, Lehner, Moffett, & Hall, 1986; Brehmer, 1972), the majority of evidence seems to indicate that team mental models improve team performance. That does not mean that team mental models are always beneficial. For one thing, sharing knowledge structures can hurt the team, as exemplified by groupthink, whereby team members blindly follow the wrong path and end up in disastrous circumstances (e.g., Janis, 1972). This is a direct result of underutilizing the resources of the team. However, groupthink is much more likely to occur when team members' mental models completely overlap with one another (Wellens, 1993). In this study, teams work on a highly interdependent task (see the Methods section), which should reduce extensive overlap between the team members' mental representations while still covering the task domain.

Team mental models can also be inaccurate representations of the team performance environment, which could be extremely detrimental to team success (Hall, Volpe, & Cannon-Bowers, 1992; Marks et al., 2000; Stout, 1994). If team members send or request information from the wrong person, but believe they are correct, the team will not be able to benefit from shared interaction and team member mental models. The problem will be exacerbated if team members continue to follow the wrong system for an extended period of time. Therefore, I hypothesize the following:

Hypothesis 16. Accurate shared interaction and team member mental models will be positively related to team performance in temporary project teams.

Transactive Memory. The level of directory updating, information allocation, and retrieval coordination within project teams also has the potential to affect team performance. Moreland (1999) notes that "the potential benefits of transactive memory for a work group's performance are clear. When group members know more about each other, they can plan their work more sensibly, assigning tasks to the people who will perform them best" (p. 5). By anticipating each other's behavior, team members may be better able to coordinate the collective behavior of the team (e.g., Murnighan & Conlon, 1991). Problem solving may also improve, as team members assign problems to those individuals who have the expertise to solve them (e.g., Moreland & Levine, 1992).

So does transactive memory actually translate into improved team performance? Unfortunately much of the empirical evidence focuses on couples (e.g., Wegner et al., 1991), which is not easily translated to the organizational environment. There is, however, some indirect evidence in the group decision-making literature. Researchers have shown that recognizing expertise, which is an essential component of transactive memory (Moreland, 1999), can lead to better group decisions (e.g., Henry, 1993; Henry, Strickland, Yorges, & Ladd, 1996; Littlepage, Schmidt, Whisler, & Frost, 1995; Littlepage & Silbiger, 1992). Henry and her colleagues, in their research, provide subjects with a number of trivia questions that they must solve as a group. When group members are able to determine each person's actual domain of expertise, shared representations can develop within the group and more accurate solutions can result. Littlepage and his colleagues, who are also interested in group problem solving, ask their subjects to figure out how to negotiate several hypothetical situations, such as surviving in the desert without enough supplies. Like Henry, Littlepage has found that group members' beliefs about relative expertise can have a significant impact on their ability to successfully solve the problem at hand.

Another line of research that may relate to the relationship between transactive memory and team performance examines the effects of group member familiarity. It is likely that directory updating, information allocation, and retrieval coordination begin to be utilized as employees work together on the same set of tasks for an extended period of time (Moreland, 1999). No one has studied this process directly, but there is a wealth of research showing that groups tend to perform better when their members are more familiar with one another (e.g., Argote, 1993; Goodman & Shah, 1992; Jehn & Shah, 1997; Murnighan & Conlon, 1991). Although there are a number of potential underlying causes, familiarity may impact performance because it gives group members the chance to recognize one another's areas of expertise (Moreland, 1999).

As described above, research on group problem solving and group member familiarity are only tangentially relevant. More direct evidence for the positive effects of transactive memory on group performance has recently begun to appear in the organizational literature. For example, Liang, Moreland, and Argote (1995) had small groups of students assemble the AM portion of an AM-FM radio. Group members were trained individually or as a group, and then were given a chance to practice assembling the radio. After practicing for about 30 minutes, the testing session began, at which point each group was asked to recall how to assemble the radio. Groups who were trained together exhibited more memory differentiation, task coordination, and task credibility, which were considered to be three factors of transactive memory. Memory differentiation referred to the tendency of group members to specialize in one aspect of the process. Task coordination was assessed by determining how well the group members worked together. Task credibility was defined as the level of trust the group members placed in each person's knowledge domain. These three factors were then positively related to the number of assembly errors made by the groups. These results have since been replicated in a number of experiments by Moreland and his colleagues (Moreland, 1999; Moreland & Myaskovsky, 2000), indicating that directory updating, information allocation, and retrieval coordination play a role in group performance. Therefore, I hypothesize that:

Hypothesis 17. Transactive memory will be positively related to team performance in temporary project teams.

The positive effects of shared mental models and transactive memory on team performance seem to be supported both theoretically and empirically within the literature. As noted in the introduction, however, the presence of acute stressors is <u>not</u> linked to team performance in this study. That relationship has been the subject of much debate. Some see it as negative, some see it as positive, and some see it as curvilinear. I do not argue that, when individuals are placed in stressful situations, there can be a number of positive consequences. In fact, in this study, I argue that team members will focus their attention on their individual task-related duties within the team in the presence of acute stressors. However, this study focuses on the negative effects by examining team members' social reactions to stressful situations. It is these reactions that have the potential to affect the team's level of performance. In other words, I believe the presence of acute stressors indirectly influences team performance by disrupting accurate shared mental models and transactive memory. Because the effects of acute stressors on team performance are thought to be indirect, not direct, I hypothesize the following:

Hypothesis 18. Accurate shared mental models and transactive memory mediate the relationship between the presence of acute stressors and team performance in temporary project teams.

Summary.

The literature review that has encompassed the last seventy pages or so was designed to develop a model of the effects of acute stress within temporary project teams. The model includes components of a number of different perspectives of the stress process. However, the focus of the model is on the responses of project team members to the introduction of acute stressors. In particular, I proposed that, in the presence of acute stressors, team members' shift their attention away from the interactive duties necessary for successful task completion. Based on information processing theory, this will result in a deterioration of the team's ability to fully develop shared mental models and utilize the directory updating, information allocation, and retrieval coordination dimensions of transactive memory systems. The negative effects of acute stressors on team processes can then be compounded or attenuated by a number of personal and situational characteristics that relate to the information processing capabilities of teams. In particular, regarding personal characteristics, I introduced the level of cognitive ability and extraversion within the team. Regarding situational characteristics, I discussed the effects of negative feedback given to the team versus an individual team member as well as the amount of prior shared information provided to each team member. Finally, I suggested that accurate shared mental models and transactive memory will affect team performance. The next section of this dissertation describes a lab study designed to test the hypotheses generated throughout the literature review.

METHODS

Participants

Participants included 396 students from an introductory management course at a large Midwestern University who were arrayed into 99 four-person teams. Out of the 396 students, 223 (56.3%) were male and 342 (86.4%) were white with an average age of 21. In exchange for their participation, each earned class credit and all were eligible for cash prizes ($400 per team) based upon the team's performance.

Design

The basic design was a 2 X 2 X 2 completely crossed factorial design conducted in a laboratory setting. Acute stressors (present versus absent), shared information (high degree versus low degree), and negative feedback (individual versus team) were manipulated. Cognitive ability and extraversion were not manipulated in this study and were operationalized as continuous variables.

A laboratory setting was chosen for a number of reasons. It allows for the observation of numerous teams performing the same task under the same type of experimental conditions. It also allows for the manipulation acute stressors, shared information, and feedback while being able to directly observe the interaction patterns within the team, which would be extremely difficult to do in a field setting. I am concerned more with the developing and testing a model of stress within teams based on information processing theory than with task itself. Because there is no reason to think that information processing theory would not be applicable in this context, this context serves as a meaningful venue for testing our hypotheses. I am simply asking the "can it happen" question which, according to Ilgen (1986), is exactly the type of question that bears investigation in this type of a laboratory setting. Furthermore, researchers have estimated that the correlation between the effect sizes obtained in the field and those obtained in the lab generally exceed .70 (Anderson, Lindsey, & Bushman, 1999). For this and other reasons, as Cook and Campbell (1979) note, "a strong case can be made that external validity is enhanced more by many heterogeneous small experiments than by one large experiment employing random selection of subjects, tasks, and times" (p. 80).

Task

Participants engaged in a modified version of the Distributed Dynamic Decision-making (DDD) Simulation (see Miller, Young, Kleinman, & Serfaty, 1998). The DDD is a dynamic command and control simulation requiring team members to monitor activity in a geographic region and defend it against invasion from unfriendly air or ground tracks or targets that enter the region.

The specific variant of this task used in this research, MSU-DDD, was developed for use in contexts where teams are comprised of anywhere from 2 to 5 members with little or no military experience. In this version of the simulation, each participant has a networked PC at his or her workstation, and uses a computer mouse to control various military sub-platforms such as tanks, helicopters, jets and AWACS reconnaissance planes. These sub-platforms are used in an effort to monitor and control a specific geographic area represented in a 20 by 20 grid.

The MSU-DDD Grid. Figure 3 is a display of the geographic region, which is partitioned into four quadrants of equal size. Each team member in a four-person team is assigned responsibility for one of the four quadrants and operates from a workstation labeled DM-1 through DM-4 in the figure. Team members are referred to as "Decision

Makers," thus the DMi notation, with DM1 the southeast (SE) quadrant, DM2 in the northwest (NW), DM3 in the southwest (SW), and DM4 in the northeast (NE) quadrant. In the center of the screen is a 4 by 4 square designated as the "highly restricted zone" which is nested within a larger 12 by 12 square called the "restricted zone." Outside the restricted zone is a neutral space. Each team member in the configuration illustrated in Figure 3 is responsible for an equal portion of highly restricted, restricted and neutral space.

The objective of the simulation is to identify any tracks that enter the space, determine whether they are friendly or unfriendly, and, if unfriendly, keep them out of the restricted zones. Each team starts with a set number of points, and loses points for each unit of time (seconds) that an unfriendly vehicle resides in a restricted or highly restricted zone. Teams also lose points whenever they disable a friendly track in any area or an unfriendly track in neutral territory. Teams with the most points were awarded cash prizes.

Bases and Vehicles. In terms of monitoring the geographic space, each team member's base (see the small black rectangles labeled DM1, DM2, etc. in Figure 3) has the same radar capacity as every other team member. Specifically, each base has a detection ring of roughly six grid units (demarcated by the circle surrounding each DM's base, as shown in Figure 3). The team member can detect the presence or absence of any track within the radius of his or her base's detection ring. To detect tracks outside of their bases' detection rings, team members have two options. They can rely on their teammates to monitor regions of the space outside their own quadrant or they can rely on the mobile assets, or vehicles, located at their base to view different sections of the screen.

Each DM has control of various types of assets that can be launched from his or her base, and then moved to different areas of the screen. These assets are semi-intelligent agents that can automatically perform certain functions (e.g., return to base to refuel, etc.). Each DM manages these semi-intelligent agents. Most of the MSU-DDD simulation is played via the assets or vehicles, and hence understanding the unique characteristics of each asset is critical to appreciating the complex nature of this task.

There are four different types of assets used in MSU-DDD; (a) AWACS planes, (b) tanks, (c) helicopters, and (d) jets. Each of these assets varies in capability across five major dimensions; (a) range of vision, (b) speed of movement, (c) duration of operability, (d) weapons capacity, and (e) identification capacity.

Capabilities are distributed among the assets so that each has both strengths and weaknesses, as shown in Table 1. Range of vision refers to the width of the detection ring around each vehicle (see Figure 3). The AWACS has the largest range of vision (radius of 4 grid units), followed by the jet, the helicopter and finally the tank (radius of 2 grid units). In terms of speed of movement, the jet moves the fastest (1 grid unit per second), followed by the AWACS, the helicopter, and finally the tank (.1 grid units per second). While the tank is limited in terms of speed and vision, it is the best asset in terms of duration of operation. It can be away from the base for 8 minutes without having to refuel. The AWACS can operate away from the base for 6 minutes, followed by the helicopter at 4 minutes, and the jet at 2 minutes. Three of the vehicles, the tank, the helicopter, and the jet, have weapons capacity, which is represented by the inner ring surrounding each vehicle. The tank has a power of 5, followed by the helicopter with a power of 3, and finally the jet with a power of 1. The AWACS has a power of zero, which means that it cannot disable any tracks on the screen. However, the AWACS plane is the only vehicle that has the ability to identify tracks on the screen. The inner ring around the AWACS plane represents its identification ring.

Tracks. Tracks enter the screen from the sides of the grid with a line (i.e., a vector) attached to them indicating the direction they are proceeding through the space. Initially, when tracks enter someone's detection ring, they show up as unidentified, which is represented by a small diamond with a question mark in the middle. For example, in Figure 3, track number 201 in the northwest quadrant has not been identified. Once the track enters an identification ring, it can be identified. When tracks are identified, the diamond turns into a box with a letter inside of it, as shown by track number 200 in DM2's restricted zone in Figure 3. Number 200 has been identified as a B target. In this study, teams were faced with four different types of targets: A, B, C, and D. Each target represented a ground target of power 1, 5, 3, and 0, respectively.

Each team faced a total of 40 targets in the first 15-minute game and 100 targets in the second 30-minute game. The 140 targets consisted of 35 of each of the four types (A, B, C, and D), and each team member saw 35 targets enter their quadrant across both games. During the second 30-minute game, a subset of tracks (four waves consisting of 8 tracks per wave = 32 tracks) originated near the corners of the Northwest, Northeast, Southwest, and Southeast quadrants and proceeded in a straight line diagonally toward the opposite corner of the task screen. Each of the DM's experienced one wave of tracks during the second 30-minute game. These waves consisted of two of each type of track (A, B, C, and D). Of these eight tracks, five stopped once they reached the highly restricted zone of the quadrant from which they entered and stayed there for ten minutes, or until they were successfully engaged. In this way, each DM had primary responsibility for locating, identifying, and engaging if necessary, a disproportionately greater amount of tracks at some point during each task.

Actions Taken Towards Tracks. Once a track moves inside the identification ring of an AWACS plane, it can be identified as either A, B, C, or D. If it is an A, B, or C track, a team member can engage the track by moving an asset near enough so that the track is within the attack ring. If the asset has the correct level of power, the track can be disabled (see Table 1). The A target can only be disabled with the tank, the B target can only be disabled with the jet, and the C target can only be disabled with the helicopter. When team members are able to quickly disable unfriendly tracks inside the restricted zones, the team will avoid losing large amounts of points. However, to maximize their score, team members also have to make sure that they are not disabling a friendly track or disabling an unfriendly outside the restricted zones.

Team Member Specialties. During the two games, knowledge regarding the targets and possession of the four different vehicles was split up in order to maximize the interdependence within the team (see Table 2). At the beginning of the first 15-minute game, each team member knew the power level of one target. DM4 knew that target A was a Ground target with a power of 1, DM3 knew that target C was a G3, DM2 knew that target B was a G5, and DM1 knew that target D was a G0. Each team member was also be responsible for one type of vehicle. DM2 had the tanks, DM3 had the helicopters, DM4 had the jets, and DM1 had the AWACS planes.

Measures

Cognitive Ability. Cognitive ability was measured by the Wonderlic Personnel Test (Form IV), which has been shown to be reliable in the educational and psychological literatures (e.g., Dodrill, 1983; McKelvie, 1989; Weeless & Serpento, 1982). Internal consistency reliabilities generally range between .88 and .94 across all forms of the Wonderlic (Wonderlic & Associates, 1983). Researchers have also found that the Wonderlic measures the verbal, quantitative, and spatial abilities that comprise *g* (Hunter, 1986; Jensen, 1977).

Although the Wonderlic is designed to measure g at the individual level, this study intends to examine cognitive ability at the team level. To aggregate the four team member cognitive ability scores, the attribute in question and the nature of the task need to be taken into consideration (LePine, Hollenbeck, Ilgen, & Hedlund, 1997). Steiner (1972) offers an aggregation guide based on the resource requirements of disjunctive, conjunctive, and additive tasks. Disjunctive tasks are structured such that there is significant overlap between member activities. This creates a situation where one team member can perform the team's task efficiently on his or her own. Conjunctive tasks, on the hand, evidence little overlap. So if one team member is not performing up to par, the rest of the team members cannot compensate. Additive tasks are an intermediary between conjunctive and disjunctive tasks. Out of Steiner's three categories, the additive model best represents the team task used in this study (see pp.75-79). The activities of the team members only evidence partial overlap with one another and each team member contributes to task performance in proportion to his or her resource level. As a result, the sum of the team members' Wonderlic scores was used to represent cognitive ability at the team level.

Extraversion. Extraversion was measured at the individual level using the NEO Five-Factor Inventory (NEO FFI). On this questionnaire, 12 items are used to measure each of the five dimensions of personality. Answers are given on a five-point Likert-type scale depending on how much they agree or disagree with the statement. The reliability and validity of this test has been demonstrated by a variety of researchers and internal consistency values for extraversion have generally been shown to be well above .80 (Costa & McCrae, 1992). In this study, coefficient alpha reached .82 for the extraversion scale. Consistent with the rationale outlined above, extraversion was operationalized at the team level using the sum of the four team members' scores.

Transactive Memory. Transactive memory has been a difficult construct to measure, as evidenced by the lack of empirical work within the organizational literature. Moreland and his colleagues (Liang et al., 1995; Moreland, 1999; Moreland, Argote, & Krishnan, 1996; 1998; Moreland & Myakovsky, 2000) are among the first researchers to attempt to measure transactive memory in a group setting. Using a research paradigm where participants attempt to assemble transistor radios as a group, Moreland and his colleagues examine behaviors that are thought to reflect memory differentiation, task coordination, and task credibility. Memory differentiation refers to the level of specialization among the group members, task coordination refers to ability of the group members to work together efficiently, and task credibility refers to the level of trust in other group members' radio building knowledge. Moreland and his colleagues watch each group perform the task and then rate the levels of memory differentiation, task coordination, and task credibility within the group on a 7-point scale.

The measurement technique of Moreland and his colleagues was <u>not</u> used in this study. It is not clear how the memory differentiation, task coordination, and task credibility relate to directory updating, information allocation, and retrieval coordination, which are the three dimensions of transactive memory that have been identified by Wegner (e.g., 1995). For example, trusting in your teammates' knowledge regarding the task does not mean that specific pieces of information will be retrieved from the person with the requisite expertise. Part of the problem stems from the task used by Moreland and his colleagues. Team members were not responsible for specific areas of the assembly process, which is a necessary component of transactive memory (e.g., Wegner, Erber, & Raymond, 1991). Therefore, it is unlikely that a system of encoding, storing, and retrieving information needs to develop among the group members in order to complete the task. Another problem lies in the fact that, although they videotaped each group session, Moreland and his colleagues did not examine specific verbal communications between the team members. Researchers have suggested that communicative behaviors are the best way to assess the three dimensions of transactive memory (e.g., Hollingshead, 1998).

In an attempt to remedy problems with previous measures of transactive memory, this study focused on the verbal communications between highly specialized team members that specifically related to directory updating, information allocation, and retrieval coordination (see Appendix B). Researchers have shown that coding verbal communication coding represents a valid measure of transactive memory (e.g., Hollinshead, 1998). Through directory updating, individuals learn what others know by becoming more familiar with their domains of expertise (e.g., Wegner, 1995). This can occur through self-disclosure and shared experience, whereby team members share their own area of expertise or ask about their teammates areas of expertise. Hollingshead (1998), when coding the verbal behavior of couples, considered both assertions about one's own expertise and questions about the other's expertise. Therefore, in this study, directory updating was measured by coding verbal communications where team members shared expertise (SE) or requested expertise (RE). Sharing expertise was defined as the distribution of knowledge by one team member regarding his or her target or vehicle specialty. For example, "I'm DM2 and I have the tanks." Requesting expertise was defined as the solicitation of information regarding another team member's target or vehicle specialty. For instance, "Who knows what the D target is?" Sharing expertise and requesting expertise were correlated .54 ($p<.01$) with one another. As a result, there was both conceptual and empirical evidence supporting the creation of an index of directory updating by combining sharing expertise and requesting expertise.

Information allocation, which is the second dimension of transactive memory, was defined as the distribution of information to the individual with the relevant area of expertise (e.g., Wegner, 1995). In this study, information allocation (IA) was measured by coding verbal communications where team members sent information to the person with the correct target or vehicle specialty. For example, "DM3, I have several C targets in my restricted zone."

Retrieval coordination, the third dimension of transactive memory, was defined as a "directory of directories," whereby individuals know exactly where to look when a specific piece of information is needed (Wegner, 1995). In this study, retrieval coordination (RC) was measured by coding verbal communications where team members requested information that is known to be part of someone's target or vehicle specialty. For instance, "DM3, what is the C target again?" Hollingshead (1998) coded similar communications demonstrating a cooperative effort to retrieve needed knowledge, which she termed transactive information search.

Two experimenters were in charge of coding transactive memory related communication within the 99 teams. In order to ensure that the coding was accurate and consistent, both experimenters participated in a two-hour training session. The session included a review of the construct definitions for each dimension of transactive memory described above as well as the coding of two practice teams. After coding each of the teams, the two experimenters received detailed performance feedback and discussed any coding discrepancies in order to ensure that they understood how to correctly identify transactive memory related communication. After the two-hour training session, both experimenters coded 17 (17%) of the teams to assess the level of interrater agreement. Although a number of indexes of interrater agreement have been utilized within the literature (Zwick, 1988), Cohen's (1960) κ has been supported as a good index of agreement when presence/absence coding schemes are used (e.g., Ellis, West, Deshon, & Ryan, in press; Stevens & Kristof, 1995). In this study, $\kappa = .77$ across all three dimensions of transactive memory ($\kappa = .76$ for directory updating, $\kappa = .76$ for information allocation, $\kappa = .72$ for retrieval coordination), which indicated that the two experimenters evidenced acceptable levels of interrater agreement. As a result, the remaining 82 teams were divided between the two experimenters (62 teams were coded by the first experimenter while 20 were coded by the second experimenter).

