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Team task interdependence perceptions: toward an integrative model of teamwork

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TEAM TASK INTERDEPENDENCE PERCEPTIONS: TOWARD AN INTEGRATIVE MODEL OF TEAMWORK

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ABSTRACT

The present study examines perceptions of task interdependence and workflow at the individual- and team-levels to evaluate the degree to which team perceptions and homogeneity of perceptions predict team communication and performance in a military combat computer simulation. Team members who perceived higher levels of task interdependence and workflow performed better at both the individual and team levels of analysis. These teams also communicated more frequently, although communication was not significantly correlated with performance. The present findings provide support for the examination of task interdependence perceptions as a means to explain team performance and communication.

INTRODUCTION

Organizations increasingly utilize teams to accomplish work that cannot be completed by individual employees alone (Brannick, Roach, & Salas, 1993; Ellis, Bell, Ployhart, Hollenbeck, & Ilgen, 2005). Organizations use teams when the required work can be completed more effectively when individuals with different backgrounds and areas of expertise are needed, the workload is too large for one individual, and monitoring of others' work is imperative (Bunderson, 2003; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). Different forms of interdependence are an important aspect of these points. Specifically, team effectiveness is largely dependent upon the coordinated actions of the team's members (Brannick et al., 1993). The purpose of the current research is to explain how team members' impressions of their dependence upon others to complete work are related to communication and performance on team-based tasks. While task interdependence refers to the objective degree to which group members are dependent upon one another to accomplish their work and is often referred to as a job characteristic (Campion, Medsker, & Higgs, 1993), task interdependence perceptions refer to subjective impressions of task interdependence. To date, most of the task interdependence literature focuses on objective interdependence (e.g., Guzzo & Dickson, 1996; Janz, Colquitt, & Noe, 1997). The focus of this project is on team member perceptions of interdependence.

The paper first reviews the relevant literature of task interdependence and introduces workflow as a related variable. Examples are then given that demonstrate the real-world applicability of analyzing perceptions of these two variables. The theoretical framework is then laid out that focuses on Social Interdependence Theory and the Theory of Planned Behavior. The theoretical background provides a framework that allows for hypotheses concerning the relationship between the perceptions of interest and communication and performance. In addition, two distinct approaches to the measurement of task interdependence and workflow perceptions are considered with hypotheses offered for the differential

effects of the two approaches. Finally, the paper addresses homogeneity of team-level perceptions for important theoretical reasons.

REVIEW OF LITERATURE

Objective Task Interdependence and Workflow

Janz et al. (1997) define work teams as "an interdependent collection of individuals, each of whom shares responsibility for organizational outcomes" (pp. 877-878). Accordingly, a defining characteristic of teams is the presence of interdependent work (e.g., Arthur, Edwards, Bell, Villado, & Bennett, 2005; Janz et al., 1997; Sundstrom, DeMeuse, & Futrell, 1990). Brannick et al. (1993) note that interdependent interaction directs teams toward achieving the "specified, shared, and valued objectives" (p. 287). Several types of interdependence have been conceptualized including task, goal and outcomes, and feedback and rewards. Evidence suggests that these types of interdependence are related, with some researchers relying on composite interdependence variables (Campion, et al., 1993; Campion, Papper, & Medsker, 1996; Gully, Incalcaterra, Joshi, & Beaubien, 2002).

It is important to first note the importance of objective task interdependence within work groups in relation to additional team variables. Task interdependence is an objective job characteristic directly related to performance in teams and may serve to increase the motivation of team members to work together as a team (Gladstein, 1984; Guzzo & Shea, 1992; Janz et al., 1997). High interdependence within teams has strengthened the importance of team-efficacy (i.e., belief in the capabilities of the team on a specific task) and cohesion (i.e., degree to which a team is united in its work through goals and objectives) on performance (Gully, Devine, & Whitney, 1995; Gully et al., 2002). Gundlach, Zivnuska, and Stoner (2006) proposed task interdependence as a moderator in the relationship between individualism-collectivism and the degree to which a collection of individuals identify themselves as being a part of a team (i.e., team identification). Therefore, it is not surprising to see positive relationships between task interdependence and team performance.

Campion and colleagues' (Campion et al., 1996; Campion et al., 1993) studies of interdependence are also important to review. The authors have also examined task interdependence as a job

characteristic, but they used employees' perceptions to measure the variable. They found employee task interdependence perceptions were positively related to employee satisfaction (Campion et al., 1993), employee and manager judgments of effectiveness (Campion et al., 1996), and productivity (Campion et al., 1993), suggesting a direct relationship between perceptions and team outcomes.

An additional variable of interest, workflow, has shown similar relationships with team outcomes. Workflow is the pattern of activities and flow of information within a team (Arthur et al., 2005; Tesluk, Mathieu, Zaccaro, & Marks, 1997). Workflow is considered in conjunction with task interdependence, because it has been noted as an objective indicator of task interdependence (Arthur et al., 2005; Beal, Cohen, Burke, & McLendon, 2003). Indeed, researchers have used workflow as an objective indicator of task interdependence, and it has been investigated for its potential role in explaining team performance (Arthur et al., 2005). Workflow has been evaluated in studies investigating the relationship between team cohesion and performance (Beal et al., 2003) and within team task analyses (Arthur et al., 2005). The similarity between workflow and task interdependence is shown in Beal and colleagues' (2003) meta-analysis, which concluded that as workflow became more intensive, cohesion's importance in determining performance increased. This is a similar relationship as found in Gully and colleagues' (1995) meta-analysis with respect to task interdependence, with cohesion's prediction of performance increasing with task interdependence.

Tesluk and colleagues (1997) proposed four patterns of workflow with increasing levels of interdependence: pooled interdependence, sequential interdependence, reciprocal interdependence, and intensive (see also Thompson, 1967). In the pooled/additive pattern, there is a separation between each members' activities and work completed with each individual's performance determined by-and-large by their own efforts. In the sequential pattern, workflow is unidirectional with team performance determined largely by one-on-one interactions between teammates. Workflow involves back-and-forth interaction in the reciprocal pattern, with back-and-forth communication influencing team performance. Finally, the

intensive pattern is characterized by close working relationships, in which individual team members working together as a team determine team performance.

Task Interdependence and Workflow Perceptions

Task interdependence perceptions refer to a team member's impressions of the dependency upon one another, to some degree, within his or her team to accomplish the work and/or carry out the tasks of the team. To illustrate the real-world applicability of examining task interdependence perceptions, consider the following example. Alex and Sandy are paired with two other individuals to complete a group assignment. Alex and Sandy have different impressions regarding how the overall assignment should be completed. Alex does not perceive the assignment to be a team assignment, but rather he believes that each member should work individually. Sandy believes that all members should work together as a team to complete the assignment. In this case, Alex perceives the assignment to be low in task interdependence. Sandy, however, perceives the assignment to be high in task interdependence. This example pertains to the assignment as a whole, but it is also possible for members to attribute different degrees of task interdependence to the assignment's individual tasks differently. For example, Alex may perceive some aspects, such as completing goals and strategizing, to be high in task interdependence; and other tasks, such as monitoring the progress of the assignment, to be low in task interdependence. With concern to task interdependence, there is a distinction to be made between perceptions as they are directed toward the overall job or toward specific team tasks (Arthur et al., 2005). That is, task interdependence perceptions can reflect a global job perception (i.e., job analysis) or pertain to specific roles and actions of an assignment (i.e., task analysis). Given these multifaceted dimensions of teamwork, teams and the members within teams are likely to differ on their task interdependence perceptions.

This example may also be applied to workflow perceptions with regard to workflow patterns within teams. Like task interdependence, workflow is an objective variable that may be perceived differently among team members. Returning to the prior example of Alex and Sandy, the two teammates

may also have different perspectives regarding workflow. Alex and Sandy may differ in the decision on how to communicate information and direct work between team members. For example, Alex may perceive each member's work production to be independent of other team members (pooled/additive workflow). Alex may see each member completing their own work and then delivering their part to another teammate who would then pass along their completed work to a third team member, and so on (sequential pattern). If Sandy perceived the process to be represented by the reciprocal pattern, she would see team performance determined by back-and-forth interaction amongst team members over a period of time. Sandy may prefer that the team members come together for problem-solving and collaboration, producing one outcome for the team as a whole (i.e., intensive pattern). It is assumed that many teams' jobs are comprised of different tasks that require differing levels of task interdependence and different workflow patterns. In the present study, the selected job is comprised of different tasks that may require different workflow patterns, and therefore results in different degrees of task interdependence perceptions among team members. This is the premise for investigating the role of task interdependence perceptions on team performance and communication.

Theoretical Framework and Statement of Hypotheses

To better understand how objective and perceptive measures of task interdependence may influence teamwork, we look to two theoretical literatures: Social Interdependence Theory and the Theory of Planned Behavior. Deutsch's (1949a & 1949b) Social Interdependence Theory (SIT) provides a basis for understanding how group members perceive interdependence and how these perceptions are related to beliefs regarding one's goals. Specifically, interdependence exists in groups where each member's outcomes are influenced by others' actions (Johnson & Johnson, 2005). Positive interdependence in SIT is a function of group members' perceptions that goal attainment depends upon whether the other group members attain their goals (Johnson & Johnson, 2002). In contrast, negative interdependence is the perception that goal attainment is independent of whether others accomplish their

goals (Johnson & Johnson, 2002). Thus, members develop perceptions concerning the nature of their dependence upon others to attain their goals. SIT offers behavioral outcomes representative of each form of interdependence. Groups with positive interdependence exercise coordination and promotive interaction, while groups with negative interdependence do not engage in interaction (Johnson & Johnson, 2002).

While SIT explains how group members perceive interdependence within their team, the Theory of Planned Behavior (TPB; Ajzen, 1991) provides a link from members' perceptions to behavior. This theory focuses heavily on the behavioral intentions of individuals, introducing the notion of perceived behavioral control and recognizing that behavior may not always be under complete volitional control. Intentions are a function of an individual's motivation, effort, and willingness to carry out a particular behavior. Moreover, Ajzen (1991) asserts that intentions are determined by attitudes toward the behavior, subjective norms, and perceived behavioral control. SIT's discussion of dependency (see Johnson and Johnson, 2005) also relates to the notion of perceived behavioral control. While SIT focuses specifically on behaviors related to goal attainment, additional behaviors may be investigated, as well. The behavior of interest in the current study is teamwork. Teamwork behaviors include the aggregation of a variety of specific behavioral processes, such as coordination and communication. Aggregating specific behaviors allows for reliability in behavioral criteria (Ajzen, 1991; Ajzen, 1988).