The frequency of communication related to directory updating, information allocation, and retrieval coordination was calculated for each of the four team members. The four team members' scores were then pooled to give an index of the team's level of directory updating, information allocation, and retrieval coordination. Aggregation was supported by calculating intraclass correlation statistics, which measure the consistency of scores within the team by comparing the between and within-team variance (see Bliese, 2000). Directory updating evidenced an ICC(1) of .41 and an ICC(2) of .74. Information allocation evidenced an ICC(1) of .35 and an ICC(2) of .68. Retrieval coordination evidenced an ICC(1) of .38 and an ICC(2) of .71. Researchers have suggested that consistencies above .30 are high enough to justify aggregation to the team level using the sum of the four team members' scores (see Klein, Bliese, Kozlowski, Dansereau, Gavin, Griffin, Hofmann, James, Yammarino, & Bligh, 2000).

Schwab (1980) defined construct validity as "the correspondence between a construct (conceptual definition of a variable) and the operational procedure to measure or manipulate that construct" (p.6). By specifying what the measure should or should not reflect, the research must convey information about the dimensionality of the construct. Information must also be provided regarding the way the dimensions relate to the overall construct in order to commence with any sort of model testing (Law & Wong, 1999). Misspecifying this relationship can result in errors when tests of significance are being interpreted. Wegner (1987; 1995) proposed that the construct of transactive memory consists of three dimensions: directory updating, information allocation, and retrieval coordination. Law, Wong, and Mobley (1998) describe several ways by which the three dimensions could relate to the overall construct.

If transactive memory conforms to a "latent" model, transactive memory would be the latent variable that partially causes directory updating, information allocation, and retrieval coordination. Measures of the three dimensions would therefore contain some variance reflecting transactive memory, some systematic variance not related to transactive memory, and error variance (Lepine, Erez, & Johnson, 2002). Law et al. (1998) describe cognitive ability as an example of a latent construct because an underlying general intelligence, or g, is thought to influence measures of more specific abilities.

If transactive memory conforms to an "aggregate" model, directory updating, information allocation, and retrieval coordination would "cause" the transactive memory construct. Transactive memory could be constructed by capturing and adding or multiplying systematic variance from each dimension (Lepine et al., 2002). Law et al. (1998) view the construct of job satisfaction as an aggregate construct because it can be formed by summing scores on a variety of dimensions such as satisfaction with pay, satisfaction with coworkers, etc.

This study considers transactive memory an aggregate construct for several reasons. First, if transactive memory were a latent construct, it could be defined as the commonality among its dimensions. Confirmatory factor analysis could then be used to estimate transactive memory from the variance-covariance matrix among directory updating, information allocation, and retrieval coordination (Law et al., 1998). In this study, a CFA was run using AMOS (version 4.01), with transactive memory as the latent variable and directory updating, information allocation, and retrieval coordination as its three indicators. The one-factor model evidenced a very poor fit to the data (GFI = .83, AGFI = .67, RMSEA = .31). Second, the three dimensions of transactive memory seem to be conceptually distinct. Engaging in behavior that relates to one dimension does not necessarily mean that the team will engage in behavior that relates to the other two dimensions. For example, a team could continually update their directories regarding separate areas of expertise yet neglect to allocate information to the correct individual. Or teams may allocate information to the correct individual but forget to update their directories when team members gain expertise in a certain area. Empirically this is supported by the insignificant correlation between directory updating and information allocation in this study (r = .10, ns). Lepine and his colleagues (2002) suggest that this provides evidence that the construct is aggregate in nature. Aggregate constructs can be formed from dimensions that are completely unrelated to one another. Third, in order for a construct conform to the latent model, it must exist "at a deeper and more embedded level than its dimensions" (Law et al., 1998, p. 742). However, transactive memory could not exist within teams without directory updating, information allocation, and retrieval coordination. For example, if team members do not become more familiar with each other's domains of expertise, encoding, storing, and retrieving information would be an individual rather than shared process. This suggests that transactive memory represents a multidimensional construct that exists at the same level as its dimensions, unlike constructs such as general mental ability and personality. Conceptually, the structural arrows seem point from directory updating, information allocation, and retrieval coordination to transactive memory (this does not imply causation, but rather that the dimensions are part of the definition of transactive memory), which provides evidence that the multidimensional construct is aggregate in nature (Law et al., 1998).

Aggregate constructs can be formed by algebraically combining the dimensions. For example, overall job satisfaction has been calculated by simply summing its dimensions (Locke, 1969). Other constructs, such as overall job characteristics, have been calculated by utilizing a multiplicative nonlinear function (e.g., Hackman & Oldham, 1976). Law and his colleagues (1998) suggest that the dimensions of an aggregate construct should be combined algebraically based on theory. Going back to Wegner's (1987; 1995) initial theory, directory updating, information allocation, and retrieval coordination are all treated as equal contributors to transactive memory. As a result, studies investigating transactive memory have weighted all three dimensions equally (e.g., Liang et al., 1995; Moreland & Myaskovsky, 2000). Because there is no theoretical evidence supporting the domination of one or more dimensions of transactive memory, directory updating, information allocation, and retrieval coordination were standardized and combined equally to form the aggregate transactive memory construct. Furthermore, because the dimensions of transactive memory are considered distinct, analyses will focus on directory updating, information allocation, and retrieval coordination along with the aggregate transactive memory variable.

Shared Mental Models. Although several techniques have been suggested, researchers have focused on the use of concept mapping as a method of measuring shared mental models in teams (e.g., Marks et al., 2000). Concept maps provide participants with a variety of prelabeled concepts, which are then placed in a prespecified hierarchical structure. The overlap between team members' concept maps indicates the level of shared knowledge within the team.

Using this technique offers a number of advantages. Concept maps graphically link concepts together (Marks et al., 2000), they can be administered to participants quite easily (Novak, 1990), and they have been used successfully within the knowledge assessment literature (Ruiz-Primo & Shavelson, 1995). However, Marks and her colleagues (2000) note that the typical use of concept maps within the literature presents a number of disadvantages. First, team members' concept maps are usually compared to one expert model and, if there are discrepancies, the model is automatically discounted as incorrect. Using concept maps in this way precludes the possibility that there are numerous ways to successfully approach a task. Second, concept maps normally depict a linear ordering of events and do not allow for the ordering of events across various branches of the map.

To try to maximize the advantages and minimize the disadvantages of using traditional concept maps, Marks and her colleagues (2000) introduced team-interaction concept maps, a variant of which was utilized in this study. Team-interaction concept maps allow for more than one correct response, computing a similarity score separately from an accuracy score. Team members are also asked about what all their teammates are doing at the same time to complete the task. More specifically, team members are given a map of a possible task scenario along with a number of concepts that represent different aspects of the task domain. Each team member completes a map by placing concepts that best represent the actions of each team member on the map (see Appendix C). The four rows represent the sequence of actions for each team member. The columns represent what the team members are doing at about the same time.

To calculate the similarity between the four concept maps, I used the scoring algorithm utilized by Marks and her colleagues (2000). One point was given when two team members shared a linked set of concepts (A-B), three points were given when three team members shared a linked set of concepts, and nine points were given when all four team members shared a linked set of concepts. Therefore, similarity scores can range from 0 (no similarity among any of the four team member concept maps) to 36 (four identical concept maps) for first concept map pictured in Appendix C. For the second concept map, two points were given when two team members shared three linked concepts (A-B-C), six points were given when three team members shared three linked concepts, and eighteen points were given when four team members shared three linked concepts. Thus, similarity scores could have ranged from 0 to 72. The similarity scores for each of the two concept maps were added together to form a total shared mental model similarity score.

Accuracy calculations also followed the work of Marks and her colleagues (2000). The accuracy of team member mental models was assessed by two judges who were SMEs in the DDD command and control simulation. Each team member's concept map was rated on a Likert-type scale of structural accuracy ranging from 1 (inaccurate) to 7 (highly accurate). Judges paid particular attention to (1) the critical DDD functions, (2) the appropriate role assignments for each team member, and (3) a reasonable sequence of actions for successful completion of the task. The two judges' evaluations were highly correlated for both the first ($r = .95$) and the second ($r = .94$) mental models. As a result, team accuracy scores were formed by averaging the two judges' accuracy ratings for individual mental models and then taking the sum of the four team members' accuracy scores.

Team Performance. The two main objectives of every DDD team are to (1) engage enemy tracks as quickly as possible once they enter one of the forbidden zones and (2) allow friendly tracks to roam freely across the screen. These two objectives are reflected in the team's offensive and defensive scores during the game. The team's offensive score starts at 1,000 points and goes up 5 points every time an enemy target is cleared from one of the forbidden zones. If a team member clears an enemy target outside the forbidden zones or clears a friendly target anywhere on the screen, the team's offensive score drops by 25 points. The team's defensive score starts at 50,000 and decreases 1 point for every second an enemy resides within the restricted zone. If an enemy enters the highly restricted zone, the team's defensive score begins to drop by 2 points per second. Team performance was measured by standardizing and combining each team's offensive and defensive scores.

Manipulations

Acute Stressors. Researchers have identified numerous aspects of the environment that can act as stressors, including job scope (e.g., Xie & Johns, 1995), role conflict and role ambiguity (e.g., Jackson & Schuler, 1985; O'Driscoll & Beehr, 1994; Schaubroeck, Cotton, & Jennings, 1989), lack of control over one's job (e.g., Averill, 1973; Friedland, Keinan, & Regev, 1992; Spector, 1986), responsibility (e.g., Cooper & Kelly, 1984; Martin & Wall, 1989; Sutherland & Cooper, 1986), temperature (e.g., Jewell, 1998; Surry, 1968), workload (e.g., Cooper & Roden, 1985; Kushmir & Melamed, 1991;

Westman & Eden, 1992), noise (e.g., Poulton, 1978; Teichner, Arees, & Reilly, 1963), and interpersonal conflict (e.g., Keenan & Newton, 1985).

The problem with many of the stressors identified in the literature is that they are impractical for laboratory investigation. For example, manipulating the workload level within the team would likely create stress and team members would likely interact less with one another. However, it would be difficult to determine whether any behavioral effects were due to the stress or the increased task requirements. The level of interaction within the team could simply be a function of more individual task-related duties. Therefore, I chose to examine the combined effects of time pressure and threat, which can be manipulated without altering the task. Researchers have shown that a combination of stressors results in an exponentially greater response rather than an additively greater one (Kahn & Byosiere, 1992).

Time pressure, which is present, at least to some degree, in much of the working world (Kelly & McGrath, 1985), has been defined as a "restriction in the time required to perform a task" (Salas, Driskell, & Hughes, 1996, p. 32) or as "a ratio of time to perform required tasks divided by the time available" (Orasanu & Backer, 1996, p. 100). It is merely the perception that there is not enough time to complete a given amount of work (Cooper et al., 2001). These perceptions have been shown to increase arousal and psychological stress levels among employees (e.g., Driskell, Salas, & Johnston, 1999; Gladstein & Reilly, 1985; Holsti, 1971; Keinan, Friedland, & Ben-Porath, 1987; Oransanu & Backer, 1996; Salas, Driskell, & Hughes, 1996; Svenson & Maule, 1993).

There is also some evidence that perceptions of time pressure lead to a breakdown in information processing. Individuals under time pressure must deal with the additional cognitive demands resulting from the requirement to process a large amount of information in a limited amount of time (Wright, 1974), forcing them to come up with a strategy to reduce the information overload. Researchers have suggested that this can lead to a more selective information processing system (Hinsz et al., 1997; Karau & Kelly, 1992; Payne, Bettman, & Johnson, 1988). A number of studies have shown that employees under time pressure focus on specific pieces of information and pay attention to a smaller set of cues when working alone (e.g., Janis, 1982; Janis & Mann, 1977; Rothstein, 1986; Svenson, Edland, & Karlsson, 1985; Wright, 1974) and when working in a team setting (Driskell et al., 1999; Gladstein & Reilly, 1985). These results have been linked to the finding that individuals narrow their attention under stress (e.g., Driskell et al., 1999; Gladstein & Reilly, 1985).

To manipulate time pressure, I extended the work of Driskell and his colleagues (1999) who told subjects to "hurry up" and "work harder" at five-minute intervals during the task. In this study, team members were informed that, because most teams fail to attend to the clock, the experimenter will make sure to keep track of the time and will let them know how much time they have left at various intervals (see Appendix A). At the 10 minute-mark, the first warning was given. Team members were told that "You now have only 20 minutes left to work on the task, which is not a lot of time. In order to perform well, you need to hurry up and work harder at keeping the forbidden zones free from enemy targets." Similar warnings were given at the 15, 20, 22, 24, 26, and 28-minute marks, letting the team members know that they had 15, 10, 8, 6, 4, and 2 minutes left respectively.

Threatening the group can only enhance the effects of the time pressure manipulation. Threat has been broadly defined "as an environmental event that has impending negative or harmful consequences for the entity" (Staw, Sandelands, & Dutton, 1981, p. 502). Researchers have shown that threats represent a significant cause of psychological and physiological stress and strain among employees (e.g., Cobb & Kasl, 1977; Jick & Murray, 1982; McGrath, 1976). Threatening employees can also affect the way that they process information. Researchers have shown that individuals restrict the amount of information that they have to deal with by focusing on internal hypotheses, prior expectations, and dominant cues and tend to behave according to well-learned or dominant response patterns (Beehr, 1995; Smart & Vertinsky, 1977; Staw et al., 1981).

One reason why such threats are experienced as stressful events is because they create a high level of uncertainty among the employees. "If any one variable were to be singled out as the predominant underlying source of occupational stress, it would be uncertainty" (Sharit & Salvendy, 1982, p. 150). The significance of uncertainty in feelings of stress and strain has been derived from expectancy theory, which examines the degree to which two organizational events are related to one another (Beehr & Bhagat, 1985).

To manipulate threat in this study, teams in the stress conditions were told the following at the 15-minute mark:

Each semester, we notice that there are a few teams that seem to lag far behind the others. We feel that this is due to a lack of motivation among certain students. Everyone gets credit for participating, so some students feel that they can slack off during their 3-hour session in the lab. When one person doesn't pull their weight in the team, the other team members need to pick up the slack for them. If one person isn't taking care of his or her duties, the team's performance will suffer. Therefore, in order to make sure you give us your full attention and effort for the next 30 minutes, we are going to put a little pressure on you. Right now, there are almost 600 students enrolled in your MGT 315 course. We assume that you would prefer not to be displayed in front of all your friends if you aren't pulling your weight in the lab today. Therefore, we are going to videotape your team's performance. If your team is one of the three lowest performers, Dr. Morgeson will show the tape to the entire MGT 315 class the last week of the semester as an example of ineffective team behavior. I don't think any of you want everything you say picked apart by Dr. Morgenson during class. So just remember that the camera will be on you for the next 30 minutes.

The specific threat utilized in this study has received little attention within the literature. However, there have been numerous studies documenting the stressful effects of performance monitoring (e.g., Aiello & Kolb, 1995; Aiello & Shao, 1993; Amick & Smith, 1992). Stress results when individual workers feel that their behavior is under observation, even if they are aware that their work is aggregated with others before being monitored (Aiello et al., 1991). Researchers have suggested that performance monitoring creates a stressful work environment by reducing the amount of control workers have over their jobs (Smith et al., 1992) and by restricting the amount of social support available within the workgroup (Amick & Smith, 1992). In this study, participants believed that their performance was being monitored via videotape. As in the workplace, participants were aware of the negative consequences that could result from non-productive behavior. Instead of the possibility of losing their jobs, participants were aware of the possibility of public humiliation.

<u>Prior Shared Information</u>. Stasser and his colleagues (e.g., Stasser, Taylor, & Hanna, 1989; Stasser & Titus, 1985; 1987; Stewart & Stasser, 1995) have conducted a number of studies focusing on the discussion of unshared and shared information within decision-making groups. Generally, they follow the same basic research paradigm. For example, Stasser and Titus (1987) distributed 24 pieces of information regarding several

hypothetical candidates for a political position. In the 33% shared condition, each candidate received the 8 pieces of shared information and 4 pieces of unshared information. In the 66% shared condition, each candidate received 16 pieces of shared information and 2 pieces of unshared information.

The manipulation of shared information in this study differed slightly from the work of Stasser and his colleagues. Four pieces of information regarding the wave attacks were distributed among the four team members (see Appendix E). Across all conditions, each team member received 2 pieces of information. Collectively, each team possessed all the information about the wave targets, but team members individually received only part of the information.

The distribution of information within the team was based on "truth supported wins" models, which suggest that it is enough for two team members to share access to the same set or information in order for the group to attend to and acquire the information collectively (Hinsz et al., 1997). Researchers have shown that groups tend to be more successful when group members have a partner to corroborate their decisions or behavior (e.g., Laughlin, 1980; Laughlin & Ellis, 1986). Pairing up two teammates together has been shown to benefit a number of different outcomes, including team learning (Ellis, Hollenbeck, Ilgen, Porter, West, & Moon, under review-a). Given these findings, creating "role partners" (two individuals who share expertise and information processing responsibilities) may allow for the optimal level of shared information within the team.

To generate a high level of prior shared information, where 100% of the information was shared, two sets of role partners were created within the team. The first set of role partners (DM1 and DM2) received information regarding the first two wave attacks, while the second set of role partners (DM3 and DM4) received information regarding the last two wave attacks. To generate a low level of prior shared information, where 50% of the information was shared, only one set of role partners was created. DM1 and DM2 received the same information as in the high prior shared information conditions regarding the first two wave attacks. However, DM3 received information regarding the first and last wave attacks, while DM4 received information regarding the second and third wave attacks. As a result, no role partner was available to corroborate information regarding the third and fourth wave attacks in the low prior shared information conditions.

Feedback. The feedback manipulation used in this study was modeled after Porter (2001). Across all eight conditions, teams received three specific goals during training (see Appendix A). First, the team members were informed that they should never allow enemy tracks to remain in the restricted zone for more than 3 minutes. Second, the experimenter advised team members to try and engage enemy tracks residing in the highly forbidden zone within 1 minute after entry. Third, team members were told that they should try not to shoot down more than 1 friendly track during the 45-minute task.

At the 15-minute mark, teams in the appropriate conditions received the following feedback manipulation, where the experimenter provided negative individual level or team level performance feedback regarding the extent to which the team member met the goals discussed prior to the first task (see Appendix A):

DM2, after watching your performance during the first 15 minutes, it appears that you have been having some difficulty with the goals we set earlier. In particular, you allowed a number of tracks to remain in your restricted zone for more than 3 minutes and several tracks remained in your highly restricted zone for well over 1 minute, which is much longer than we discussed. In addition, you have already shot down more than 1 friendly track in your quadrant. By not doing these things, your performance has probably hurt the team's score.

Although the individual level feedback could have potentially been given to any of the team members, DM2 was randomly selected as the recipient for the duration of the study. Negative feedback was always be given in the presence of all four team members.

Procedure.

Immediately after entering the laboratory and filling in a consent form, participants were randomly assigned to a four-person DDD team. The team was then escorted into a room in which they worked on the team task. Once in the room, each participant was randomly assigned to one of four computer stations (e.g., DM1, DM2, DM3, or DM4). After being seated at their respective stations, participants completed the Wonderlic Personnel Test and the NEO FFI.

For the next hour, the participants were trained on the declarative and procedural knowledge necessary for successful task completion. Participants were first trained on various aspects of the task, including the location of the bases, the scoring, the functions of the various rings, the different vehicles, and the tracks (see Appendix A). Participants then played a 45-minute practice game, where they learned how to launch and move vehicles, identify tracks, and attack targets. During the practice game, team members owned one tank, one AWACS plane, one helicopter, and one jet. They were also told that the A, B, C, and D targets corresponded to ground targets with power 0, 1, 3, and 5, respectively.

Immediately following the training, the goals, which were described earlier, were set for the team. All participants, regardless of experimental condition, received the same goals. Therefore, goals were constant across all teams and all participants and were not confounded with the experimental manipulations. The goal setting intervention was merely a component of the feedback intervention, which provided information regarding the extent to which team members met the performance standards set forth during the goal setting intervention.

Team members were also told that they would each have their own specialties during the game. Specifically, each team member possessed only one vehicle during the game and only knew the power of one target. Each team member was given a sheet that illustrated their own specific role, which they were able to keep during both games (see Appendix D). They were informed that a few pieces of information may overlap with the information given to other team members (depending on the condition they are in), but most would only be known by one team member.

At the end of the first 15-minute task, the trainer recorded the team's scores. The trainer then provided negative performance feedback to either DM2 or the team as a whole, depending on condition. If the team was in one of the acute stressor conditions, they were then told that their performance would be videotaped and they might be in jeopardy of having the tape shown in front of the entire class as an example of ineffective teamwork. They were also told that the experimenter would keep track of the time during the second game and would warn the team at various intervals when time was beginning to run short.

During both games, the experimenter remained in the room in order to record any transactive-related communication within the team. After the second 30-minute game, team members first completed the manipulation check for the acute stressor manipulations, then the shared mental models measure, and then the manipulation check for feedback manipulation. Once all of the team members completed the post-task measures, they were debriefed and dismissed. The debriefing first informed participants that their team performed well enough that there was no chance that their performance would be shown and critiqued in front of the whole class. They were also told that, if they received feedback regarding their performance, it may or may not have been related to their actual behavior.

RESULTS

Manipulation Checks.

Acute Stressors. To examine the effectiveness of the acute stressor manipulation introduced in this study, several scales were utilized. First, participants completed the Pressure/Tension scale from the Intrinsic Motivation Inventory (see Appendix F), which has been developed and utilized by Deci and Ryan and their colleagues (e.g., Ryan, 1982; Ryan, Mims, & Koestner, 1983; Ryan, Koestner, & Deci, 1991; Deci, Eghrari, Patrick, & Leone, 1994). The scale has been shown to be both reliable and valid (e.g., McAuley, Duncan, & Tammen, 1987). Coefficient alpha for this study was .85. Answers ranged from 1 (not at all true) to 7 (very true). As expected, individuals in the acute stress conditions felt more tense ($M = 4.62$, $SD = 1.31$) than individuals in the non-stress conditions ($M = 4.29$, $SD = 1.28$), $t(394) = 2.53$, $p < .05$. Second, participants completed the Affective (Negative) Thought scale, as shown in Appendix F, which has evidenced acceptable psychometric properties across a number of empirical studies (e.g., Kanfer & Ackerman, 1989; Kanfer, Ackerman, Murtha, Dugdale, & Nelson, 1994). In this study, coefficient alpha reached .77. Responses to the Affective (Negative) Thought scale were on a Likert-type 5-point scale from strongly disagree to strongly agree. Individuals in the acute stress conditions experienced more negative thoughts ($M = 2.90$, $SD = .82$) than individuals in the non-stress conditions ($M = 2.69$, $SD = .81$), $t(394) = 2.50$, $p < .05$. Third, participants completed the 20-item STAI State Anxiety scale (Spielberger, 1983). The scale has been shown to evidence acceptable levels of reliability and validity (see Spielberger & Reheiser, 1995) and has been frequently utilized within the stress literature (e.g., Spector, Dwyer, & Jex, 1988). Coefficient alpha was .92 in this study. Higher levels of state anxiety were reported in the acute stress conditions (M = 1.99, SD = .56) than in the non-stress conditions (M = 1.79, SD = .49), $t(394) = 3.78$, $p < .01$. Fourth, participants completed four questions designed to assess reactions to each of the specific acute stressor manipulations. Regarding time pressure, participants were asked the extent to which they "felt a lot of time pressure during this task" and "felt stressed because there was not enough time to complete the task." Coefficient alpha reached .87 for these two items. Individuals in the acute stress conditions felt more time pressure (M = 4.38, SD = 1.64) than individuals in the non-stress conditions (M = 3.58, SD = 1.67), $t(394) = 4.80$, $p < .01$. Regarding threat, participants were asked the extent to which "the idea that other students may be aware of my performance on this task was very stressful" and the extent to which they "felt a lot of pressure to perform well on this task because there was a chance that others could observe my behavior." Coefficient alpha reached .88 for these two items. Individuals in the threat conditions felt more stress (M = 3.60, SD = 1.76) than individuals in the non-threat conditions (M = 2.52, SD = 1.38), $t(394) = 6.75$, $p < .01$. Finally, participants indicated, on a scale from 1 (not at all stressed) to 7 (very stressed), how stressed they felt while playing the DDD command and control simulation. Participants in the stress conditions reported feeling more overall stress (M = 4.18, SD = 1.49) than participants in the non-stress conditions (M = 3.54, SD = 1.35), $t(394) = 4.49$, $p < .01$. The manipulation checks all point to the same conclusion: the acute stressor manipulation was highly effective. Table 4 provides the means, standard deviations, and intercorrelations among the acute stressor manipulation checks. A number of team members in the stress conditions also verbally supported the effectiveness of the acute stressor manipulation with comments such as "I'm starting to sweat. This is stressing me out!" "I want to punch the screen right now!" and (my favorite) "Dude, back off."

Feedback. The following three items assessed the effectiveness of the feedback manipulation used in this study: (1) "Over the course of the two games you just played, did the experimenter provide any information regarding progress toward the goals that were set during training?" (2) "If the experimenter did provide such information, was it generally positive or negative in nature?" (3) "If the experimenter did provide such information, who was it given to (i.e., DM2, DM1, DM3, DM4, or the team as a whole)?" Regarding the first question, 99.0% of the participants agreed that they received some sort of feedback concerning the three goals that were set during the training session. The majority of participants (93.7%) also agreed that the feedback they received was generally negative in nature. In the individual negative feedback conditions, 87.5% of the students thought that DM2 received the information. In the team negative feedback conditions, 99.5% of the students recognized that the team as whole received the information. Participants in the team negative feedback conditions indicated that the feedback was directed at the team as a whole more frequently ($M = 5.00$, $SD = .00$) than participants in the individual negative feedback conditions ($M = 2.32$, $SD = .95$), $t(394) = 39.30$, $p < .01$. In sum, 88.4% of the participants responded correctly to all three questions, suggesting that the feedback manipulation was successful.

One concern was that the individual negative feedback manipulation could have put undue stress on DM2. As a result, DM2's scores on the acute stressor manipulation checks were compared to DM1, DM3, and DM4 across the individual negative feedback conditions. DM2 did not report feeling more tense ($M = 4.43$, $SD = 1.32$) than the rest of the team ($\underline{M}$ = 4.34, $\underline{SD}$ = 1.26), $\underline{t}(198) = .40$, ns. DM2 also failed to report higher levels of state anxiety ($\underline{M}$ = 1.97, $\underline{SD}$ = .57) than his or her teammates ($\underline{M}$ = 1.81, $\underline{SD}$ = .51), $\underline{t}(198) = 1.92$, ns. Furthermore, DM2 did not report feeling more time pressure ($\underline{M}$ = 3.88, $\underline{SD}$ = 1.76) than the rest of the team ($\underline{M}$ = 3.94, $\underline{SD}$ = 1.65), $\underline{t}(198) = -.22$, ns, or more threat ($\underline{M}$ = 3.38, $\underline{SD}$ = 1.75) than his or her teammates ($\underline{M}$ = 2.91, $\underline{SD}$ = 1.58), $\underline{t}(198) = -1.79$, ns. DM2 differed only when his or her scores on the Affective (Negative) Thought scale ($\underline{M}$ = 3.18, $\underline{SD}$ = .88) were compared with the rest of the team ($\underline{M}$ = 2.64, $\underline{SD}$ = .78), $\underline{t}(198) = 4.06$, $p < .01$. These results suggest that, in general, DM2's level of stress was not influenced by the individual negative feedback manipulation.

Another concern was that participants' perceptions of procedural justice would be affected by the time pressure and threat manipulations, even though they were told about the possibility that their performance would be recorded and they were free to leave at any time. Therefore, for the first ten teams, participants completed a four-item procedural justice measure adapted from Greenberg (1993; 1994). Answers were given on a five-point scale from strongly disagree to strongly agree. An example item was "the procedures used in the lab today were fair and aboveboard." Participants in the acute stressor conditions did not report lower levels of procedural justice ($\underline{M}$ = 2.38, $\underline{SD}$ = .78) than participants in the non-stress conditions ($\underline{M}$ = 2.41, $\underline{SD}$ = .78), $\underline{t}(40) = .10$, ns.

<u>Prior Shared Information</u>. According to the formulas developed by Stasser and his colleagues (e.g., Stasser, Taylor, & Hanna, 1989; Stasser & Titus, 1985; 1987) regarding the discussion of shared vs. unshared information, information regarding the four wave attacks should be discussed more frequently in the high prior shared information conditions vs. the low prior shared information conditions. Teams with high

levels of prior shared information should also discuss the third and fourth wave attacks more frequently than teams with low levels of shared information. Results indicated that the first two waves were discussed among team members with high levels of prior shared information ($\underline{M}$ = 5.73, $\underline{SD}$ = 3.39) about as frequently as team members with low levels of prior shared information ($\underline{M}$ = 4.64, $\underline{SD}$ = 2.43), $\underline{t}(97) = 1.83$, ns. The third and fourth wave attacks, on the other hand, were discussed among team members with high levels of prior shared information ($\underline{M}$ = 3.72, $\underline{SD}$ = 2.61) significantly more frequently than team members with low levels of prior shared information ($\underline{M}$ = 2.16, $\underline{SD}$ = 1.69), $\underline{t}(97) = 3.52$, $p<.01$. Overall, the wave attacks were discussed among team members with high levels of prior shared information ($\underline{M}$ = 9.45, $\underline{SD}$ = 5.38) significantly more frequently than team members with low levels of prior shared information ($\underline{M}$ = 6.81, $\underline{SD}$ = 3.70), $\underline{t}(97) = 2.84$, $p<.01$. This suggests that the prior shared information manipulation influenced the discussion of shared vs. unshared information as expected.

Tests of Hypotheses

Means, standard deviations, and intercorrelations among all the variables included in the hypothesis tests are included in Table 5. Two teams were eliminated from the analyses due to changes in the task that occurred after their participation. The timing of the targets was altered, making the task much more difficult for subsequent teams. As shown in Table 5, shared mental model similarity and shared mental model accuracy were highly related to one another. Marks and her colleagues (2000) reported a similar relationship between shared mental model similarity and accuracy. Yet the two variables were kept distinct. Their results indicated that the two variables exhibited an interactive effect on team communication processes above and beyond the direct effects. In order to investigate the interactive effects of mental model similarity and accuracy on team performance in this study, the two variables were not combined together.

The hierarchical regression analyses designed to test the hypotheses proceeded in several stages. First, the variables utilized in testing the hypotheses were centered. Second, a series of regressions were run to examine the direct and interactive effects of the five independent variables on shared mental model similarity, shared mental model accuracy, directory updating, information allocation, retrieval coordination, and transactive memory. Each regression consisted of three steps. Stress was entered in the first step, followed by the situational or personal characteristic of interest in the second step, followed by their interaction in the third step. Because the independent variables were not significantly related to one another, order of entry did not affect significance levels. It also allowed for an examination of the amount of variance in each dependent variable that could be attributed to the acute stressor manipulation and each situational and personal characteristic. Separate regressions were run for each situational and personal characteristic because, with only 97 teams, degrees of freedom becomes an issue when all five independent variables and their interactions are in one equation. Third, regressions were run to determine whether directory updating, information allocation, and retrieval coordination affected shared mental model similarity and shared mental model accuracy. Fourth, regressions were run to examine the effects of shared mental model similarity, shared mental model accuracy, directory updating, information allocation, retrieval coordination, and transactive memory on team performance. Fifth, regressions were run to test for shared mental model similarity, shared mental model accuracy, directory updating, information allocation, retrieval coordination, and transactive memory as mediators of the relationship between stress and team performance based on the recommendations of Baron and Kenny (1986) and James and Brett (1984).

Hypothesis 1. Hypothesis 1 proposed that the presence of acute stressors would be negatively related to shared mental model development. As shown in Table 6, the presence of acute stressors, entered as the first hierarchical step, accounted for a significant 22% of the between-team variance in shared mental model similarity and a significant 28% of the between-team variance in shared mental model accuracy. The direction of the relationship indicated that acute stressors negatively impacted similar ($\beta = -.47$, $p<.01$) and accurate ($\beta = -.53$, $p<.01$) shared mental models, supporting Hypothesis 1.

Hypothesis 2. Hypothesis 2 predicted that the presence of acute stressors would be negatively related to transactive memory. Table 7 shows that teams faced with acute stressors evidenced significantly lower levels of directory updating ($\beta = -.32$, $p<.01$), information allocation ($\beta = -.32$, $p<.01$), and retrieval coordination ($\beta = -.49$, $p<.01$). Entering the presence of acute stressors as the first hierarchical step in the regression also negatively affected the aggregate transactive memory variable ($\beta = -.52$, $p<.01$). The presence of acute stressors explained 10% of the between-team variance in directory updating, 10% of the between-team variance in information allocation, 24% of the variance in retrieval coordination, and 27% of the variance in transactive memory. These results offer strong support for Hypothesis 2.

Hypothesis 3. Table 8 addresses Hypothesis 3 by providing the results of regressing shared mental model similarity and accuracy on directory updating, information allocation, retrieval coordination, and transactive memory. Directory updating, information allocation, and retrieval coordination were entered in one hierarchical step to assess their unique contributions to shared mental models. Retrieval coordination explained a significant percentage of unique variance in shared mental model similarity (ß = .39, p<.01), while information allocation (ß = .20, p<.05) and retrieval coordination (ß = .32, p<.01) explained a significant portion of variance in shared mental model accuracy. The aggregate transactive memory variable was highly related to both shared mental model similarity (ß = .48, p<.01) and shared mental model accuracy (ß = .46, p<.01), explaining 23% and 21% of the between-teams variance respectively. These results do not support Hypothesis 3, which predicted that directory updating would be the primary determinant of shared mental model development.

Hypothesis 4. The results for the effects of cognitive ability on shared mental model similarity and shared mental model accuracy did not support Hypothesis 4, which predicted that teams high in cognitive ability would be in a better position to develop shared mental models. As shown in Table 6, entered as a second step, cognitive ability failed to predict shared mental model similarity (ß = .10, ns) and shared mental model accuracy (ß = -.01, ns). Cognitive ability explained almost no variance in shared mental model similarity (ΔR^2=.01) and shared mental model accuracy (ΔR^2=.00) beyond the effects of acute stressors.

Hypothesis 5. Hypothesis 5 predicted that cognitive ability would positively affect transactive memory. Table 7 shows that cognitive ability, entered in the second step of the regression, was unrelated to directory updating (ß = -.07, ns), information allocation (ß = .15, ns), and retrieval coordination (ß = .10, ns). Cognitive ability was also unrelated to transactive memory (ß = .08, ns). Cognitive ability explained little variance in directory updating (ΔR^2=.01), information allocation (ΔR^2=.02), retrieval coordination (ΔR^2=.01), and transactive memory (ΔR^2=.01) beyond the effects of acute stressors. Thus, Hypothesis 5 was not supported.

Hypothesis 6. Hypothesis 6 proposed that cognitive ability would moderate the relationship between the presence of acute stressors and team processes. As shown in Table 6, the interaction between stress and cognitive ability entered in the third hierarchical step failed to relate to shared mental model similarity (ß = .04, ns) and shared mental model accuracy (ß = .11, ns). Table 7 shows that the interaction between stress and cognitive ability was not significantly related to directory updating (ß = .09, ns), information allocation (ß = -.05, ns), retrieval coordination (ß = -.02, ns), or transactive memory (ß = .01, ns). As the interaction failed to explain a significant amount of variance in any of the team processes above and beyond the direct effects, Hypothesis 6 was not supported.

Hypothesis 7. Hypothesis 7 proposed that high levels of extraversion would strengthen shared mental models in temporary project teams. The mean level of extraversion within the teams, entered as the second hierarchical step as shown in Table 6, was unrelated to shared mental model similarity (ß = .11, ns) and shared mental model accuracy (ß = .02, ns). Because extraversion explained an insignificant 1% of the between-teams variance in shared mental model similarity and 0% of the between-teams variance in shared mental model accuracy, Hypothesis 7 was not supported.

Hypothesis 8. Table 7 shows that extraversion, entered as the second step, failed to predict directory updating (ß = .08, ns), information allocation (ß = .04, ns), and retrieval coordination (ß = .01, ns). Extraversion was also unrelated to the aggregate transactive memory variable (ß = .06, ns). In total, extraversion explained 1% of the between-teams variance in directory updating, 1% of the between-teams variance in information allocation, 0% of the between-teams variance in retrieval coordination, and 0% of the between-teams variance in transactive memory. Therefore, Hypothesis 8, which predicted that extraverted teams would exhibit more directory updating, information allocation, and retrieval coordination, was not supported.

Hypothesis 9. Hypothesis 9 proposed that extraversion would moderate the effects of acute stressors on team processes. However, as shown in Table 6, the interaction between extraversion and stress, entered as the third step in the regression, failed to predict shared mental model similarity (ß = -.03, ns) and shared mental model accuracy (ß = -.07, ns). The results were similar for directory updating (ß = -.07, ns), information allocation (ß = -.03, ns), and retrieval coordination (ß = .04, ns). The interaction term also failed to predict transactive memory (ß = -.03, ns). Because the interaction between extraversion and acute stressors did not explain a significant percentage of variance in any of the team process variables, Hypothesis 9 was not supported.

Hypothesis 10. Hypothesis 10 proposed that the level of prior shared information would positively relate to shared mental model similarity and shared mental model accuracy. Table 6 shows that prior shared information, entered as the second hierarchical step, was significantly and positively related to both shared mental model similarity (ß = .21, $p<.05$) and shared mental accuracy (ß = .21, $p<.05$). Despite the strong effects of stress, the level of prior shared information explained a significant 4% of the between-teams variance in shared mental model similarity and 5% of the between-teams variance in shared mental model accuracy. Thus, Hypothesis 10 was supported.

Hypothesis 11. Hypothesis 11 examined the relationship between prior shared information and transactive memory. As shown in Table 7, the amount of shared information, entered as the second step, failed to predict directory updating (ß = .13, ns), information allocation (ß = -.07, ns), and the aggregate transactive memory variable (ß = .10, ns). However, the level of prior shared information was positively related to the level of retrieval coordination within the team (ß = .15, p<.10). Prior shared information explained a significant 2% of the variance in retrieval coordination over and above the effects of stress, partially supporting Hypothesis 11.

Hypothesis 12. Hypothesis 12 predicted that the level of prior shared information would help to buffer the effects of acute stressors on team processes. Prior shared information had no influence on the relationship between acute stressors and shared mental models, as shown in Table 6. The interaction between stress and shared information, entered as the third hierarchical step, was unrelated to shared mental model similarity (ß = .08, ns) and shared mental model accuracy (ß = .16, ns), explaining 0% and 1% of the variance respectively. The results regarding directory updating, information allocation, and retrieval coordination were slightly more promising. Table 7 shows that, although the interaction between stress and shared information fails to predict directory updating (ß = -.17, ns), information allocation (ß = .08, ns), and transactive memory (ß = -.20, ns), the interaction relates to the level of retrieval cordination within the team (ß = -.34, p<.05), explaining a significant 4% of the variance. As shown in Figure 4, teams experiencing acute stressors exhibited less of a reduction in retrieval coordination when there was a high level of prior shared information. As a result, Hypothesis 12 was partially supported.

Hypothesis 13. Hypothesis 13 proposed that providing negative feedback to one individual rather than the team as a whole would damage shared mental models. Table 6 indicates that the type of negative feedback provided to the team, entered as the second hierarchical step, had little impact of shared mental model similarity (ß = .07, ns) and shared mental model accuracy (ß = .03, ns). Feedback explained an insignificant 1% of the between-teams variance in shared mental model similarity and 0% of the between-teams variance in shared mental model accuracy. So Hypothesis 13 was not supported.

Hypothesis 14. Table 7 shows that feedback, entered in the second step, had little impact on directory updating (ß = .01, ns), information allocation (ß = .02, ns), retrieval coordination (ß = .10, ns), and transactive memory (ß = .06, ns) beyond the effects of acute stressors. Feedback explained an insignificant 1% of the variance in retrieval coordination and 0% of the variance in directory updating, information allocation, and transactive memory. Therefore, Hypothesis 14, which proposed that providing negative feedback to one team member would negatively impact transactive memory, was not supported.

Hypothesis 15. Hypothesis 15 proposed that providing negative feedback to the team as a whole would ameliorate the effects of acute stressors on team processes. As shown in Table 6, the interaction between feedback and stress, entered as the third step in the regression, was unrelated to shared mental model similarity (ß = -.14, ns) and shared mental model accuracy (ß = -.12, ns). The interaction term explained an insignificant 1% of the variance in shared mental model similarity and 0% of the variance in shared mental model accuracy. Table 7 shows that the interaction between feedback and stress was also unrelated to directory updating (ß = .04, ns), retrieval coordination (ß = -.24, ns), and transactive memory ($\beta = -.23$, ns). However, the interaction was related to the level of information allocation within the team ($\beta = -.29$, $p<.10$), explaining a significant 3% of the variance. As shown in Figure 5, the negative impact of acute stressors on information allocation was exacerbated by the provision of negative individual feedback. Therefore, Hypothesis 15 was partially supported.

Hypothesis 16. Hypothesis 16 proposed that shared mental model accuracy would explain a significant portion of variance in team performance. As shown in Table 9, shared mental model accuracy and shared mental model similarity, entered together in the first step of the regression, explained a significant 23% of the variance in team performance. However, shared mental model accuracy was significantly related to team performance ($\beta = .40$, $p<.05$), while shared mental model similarity was unrelated to team performance ($\beta = .08$, ns). Because shared mental model accuracy explained a significant portion of unique variance in team performance, Hypothesis 16 was supported.

Hypothesis 17. Hypothesis 17 predicted that transactive memory would relate to team performance. Table 9 indicates that, entered as the first block in the regression, directory updating, information allocation, and retrieval coordination explained a significant 16% of the variance in team performance. However, information allocation ($\beta = .18$, $p<.10$) and retrieval coordination ($\beta = .26$, $p<.05$) were positively related to team performance, while directory updating was unrelated to team performance ($\beta = .10$, ns). Only information allocation and retrieval coordination explained a significant portion of unique variance in team performance. As an aggregate variable, transactive memory was positively related to team performance ($\beta = .39$, $p<.01$), explaining 15% of the variance. Consequently, Hypothesis 17 was partially supported.

Hypothesis 18. Hypothesis 18 proposed that shared mental models and transactive memory would mediate the relationship between stress and team performance. In order to test for mediation, it is necessary to demonstrate that (a) both the independent (stress) and the mediating (shared mental models, directory updating, information allocation, retrieval coordination) variables relate to the dependent variable (team performance), (b) the independent variable relates to the mediating variables, and (c) the relationship between the independent variable and the dependent variable becomes negligible or is reduced significantly when controlling for the mediating variables (Baron & Kenny, 1986; James & Brett, 1984).

Regarding shared mental models, Table 10 shows that stress is significantly related to team performance ($\beta = -.43$, $p<.01$). Table 9 shows that shared mental model similarity is not related to team performance ($\beta = .08$, ns), while shared mental model accuracy is significantly related to team performance ($\beta = .40$, $p<.05$). Therefore, stress and shared mental model accuracy pass the first mediation requirement. Stress is significantly related to shared mental model accuracy ($\beta = -.53$, $p<.01$), as shown in Table 6, which passes the second mediation requirement. As shown in Table 10, the amount of variance in team performance explained by stress drops significantly from 18% to 4% when controlling for shared mental model accuracy, indicating that shared mental model accuracy mediates the relationship between stress and team performance.

Regarding directory updating, information allocation, and retrieval coordination, Table 9 shows that information allocation ($\beta = .18$, $p<.10$) and retrieval coordination ($\beta = .26$, $p<.05$) relate to team performance, while directory updating does not ($\beta = .10$, ns). As noted above, stress is significantly related to team performance. Therefore, stress, information allocation, and retrieval coordination pass the first mediation requirement. Table 7 indicates that stress is related to both information allocation ($\beta = -.32$, $p<.01$) and retrieval coordination ($\beta = -.49$, $p<.01$), which passes the second mediation requirement. As shown in Table 10, the amount of variance in team performance explained by stress drops significantly from 18% to 7% when controlling for information allocation and retrieval coordination, indicating that information allocation and retrieval coordination mediate the relationship between stress and team performance.