One's perceptions about the attainment of his or her goals and the degree to which the member perceives goal attainment to be dependent upon others are expected to affect his or her behavioral intention toward goal attainment. Thus, teamwork behaviors are likely to differ between positive and negative interdependence groups. In the context of this study, perceptions of task interdependence are hypothesized to affect behavioral intention regarding teamwork and coordination. In this sense, perceptions are equated with attitudes toward teamwork behavior, one determinant of behavioral intention toward teamwork. Thus, stronger perceptions of task interdependence should be related to behavioral

intention via effort, leading to an increase in the likelihood of teamwork behaviors (e.g., communication). By its very definition, the elements of performance that require coordination among team members, teamwork requires the recognition of interdependence by team members (Salas, Cooke, & Rosen, 2008). The relationship between input characteristics and teamwork has been examined before with regard to team members' collective orientation (i.e., tendency to engage in teamwork, or collective, behavior) (Driskell & Salas, 1992). The significant intention-behavior relationship has been determined in past research (e.g., Sheppard, Hartwick, & Warshaw, 1988). In sum, this project will draw on SIT and TPB to explore the degree to which task interdependence and workflow perceptions are related to team communication and performance (see Figure 1). As mentioned above, team communication is an important aspect of teamwork that is one of the outcomes of interest in the present study.

One aspect of the present research is to understand how perceptions of interdependence affect communication within teams. Communication has long been recognized as an important dimension of teamwork (i.e., team processes; Helmreich & Foushee, 1993; Morgan, Glickman, Woodard, Blaiwes, & Salas, 1986). Williges, Johnston, and Briggs (1966) examined the importance of communication and its effect on performance when it was required and not required, finding that when it was required, it was influential in team performance. However, when verbal communication was not required and participants had to rely on verbal-visual cues, communication did not affect performance. This finding lends itself to the discussion of team members' perceptions. One specific question of interest is whether perceptions of task interdependence and workflow lead to a perceived requirement of communication. Specifically, do increased perceptions of task interdependence serve as a self-appointed requirement (e.g., recognition) for team communication in tasks? Teams whose members believe they are dependent upon one another to accomplish their work should engage in a greater amount of teamwork activities. In a team task where verbal communication is the medium of interaction, increased effort via recognition of this dependency upon one another should result in greater communication between team members. Along these lines, it is

expected that teams that have higher perceptions of task interdependence communicate more frequently than teams with lower perceptions of task interdependence. Mean team-level perceptions of task interdependence and workflow are of interest when predicting the total frequency of team communication. As discussed above, the Theory of Planned Behavior suggests a direct, positive relationship between mean team-level task interdependence perceptions and communication (e.g., a teamwork behavior). With this in mind, the following hypothesis is given with respect to communication frequency.

Hypothesis 1a: Mean team-level perceptions of task interdependence will be positively related to the frequency of team communication.

Hypothesis 1b: Mean team-level perceptions of workflow will be positively related to the frequency of team communication.

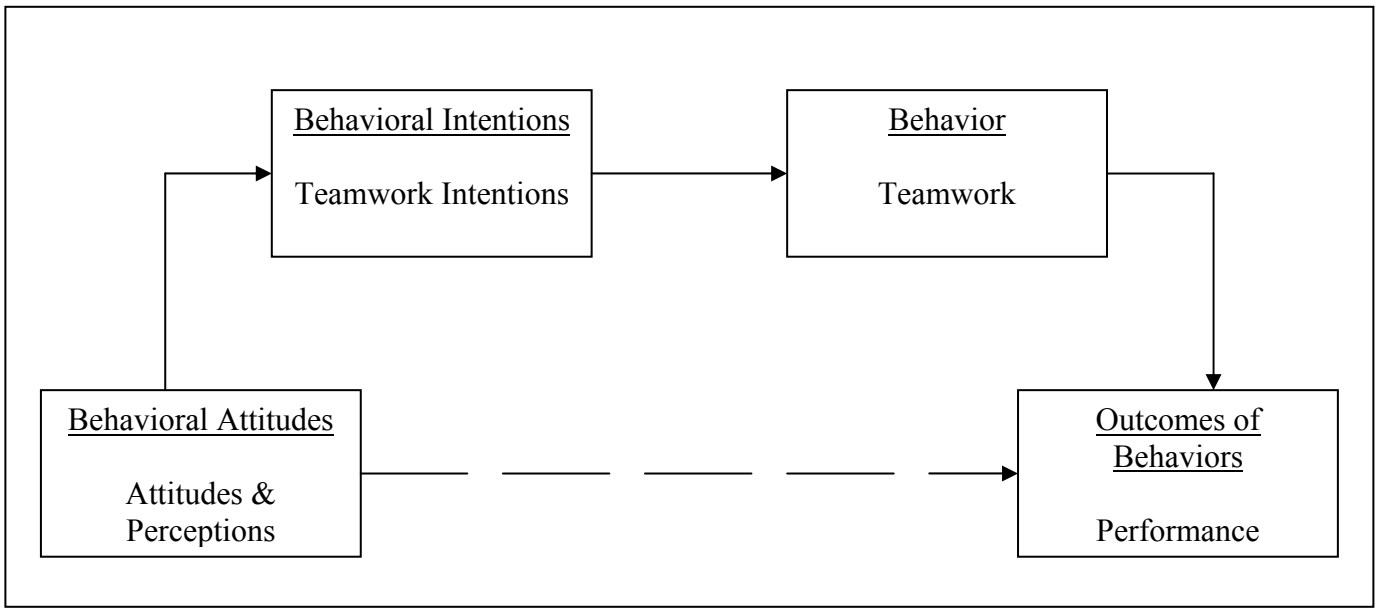

Figure 1 – General Theoretical Framework

Team communication is related to team effectiveness (Brannick et al., 1993). Furthermore, frequency of communication was positively related to team performance across tasks similar to the one investigated in the present study (Foushee & Manos, 1981; Roberts & O'Reilly, 1976). Team communication facilitates effective performance of additional teamwork variables, including monitoring

teammates' performance (Dickinson & McIntyre, 1993). Communication represents an important aspect of teamwork in the present study. Therefore, teams who communicate more frequently should perform better. Communication frequency is likely to facilitate performance through coordination and feedback, among other teamwork factors (Dickinson & McIntyre, 1993). Thus, frequency of communication should be positively related to team performance in the current study.