The aggregate transactive memory variable was also examined as a potential mediator. Table 9 shows that transactive memory significantly relates to team performance ($\beta = .39$, $p<.01$). Because stress also predicts team performance, the first mediation requirement is fulfilled. Stress also significantly relates to transactive memory ($\beta = -.52$, $p<.01$), passing the second mediation requirement (see Table 7). As shown in Table 10, the amount of variance in team performance explained by stress drops significantly from 18% to 7% when controlling for transactive memory, indicating that transactive memory mediates the relationship between stress and team performance. In sum, these results offer partial support for Hypothesis 18.

Supplemental Analyses

Table 3 provides a summary of which hypotheses were supported and which were not. However, in this section, I go beyond specific hypotheses and examine some issues that bear further investigation. In particular, I investigate an alternative operationalization of cognitive ability and extraversion, shared mental models as mediators of the relationship between shared information and team performance, the interactive effects of shared mental model similarity and accuracy on team performance, and the relationship between team processes and team performance in game 1. Finally, I double-check the regression results regarding the three manipulations utilizing MANOVA.

Hypotheses 4-9, which examined the effects of cognitive ability and extraversion on the relationship between stress and team processes, were all unsupported. Because the task was considered to be additive in nature, the mean was used to represent the level of cognitive ability and extraversion in the team. However, it could be argued that the task is more conjunctive than additive in nature. For example, only one team member was able to identify targets on the screen. Therefore, Hypotheses 4-9 were re-examined using the minimum score on the Wonderlic and the NEO within the team. Only the results for Hypothesis 4 changed. Cognitive ability, entered in the second step after stress, was significantly related to shared mental model similarity ($\beta = .15$, $p < .10$), partially supporting Hypothesis 4. However, the marginality of these results suggest that the individual differences examined in this study had little influence on the relationship between stress and team processes.

The results regarding Hypothesis 10 indicated that the level of prior shared information was positively related to shared mental model similarity and shared mental model accuracy. Although it was not specifically hypothesized, shared mental models could mediate the relationship between the level of prior shared information and team performance. The first requirement for mediation is that both the independent (prior shared information) and the mediating (shared mental models) variables relate to the dependent variable (team performance). Regressing team performance on the level of prior shared information, it was found that prior shared information explained an insignificant 1% of the variance in team performance. Therefore, prior shared information failed to pass the requirements for mediation.

Testing for Hypothesis 16, it was determined that shared mental model accuracy, not shared mental model similarity, explained a significant amount of variance in team performance. Although the hypothesis was confirmed, another possible relationship could emerge. Marks et al. (2000) found that shared mental model accuracy and shared mental model similarity interacted in their prediction of team outcomes. In order to test this relationship, team performance was regressed on shared mental model similarity and shared mental model accuracy in the first step and their interaction in the second step. The results indicated that the interaction explained a significant 4% of the variance in team performance ($\beta = .25$, $p<.05$). As shown in Figure 6, shared mental model similarity reduced team performance when shared mental model accuracy was low. Shared mental model similarity had little effect on team performance when shared mental model accuracy was high.

According to Hypothesis 17, directory updating, information allocation, and retrieval coordination were expected to relate to team performance. Only information allocation and retrieval coordination explained a significant amount of unique variance in team performance. However, Wegner (1987; 1995) suggested that, when groups initially form, directory updating is most important. The effects should only be enhanced for tasks similar to the one used in this study, where team members' areas of expertise remain static. Team members did not have to concentrate on constantly updating their directories. Once their directories were initially updated, team members could concentrate on information allocation and retrieval coordination. As shown in Table 11, during the initial 15-minute task, directory updating was highly related to team performance ($\beta = .32, p<.01$), while information allocation ($\beta = -.08$, ns) and retrieval coordination ($\beta = .02$, ns) were not. Table 12 shows that the level of directory updating during the first 15 minutes also contributed to shared mental model similarity ($\beta = .18, p<.10$) and shared mental model accuracy ($\beta = .20, p<.05$). This provides further evidence that, while directory updating, information allocation, and retrieval coordination all contribute to transactive memory, they should be viewed as distinct dimensions and transactive memory should be viewed as an aggregate construct.

Because this study examined the direct and interactive effects of continuous individual difference variables on team processes, multiple regression was the appropriate analytic strategy. However, the categorical nature of the manipulations would suggest the use of multivariate analysis of variance (MANOVA). Therefore, to double-check the results, a MANOVA was run examining the effects of the three manipulations on the team process variables. The results revealed a significant effect of the acute stressor manipulation on shared mental model similarity ($F(5, 85) = 26.99, p<.01$), shared mental model accuracy ($F(5, 85) = 37.71, p<.01$), directory updating ($F(5, 85) = 10.64, p<.01$), information allocation ($F(5, 85) = 10.40, p<.01$), retrieval coordination ($F(5, 85) = 32.65, p<.01$), and transactive memory ($F(5, 85) = 36.05, p<.01$). The prior shared information manipulation evidenced direct effects on shared mental model similarity ($F(5, 85) = 5.03, p<.05$), shared mental model accuracy ($F(5, 85) = 6.15, p<.05$), and retrieval coordination ($F(5, 85) = 2.68, p<.10$). Regarding interactions, there was a significant interaction between the feedback and acute stressor manipulations on information allocation ($F(5, 85) = 3.12, p<.10$). There was also a significant interaction between the prior shared information manipulation and the acute stressor manipulation on retrieval coordination ($F(5, 85) = 4.81$, $p<.05$). The results of the MANOVA analyses mirror the results of the regression analyses, offering additional support for the hypotheses tests described in the previous sections.

DISCUSSION

The purpose of this study was to develop and test a model of stress in team-based work structures. Based on information processing theory, stress was proposed to negatively impact team processes leading to decrements in team performance. The results supported this hypothesis, indicating that stress was negatively related to both transactive memory and shared mental models. Transactive memory and shared mental models were then shown to mediate the relationship between stress and team performance. A number of personal and situational characteristics were also proposed to affect the relationship between stress and team processes. Results indicated that cognitive ability and extraversion had little impact on team processes and failed to ameliorate the effects of stress on transactive memory and shared mental models. Results regarding the two situational characteristics, feedback and prior shared information, were mixed. The level of prior shared information was positively related to the level of retrieval coordination within the team, as well as shared mental model similarity and accuracy. Prior shared information also buffered the negative effects of stress on the level of retrieval coordination within teams. Providing negative feedback to the team as a whole rather than to an individual team member did not directly affect team processes, but it helped to moderate the negative effects of stress on the level of information allocation within teams. These results have a number of theoretical and practical implications.

Theoretical Implications

Cognitive psychologists generally accept the proposition that an individual's attention narrows under stress, focusing on sources of information that are considered a priority (e.g., Bacon, 1974; Easterbrook, 1959). In teams, attention can be focused on the task, the self, or the group (Hinsz et al., 1997). Researchers have suggested that, under stress, team members tend to become more self-focused and less team-focused (e.g., Driskell et al, 1999). A number of studies have supported this assertion by showing that interaction is reduced in stressful situations (e.g., Gladstein & Reilly, 1985). In this study, results indicated that team members focused less on secondary task duties and engaged in less interaction under stress, supporting past research.

However, this study went a step further by also proposing that, by reducing interaction and becoming more team-focused, stressed teams have trouble collectively processing information. Information processing systems within teams require team members to process information between as well as within the minds of the team members (Ickes & Gonzales, 1994). Team members need to develop a common frame of reference, attend to the correct set of information, combine pieces on information into a shared representation for the entire team, store a section of the shared representation in memory, and retrieve it from memory when needed (Hinsz et al., 1997). Shared mental models and transactive memory each represent portions of the team's collective information processing system. The results of this study showed that shared mental models and transactive memory were both negatively affected under stress. Shared mental models became less similar and less accurate, and team members engaged in less directory updating, information allocation, and retrieval coordination. Stressed team members had trouble developing a shared representation of the roles and responsibilities of their teammates and failed to utilize a transactive memory system to distribute the information within the team. Team members found it difficult to split up the team's information processing duties. When stressful environmental conditions presented themselves, teams clearly failed to process information between the minds of the team members, supporting the idea that stress undermines the team's collective information processing system.

It is possible that the negative effects of stress on transactive memory and shared mental models could have been due to decreased willingness to communicate within the team. That is, under stress, teams simply evidence less of a willingness to speak to one another. This could have been of particular concern in this study, where participants agreed to be videotaped during the task. However, the data indicate that teams under stress exhibited similar amounts of overall communication (M = 128.95, SD = 47.18) than teams in the non-stress conditions (M = 140.80, SD = 53.13), $t(95) = 1.16$, ns. These results indicate that team members still talked under stress, but they talked about the wrong things. They failed to utilize specific communications that would benefit the development of transactive memory systems and shared mental models. This also provides additional evidence for the validity of the transactive memory measure utilized in this study.

Although the results of this study supported the hypothesized disruption in teams' information processing systems, a number of personal and situational characteristics were proposed to influence the relationship between stress and team processes. The results regarding cognitive ability and extraversion, the two personal characteristics examined in this study, were disappointing. Neither individual difference variable had any effect on transactive memory or shared mental models. Individual differences also failed to moderate the negative effects of stress on the two team processes. This does not support the idea that teams high in cognitive ability are able to develop effective systems of interaction in order to effectively share and consider different pieces of information (Hollenbeck et al., 1996). Results suggested that teams high in cognitive ability were not able to pay more attention to both task-related and team-related duties, thereby improving the efficiency and effectiveness of their encoding, storage, and retrieval systems in stressful situations. Results also failed to support the notion that teams high in extraversion tend to develop more effective communication networks when the task requires a high level of interaction (Barrick et al., 1998). Under stress, teams high in extraversion shifted the same amount of attention away from the interactive duties of the task.

A possible explanation for the lackluster findings regarding cognitive ability and extraversion deals with the complexity of the task experienced by participants. Mischel (1977) proposed that situations can be characterized by the degree to which there are well-recognized and accepted rules of conduct that constrain and direct behavior (Weiss & Adler, 1984). According to Mischel (1977), when (1) everyone is pressured to view the situation in the same way, (2) there are uniform expectancies regarding appropriate behavior, (3) adequate incentives are offered for the correct response pattern, and (4) everyone has the skills the task requires, the task may not be complex enough to be susceptible to the effects of individual difference variables. Although the laboratory is an accepted local for testing theory-derived predictions under controlled conditions, researchers often underestimate the effects of task complexity. In fact, the goal of most lab experiments is to create situations in order to maximize variance attributed to the study's manipulations. Adding the use of homogenous samples with restricted variance on individual difference variables creates a situation where individual differences have a very small chance of exhibiting direct or moderated effects (Weiss & Adler, 1984). For example, Ganster (1980) examined the effects of several individual difference variables on the relationship between task characteristics, task perceptions, and satisfaction. The task manipulations explained between 45% and 74% of the variance in task perceptions and 58% of the variance in satisfaction. The individual differences accounted for little additional variance in the dependent variables. Weiss and Adler (1984) attributed the weak and inconsistent effects of the individual differences to aspects of the task. In this study, stress accounted for between 10% and 28% of the variance in team processes. In addition, the DDD command and control simulation tends to provide team members with uniform expectancies regarding appropriate response patterns and those types of behaviors are rewarded (e.g., shooting enemy targets inside versus outside the restricted zones). Teams received feedback regarding their performance, which "provides clear information about where teams need to focus their effort in order to be effective" (LePine, Hollenbeck, Ilgen, Colquitt, & Ellis, 2002). Although this may have contributed to the reduction or elimination of individual difference effects, past research using the DDD has found effects for individual differences (e.g., Hollenbeck et al., 2002). However, this is the first DDD study to combine a functional structure with information about the workload distribution during the task, specific performance feedback regarding progress toward their three goals, and specific areas of expertise for each team member. Participants' behavior was constrained and restricted to a greater degree in this study than in the past, which may have reduced task complexity, thereby limiting the potential explanatory power of cognitive ability and extraversion within teams.

Although the effects of cognitive ability and extraversion were nonexistent, the results regarding prior shared information were more positive. Teams that shared 100% of the information regarding future workload distribution problems during the task developed more similar and more accurate shared mental models and engaged in more retrieval coordination. Prior shared information also helped to moderate the negative effects of stress on retrieval coordination. Results indicated that teams distributed information within the team more frequently when it was shared. This supports the work of other researchers interested in the discussion of shared and unshared information within groups (e.g., Stasser & Titus, 1985). However, in this study, team members in the high prior shared information conditions were paired up. Studies have shown that pairing team members together may positively affect the level of information processing within teams (Ellis, Hollenbeck, Ilgen, Porter, West, & Moon, under review-a; Hinsz et al., 1997). Bion (1961) proposed that unconscious forces pressure team members to pair up with other individuals. Team members want to feel unified with, not isolated from, others. A number of benefits, including improved team processes, may result. The results of this study support this assertion by showing that giving two team members access to the same information improves shared mental models and retrieval coordination. The results also partially support the notion that pairing team members together creates a social support network that helps to lessen the negative effects of stress on transactive memory.

Feedback is another situational characteristic that was proposed to influence the relationship between stress and team processes. Results indicated that providing negative feedback to one team member rather than the team as a whole did not directly affect shared mental models or transactive memory. This did not support the proposed relationship between feedback type and information processing efficiency and effectiveness. However, results partially supported the idea that team level feedback provides information that can help team members effectively cope with stressful situations. Feedback moderated the relationship between stress and the information allocation dimension of transactive memory. When DM2 received the negative feedback, teams evidenced lower levels of information allocation under stress than when the team as a whole received the feedback. Team members receiving team level feedback appeared to shift less of their attentional resources away from their interactive team duties in stressful situations.

The weakness of the feedback manipulation may have been partially due to the task environment. Each team was given negative feedback concentrating on three areas: (1) clearing the restricted area of enemy tracks within 3 minutes, (2) clearing the highly restricted zone of enemy tracks within 1 minutes, and (3) avoiding engaging friendly tracks. It was proposed that giving this feedback to one team member would pressure team members to concentrate more on their own duties and ignore the collective duties of the team. However, by giving each team member a very specific area of expertise, I may have made it very difficult to accomplish their goals without their teammates' participation. For example, if DM4 encountered a track with a power of 5 in his or her restricted area, he or she had to ask DM2 for help because he or she only had 4 jets (i.e., power of 1). In other words, both types of feedback may have motivated team members to try to work together as a collective unit because it was very difficult for team members to concentrate solely on their own duties. This may have eliminated any differential effects between the individual and team negative feedback conditions.

Clearly the strongest results revolve around the negative effects of stress on transactive memory and shared mental models. However, the disruption in information processing due to the introduction of acute stressors would mean little if team performance were not affected. Results showed that shared mental models and transactive memory mediated the relationship between stress and team performance. This supports the theory that the effects of stress on team performance are indirect, not direct, functioning according to the input-process-outcome model propounded by researchers (e.g., Hackman & Oldham, 1975). These results also support the importance of information processing in the relationship between stress and team performance. Without the ability to collectively process information, teams may be at a serious disadvantage and may have trouble completing the tasks they are given, as suggested by researchers (e.g., Hinsz et al., 1997).

The specific effects of shared mental models on team performance support the findings of other researchers (Marks et al., 2000). While shared mental model accuracy and shared mental model similarity were highly related to one another, they evidenced interactive effects on team performance. Shared mental model similarity reduced team performance when shared mental model accuracy was low but had little effect on team performance when shared mental model accuracy was high. The results of this study suggest that, when operationalizing and analyzing shared mental models, accuracy and similarity should be kept distinct from one another.

The specific effects of transactive memory on team performance are more intriguing and have a number of theoretical implications. Although Moreland and his colleagues (e.g., Moreland, 1999; Moreland & Myaskovsky, 2000) have found that task credibility, task coordination, and memory differentiation relate to team performance, this is the first study to show that directory updating, information allocation, and retrieval coordination all have the potential to affect team performance. Results showed that, in this study, directory updating was the primary influence early on in the process, while information allocation and retrieval coordination became more important as time progressed. However, the task in this study remained fairly static and team members' areas of expertise did not expand or contract. In these situations, continually updating one's directory may become useless and perhaps even counterproductive. When new responsibilities arise or team members gain additional knowledge or skill, which would likely happen in most organizations, directory updating could become more important.

The results regarding transactive memory also provide additional evidence that the construct may be aggregate in nature. The dimensions exhibited differential relationships with team performance depending on the duration of the task. Initially, directory updating determined whether teams were effective or not. However, after team members gained knowledge regarding each other's areas of expertise, they began to utilize information allocation and retrieval coordination to become more effective. With latent constructs, the dimensions are merely manifestations of some deeper, more embedded construct (Law et al., 1998). Measures of each dimension should therefore be highly related to one another because, if transactive memory is operating as a latent construct, team members should utilize similar amounts of directory updating, information allocation, and retrieval coordination. However, the three dimensions evidenced low correlations with one another because team members may not need to use all three to enjoy a fully functioning transactive memory system. This supports the idea that the arrows point to the transactive memory construct and not away from it (Lepine et al., 2002). Lepine and his colleagues suggest that, if the construct is aggregate, future research should examine the directory updating, information allocation, and directory updating as separate dimensions. Although the results of this study found few differential effects, it is likely that certain predictors of transactive memory exhibit different relationships with directory updating, information allocation, and retrieval coordination.

If transactive memory is an aggregate construct, it can be formed by algebraically combining directory updating, information allocation, and retrieval coordination (Lepine et al., 2002). In this study, there was a lack of previous conceptual and empirical evidence supporting the domination of one or more dimensions of transactive memory, so they were combined equally to form the aggregate transactive memory construct. However, results indicate that this may be inappropriate in some situations. For example, if the team has been together for an extended period of time and team members' areas of expertise have remained static, it may be useful to weight information allocation and retrieval coordination more heavily. Researchers need to determine which dimensions are most important, given the situation. This is the first study to suggest that it may make conceptual and empirical sense to combine directory updating, information allocation, and retrieval coordination unequally.

Finally, this is the first study to examine the relationship between transactive memory and shared mental models. The results show that both were related to one another, supporting the proposition that both comprise portions of the team's collective information processing system. However, the three dimensions of transactive memory were not equally strong predictors of shared mental model similarity and shared mental model accuracy. When the team members initially began the task, and were unaware of each other's areas of expertise, directory updating played the major role in determining the degree to which their shared mental models were similar to one another and accurate. As the task progressed, directory updating began to become less influential and information allocation and retrieval coordination began to contribute to the development of shared mental models. Conceptually, this indicates that, once team members are aware of each other's areas of expertise, they may need to utilize information allocation and retrieval coordination to keep the roles and responsibilities of their teammates fresh in their minds. If team members fail to use retrieval coordination and information allocation, their shared interaction and team member mental models may become less similar and less accurate.

Practical Implications.

Practically, the results of this study may help to explain why certain problems arise in real-world stressful situations. As noted in the introduction, the USS Vincennes mistakenly shot down an Iranian passenger airline in 1988. At the time of the accident, the Vincennes was engaged in a gun battle with Iranian gunboats. The situation became increasingly hectic as U.S. military personnel scrambled to avoid further loss of life. Suddenly the Iranian airliner appeared on U.S. radar screens about 20 miles away heading directly for the Vincennes. The airliner was one of hundreds of blips on the radar screen. Without speaking to the officer responsible for coordinating anti-air warfare, two console operators reported that the airliner was descending. The airliner was actually ascending, which the officer would have known because it was his area of expertise. If the console operators would have remembered who was responsible for what, the accident may have been avoided. It appeared that shared interaction and team member mental models deteriorated under the stress of the attacks (Collyer & Malecki, 1998). The results of this study provide empirical evidence to support the negative effects of stress on shared mental models in team contexts.

Similar problems arose during the terrorist attacks of 9/11. News of the attacks dominated television stations and newpapers, ingraining the pictures of suffering and grief in the mind of people in and outside of the United States. Several days after the attacks, a national survey was conducted to determine how far reaching the effects were. Results showed that 90% of those polled reported at least one or more symptoms of stress (Schuster et al., 2001). The stress caused by 9/11 may have hit those closest to the attacks the hardest. Government agencies such as the FBI and the CIA were responsible investigating the incident and ensuring that all U.S. citizens remained safe and secure in the aftermath of the attack on national security. Weeks later, the behavior of agencies such as the CIA and the FBI immediately before and after the incident underwent close scrutiny. It was found that the various agencies, who were supposed to be working together as a collective unit, had trouble "connecting the dots." More specifically, they failed to share vital pieces of information with each other and local police departments (e.g., Gates, 2002; Tumulty, 2002). The various agencies did not know who had what or who needed what information. It was also unclear who could be given access to certain pieces of information. Each agency possessed a specific area of expertise that others were unaware of and they failed to ask each other for the information. As a result, information could not be given to the people who needed it. To connect the dots, the agencies needed to update their directories, allocate information, and coordinate the retrieval of information. However, the results of this study show that, during stressful encounters, transactive memory breaks down, which could have created some of the interagency problems during 9/11.

Fortunately, there may be a practical solution to the problems associated with stress in teams: team training. After the USS Vincennes mistakenly shot down the Iranian passenger airline, a group of researchers began a research and development program called Tactical Decision Making Under Stress (TADMUS). The program had a number of goals, including the development of training and simulation principles for stressful situations. Collyer and Malecki (1998) noted that "the focus of this task is on developing and demonstrating a variety of individual and team training strategies and techniques to minimize the adverse effects of stress" (p. 11). The strategies that were developed by TADMUS focused on shared situational models of the task environment and the task itself, as well as shared models of interaction requirements and responsibilities. TADMUS researchers suggested that shared mental model training could help individuals and teams perform under stress (Serfaty, Entin, & Johnston, 1998). However, Serfaty and his colleagues merely assumed that shared mental models suffer during stressful situations. The TADMUS project never examined the effects of stress on any team process variable. In order to develop a training program, a needs assessment should always be performed to determine where trainees lack the requisite knowledge, skill, or ability (e.g., Ostroff & Ford, 1989). If stress does not negatively affect shared mental models, training would be more beneficial in other areas.