Hypothesis 2: The frequency of communication will be positively related to team performance.

The Theory of Planned Behavior states that perceived behavioral control is a determinant of behavior (Ajzen, 1991). Volitional control includes the knowledge, skills, and abilities (KSA's) that are relevant for the behavior in question. In the present study, two indicators of ability were assessed: self-reported gaming ability and baseline performance. Both of these variables are likely to affect perceived behavioral control. With self-reported gaming ability, participants are reporting on their ability to play computer and video games, which is directly relevant to the task at hand. With baseline performance, participants are able to receive feedback toward their perceived behavioral control. Additionally, the well-known formula of performance:

$$\text{Performance} = \text{Motivation} * \text{Ability}$$

asserts that ability is a determinant of performance. Therefore, the following hypotheses are made concerning individual and team performance.

Hypothesis 3a: Individual gaming ability will be positively related to individual performance.

Hypothesis 3b: Individual baseline ability will be positively related to individual performance.

Hypothesis 4a: Mean team-level gaming ability will be positively related to team performance.

Hypothesis 4b: Mean team-level baseline ability will be positively related to team performance.

Individual differences in perceptions of task interdependence indicate one's recognition of the dependency upon one another within the team to perform the team's tasks. Individuals who hold the belief that they should work together with their teammates likely will. It is expected that individuals will be able to improve their individual performance by working with their teammates. Thus, individuals who hold this belief to a greater extent are likely to have higher performance than individuals who hold this belief to a lesser extent. Further, as Janz et al.'s (1997) work pointed out, individual recognition may also lead to increased in motivated behavior. Therefore, perceptions of task interdependence and workflow should be positively related to individual performance. Differential predictive power of task interdependence and workflow perceptions are discussed later. The following hypothesis is posited.

Hypothesis 5a: Individual-level perceptions of task interdependence will be positively related to individual performance.

Hypothesis 5b: Individual-level perceptions of workflow will be positively related to individual performance.

The concept of interdependence has been used at different levels of analysis. For instance, interdependence has been conceptualized at the individual- (Billings, Klimoski, & Breaugh, 1977), team- (Campion et al., 1996; Campion et al., 1993) and organizational-level (e.g., Aiken & Hage, 1968). Furthermore, Mathieu et al. (2000) emphasized the predictive utility of additive knowledge (e.g., knowledge distinct to individual members) in addition to collective knowledge (e.g., knowledge shared by members). This principle should apply to the current research, as well. Specifically, in addition to homogeneity measures of team-level task interdependence and workflow, an additive approach to measuring team-level task interdependence and workflow perceptions is included. Moreover, there is an inherent interest in evaluating perceptions of task interdependence at the team level. In the present study,

team-level measures of task interdependence will include both a dispersion variable (e.g., homogeneity of perceptions) and a mean (e.g., additive) team-level variable. Team-related concepts, such as task interdependence perceptions, that are related to team outcomes may provide a stronger relationship with other team variables when aggregated to the team-level than when examined at the individual level (Gully et al., 1995).

It follows from the previous rationalization that mean perceptions across team members should be positively related to teamwork effort, and ultimately, team performance. Specifically, teams whose members hold the belief that they should work together probably will work together to a greater extent than those teams whose members do not hold this belief. Since teamwork is expected to facilitate team performance, these teams who work together should perform better as well. As discussed above, a similar relationship was determined regarding members' collective orientation (Driskell & Salas, 1992). Specifically, collective behavior led to increased team performance. Further, previous research suggests that motivation, cohesion, efficacy, and group identification may also play a role (Campion et al., 1993; Campion et al., 1996; Gully et al., 1995; Gully et al., 2002; Gundlach et al., 2006; Janz et al., 1997). Teams with members who hold intensive perceptions may improve their performance through increased motivation, cohesion, efficacy, and identification. This relationship is also expected with respect to perceptions of workflow. A visual model for the relationships among team-level variables of interest is presented in Figure 2.

Hypothesis 6a: Mean team-level perceptions of task interdependence will be positively related to team performance.

Hypothesis 6b: Mean team-level perceptions of workflow will be positively related to team performance.

As mentioned above in the examples of member's perceptions, it is important to note that task interdependence and workflow perceptions may differ regarding the overall job and the specific tasks of

the team. Furthermore, these two types of perceptions (workflow and task interdependence) and units of measurement (task analysis versus job analysis) may differentially relate to team communication and performance. Perceptions of task interdependence and workflow were assessed regarding perceptions of the overall job (e.g., job analysis approach) and individual tasks (e.g., task analysis approach). Arthur et al. (2005) presented two team task analysis scales in their research on task interdependence. Task analysis refers to the defining of a job by the tasks or individual activities involved in performing the job. Team task analysis[1] applies the procedure to team tasks. The task analysis approach presents an aggregate of task interdependence and workflow perceptions across team tasks identified by the task analysis. One of the main goals of the development of these scales, as stated by the researchers, was to quantitatively assess team interdependence for practical purposes (e.g., team training interventions). These scales are used in the present study to assess team members' perceptions of task interdependence and workflow. Arthur et al.'s (2005) measures of workflow allow team members' to indicate the workflow pattern, from Tesluk et al.'s (1997) four patterns of teamwork, that is most representative of both specific tasks and the overall job in which the team members are completing. Arthur et al.'s scales focus on specific tasks (e.g., task-analysis variable), while Campion et al. (1993; 1996) and others (e.g., Janz et al., 1997) applied a general approach focusing instead on participants' jobs, overall (e.g., job-analysis variable). Thus, the former scales allow for a more precise, specific measurement of task interdependence.