This study provides empirical justification for the development and use of training programs designed to improve not only shared mental models, but also transactive memory, in teams under stress. Two training programs in particular have the potential to provide the knowledge, skill, and ability to weather demanding environmental conditions and strengthen the interconnections within teams: cross-training and transportable teamwork skills training. Cross-training has been defined as "an instructional strategy in which each team member is trained in the duties of his or her teammates" (Volpe, Cannon-Bowers, Salas, & Spector, 1996, p. 87). Researchers have suggested that cross-training encourages team members to understand the behavior of their teammates, which positively affects team processes such as communication and coordination (Blickensdorfer, Cannon-Bowers, & Salas, 1998). Volpe and her colleagues (1996) and Cannon-Bowers and her colleagues (1998) rotated team members so that each could experience the roles and responsibilities of their teammates. Both studies found that the positional rotation form of cross-training improved information distribution and team performance. Marks and her colleagues (2002) examined two less in-depth forms of cross-training: positional clarification and positional modeling. Positional clarification provides team members with verbal information regarding their teammates' jobs. Positional modeling involves verbally discussing and observing team members' roles. Marks and her colleagues found that both forms of cross-training significantly affected the level of shared mental models within teams.

While cross-training is task specific, transportable teamwork skills training can be given to employees even if they switch teams and tasks on a frequent basis. Transportable teamwork skills training has been defined as an instructional strategy in which team members are trained in team- and task-generic knowledges, skills, and attitudes (Ellis, Bell, & Ployhart, under review-b). Smith-Jentsch and her colleagues (1996), in one of the first studies examining the effects of transportable teamwork skills training, trained 60 undergraduates in team performance-related assertiveness, which can be defined as the ability of team members to share their opinions with their teammates in a manner that is persuasive to others. Participants were trained as individuals using one of three training methods: behavioral role modeling, lecture with demonstration, and lecture based training. All three training methods were team- and task-generic. Participants were then paired up to complete a PC-based flight simulation task as a two-person team. Results indicated that the three transportable teamwork skills training programs produced more positive attitudes regarding team performance-related assertiveness. Behavioral role modeling also had a significant positive effect on performance-related assertive behavior. Cannon-Bowers and her colleagues (1995) suggested that transportable teamwork skills training positively influences team effectiveness by strengthening the interconnections between team members. Ellis and his colleagues (under review-b) went a step further by proposing that transportable teamwork skills training improves the information processing systems operating within teams. In their study, participants were trained in a variety of transportable skills before being placed in a team environment. Teams then completed a command and control simulation, where they were allowed to interact freely with one another. Results indicated that training positively affects both team learning and backup behavior by increasing the amount of knowledge sharing and backup requests in temporary project teams.

Cross-training and transportable teamwork skills training have been conceptually and empirically linked to the information processing capabilities of teams. Researchers have shown that these types of training programs have the potential to impact shared mental models (Marks et al., 2002). Similar types of training have also been linked to transactive memory (Liang, Moreland, & Argote, 1995). Team training likely affects shared mental models and transactive memory because processing information between group members became easier, allowing them "to better coordinate and differentiate member skills and knowledge of the task" (Hinsz et al., 1997, p. 53). The results of this study suggest that these types of training programs may be the perfect solution in times of stress.

<u>Limitations and Directions for Future Research</u>.

Despite the theoretical and practical implications of the results, there are a number of limitations that bear further investigation. For one thing, this study took a response-based perspective to the study of stress in temporary project teams. Although aspects of stimulus-based, interactive, and transactional theories were included, the main focus was on team processes. The stress literature would benefit from a further investigation of stress in teams utilizing one of the other three perspectives.

From a stimulus-based perspective, research is needed to investigate the effects of different environmental characteristics on the level of stress within teams. The combination of time pressure and threat were used to maximize the level of stress within teams. Results could not differentiate the unique effects of each stressor. Because the two manipulations were combined together, this presents a confound that could influence the effects of stress. Time pressure varied by time period but the stress of being videotaped was consistent across time. The impact of this limitation is minimal, however, because time did not significantly affect the relationship between stress and transactive memory and shared mental models.

There are also a number of potential stressors that are unique to team contexts, such as team member conflict, breakdowns in communication, and layoffs within the team, that were not investigated in this study. Because team members are interdependent, stressors that affect one team member may still influence the team's collective information processing capabilities. For instance, threatening to layoff one team member may affect the level of transactive memory and shared mental models within the team. In addition, this study concentrated on the effects of acute stress. Chronic stress exerts an influence on employees over a much longer period of time, which could influence transactive memory and shared mental models differently than acute stress. For example, with acute stressors, the effect on team processes may be greatest immediately after the incident. With chronic stressors, the effects may take years to manifest themselves within teams.

Future research should also continue to take an interactive perspective by investigating other personal and situational characteristics as possible moderators of the relationship between stress and team processes. This study concentrated on cognitive ability, extraversion, feedback, and shared information, which can be linked to the team's collective information processing capabilities. However, stress researchers have identified a number of other personal variables, including Type A behavior pattern, negative affectivity, and hardiness, that have been shown to ameliorate the negative effects of stress at the individual level (see Cooper et al., 2001). Little has been done to examine such variables at the team level. Aggregating these types of personal characteristics in teams may determine whether transactive memory and shared mental models remain intact during stressful situations.

There are also a number of situational characteristics that bear further investigation. For instance, the type of team encountering stress could influence the degree to which transactive memory and shared mental models deteriorate. This study focused on project teams, where team members come together for a short period of time to handle a set number of tasks (Allred et al., 1996). Because project team members have little experience with one another, they spend most of their time in the "forming" and "storming" stages, where communication and interaction are essential. They often fail to reach the "norming" stage, where team members' mental representations reach maturity and communication plays less of a role (Cannon-Bowers & Salas, 1997). However, organizations utilize a variety of teams, including top management teams, virtual teams, sales teams, service teams, assembly teams, etc. Sundstrom and Altman (1989) categorized work groups according to four characteristics: work team differentiation (redundancy of member roles), external integration (synchronization with constituents external to the group), work cycles (the length and uniqueness of a performance event), and typical outputs (physical versus non-physical outcomes). Teams with little team member differentiation or teams with long work cycles may be more impervious to stress. In these types of teams, communication and interaction play less of a role or have become routine. Future research needs to examine the stress process in these types of teams.

Matching the environment to the team's structure may also represent an important characteristic of the situation. In this study, teams were structured functionally and team members were grouped based on the similarity of the work that they performed. Functional structures create narrow and specialized roles with high interdependence requirements. According to Structural Contingency Theory, functionally structured teams tend to perform best in relatively predictable and stable environments (Burns & Stalker, 1961). However, the environment faced by teams in this study was unstable and unpredictable, which "create[d] changing and complex contingencies that overwhelm the simple and specialized subunits" (Hollenbeck, Moon, Ellis, West, Ilgen, Porter, & Wagner, 2002). Hollenbeck and his colleagues have shown that teams in situations of external misfit, where the environment and the structure do not match, tend to be much less effective. Future research is needed to determine whether external fit has implications for the relationship between stress and team processes. In functional structures, behavior may be much more routine when the environment is relatively stable and predictable. This could offer an advantage to teams by moderating the negative effects of stress on transactive memory and shared mental models.

The transactional perspective may also offer an avenue for further stress research in teams. Folkman and his colleagues (e.g., 1984) suggest that the way individuals cognitively appraise and cope with the situation could also have beneficial effects in the stress process. When individuals encounter stress, they determine whether the situation represents harm, threat, or challenge through the primary appraisal process. The secondary appraisal process then searches for the appropriate coping resources. However, little has been done to investigate stress in teams from a transactional perspective. Do team members appraise the same situation differently or is there some sort of shared primary appraisal? Can team members utilize their teammates' coping resources? Are the coping strategies used by teams the same as those used by individuals? Future research is needed to examine the effects of cognitive appraisal on the stress process in teams.

While viewing stress in teams from stimulus-based, interactive, and transactional perspectives may be beneficial, there is much more work that needs to be done regarding team members' responses to stress. In this study, we focused on transactive memory and shared mental models. However, there are a number of other outcomes that need to be examined. For example, Ellis and his colleagues (under review-a) used an information processing framework to investigate the degree to which certain personal and situational characteristics influenced team learning. In line with information processing theory, they found that teams learned more when composed of individuals who were high in cognitive ability, when the workload was distributed evenly, and when the team utilized a paired structure. Conversely, team learning was negatively affected when teams were composed of individuals who were high in agreeableness. The results of Ellis and his colleagues support the notion that the team's ability to collectively process information is critical for the team learning process. Because team learning appears to rely on the collective information processing capabilities of the team members, it may be particularly susceptible to the effects of stress. Other researchers have suggested that backup behavior, which represents one of the critical aspects of teamwork (Dickenson & McIntyre, 1997; McIntyre & Salas, 1995), depends on the team's information processing system (Ellis et al., under review-b). Marks and her colleagues (2001) define backup behavior as "assisting team members to perform their tasks, which may occur by (1) providing a teammate verbal feedback or coaching, (2) assisting a teammate behaviorally in carrying out actions, or (3) assuming and completing a task for a teammate" (p. 367). Ellis and his colleagues (under review-b) found that training teams in transportable teamwork skills strengthened the interconnections between the team members and resulted in higher levels of backup behavior. If stress weakens the interconnections between team members, backup behavior may be reduced or eliminated within teams under stress.

Conclusion.

The results of this dissertation suggest that stress exerts a strong influence on the interaction processes within teams. In this study, the effects were particularly detrimental to transactive memory and shared mental models. Consequently, teams under stress were much less effective than teams in the control condition. It is suggested that this reflects a disruption in the teams' collective information processing systems. Although these results further our understanding of the stress process in teams, few prescriptions are offered to alleviate the negative effects of stress on team processes. The personal and situational characteristics examined generally failed to moderate the relationship between stress and transactive memory and shared mental models. However, it is hoped that this dissertation serves as an impetus for further research examining not only the stress process within teams but also methods to bolster the information processing capabilities of teams under stress.

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APPENDIX A: TABLES

Table 1

Summary of Assets and Tracks

	Assets					Tracks			
	Duration (in min.)	Speed	Vision	Power?	Identify ring?	Speed	Power	Nature	Need to Disable
Assets									
Tank	8:00	slow	very limited	yes (5)	no				
Helicopter	4:00	medium	limited	yes (3)	no				
Jet	2:00	very fast	far	yes (1)	no				
AWACs	6:00	fast	very far	no	yes				
Tracks									
D						Slow	none	Friendly	TK, HE, JT
B						Slow	low (1)	Enemy	JT
C						Slow	med. (3)	Enemy	HE
A						Slow	high (5)	Enemy	TK

Notes: For vehicles: *duration* = amount of time a vehicle may stay away from the base before needing to refuel, *speed* = how fast the vehicle travels across the game screen, *vision* = refers to the range of vision the vehicle has to both see and identify tracks, *power* = the ability of the vehicle to engage enemy tracks. For tracks: *nature* = whether the track is an enemy or friend, *speed* = how fast the track travels across the game screen, *need to disable* = which of the vehicles can successfully engage the track.

Table 2

Team Member Specialties

Team Member	Target	Vehicle
DM1	D (GO)	AWACS
DM2	B (G5)	Tank
DM3	C (G3)	Helicopter
DM4	A (G1)	Jet

Table 3

Summary of Hypotheses

Hypothesis	Supported?
H1: Acute Stressors → Shared Mental Models	Yes
H2: Acute Stressors → Transactive Memory	Yes
H3: Directory Updating → Shared Mental Models	No
H4: Cognitive Ability → Shared Mental Models	No
H5: Cognitive Ability → Transactive Memory	No
Cognitive Ability ↓ H6: Acute Stressors → Shared Mental Models Transactive Memory	No
H7: Extraversion → Shared Mental Models	No
H8: Extraversion → Transactive Memory	No
Extraversion ↓ H9: Acute Stressors → Shared Mental Models Transactive Memory	No
H10: Prior Shared Information → Shared Mental Models	Yes
H11: Prior Shared Information → Transactive Memory	Partially
Prior Shared Information ↓ H12: Acute Stressors → Shared Mental Models Transactive Memory	Partially

H13: Feedback → Shared Mental Models	No
H14: Feedback → Transactive Memory	No
Feedback ↓ H15: Acute Stressors → Shared Mental Models Transactive Memory	Partially
H16: Shared Mental Models → Team Performance	Yes
H17: Transactive Memory → Team Performance	Partially
H18: Acute Stressors → Shared Mental Models Transactive Memory → Team Performance	Partially

Table 4

Means, Standard Deviations, and Intercorrelations Among Acute Stressor Manipulation Checks

Variable	Mean	SD	1	2	3	4	5	6
1. Pressure/Tension	4.46	1.31	--					
2. Affective (Negative)Thought	2.80	.82	.44**	--				
3. STAI State Anxiety	1.89	.53	.64**	.54**	--			
4. Time Pressure	3.99	1.70	.48**	.41**	.45**	--		
5. Threat	3.07	1.67	.38**	.37**	.49**	.45**	--	
6. Overall Stress	3.86	1.45	.66**	.42**	.59**	.64**	.54**	--

Note: N=396. **p < .01.

Table 5

Means, Standard Deviations, and Intercorrelations Among Variables Included in Hypothesis Tests

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Stress	.49	.50	--											
2. Cognitive Ability	24.65	3.00	-.14	--										
3. Extraversion	3.66	.27	.06	-.04	--									
4. Prior Shared Information	.49	.50	-.03	.08	-.10	--								
5. Feedback	.49	.50	.01	.11	.14	.05	--							
6. Directory Updating	16.78	7.84	-.32**	-.02	.06	.14	.00	--						
7. Information Allocation	14.20	11.31	-.32**	$.19^{\dagger}$	.02	-.06	.01	.10	--					
8. Retrieval Coordination	1.59	2.06	-.49**	$.17^{\dagger}$	-.02	.17	.10	.49**	.23*	--				
9. Transactive Memory	.02	.72	-.52**	.15	.03	.11	.05	.74**	.62**	.80**	--			
10. Shared Mental Model Similarity	35.00	20.25	-.47**	.16	.08	.22*	.07	.32**	.24*	.48**	.48**	--		
11. Shared Mental Model Accuray	43.31	6.96	-.53**	.07	-.05	.23*	.03	.29**	.29**	.42**	.46**	.85**	--	
12. Team Performance	-.04	1.70	-.43**	.25*	-.05	.08	.15	.24**	.25*	.35**	.39**	.43**	.47**	--

Note: N=97. Stress was coded 0 for no stress and 1 for stress. Prior shared information was coded 0 for low prior shared information and 1 for high prior shared information. Feedback was coded 0 for individual negative feedback and 1 for team negative feedback. $^{\dagger}p<.10$ $*p<.05$ $**p<.01$.

Table 6

Effects of Stress, Situational, and Personal Characteristics on Shared Mental Model Similarity and Shared Mental Model Accuracy

		SMMS			SMMA		
Hierarchical Step	Independent Variable	ß	Total R^2	ΔR^2	ß	Total R^2	ΔR^2
1	Stress	-.47**	.22**	.22**	-.53**	.28**	.28**
2	Cognitive Ability	.10	.23**	.01	-.01	.28**	.00
3	Stress x Cognitive Ability	.04	.23**	.00	.11	.29**	.01
2	Extraversion	.11	.23**	.01	-.02	.28**	.00
3	Stress x Extraversion	-.03	.23**	.00	-.07	.29**	.00
2	Shared Information	.21*	.26**	.04*	.21*	.32**	.05*
3	Stress x Shared Information	.08	.27**	.00	.16	.34**	.01
2	Feedback	.07	.23**	.01	.03	.29**	.00
3	Stress x Feedback	-.14	.23**	.01	-.12	.29**	.00

Note: N=97. SMMS=Shared Mental Model Similarity; SMMA= Shared Mental Model Accuracy. * $p < .05$. ** $p < .01$.

Table 7

Effects of Stress, Situational, and Personal Characteristics on Directory Updating, Information Allocation, Retrieval Coordination, and Transactive Memory

		DU			IA			RC			TM		
Hierarchical Step	Independent Variable	ß	Total R^2	ΔR^2	ß	Total R^2	ΔR^2	ß	Total R^2	ΔR^2	ß	Total R^2	ΔR^2
1	Stress	-.32**	.10**	.10**	-.32**	.10**	.10**	-.49**	.24**	.24**	-.52**	.27**	.27**
2	Cognitive Ability	-.07	.11**	.01	.15	.12**	.02	.10	.25**	.01	.08	.28**	.01
3	Stress x Cognitive Ability	.09	.11**	.00	-.05	.12**	.00	-.02	.25**	.00	.01	.28**	.00
2	Extraversion	.08	.11**	.01	.04	.10**	.00	.01	.24**	.00	.06	.28**	.00
3	Stress x Extraversion	-.07	.11**	.00	-.03	.10**	.00	.04	.24**	.00	-.03	.28**	.00
2	Shared Information	.13	.12**	.02	-.07	.10**	.01	$.15^{\dagger}$	.26**	$.02^{\dagger}$	.10	.28**	.01
3	Stress x Shared Information	-.17	.13**	.01	.08	.11**	.00	-.34*	.30**	.04*	-.20	.30**	.01
2	Feedback	.01	.10**	.00	.02	.10**	.00	.10	.25**	.01	.06	.28**	.00
3	Stress x Feedback	.04	.10**	.00	$-.29^{\dagger}$	.13**	$.03^{\dagger}$	-.24	.27**	.02	-.23	.29**	.02

Note: N=97. DU=Directory Updating; IA=Information Allocation; RC= Retrieval Coordination; TM=Transactive Memory.
$^{\dagger}p<.10$ * $p < .05$. ** $p < .01$.

Table 8

Effects of Directory Updating, Information Allocation, and Retrieval Coordination on Shared Mental Model Similarity and Shared Mental Model Accuracy

		SMMS			SMMA		
Hierarchical Step	Independent Variable	ß	Total R^2	ΔR^2	ß	Total R^2	ΔR^2
1	Directory Updating	.12	.25**	.25**	.11	.22**	.22**
	Information Allocation	.14			.20*		
	Retrieval Coordination	.39**			.32**		
1	Transactive Memory	.48**	.23**	.23**	.46**	.21**	.21**

Note: N=97. SMMS=Shared Mental Model Similarity; SMMA= Shared Mental Model Accuracy. * $p < .05$. ** $p < .01$.

Table 9

Effects of Directory Updating, Information Allocation, Retrieval Coordination, Transactive Memory, Shared Mental Model Similarity, and Shared Mental Model Accuracy on Team Performance

		Team Performance		
Hierarchical Step	Independent Variable	ß	Total R^2	ΔR^2
1	Shared Mental Model Similarity	.08	.23**	.23**
	Shared Mental Model Accuracy	.40*		
1	Directory Updating	.10	.16**	.16**
	Information Allocation	$.18^{\dagger}$		
	Retrieval Coordination	.26*		
1	Transactive Memory	.39**	.15**	.15**

Note: N=97. SMMS=Shared Mental Model Similarity; SMMA= Shared Mental Model Accuracy. $^{\dagger}p<.10$ * $p < .05$. ** $p < .01$.

Table 10

Regression Analysis of Information Allocation, Retrieval Coordination, and Shared Mental Model Accuracy as Mediators of the Relationship between Stress and Team Performance

Variable	ß	R^2	ΔR^2
Phase 1: Direct Effect of Stress on Team Performance			
Step 1		.18**	.18**
Stress	-.43**		
Phase 2a: Effect of Stress on Team Performance After Controlling for Shared Mental Model Accuracy			
Step 1		.22**	.22**
Shared Mental Model Accuracy	.34**		
Step 2		.26**	.04*
Stress	-.24*		
Phase 2b: Effect of Stress on Team Performance After Controlling for Information Allocation and Retrieval Coordination			
Step 1		.15**	.15**
Information Allocation	.11		
Retrieval Coordination	.17		
Step 2		.22**	.07**
Stress	-.31**		
Phase 2c: Effect of Stress on Team Performance After Controlling for Transactive Memory			
Step 1		.15**	.15**
Transactive Memory	.23*		
Step 2		.22**	.07**
Stress	-.31**		

Note: N=97. ß is the standardized regression coefficient from the full regression equation with all the predictor variables. Increments for variables entered at the R^2 significance levels are based on F tests for that step.* $p < .05$. ** $p < .01$.

Table 11

Supplemental Analyses of the Effects of Directory Updating, Information Allocation, and Retrieval Coordination on Team Performance During the Initial 15-Minute Task

		Team Performance		
Hierarchical Step	Independent Variable	ß	Total R^2	ΔR^2
1	Directory Updating	.32**	.10*	.10*
	Information Allocation	-.08		
	Retrieval Coordination	.02		

Note: N=97. ** $p < .01$.

Table 12

Supplemental Analysis of the Effects of Directory Updating, Information Allocation, and Retrieval Coordination on Shared Mental Model Similarity and Shared Mental Model Accuracy During the Initial 15-Minute Task

		SMMS			SMMA		
Hierarchical Step	Independent Variable	ß	Total R^2	ΔR^2	ß	Total R^2	ΔR^2
1	Directory Updating	.18†	.09*	.09*	.20*	.08*	.08*
	Information Allocation	-.15			-.13		
	Retrieval Coordination	-.13			-.09		

Note: N=97. SMMS=Shared Mental Model Similarity; SMMA= Shared Mental Model Accuracy. † $p<.10$ * $p < .05$. ** $p < .01$.