Furthermore, the theoretical framework of TPB supports the argument that the task analysis approach allows for a stronger relationship between members' perceptions and team outcomes. Specifically, it is expected that team members will evaluate each task differently with regard to its degree of task interdependence and specific pattern of workflow required. This is related to previous research that has noted the ability of individuals to distinguish between different levels, types, and consistencies of

[1] Team task analysis has also been referred to as teamwork analysis (Klimoski & Zurkin, 1999) and collaborative task analysis (McNeese & Rentsch, 2001).

performance (DeNisi & Stevens, 1981; Fox, Bizman, & Garti, 2005; Newman, Krzystofiak, & Cardy, 1986; Steiner, Rain, & Smalley, 1993). Likewise, it is expected that individuals may distinguish between different tasks when considering task interdependence and workflow. Furthermore, members' perceptions regarding these tasks should serve as a stronger indicator of teamwork behavioral intentions than perceptions regarding the job overall.

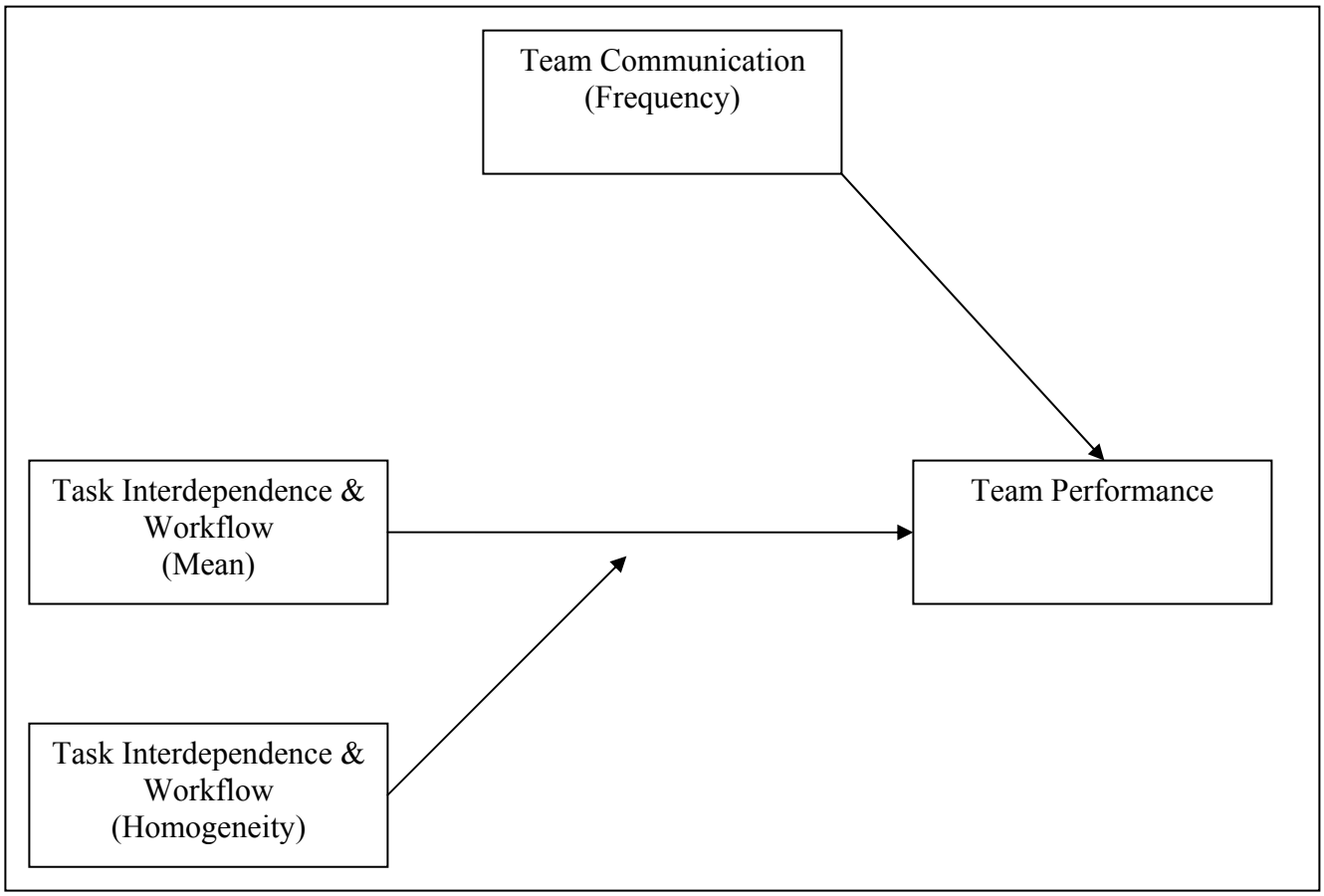

Figure 2 – Proposed Team-level Model

The theoretical model displayed in Figure 1 hypothesizes relationships between participants' behavioral attitudes and communication and performance. However, the strength of these proposed relationships may differ based on how one assesses these attitudes, or perceptions. Specifically, the degree to which impressions of one's dependence upon others for the overall job may serve as a more, or less, important factor than impressions of one's dependence upon others for each specific task when