APPENDIX B: FIGURES

Figure 1
Theoretical Model of Stress in Team-Based Work Structures

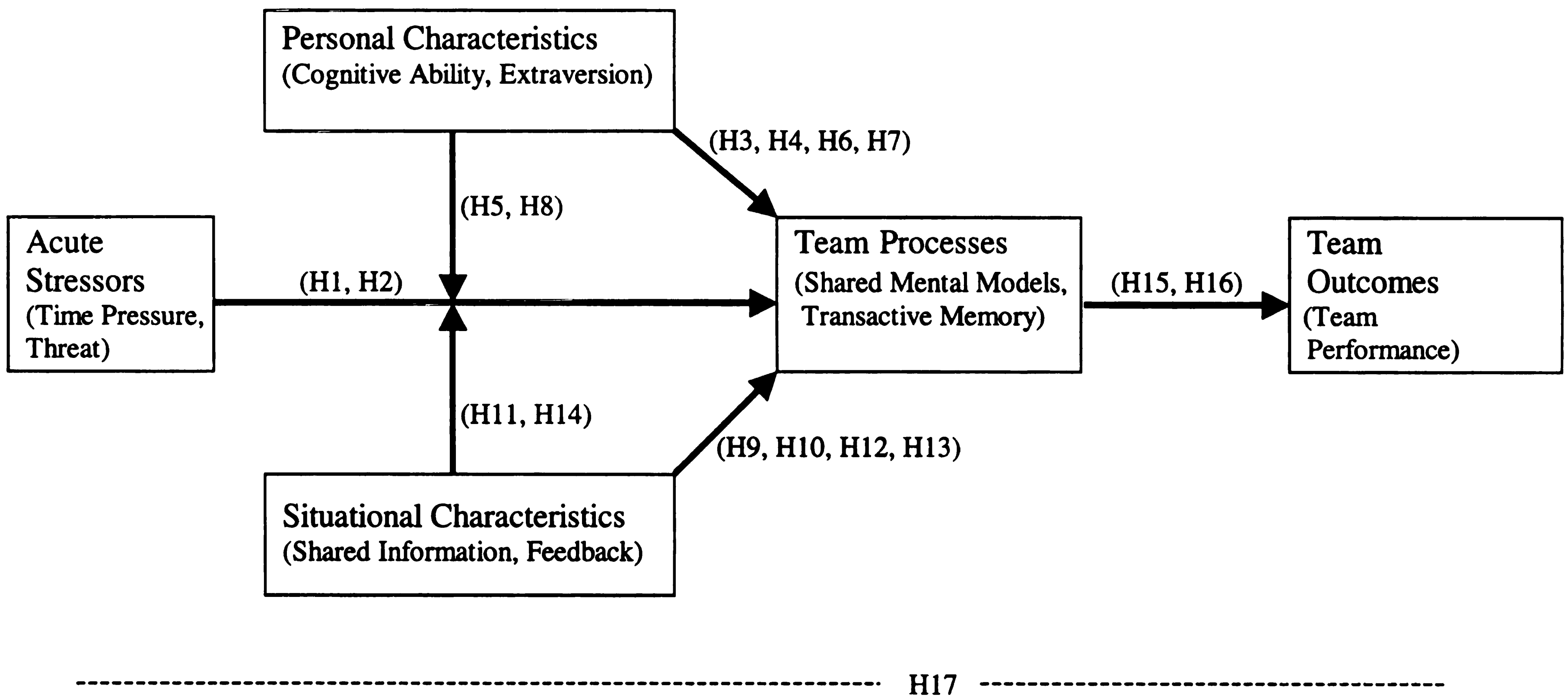


Figure 2

Generic Information-Processing Model

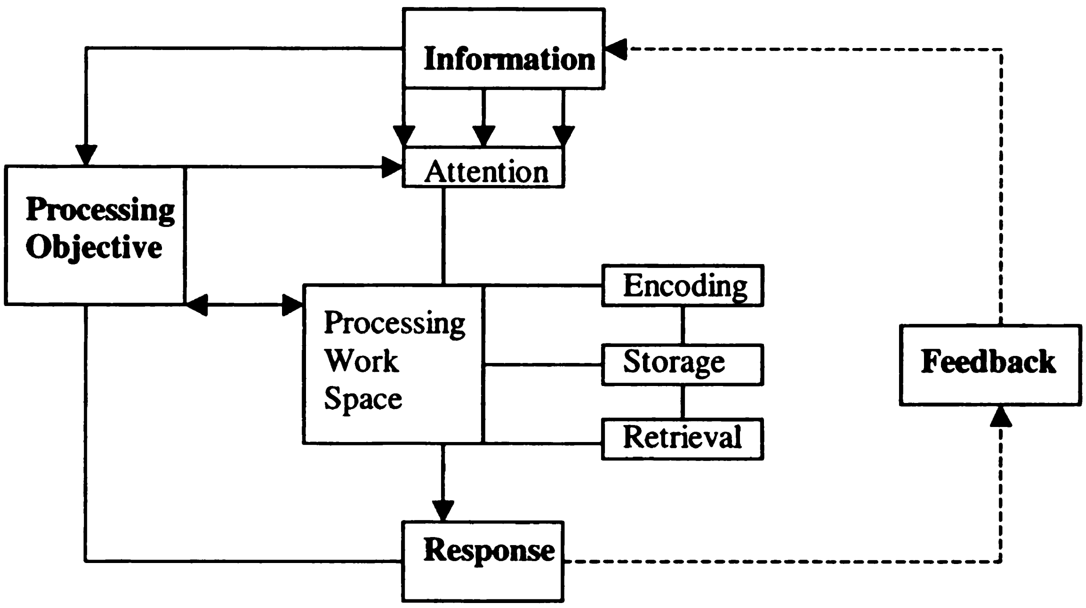


Figure 3

The DDD Grid, Including Bases, Vehicles, and Tracks

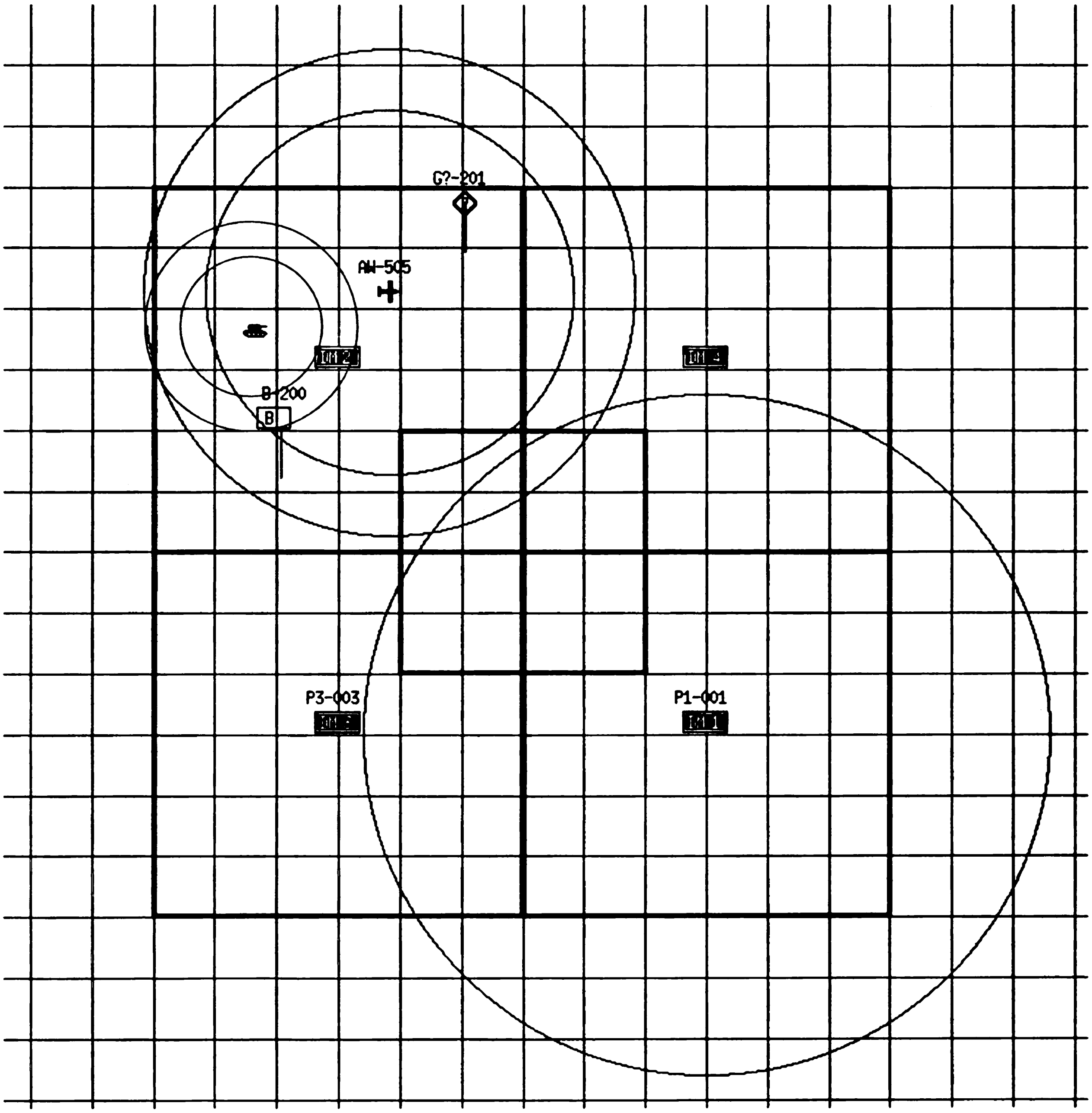


Figure 4

The Effect of the Interaction Between Stress and Shared Information on Retrieval Coordination

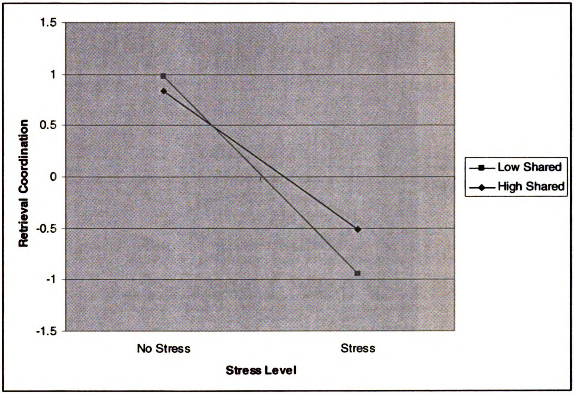


Figure 5

<u>The Effect of the Interaction Between Stress and Feedback on Information Allocation</u>

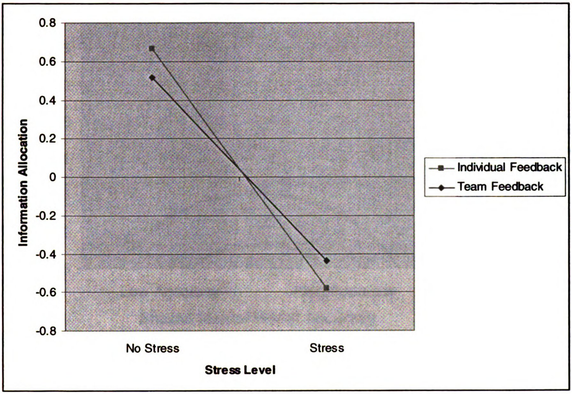
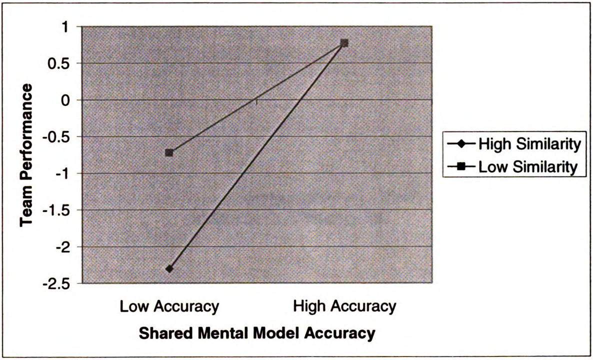


Figure 6

The Effect of the Interaction Between Shared Mental Model Similarity and Shared Mental Model Accuracy on Team Performance



APPENDIX C
DISSERTATION PROTOCOL

Part 1. Study Overview

The present investigation seeks to explore the effects of acute stressors on transactive memory and shared mental models in temporary project teams by taking an information processing approach. The presence or absence of acute stressors represents the main manipulation. However, feedback and the amount of shared information possessed by each team member will also be manipulated. Therefore, a 2 (acute stressor vs. no stressors) × 2 (negative individual feedback vs. negative team feedback) x 2 (high level of shared information vs. low level of shared information) between team design will be used.

Condition 1: Acute stressors x negative team feedback x high level of shared information
Condition 2: Acute stressors x negative individual (DM2) feedback x high level of shared information
Condition 3: Acute stressors x negative team feedback x low level of shared information
Condition 4: Acute stressors x negative individual (DM2) feedback x low level of shared information.
Condition 5: No acute stressors x negative team feedback x high level of shared information
Condition 6: No acute stressors x negative individual (DM2) feedback x high level of shared information
Condition 7: No acute stressors x negative team feedback x low level of shared information
Condition 8: No acute stressors x negative individual (DM2) feedback x low level of shared information.

Teams will be randomly assigned to one of the eight conditions. Within each team, the four participants will be randomly assigned to one of four positions in the team (i.e., DM1-4). Each team will go through a 40 minute practice task, one 15-minute experimental task, and one 30 minute experimental task.

After the practice task, the shared information manipulation will be introduced depending on condition. Each team member will be given their specialty sheet informing them about their specific area of expertise during the task. For example, DM2 will know that DM4 will be in charge of the jets and that the C target represents a G3. DM1 will also have information regarding the wave targets that will enter the screen during the task. That information may be shared with the other team members, depending on the condition they are in. The sheets labeled LS in the upper right corner are for the low shared information condition and the sheets labeled HS in the upper right hand corner are for the high shared information condition.

After the first 15 minute experimental task, the feedback and acute stressor manipulations will be introduced depending on the condition. Negative feedback will be given to one individual team member or the team as a whole. If acute stressors are to be manipulated, the clocks will be taken off each team member's screen and the team members will be informed that the experimenter will warn them at specific intervals during the task when time is running short. They will also be informed that their credit is not guaranteed and may be in jeopardy of they don't perform up to par.

Part 2. Preparation for the Experiment and Participant Orientation

Also, before participants enter the lab, the experimenter should:

1. Put keyboards on top of monitors.
2. Wonderlic and short form NEO w/ small bubble sheet at each station.
3. Call up the training task using the steps below.

    a. At the dos prompt at L0, type "con." A blue controller window will appear. In this blue con window:
    b. Select "Pilot01" from the **Team Name** section (can actually select any name)
    c. Select the training task (**alekstrain**) from the **Expt #** section
    d. Click on "Start New Game."
    e. Click "OK to overwrite log file?" if necessary
    f. Highlight the xterm window, you should see "Start Five Locals, Please."
    g. Go to station DM1 and bring up the task-playing screen by entering L1 at the command prompt.
    h. Repeat step g at each station by entering L2-L4 at the command prompt depending on the station.

As participants enter the laboratory, the experimenter should have the participants read and sign the **Consent Form**, which will be used to award course credit.

Bring four participants into the laboratory and let them choose their own station.

Part 3. The Wonderlic and NEO

Welcome to the Teamlab. As we told you in your first section meeting for MGT 315, you will be playing a command and control computer simulation as a team today. However, before we get to the computer task, there are two short questionnaires that you need to complete. Any answers you provide are confidential, have no impact on any credit you may receive for participating in this study, and have no impact on your team's performance.

The first is called the Wonderlic, which is on your desk right now. Please take it out and write your name and PID on the top somewhere. The Wonderlic is a timed, 12-minute test of problem solving ability that is used to select employees for a variety of jobs from civil service workers to investment bankers. If you look at section 4 on the first page, you can see the types of questions that you will be faced with. There are verbal questions, math questions, analytical reasoning questions, and others. There are 50 questions total, and you need to try to complete as many as you can in the 12 minutes provided. Students rarely complete all 50 questions, so don't worry if you don't make it all the way through. Please write your answers directly on the page in the spaces that are provided. If there are no questions, please turn the page and begin.

Using a stopwatch, make sure that they work on the Wonderlic for exactly 12 minutes. Then pick up the Wonderlics and file them.

The second questionnaire is a short personality questionnaire called the NEO, which is also on your desks. Please take one of the small bubble sheets and fill in your last name and PID. The NEO consists of 60 statements that you either agree or disagree with. Read each statement and then answer on a scale from 1-strongly disagree to 5-strongly agree. All answers go on the bubble sheet. This questionnaire is not timed, so go through at your own pace.

Part 4. Binder Training

The experimenter should now instruct the participants to follow along as he/she covers the information in the binders located at each station. The information that should be covered is below. **NOTE THAT YOU SHOULD REFER TO THE "TASK" RATHER THAN THE "GAME"**

Page 1 "Welcome to the team effectiveness lab"

Please take the binder at your station and open it up to the first page. This page offers some background into the teamlab, so just follow along as I go through each point. Our purpose here is to improve individual and team performance in organizations. Who benefits? Society, MSU, and, most importantly, you the students. You get your course credit and experience in teams. Plus we will award cash prizes to top performing teams. In fact, each team member in the highest performing teams will receive a check for $100 at the end of the semester.

Page 2 "The Task"

The task you are going work on is called DDD. It's on your screens right now, but nothing's going to happen until I start it up. Basically the task simulates a military command and control context, where you own and operate various vehicles, such as helicopters, jets, tanks, and radar planes. The object is to monitor restricted airspace and prevent enemy vehicles from entering forbidden locations by detecting them, identifying them, and attacking them if necessary. However, you must not attack any friendly vehicles that are operating in the same locations. As a side note, only the vehicles get destroyed, not any of the people. Everyone escapes safely.

Your time here will be broken down into three parts. The first part is what we are doing now. I will give you a quick general overview of the task. Here I will explain the task screen, the scoring, the vehicles you will operate and the targets you will face. Next, I will give you an opportunity to practice working on the task for an hour or so. This is where you will really learn the mechanics of the task and begin interacting as a team. Finally, you will work on the actual task, which consists of a 15-minute task followed by a 30-minute tasks. Your performance during the 15-minute and 30-minute tasks will decide whether or not your team receives a cash prize.

Pages 4 The Task Screen and Scoring

This page shows you a diagram of your task screen. You can also refer to your monitor screen if that's more clear for you. There are two sections of the screen: the task area which is the gridded section, and the report area which is shaded in blue. The first thing we're going to do is go over the task area.

The task area is basically one geographic area broken down into four separate quadrants. Each of you has a home base inside your quadrant – that base shows up in your binder as a black rectangle. If you look closely you will see your station's name inside, DM1, 2, 3, or 4. These names correspond to the ones posted above your cubicles. Does everyone see where their base is? Also note that the writing above your base is in a specific color. Your vehicles will also having writing in the same color above them during the task. So DM1 is red, DM2 is purple, DM3 is green, and DM4 is yellowish-orange.

Now, within the grid system is a large green square, this is a restricted area which is called "THE FORBIDDEN ZONE." This is the area that you must keep enemies from entering. Within the green Forbidden Zone is a red square. This is "THE REALLY FORBIDDEN ZONE." This is the area you DEFINITELY must keep free from enemies. The way the task is scored is that, if an enemy were to enter the Forbidden Zone – the green square -- you will lose 1 point per second from your score. If an enemy were to enter the Really Forbidden Zone – the red square – you will lose 2 points per second from your score.

So you're going to want to destroy enemy targets as soon as they enter the Forbidden Zone. In fact, if you do that, you'll get 5 points. However, you have to be careful not to destroy them before they get into the Forbidden Zone – if you do that you'll actually lose 25 points. You'll also lose 25 points if you accidentally destroy a friendly target, no matter where it is on the screen.

If you lose or gain points, it registers on the scoring bars, which are to the right in the blue-shaded report area. If you notice, you have six different scoring bars- offensive and defensive scoring bars for the individual, the group, and the team. You don't need to worry about the scoring bars for the group. You will only be looking at the individual and team scoring bars during the task. Let's say that an enemy target enters the screen at the top left corner and makes its way into DM2's green zone. Since it is an enemy, DM2 will be losing 1 point per second on his/her individual defensive score and 1 point per second on the team's defensive score. However, no one else's individual defensive scoring bar will go down because it's only in DM2's quadrant. As you can see, the defensive scoring bars are completely full. That means defensive scores can ONLY go down. And they will go down because you cannot shoot down any enemy target before it gets within the green forbidden zone.

You can, however, gain offensive points. So if DM2 were to destroy that target he/she would get 5 points on his/her individual offensive score and the team would get 5 offensive points. However, none of the other individual offensive scoring bars would go up because DM2 was the one who shot it down. If DM3 sent a vehicle to DM2 to shoot the target down, DM3 and the team would get 5 points. You can go anywhere on the screen and, as long as the target is an enemy and within the big green box, you will get 5 points for shooting it down. However, if one of you screws

up and shoots down a friendly or shoots an enemy outside of the forbidden zone, your offensive score is the one that drops by 25 points.

To reiterate the scoring, your offensive score is affected by attacking things. You can either gain 5 points or lose 25 points. Your defensive score is affected by having things in the green or red Forbidden Zones. You can either lose 1 point per second or 2 points per second.

Now I'm going to quickly go over the rest of the blue-shaded report area. Above the scoring bars is a clock, which tells you how much time has expired in the task. Under the scoring bars is a black bar, which is called the busy signal. Basically, when you launch something, it indicates the length of time your base requires before it can launch again. Under the busy signal are a set of buttons. Again, when the practice task starts, I'll tell you what each of those buttons does. Under the buttons is the message box. You will be able to talk as much as you want during the task, so you will never need to use the message box. In fact, you should feel free to talk as much or as little you like during the task. However, remember that there are four members of your team, all of whom will be staring at a computer screen during the entire task. So when you communicate with your teammates, be specific. Make sure they know who you are talking to, who you are, and exactly what you want. For example, if you are DM3 and you need to ask DM2 something, say "DM2? This is DM3. Is that target in your red box an enemy?" Or, "I'm DM3 and I need DM2 to send a helicopter to the upper left corner of my forbidden zone." When everyone is concentrating on what they are doing, they will often ignore communication within the team unless it is specifically directed at them. And recognizing voices is extremely difficult. So tell them your station number as well. If you communicate efficiently and effectively with one another, you will have a much better chance at getting the $100 cash prize. Finally, on the bottom of the screen are two long windows: the report and confirmation windows. Basically, everything you do is written in text in one of those windows. You will not use either of the windows during the actual task, so don't worry about them.

The last thing on your screens that we need to discuss is the black ring around your base. Any black ring that you see on your screen is what's called a detection ring. Detection rings let you see targets on the screen. That means that the detection ring around your base allows you to see targets on about 1/4 of the screen. Each team member can see a different portion of the screen with his or her base. You will not be able to see targets in your teammates' detection rings. When a target enters your detection ring, you will be able to see it, but you won't know whether it is a friend or foe. Targets initially enter as unidentified. In order to identify targets on the screen or detect targets at points on the screen that aren't covered by your base's detection ring, you need to use the vehicles that are stationed at your base.

Pages 6-7 The Vehicles

As you can see, there are four different types of vehicles. You each will have a certain combination of these vehicles during the task. The vehicle on the left is the jet (it says JT above it), on the top is the tank (TK), on the bottom is the helicopter (HE), and on the right is the radar plane (AW), which is technically called an AWACS plane. If you notice, all four vehicles have two rings around them. The outer black ring works like the black ring around your base. So you can launch any of your vehicles, send them into one of your teammate's quadrants, and, as soon as targets get within the detection ring of your vehicle, they will pop up on your screen. But they will still pop up as unidentified. That is what the inner blue ring surrounding your AWACS is for. Once they get within the blue ring of your AWACS plane, you will be identify them as friendly or enemy by clicking on them a couple of times with the mouse. If you notice, the AWACS is the only vehicle with a blue identification ring. You can ONLY identify targets as friendly or enemy with the AWACS plane.

If you notice, the second ring around the tank, the jet, and the helicopter is red. That is your attack ring. Once a target is inside the attack ring of the tank, the jet, or the helicopter, you can try to shoot it down. You CANNOT shoot anything down with the AWACS plane. And you can only shoot down specific targets with specific vehicles, as shown in the power column in the chart on the facing page.

The tank has a power of 5, the helicopter has a power of 3, the jet has a power of 1, and the AWACS has a power of 0. The tank is the most powerful vehicle and can shoot down targets with a power of 5 or less, the helicopter can only shoot down targets with a power of 3 or less, and the jet can only shoot down targets with a power of 1 or less. So the power level of your vehicle must be EQUAL TO OR GREATER THAN the power level of the target. The AWACS, as I said before, is a radar plane so it doesn't have any power to destroy enemies. There are also a number of other differences between the various vehicles. You can see that the ring diameter is different, so you can see things that are far away with the AWACS but you have to be right next to them with the tank. Also notice the red line coming out of each of the vehicles. That denotes the speed of the vehicle. The tank is the slowest, while the jet is the fastest.

One thing you must remember is that you only get one shot with each vehicle, then you are out of ammunition and you must return that vehicle to the base to reload. After attacking, you MUST ALWAYS return your vehicle to your base in order to reload. I'll explain how to do that once the practice task starts.

The last thing you see regarding the vehicles is fuel time. The chart shows you how much time you have to move each vehicle around the screen until they run out of gas. For example, you have 8 minutes to move the tank around the screen. After the 8 minutes is up, the tank will turn into an X and it will automatically return to its base. As soon as it gets back to the base you can launch it again for another 8 minutes. So if you see your vehicle X out during the task for no reason, you probably just ran out of gas.

Pages 8-9 The Targets

If you look at the chart, you can see that there will be four different types of targets entering the screen. The G0 is a friendly target, while the G1, G3, and G5 are all enemy targets. However, the targets will not show up as G0-G5 on your screens.

If you look at the close-up of DM2's quadrant, you can see what the targets are going to look like. When targets first enter your detection ring, which is the black ring, they are going to show up looking like #216 in your notebook- a diamond with a question mark in the middle. They will always look that way no matter if they are a friend or foe. You have to manually identify them as friendly or enemy once they enter the blue ring of an AWACS plane. As you can see, #209 has entered the blue ring of DM2's AWACS plane and DM2 has manually identified it. When targets are identified, they show up as a box. Inside that box is what type of target it is. So you can see that #209 is a B target. The B target corresponds to one of the G targets. There are four different symbols, A, B, C, and D, that represent G0, G1, G3, and G5s.

Information about the power level of the A, B, C, and D targets, as well as the vehicles at each team member's base, is contained on the specialty sheets for each base.

Give them the specialty sheets for the practice task

During the practice task, each team member's specialty sheet will contain the exact same information. Team members will not have specific areas of expertise. Each team member will have one jet, one helicopter, one tank, and one AWACS plane at his or her base and will know that the A, B, C, and D targets will represent ground targets with power 0, 1, 3, and 5, respectively. During the 15-minute and 30-minute task, team members will be given separate specialty sheets containing information regarding each team member's specific area of expertise, which will be discussed later.

That means that, for the practice task, B, C, and D are enemy targets while the A target is friendly, as you can see on your specialty sheets. So target #209, a B target, is an enemy target with a power of 1. Looking at where it is on the screen, would you want to shoot it down right now? . . . (Yes) **You can see that there is a helicopter next to target #209. Can the helicopter shoot it down? . . . .** (Yes) **What other vehicle ir vehicles could you use to shoot it down? . . . .** (A jet or a tank). **So you can shoot down #209 with any of your attacking vehicles. Which one would be the better choice during the game and why? . . . .** (The jet, because you would want to save your helicopter and tank for targets that require more power). **So if you want to be really efficient, you should try to match the power level of your vehicle with the power level of the target. #205 has also has been identified by DM2 because it too turned**

into a box on the screen. Would you want to shoot this target down? . . . . (No) **Why not? . . .** (Because it is a friendly target) **What about #212? Would you want to shoot that target down? . . . .** (No) **Why not? . . . .** (Because it is outside of the forbidden zones)

The last thing we have to talk about are the U targets, or the unknown targets. During the 15-minute and 30-minute tasks, you will encounter four additional target symbols, U+, UX, U-, and U#. They will appear on your screens as usual. That is, as a diamond with a question mark in the middle. However, when you identify them, they will not show up as A, B, C, or D inside the box. They will show up as U+, UX, U-, and U#. Each will correspond to a G0, G1, G3, or G5. However, the power level of the U targets will not be contained on any of the team members' specialty sheets. As a team, through trial and error learning, you need to figure out which is which, especially since one of the U targets is friendly. How do you do that? Let's say that the UX enters DM2's portion of the forbidden zone and DM2 notices that his or her individual defensive score is NOT going down. DM2 would immediately know that the UX target was what? . . . . . (a G0) **If DM2 is losing points, and he or she sends a TANK over to shoot it down, and is successful, what would DM2 know about the UX? . . . . .** (That it is a G5, G3, or G1) **If DM2 sent a jet over to the UX and successfully shot it down, what would DM2 know about the UX? . . . . .** (That it's a G1). **Clearly you need to learn the power level of each U target in order to be successful. This process will move much more quickly if team members communicate with one another, especially since the power level of the U targets will remain consistent through both tasks.**

So during the tasks, you will encounter eight different target symbols: A, B, C, D, U+, U-, U#, and UX. Each symbol corresponds to a G0, G1, G3, or G5. You will be provided information regarding the power level of the A, B, C, and D targets, but you will <u>not</u> be provided information regarding the power level of the U+, U-, U#, or UX targets. Those you have to figure out through trial and error.

Page 10 A Successful Attack

So just to reinforce what we have been talking about so far, I want to reiterate what constitutes a successful and an unsuccessful attack. To get five points you must attack an ENEMY target ANYWHERE inside the big green box. Plus, it has to be within the RED ring of your vehicle and you MUST have ENOUGH power. Remember that, if you do shoot something, you must always return the vehicle to your base before attacking again, because you lose all of your power after one attack. If you look at your score and you lost 25 points, that means that you either attacked something OUTSIDE of the forbidden zone or you attacked a FRIENDLY. If the enemy is too far away or you don't have enough power, you will be unsuccessful, but your points will remain the same. You will only be losing time.

Part 5. Hands-On Training

You will be using the mouse to do everything in the task. The left button does pretty much everything in the task. So when I say click on something, I mean left click. The right click opens up specific windows on the screen, which you will see in a little bit. Using the mouse, click on the start button on the right hand side of the screen in the report area. It should say refresh if you clicked correctly.

(Click "start" on DM0's computer).

Ok, so now you can see that the clock has started. The practice targets don't come up for a while yet, so we're going to practice a few basic things. The first thing we are going to practice is zooming in- BUT DON'T DO ANYTHING YET. If there are a lot of targets in one portion of the screen, you will find it difficult to specify which one you want to identify and which you want to attack. So you can zoom in on that portion of the screen. Ok, everyone go ahead and click the "zoom in" button and move your cursor back onto the task area- DON'T CLICK AGAIN UNTIL I TELL YOU WHAT TO DO. So you can see that your cursors have changed into a weird shape.

If you click on something, and your cursor changes, but you wanted to click something else, you can go over to the cancel button next to the refresh button. Everyone go ahead and click cancel. Your cursors are now back to normal.

Ok, go ahead and click on zoom in again and move the strange cursor to the exact center of the grid, where the four Forbidden Zones meet. Now click on that point, and KEEP THE BUTTON CLICKED DOWN. Keeping the button down, drag your mouse to the opposite corner of your Forbidden Zone. You should be creating a box around your Forbidden Zone. Now let go.

(Make sure that each person does it correctly)

Ok, to zoom out you just have to click on the "zoom out" button in the report area. Once you've done that, I want you to practice zooming in one more time. This time zoom in on your portion of the red box in the center of the screen.

(Make sure each person does it correctly)

Remember the zoom in function during the task. Most people forget about it and it makes the task much more difficult.

Now we are going to do is launch something from your base. To do that you have to open up a menu from your base. So put your cursor right on top of your base and RIGHT click. You'll see a long menu. Go all the way to the bottom and click on "Info on Asset." When you do that, your launch window will pop up.

(Make sure they have the correct window up).

Before I talk about what's inside this box, I want to explain a couple of things about these windows. This is UNIX, not Windows, so you CANNOT close the windows using one of the little buttons in the upper right hand corner. If you do, it will exit you out of the system and I will have to restart the task. The only way to close one of these windows is to click on the "cancel" or "ok" buttons on the bottom.

In the launch window, you always want to look at the columns in the middle of the window. The first column says "Sub," which lists the vehicle that are stationed at your base. You can only launch things one at a time, so you want to pick out the one vehicle you want to launch. Then look to the "Aboard" column. If it says yes in the aboard column, you're ok. If it says no, the vehicle is already on the screen and you can't launch something twice. After you make sure it says yes, move to the launch column. The left pointing arrows don't do anything. You always want to click the right pointing arrows. In this case, I want you to launch the tank, so please click the right pointing arrow for the tank. The arrow will highlight in black and then go down and click the "ok" button. Your base will turn into an X for a few seconds and your vehicle will appear next to it.

(Make sure everyone launches their tank correctly).

The detection and attack rings will appear around your tank as soon as you start moving it, which we are going to do now. You can find the Move option by right-clicking on your vehicle. So everyone right click on you tank, then click on Move Fast. Now your cursor looks like a plus sign. Take the plus sign, put it in someone else's quadrant, and click. The vehicle will move to the exact spot you just clicked on. While it's moving, right click on it again, get the plus sign up, and put it somewhere else on the screen to change its direction. You can also make it stop on the screen. Right click on it again and click on stop, which is the fourth button down in the menu.

(Make sure that they move their vehicles correctly).

During the task, you will have all four vehicles on the screen. Sometimes you will get confused and forget which ones you used to attack with. Remember, you only get one shot per vehicle. However, you can check how much power you have left by right clicking on your vehicle and going down to "Info on Asset." You will get a square window in the middle of the screen. This window tells you two important things. First, it tells you how much time your vehicle has left before it's going to return to your base, indicated by the "time remaining for use." Second, it tells you how much power you have left. In this case, it says power 5 because you haven't attacked anything with your tank. Go ahead and click on "ok" to close this window.

Let's pretend that you attacked a target with your vehicle, so you used your one shot. That means that you have to return that vehicle to your base. To do that, you

have to right click on your vehicle again. This time go about half way down in this box to where it says "Return." Go ahead and click on "Return" and then click on "ok" when the next box comes up. You'll see that your vehicle automatically returns to your base when you do that. You MUST use the "Return" option to return your vehicle. You CANNOT just move your vehicle near your base.

Ok, now I want you to practice what we have been doing. I want you to launch all four of your vehicles and then I want you to move each one to a different corner of your Forbidden Zone. Remember, you can only launch one at a time. So launch one and move it to one corner. Then, while the first one is moving, go back and launch another from your base. When you launch everything, pay attention to the different ring radiuses and the different vehicles speeds.

(Again, make sure they are doing everything correctly and wait for everyone to deploy all their vehicles).

Ok, now go ahead and return your vehicles to your base.

(Make sure everything returns correctly).

10:00 Identifying a Friendly

Four targets will enter at the corners of the screen. Before they do, please launch your AWACS. Once it is launched, move it to the corner of the forbidden zone which you do not share with any of your teammates.

(Wait until they get their AWACS close to the target).

Once the target gets within the blue ring of your AWACS, you will be allowed to identify it as either a friend or enemy. Right-click on the target, then choose the "Identify" option. Now you identification window will pop up in the middle of the screen. This window will appear every time you want to identify a target.

(Make sure they have the identify window on their screens).

You always do the same thing to identify a target using this window- first click on the "Fused" button at the top of the window and then go down and click on "ok."

Now you can see that the target has an "A" in the middle of its box, so, looking at your specialty sheet, you know that it's a friendly target. Now look at your individual defensive score -- it's NOT going down. So that's another way to determine whether the target is a friendly or an enemy without having to manually identify it.

Another option you have is to transfer the identity of that target to your teammates. To do that, you right click on the target again and go down to "Transfer Info." Then

click on "all linked DMs" in the next box that appears. You just transferred the identity of that target to the rest of your team. So now when that target enters your teammates DETECTION RING, it will appear as an "A" and not a question mark. This does NOT make these targets automatically appear on everyone's screens. The target still MUST be in someone's detection ring in order for them to see it.

Just leave your AWACS plane at the outside corner of your forbidden zones.

12:00 Practicing Identifying and Transferring Info

Another set of friendly ground targets will come into the corners of the screen. Practice identifying and transferring that identity to your teammates. Watch your defensive scores again.

13:00 Attacking Some G1's

The next targets will come in from the corners again. Identify the targets with your AWACS plane. You do not have to transfer the information. As you can see, they are B targets. So launch your jets and move them close enough so that the target is inside the jet's attack ring.

(Make sure they are following ok)

You attack something by right-clicking on your vehicle and choosing Attack. Once you choose Attack your cursor will turn into a big black "X." Put it directly over the target and click. Your Jet and the target will then X-out and you will see a red explosion and it will say "hit- +5 points."

(Make sure everyone is following along. If they missed the first target, they may be able to catch one coming from another quadrant).

Always look for the fire. If you don't see the fire and the hit sign, you did something wrong. Now look at your offensive scores. Each individual score went up 5 and the team offensive score went up 20. Since you attacked with your Jet you have to ALWAYS remember to return it to your base. So go ahead and do that now. And return your AWACS plane as well.

15:00 Attacking Something Outside the Forbidden Zone

The next targets are going to enter at the corners again, but this time they are going to stop just outside your forbidden zone. So launch your AWACS and move it close to the target so you can identify it.

(Wait for everyone to identify it as an enemy).

Ok, do you want to attack this target right now? . . . . No you don't because it's outside your Forbidden Zone, but you do want to watch it because it could come in at anytime. However, just to show you what happens when you make a mistake, go ahead and launch your helicopter and attack the target outside the Forbidden Zone. Watch what happens.

(Make sure they all do it correctly).

So when you attack an enemy outside of the Forbidden Zone, or you attack a friendly anywhere on the screen, you'll get an X and it will say "error -25 points." Make sure you always look for the fire when you attack something or you'll start losing a lot of points. Now that you used up your Helicopter's power, you have to return it to your base, so go ahead and do that before the next targets come onto the screen.

18:00 Attacking Enemies Inside the Forbidden Zone

Four targets are going to come in from the corners again, but this time they are going to sit just inside of your forbidden zone and you will be losing points off your defensive score. So, launch you AWACS to go see what it is. Then launch an attacking vehicle of your choice and go destroy the enemy target.

(Make sure they do everything okay).

Since you used your Jet to attack the target, what do you have to do with it now? . . . Right, return it to your base.

20:00 Dealing With a Wave Attack

The next thing that you are going to have to deal with is a wave attack. Wave attacks will occur at regular intervals during the task. When wave attacks occur, one team member will get bombarded by a eight targets at once. I want everyone to look at DM2's screen . . . . As you can see, DM2 is experiencing a wave attack where eight targets are entering his or her forbidden zone. Wave targets will move into the forbidden zone, where they will sit, causing you and your team to lose a lot of points. To effectively deal with the wave attack, all the team members need to help out. Here's where your communication skill becomes very important. You can see your teammates' vehicles moving across the screen when they are helping you out. So direct them to the correct targets, tell them where targets are, which target numbers they should get, etc. Also keep them informed when targets are eliminated so they don't send their vehicles all the way over to you only to find out that they aren't needed. Because you can only see what is within your rings, you need to specifically direct other team members so that you can maximize your score. Right now, I want each of you to practice some of these things by first launching your vehicles and then moving them into DM2's zone.

25:00 Practice Time

For the next 20 minutes I'm going to let you work at the task on your own for practice. This is a good time for you to get accustomed to doing the things that you have learned and get used to working together as a team. Remember, when you are communicating with one another, make sure that you tell people which DM you are, which DM you are talking to, and specifically what you want. I will remain in the room while you practice, so that I can answer any questions you may have or help you if let me know you need help.

(The experimenter should now watch the team work at the task for the next 20 minutes and answer questions and help the participants when asked. MAKE SURE that the team members at least try to use station numbers when asking for or requesting specific pieces of information).

(At 40 minutes, the quit box will come up on their screens indicating the end of the practice task. Click on "terminate experiment" in the controller window).

Part 6. Before the 15-minute task

Give them all a bathroom break while you set up the first task:

a. At the dos prompt at L0, type "con." A blue controller window will appear. In this blue con window:
b. Select the appropriate Team Name based on list in the log book (e.g., c8t5a . . . condition 8, team 5, first task).
c. Select the first task (**aleks15**) from the **Expt #** section. All teams will complete this task first.
d. Click on "Start New Game."
e. Highlight the xterm window, you should see "Start Five Locals, Please."
f. Go to each station and enter L0-L4 at the command prompt.

When they all get back in the room, ask them if they have any questions regarding any of the training.

We are almost ready to start the actual task. Before we do, there are several things we need to discuss.

First, to help you be more effective at the task, I'm going to set three goals related to your performance. If you keep these goals in mind, and try to meet them, it should help your team perform well.

These goals are as follows:
You should:

1. **Never allow <u>enemy</u> targets to remain in the restricted zone for more than 3 minutes.**

2. **Try and engage <u>enemy</u> targets residing in the highly forbidden zone within 1 minute after entry.**

3. **Try not to shoot down more than 1 <u>friendly</u> target during the 45-minute task.**

If you focus on doing the things I just mentioned, it will increase your chances of earning the bonus prize of $100 each.

Second, as discussed earlier, team members will have new specialty sheets for the tasks that count. Unlike the practice task, each team member will now have a specific area of expertise. To create areas of expertise within the team, the vehicles and knowledge about the targets will be split up among the team members. Regarding the vehicles, each team member will be responsible for one type of vehicle. That means that one team member will have four tanks, one team member will have four helicopters, one team member will have four jets, and one team member will have four AWACS planes stationed at their base. Regarding the four targets, the A, B, C, and D targets will still correspond to G0, G1, G3, and G5, but not in that order. Each team member will know the power level of exactly one target. This information is contained on each of your specialty sheets.

Pass out the correct specialty sheets depending on condition (in the low shared information conditions, they only get 1 piece of information regarding the wave targets)

Although each team member will individually know less about the task, collectively the team will possess the same set of vehicles and will know the power of the A, B, C, and D targets.

Finally, your specialty sheets contain information regarding the wave targets that will be entering the screen at various points during the task. Your specialty sheets tell which DM will be receiving the wave of targets, when and where the wave will enter the screen, and what targets the wave will consist of. The wave targets represent a significant portion of the total number of targets during the task. Therefore, how you deal with the wave targets will have a large influence on your scores. The information contained in your specialty sheets can help you prepare for the wave targets and should help you increase your score. You may be the only one in possession of the wave target information provided on your specialty sheet or you may share that information with your teammates.

That means that information and expertise is split up between the team members. At the beginning of the task, you will not know what your teammates' specialties consist of. So you will not know who has what vehicle and who knows what each target corresponds to. Therefore, you need to work together in order to perform well as a team and have a chance at the bonus money.

You CANNOT write anything down during the task. That means that your communication skills are of utmost importance. That also means that there will be a lot of information that, as a team, you need to remember. However, each team member does <u>not</u> need to remember all the information themselves. You should try and utilize your teammates' knowledge so that you don't get confused during the task. For example, let's say that you are DM2 and you get a C target in your forbidden zone. Maybe you don't know what the C target represents, but you know DM4 has it on their specialty sheet. Then ask DM4 specifically for the information you need. "DM4, this is DM2. What was the power level of the C target?" That way, you don't have to overload your brain with information. You only need to have a general idea of who knows what. If you try and retrieve information just by yelling things out to the whole team, no one will know who you are talking to. In other words, your comments will get lost or ignored because your teammates are concentrating on their own duties. In addition, if you don't specify who you are talking to, all the team members will have to think about whether they have the information you need, distracting them from what they are doing. This will <u>really</u> hurt the efficiency and effectiveness of the team as a whole.

Let me give you another example. Let's say you are DM3 and you have a target with power 5 in your quadrant, but you only have the jets. In this situation, most teams are very inefficient. They ask "Who has the tanks?." Then they have to say "Can

you come and help me. I'm DM3." This takes time and blocks the lines of communication within the team. Instead, you should know exactly who to direct the request to. If DM4 has the tanks, say something like "DM4, this is DM3. I have an enemy with power 5 in my forbidden zone." If you can always use the same communication format by giving your station number, the station number of the person you are talking to, and very specific information, you will have a much better chance at earning the $100 cash prize. The more you communicate this way, the better you will do as a team. That means that you <u>must</u> try to get to know what each team member can and cannot do. The only way you will learn this information is by specifying who you are, who you are talking to, and exactly what you need.