considering behavioral intentions. Additional types of interdependence (e.g., reward/feedback & goal/outcome) may have exhibited stronger relationships due to a fit with the more appropriate approach to measurement. For instance, it seems probable that teams' rewards, feedback, goals, and outcomes will be based upon the job done overall, and therefore should be measured using the job analysis approach. This premise is supported by Campion et al.'s (Campion et al., 1996; Campion et al., 1993) findings that other interdependence-types (i.e., goal; feedback and rewards) were often more strongly related to team outcomes than task interdependence. Specifically, they assessed the different types of interdependence with similar, broad measures that did not include assessments of interdependence across multiple tasks, but instead focused on the overall job. Therefore, these perceptions should be more strongly related to the outcome variables of interest in the present study.

Hypothesis 7a: The task analysis approach to measuring task interdependence and workflow will serve as a more important predictor of team performance than the job analysis approach.

Hypothesis 7b: The task analysis approach to measuring task interdependence and workflow will serve as a more important predictor of team communication than the job analysis approach.

In addition to the discussion of specific approaches to measuring these perceptions, task interdependence and workflow perceptions, it is acknowledged that the two are related but separate variables. Task interdependence perceptions are expected to more strongly relate to the team variables of interest. While workflow patterns and task interdependence are related to one another, team members may perceive them as very different variables. In fact, workflow may indicate work complexity, increasing from the pooled/additive to the intensive pattern. Perceptions of complexity are not expected to relate to one's intention to engage in teamwork. Perceptions of task interdependence, on the other hand, are expected to directly influence one's intentions to engage in teamwork. Thus, these perceptions

should more strongly related to team communication and performance. With these points in mind, the following hypothesis is given.

Hypothesis 8a: The task interdependence variables will serve as more important predictors of team performance than will the corresponding workflow variables.

Hypothesis 8b: The task interdependence variables will serve as more important predictors of team communication than will the corresponding workflow variables.

In addition to the discussion of mean team-level perceptions, previous research has examined the importance of homogeneity of perceptions within teams. Furthermore, Klein, Conn, Smith, and Sorra (2001) noted that homogeneity of perceptions, or within-group agreement, should be considered when the focus is on group-level constructs, as in the current study. Homogeneity of perceptions refers to the overlap, or shared, perceptions among team members (Mason, 2006). Mason (2006) evaluated the homogeneity of team members' perceptions assessing several constructs including task variety and identity, along with task and outcome interdependence. In this study, task interdependence was used as a variable of social influence, as communication among individuals was believed to affect perceptions of the variable. The discussion of homogeneity of perceptions lends itself to recent discussions of team mental models.

The investigation of team shared mental models regarding tasks has shown a positive relationship between similarity of mental models and group performance (e.g., Mathieu et al., 2000; Peterson, Mitchell, Thompson, & Burr, 2000). The concept of shared team mental models refers to shared knowledge structures about teams and team processes (Mathieu et al., 2000). In the present study, mean team-level perceptions of task interdependence and workflow are considered as an aspect of members' team mental models. An additional topic of interest within the realm of team mental models is the question of accuracy. Recent research has established the accuracy of within-group perceptions to be just as important as homogeneity of perceptions. Indeed, accuracy may be a stronger predictor of team

performance than mental model similarity, or within-group homogeneity of perceptions (e.g., Edwards, Day, Arthur, & Bell, 2006). Likewise, homogeneity of task interdependence and workflow perceptions should only improve team performance when agreement is toward higher perceptions. One would not expect teams who agree that each member should work alone to engage in teamwork. Thus, only teams who agree that each member's work is dependent upon other members should engage in teamwork, relating to higher performance. This is because agreement at the low end would not facilitate effort toward teamwork and therefore should not increase performance. For example, team members that agree that a task requires little task interdependence may be incorrect, as previous research has noted that teams may be in high agreement but not always correct (e.g., Groupthink; Janis, 1972; Janis, 1982). Thus, the following hypotheses are given.

Hypothesis 9a: Mean team-level perceptions of task interdependence will moderate the relationship between homogeneity of perceptions and team performance, such that as mean team-level perceptions of task interdependence increase across teams, homogeneity of perceptions will more strongly relate to team performance.

Hypothesis 9b: Mean team-level perceptions of workflow will moderate the relationship between homogeneity of perceptions and team performance, such that as mean team-level perceptions of workflow increase across teams, homogeneity of perceptions will more strongly relate to team performance.

MATERIALS AND METHODS

Sample

Sixteen teams of three to four undergraduate college students at a large southeastern university participated in the present study. The total sample consisted of 58 participants, of which 77.6 percent (N = 45) were male. The mean age of participants was 21.23 years, and the ages ranged from 18 to 42 years (SD = 3.65). All but one participant, who was 42 years old, were in the range of 18-29 years of age.

On four instances, one member was absent from the first session, and the participant was therefore excluded from completing subsequent sessions. Three-member teams completed the entire experiment. One team of two members was excluded from the analyses, as was an additional team due to no responses for the task interdependence and workflow scales. Therefore, 14 teams were used in the analysis: four three-player teams, 10 four-player teams. Team members were assigned to one of four roles (surface, electronic warfare, air, fleet commander) based on randomly assigned seating. In teams of three, the role of fleet commander was omitted (e.g., surface commander N = 14; electronic warfare commander N = 14; air commander N = 14; fleet commander N = 10), which did not affect the responsibilities of the other three team members.

Approximately 53 percent of participants considered themselves to have average gaming ability. Novices and experts made up approximately 16 and 31 percent of the sample, respectively. Teams consisting of three members (N = 4) did not perform significantly different than teams consisting of four members (N = 10), $t(3.08) = -.84$, $p > .10$, therefore it was deemed appropriate to include three- and four-member teams together in the following analyses.

Procedure

Participants were paid $14 an hour for 14 hours of participation across two weeks, in which seven days of the nine-day duration included two-hour sessions. The recruitment flyer (see Appendix A) was sent via e-mail to all undergraduates of the College of Business. Team membership was based on

schedule availability, due to the time constraints of the study. There were three schedules for participants to choose from (i.e., 2-4 P.M., 4-6 P.M., & 6-8 P.M.). Teams participated in a simulated virtual team experience with synchronous interaction. Synchronous interaction refers to interaction in which team members may communicate simultaneously via electronic media (Muchinsky, 2006). Virtual teams are those in which the primary source of communication is through forms of information and electronic media, with little or no face-to-face interaction (Jarvenpaa & Leidner, 1999). The term simulated is used since team members worked in the same room separated into compartments with computers. The only exception was that the fleet commander could view other members' screens by using a toggle feature available for his or her computer only. The present study utilized a task that allowed for distributed interaction (i.e., each member has his or her own responsibilities within the game and interaction is directed toward coordination) among team members. The computer software program, Jane's Fleet Command (Sonalysts, 2000), is a military combat computer simulation noted to be "an ecologically valid laboratory analogue of the types of cognitive, information processing, and decision-making tasks and activities present in operational command-and-control environments in military, civilian first-responder, and other similar settings" (Woehr, 2005, p. 4).

It was possible that participants may be acquaintances and that familiarity may present confounds to team communication and performance. In fact, eight teams included at least one team member who reported knowing at least one of their teammates prior to the beginning of the study. Independent samples t-tests examined whether individuals who reported knowing a teammate differed significantly from individuals who did not know any of their teammates prior to the beginning of the study. The t-test examining differences for individual performance were not significant. Independent samples t-tests examined whether teams with at least one participant who reported knowing a teammate differed significantly from teams with teammates who did not know one another prior to the beginning of the

study differed regarding team performance and team communication. Both tests were nonsignificant, suggesting no difference between the two groups.

This study's design took place in three types of sessions: pre-sessions, individual sessions, and team sessions (see Appendix B for timelines for first and second weeks). Participants were given general information regarding the study during the sign-up pre-session and were scheduled for participation in the study. The initial pre-session occurred on the first day of the study. Participants signed consent forms and completed a web-based individual differences questionnaire during the second pre-session, which occurred on the third day of the week. The two pre-sessions lasted approximately 60 minutes each.

Individual sessions took place on Day 4 and 5 of the study, in which participants were assigned to a personal workstation based on randomly assigned seating. Each workstation consisted of a computer, keyboard, and headset. During the individual sessions, participants completed individual missions within the same setting as the team sessions. Participants were given directions regarding all of the specific roles of the simulation and completed each individual mission without the aid of their teammates. Participants first completed an individual baseline performance assessment of the computer simulation that lasted 15 minutes. Participants completed individual sessions in the same room with their teammates. Participants received two 10-minute training sessions in each of the two individual sessions. The four training sessions were presented in order of increasing specificity and complexity. During the first training session, participants were introduced to the basic systems of Jane's Fleet Command, including the interface, symbols, and issuing orders to identify and engage the enemy. The second and third training sessions introduced participants to more advanced systems, including weapon deployment, launching aircraft, sensor operation, and sensor deployment. The final training session was concerned with advanced strategies, including electronic warfare and strategic maneuvering. Instruction took place while the program was active, thus allowing participants to follow the proctor's instructions. For each training session, a handout was given to each of the participants with additional information.

A practice then test mission followed each training session. Practice and test missions were both 15 minutes in duration. Proctors stated before each mission that test missions would count toward the participants' overall score while practice missions would not. Additional individual differences variables were assessed using web-based questionnaires administered at the end of each individual session.

Team sessions took place on the final five days (e.g., Monday through Friday) of the study's second week. During the first team session, participants were assigned team member roles, were given a training overview, and received instructions regarding the use of the headsets. In the training overview, participants received information regarding the responsibilities and capabilities of each team member role, including their own. Then, teams completed one practice and one test mission, each lasting 30 minutes. The remaining team sessions consisted of two practice and test missions, each practice mission followed by a test mission. In total, five team missions were presented in order of increasing difficulty, with the final four missions containing two very similar missions (e.g., "A" and "B"). The task interdependence and workflow assessments were administered via web-based questionnaire at the end of the final team session. A timeline for the study is given in Appendix B.

Measures

Archival, observation, and survey data were collected and used in this study after obtaining institutional review board approval. Performance variables and team communication were assessed using archival and observation data, respectively. Survey data were used to assess perceptions of task interdependence and workflow.

Performance data were calculated by Jane's Fleet Command, indicated by mission effectiveness scores given at the end of each mission. Mission effectiveness scores were based on points earned by completing mission goals, destroying enemy ships and aircraft, and also points lost by not completing mission goals, destroying friendly ships and aircraft, or lowing one's own ships or aircraft. Therefore, negative performance scores were possible. Proctors informed participants to not be discouraged by what

seem like low scores, and instead consider their current score and previous scores. In this way, current performance was viewed in relative terms in relation to past performance.