Finally, remember that during both tasks, you will encounter U targets. When you first detect the U targets, they will look like any other target. In other words, they will appear as a diamond with a question mark in the middle. However, when you identify them, they will not appear as A, B, C, or D. They will appear as U+, U-, U#, and UX. You must find out, through trial and error learning, what each U target's power is if you hope to do well in the task. Each U target corresponds to a G0, G1, G3, or G5. Their power remains the same across both tasks, so once you figure out what they are, you should have no trouble dealing with them.

(The experimenter should then instruct the participants to press START in the report area of the screen. Once all participants verify that they have REFRESH on their screens, the experimenter should then press START at DM0 to begin the task. The experimenter should stay in the room to provide assistance in case there is a problem with the computers as the participants complete the 30-minute task.)

During the first task, the experimenter should remain seated in front of and watch the DM0 screen as to get a sense as to how the participants are handling the task. It is very important that the experimenter appears to be watching the participants' performance since the experimenter will be provide performance feedback to one of the participants in the experimental conditions. The participants need to believe that the feedback is veridical. The experimenter also needs to stay in the room in order to record any communication between the team members.

They CANNOT write anything down during either task, so take away any writing utensils they may have on their desks.

Part 7. After the First 15-Minute Task

Immediately after the first task, the experimenter should instruct the participants not discuss their scores with each other as he or she records them. The experimenter should check to ensure that all of the participants' team scores match, the participants in the north group have matching group scores, and the participants in the south group have matching group scores. The experimenter should then press "TERMINATE EXPERIMENT" at the controller window.

DO NOT read the following manipulations. Try to do it from memory.

You have now finished the first 15-minute task. Before we start the final 30-minute task, there are a couple of things we need to discuss. The first concerns your progress toward the goals we set before the first task.

<u>Individual Feedback Manipulation (conditions 2, 4, 6, 8)</u>

DM2, after watching your performance during the first 15 minutes, it appears that you have been having some difficulty with the goals we set earlier. In particular, you allowed a number of targets to remain in <u>your</u> restricted zone (i.e., your portion of the green box) for more than 3 minutes and several targets remained in <u>your</u> highly restricted zone (i.e., your portion of the red box) for well over 1 minute, which is much longer than we discussed. In addition, you have already shot down more than 1 friendly target in <u>your</u> quadrant. By not doing these things, <u>your</u> performance has probably hurt the team's chances at earning the bonus money.

<u>Feedback Manipulation (conditions 1, 3, 5, 7)</u>

After watching your team's performance during the first 15 minutes, it appears that the team as a whole has been having some difficulty with the goals we set earlier. In particular, the team as a whole allowed a number of targets to remain in the restricted zone for more than 3 minutes and several targets remained in the highly restricted zone for well over 1 minute, which is much longer than we discussed. In addition, the team as a whole has already shot down more than 1 friendly target on the screen. By not doing these things, your team's collective performance has probably hurt the team's chances at earning the bonus money.

<u>Acute Stressor Manipulation (conditions 1-4)</u>

Each semester, we notice that there are a few teams that seem to lag far behind the others. We feel that this is due to a lack of motivation among certain students. Everyone gets credit for participating, so some students feel that they can slack off during their 3-hour session in the lab. When one person doesn't pull their weight in the team, the other team members need to pick up the slack for them. If one person isn't taking care of his or her duties, the team's performance will suffer. Therefore, in order to make sure you give us your full attention and effort for the next 30

minutes, we are going to put a little pressure on you. Right now, there are almost 600 students enrolled in your MGT 315 course. We assume that you would prefer not to be displayed in front of all your friends if you aren't pulling your weight in the lab today. Therefore, we are going to videotape your team's performance. If your team is one of the three lowest performers, Dr. Morgeson will show the tape to the entire MGT 315 class the last week of the semester as an example of ineffective team behavior. I don't think any of you want everything you say picked apart by Dr. Morgenson during class. So just remember that the camera will be on you for the next 30 minutes.

Pass out fake release form and have them sign

We also may be putting some additional pressure on you by warning you at frequent intervals if time is getting short and you have too many enemy targets in the forbidden zones and you really need to hurry up. Often team members lose track of the time and end up with large numbers of targets in their forbidden zones. A little time pressure should help you remain extremely vigilant during the entire 30-minute task.

Finally, before we start the second task, I should let you know that each team member will have the same area of expertise and will be responsible for the same knowledge regarding the targets and the same set of vehicles. In addition, the U target symbols will remain the same.

Call up the second task using the steps below.

a. At the dos prompt at L0, type "con." A blue controller window will appear. In this blue con window:
b. Select the appropriate Team Name based on list in the log book.
c. Select the first task (**aleks30**) from the **Expt #** section. All teams will complete this task first.
d. Click on "Start New Game."
e. Highlight the xterm window, you should see "Start Five Locals, Please."
f. Go to each station and enter L0-L4 at the command prompt.

(The experimenter should then instruct the participants to press START in the report area of the screen. Once all participants verify that they have REFRESH on their screens, the experimenter should then press START at DM0 to begin the task. The experimenter should stay in the room to record communication between the team members)

For conditions 1-4, read the following statement (you can alter it a bit so it doesn't seem so static) at the following times: 10, 15, 20, 22, 24, 26, 28

You now have only xx **minutes left to work on the task, which is not a lot of time. In order to perform well, you need to hurry up and work harder at keeping your forbidden zones free from enemy targets.**

Part 8. After the Second 30-Minute Task

You are done working on the task now. The last thing you need to complete is the post-game questionnaire. Please fill in your name and PID on the front and begin answering the questions until it says stop. The first set of questions asks you about how you felt during the task and how you feel now after the task is completed. Please take your time and answer all of the questions honestly. Only the experimenters will see your answers to the survey questions.

While the participants are filling in the acute stressor manipulation checks, go ahead and record their scores in the logbook. Once they all finish the first section, take them through the cognitive maps portion of the questionnaire.

Ok, the next portion of the questionnaire is a little more difficult. Please turn the page and I'll explain what you need to do. As you can see, there are a number of empty bubbles connected to one another. The objective of the team is to clear DM1's zone of enemy target. Your job is to indicate the steps each team member needs to go through in order to reach your objective by filling in the bubbles for each team member using the options provided. So you need to think about each team member's area of expertise and what they need to do in this situation. For example, in DM1's first bubble, you could write in "Attack A targets" if you think that's what DM1 should do first. Does everyone understand? . . . . . . There are several of these sheets that you have to complete. After you finish, there are a number of other questions that you need to answer. The instructions for those questions are provided, but if you have any questions, let me know.

The experimenter should now allow the team the remaining time to complete the post-game questionnaire. When they finish, they can leave the lab. However, before they leave, the experimenter should thank each participant and ask them not to talk with anyone about the experiment. The experimenter should also debrief the participants as follows:

(In the acute stressors condition)
Before you leave, I just want to let you know that you will not see your team's performance replayed during the last class of the semester. After looking at your performance across both tasks, there is almost no chance that your team will be one of the three at the bottom of the list. You all put forth a lot of effort and that is reflected in your scores, which, at the end of the semester, will likely fall well above the average score for the class.

I also want to let you know that during the experiment, you may or may not have received some information about how you or your team performed on the task. This information may or may not have reflected your actual performance on the task.

However, only the actual performance of the team will be used to determine which teams will be awarded the cash prizes.

Also, we would greatly appreciate it if you could do us a favor and not discuss the experiment in detail with any of your classmates or anyone else that may be coming into the laboratory during this semester to participate in the experiment. For us, your discretion helps maintain the integrity of the experiment study. For you, you will be competing against others who will work on the task, so the more insight you provide others about the experiment, the more you reduce your chances for winning the cash prize.

Thanks. We really appreciate your participation.

The experimenter should also address any questions/concerns participants have in regards to the experiment.

After the participants leave, the experimenter should:

1. check to make that the scores have been recorded
2. collect all measures/scantrons and make sure all the necessary identifying information has been provided
3. file all the information in the drawer labeled **Aleks' Dissertation**.

APPENDIX D: COMMUNICATION CODING

Team: _______ Coder: ______________________ Date/Time: ___________

Time	DM1 (Red)	DM2 (Purple)	DM3 (Green)	DM4 (Yellow)
	[ ]	[ ]	[ ]	[ ]
0-2				
2-4				
4-6				
6-8				
8-10				
10-12				
12-15				
0-2				
2-4				
4-6				
6-8				
8-10				
10-12				
12-14				
14-16				
16-18				
18-20				
20-22				
22-24				
24-26				
26-28				
28-30				

Directory Updating

SE- sharing information about one's own target or vehicle specialty (e.g., "I'm DM2 and I have the tanks.")

RE- requesting information about someone else's target or vehicle specialty (e.g., "Who knows what the D target is?")

Information Allocation

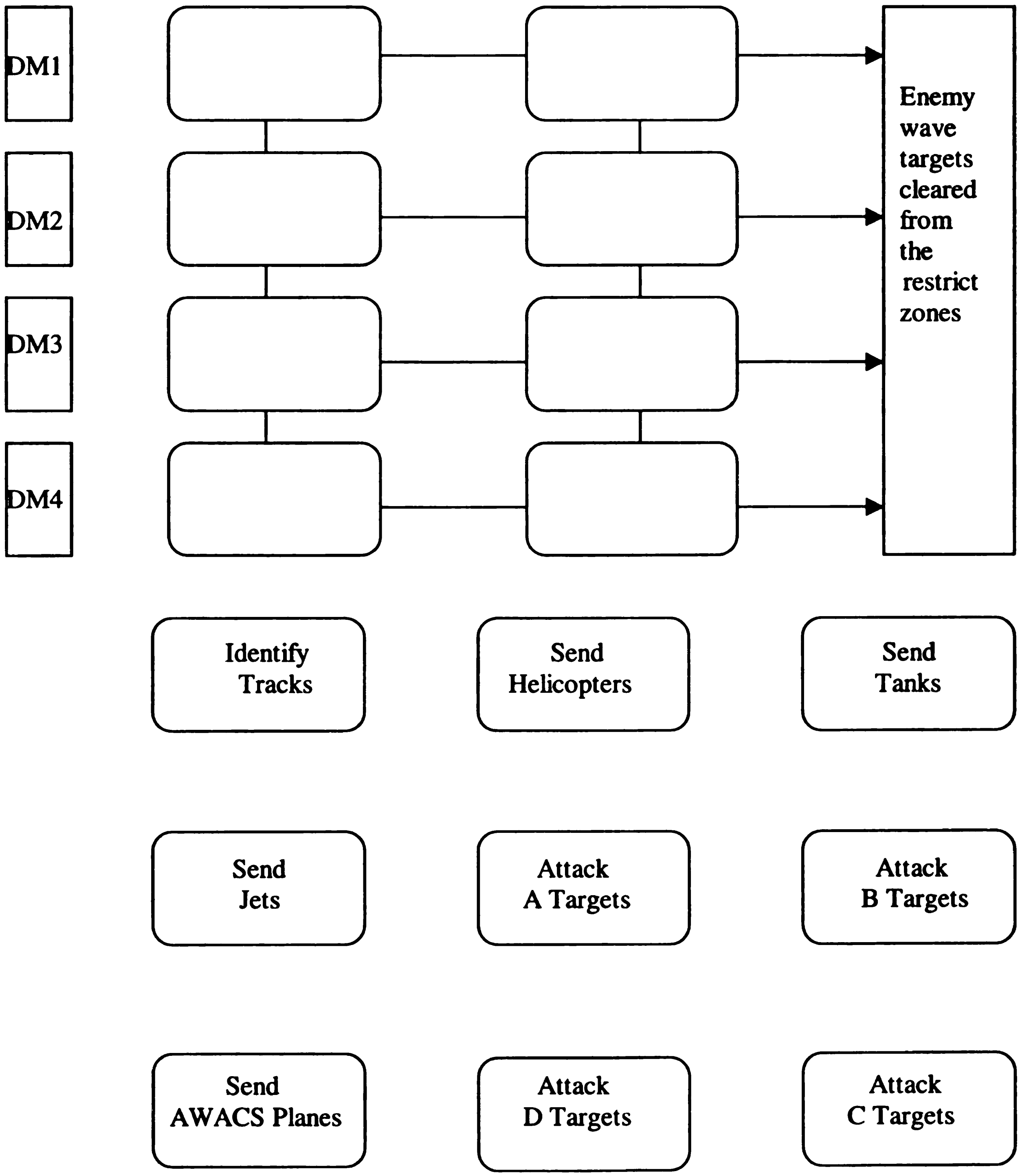
IA- allocating information to the person with the correct target or vehicle specialty (e.g., "DM3, I have several C targets in my restricted zone")

Retrieval Coordination

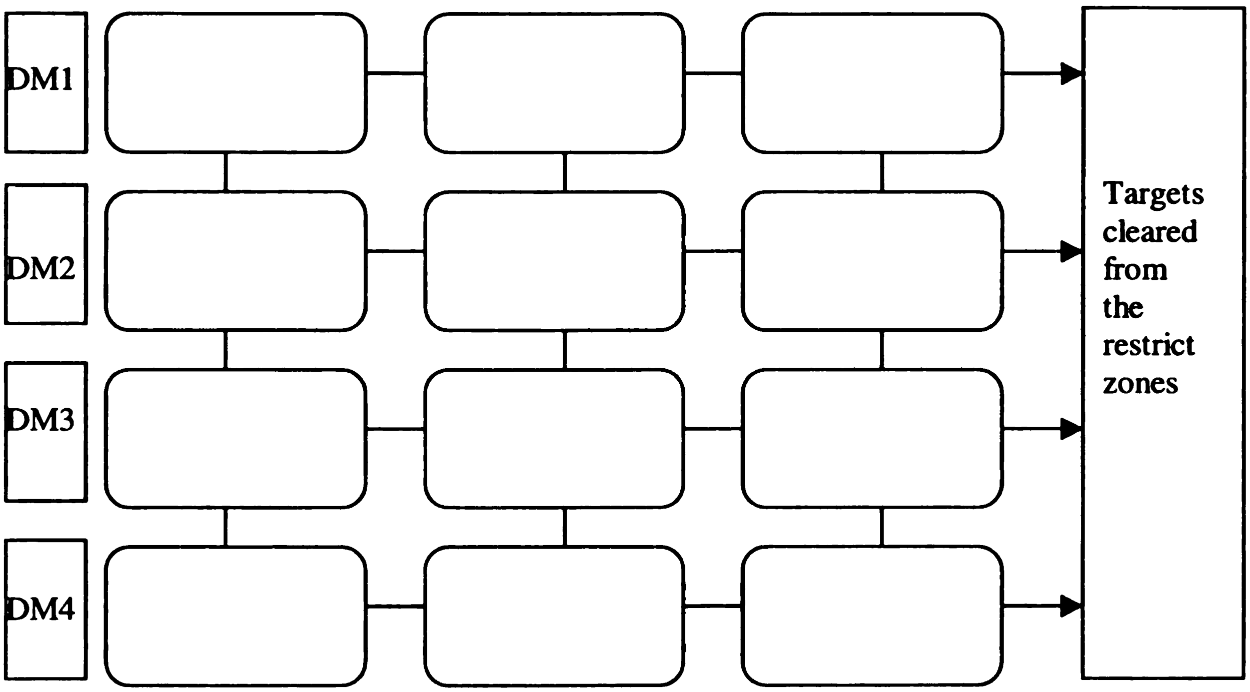
RC- requesting information that is known to be part of someone's target or vehicle specialty (e.g., "DM3, what is the C target again?")

APPENDIX E: SHARED MENTAL MODELS MEASURE

Situation #1: DM1 is getting attacked by a wave of eight unidentified targets, some of which are enemies. All eight ground targets slowly move through DM1's restricted area and stop inside DM1's highly restricted area (i.e., the red box). They are the only targets on the screen. What are the actions that each team member needs to go through in order to clear the enemy targets from the forbidden zones?



Situation #2: There are a number of targets on the screen. DM2 has 2 B targets inside his or her restricted zone (i.e., the green box). DM3 has 2 C targets in his or her restricted zone. DM1 has 2 D targets in his or her restricted zone. DM4 has a wave of eight unidentified targets about to enter his or her restricted zone. What are the actions that each team member needs to go through in order to maximize the team's score?



Send tanks to DM4	Send helicopters to DM4	Transfer identity of targets	Attack any D targets in DM4
Send jets to DM4	Attack 2 C targets	Attack any A targets in DM4	Ask for help
Send AWACS planes to DM4	Attack 2 D targets	Attack any B targets in DM4	
Identify targets	Attack 2 B targets	Attack any C targets in DM4	

DM1 Role Description

Vehicle Specialty:

You will be in charge of four **AWACS** planes during both games

Target Specialty:

The **D** target represents a **GO**, or a friendly ground target, and this will remain consistent across both games.

Task Information:

You will receive a wave of eight targets, two GOs, two G1s, two G3s, and two G5s, during the first ten minutes of the second 30-minute game. These targets will enter at the lower right-hand corner of the screen and will proceed to the highly restricted area.

DM3 will receive a wave of eight targets, two GOs, two G1s, two G3s, and two G5s, during the last ten minutes of the second 30-minute game. These targets will enter at the lower left-hand corner of the screen and will proceed to the highly restricted area.

APPENDIX G: SHARED INFORMATION MANIPULATION

	High Level of Shared Information	Low Level of Shared Information
DM1	(1) DM4 will be the first person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 10-minute mark of the second 30-minute game. These targets will enter at the upper right-hand corner of the screen and will proceed to the highly restricted area. (2) DM3 will be the second person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 15-minute mark of the second 30-minute game. These targets will enter at the lower left-hand corner of the screen and will proceed to the highly restricted area.	(1) DM4 will be the first person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 10-minute mark of the second 30-minute game. These targets will enter at the upper right-hand corner of the screen and will proceed to the highly restricted area. (2) DM3 will be the second person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 15-minute mark of the second 30-minute game. These targets will enter at the lower left-hand corner of the screen and will proceed to the highly restricted area.
DM2	(1) DM4 will be the first person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 10-minute mark of the second 30-minute game. These targets will enter at the upper right-hand corner of the screen and will proceed to the highly restricted area. (2) DM3 will be the second person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 15-minute mark of the second 30-minute game. These targets will enter at the lower left-hand corner of the screen and will proceed to the highly restricted area.	(1) DM4 will be the first person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 10-minute mark of the second 30-minute game. These targets will enter at the upper right-hand corner of the screen and will proceed to the highly restricted area. (2) DM3 will be the second person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 15-minute mark of the second 30-minute game. These targets will enter at the lower left-hand corner of the screen and will proceed to the highly restricted area.
DM3	(1) DM2 will be the third person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 20-minute mark of the second 30-minute game. These targets will enter at the upper left-hand corner of the screen and will proceed to the highly restricted area. (2) DM1 will be the last person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 25-minute mark of the second 30-minute game. These targets will enter at the lower right-hand corner of the screen and will proceed to the highly restricted area.	(1) DM4 will be the first person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 10-minute mark of the second 30-minute game. These targets will enter at the upper right-hand corner of the screen and will proceed to the highly restricted area. (2) DM1 will be the last person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 25-minute mark of the second 30-minute game. These targets will enter at the lower right-hand corner of the screen and will proceed to the highly restricted area.
DM4	(1) DM2 will be the third person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 20-minute mark of the second 30-minute game. These targets will enter at the upper left-hand corner of the screen and will proceed to the highly restricted area. (2) DM1 will be the last person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 25-minute mark of the second 30-minute game. These targets will enter at the lower right-hand corner of the screen and will proceed to the highly restricted area.	(1) DM3 will be the second person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 15-minute mark of the second 30-minute game. These targets will enter at the lower left-hand corner of the screen and will proceed to the highly restricted area. (2) DM2 will be the third person to receive a wave of eight targets (i.e., two As, two Bs, two Cs, and two Ds) around the 20-minute mark of the second 30-minute game. These targets will enter at the upper left-hand corner of the screen and will proceed to the highly restricted area.

APPENDIX H: ACUTE STRESSOR MAINPULATION CHECK

Pressure and Tension

For each of the following statements, please indicate how true it is for you, using the following scale:

1	2	3	4	5	6	7
Not at all True			Somewhat True			Very True

1. I felt very tense while doing this activity.
2. I was anxious while working on this task.
3. I felt pressured while doing this activity
4. I did not feel nervous at all while doing this task.
5. I was very relaxed while doing this task.

Affective (negative thoughts)

6. I became frustrated with my inability to improve my performance.
7. I thought about how poorly I was doing.
8. I was very satisfied with my overall performance on this task.
9. I got mad at myself during the task.

State Anxiety

A number of statements which people have used to describe themselves are listed below. Reach each statement and then circle the appropriate number to the right of the statement to indicate how you feel ***right now***, that is, at ***this moment***. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best. Use the following scale:

Not at All	Somewhat	Moderately So	Very Much So
(1)	(2)	(3)	(4)

10. I feel calm.
11. I feel secure.
12. I am tense.
13. I feel strained.
14. I feel at ease.
15. I feel upset.

16. I am presently worrying over possible misfortunes.
17. I feel satisfied.
18. I feel frightened.
19. I feel comfortable.
20. I feel self-confident.
21. I feel nervous.
22. I am jittery.
23. I feel indecisive.
24. I am relaxed.
25. I feel content.
26. I am worried.
27. I feel confused.
28. I feel steady.
29. I feel pleasant.

Time Pressure and Threat

For each of the following 4 statements, please indicate how true it is for you, using the following scale:

1	2	3	4	5	6	7
Not at all True			Somewhat True			Very True

30. I felt a lot of time pressure during this task
31. I felt stressed because there was not enough time to complete the task
32. The idea that other students may be aware of my performance on this task was very stressful
33. I felt a lot of pressure to perform well on this task because there was a chance that others could observe my behavior

Overall Stress

34. How stressed did you feel while playing the DDD command and control simulation?

1	2	3	4	5	6	7
Not at all Stressed			Somewhat Stressed			Very Stressed