Individual baseline performance is defined as an individual's performance before team missions. Baseline performance was calculated from mission effectiveness scores for the second individual session, after individuals received training related to both the basic and advance systems of Jane's Fleet Command. The mission effectiveness score was formulated by the software program and reflects the degree to which the individual effectively completed their responsibilities in performing the mission (M = -1.65, SD = 8.72). Individual baseline scores ranged from –26.8 to 24.5.

Team baseline performance was the average baseline performance score across the individuals within each team, and was calculated for each team based on the mean individual baseline performance of its members (M = -1.83, SD = 4.23). Team baseline values ranged from –11.4 to –5.2.

Individual performance referred to each individual's mission effectiveness score averaged across practice and test missions during team sessions. The software program formulated mission effectiveness scores for each individual for each practice and test mission during team sessions (M = -9.20, SD = 26.92). Individual performance averages ranged from –109.9 to 14.9.

Team performance refers to the average individual performance within the team, and was calculated for each team based on mean individual performance of its members (M = -9.20, SD = 27.15). Team performance values ranged from –99.2 to 14.1. The decision to include performance scores from both practice and test missions allows for the analysis of all of the performance data, rather than a subset. Hence, the performance variables exhibit a greater indication of performance, because more data is included within each variable.

There was a large, significant positive correlation between participants' test and practice mission performance scores (Individual-level: $r = .74$, $p < .001$; Team-level: $r = .89$, $p < .001$). Paired samples t-

tests were nonsignifcant for both the individual- and team-level data, $t(41) = -1.25$, $p > .05$ and $t(13) = -.55$, $p > .05$, respectively. Therefore, the decision to include both practice and test missions was justified.

Team communication indicates the frequency of verbal communication within each team. Team communication was coded using a behavior- and frequency-based system previously used by Urban, Bowers, Monday, and Morgan (1995). Only complete and intelligible communication units were coded. A communication unit was defined as a complete verbal expression by a single team member. Communication units were evaluated and coded based on their fit into one of nine categories: question, answer, request, response to request, answer forming request, acknowledgement, statement, other, and repeated communication (see Appendix C). Consider the following team member exchange between Alex and Sandy. Alex says, "Sandy, can you send your missiles towards that land site?." Sandy responds by saying, "I'll send them now." Alex replies, "Thanks." The previous exchange would be coded as: Request (i.e., Alex's first statement), Response (i.e., Sandy's statement), and Acknowledgement (i.e., Alex's second statement). Repeated communication units were defined as repeating or asking a team member to repeat what was just said. Since this is indicative of communication inefficiency, these units were not included in the total frequency of communication units included for the communication variable. In addition to the nine communication categories, Urban and colleagues (1995) produced two additional communication variables. Asking behavior consisted of questions and requests. Responding behavior consisted of answers, responses to requests, and answer forming requests.

Communication was recorded for each team for each mission. Team communication was coded for each team for one 30-minute test mission deemed to be representative of all test missions (e.g., Team test mission 3A or 3B; see Appendix B) at the conclusion of the study by subject matter experts (SMEs) (the principal investigator and three trained graduate research assistants). The decision regarding the representative mission was made before hypotheses were posited for the present study, and was deemed representative in terms of its moderate level of difficulty. The representative mission was conducted on

the third day of team missions, which gave teams the opportunity to work together for two days prior. Due to technical issues with recording, there was variation in recorded time across teams (26.8 to 34.43 minutes).[2] However, in the two teams with mission times over 30 minutes, there was dead time equivalent to the amount of time above 30 minutes. Therefore, team communication frequency was calculated as the average amount of communication units per minute (M = 3.53, SD = 3.42). For example, a team that made 145 communication units over a 28.45-minute period would have a communication average of 5.10 (i.e., 145/28.45 = 5.097). The same formula was used to calculate frequency averages for the nine communication categories. Communication for the representative mission was coded for each team, in addition to coding a 10-minute sample recording from a team mission. After initial codes were generated for the sample recording, discrepancies were discussed and consensus was reached.

The fifth category of communication, Answer Forming Request, was eliminated due to the absence of this communication-type across all teams. Table 1 shows the correlations between the author and research assistant and the effective reliability for each of the communication categories. The effective reliability was calculated by the redefined Spearman-Brown formula:

$$\frac{nr}{1 + (n-1)r}$$

where n is the number of raters and r is the correlation between raters (Bordia, DiFonzo, & Chang, 1999; Li, Rosenthal, & Rubin, 1996).

Individual gaming ability refers to beliefs regarding one's ability to perform well on video and computer games. The measure assessed participants' self-reported ability to play computer and video games (e.g., "Generally, what is your playing ability regarding video/computer games") prior to training. Responses ranged from 1 ("Novice") to 3 ("Expert") (M = 2.16, SD = .67).

[2] Technical issues included errors activating the recording device once the team began the mission or de-activating the recording device once the team ended the mission. Additionally, team missions ended when the goals for that mission were completed.

Team gaming ability refers to the average gaming ability across individuals within each team, and was calculated for each team based on the mean individual gaming ability of its members (M = 2.14, SD = .42).

Individual task interdependence perceptions refer to individual self-reported perceptions of the degree to which the tasks and overall job are team-based. Two task interdependence scales were constructed; one is measured at the job-level (job analysis), and one is measured at the task-level (task analysis). The scales were adapted from Arthur et al.'s (2005) team task analysis scales and were developed to assess team members' perceptions regarding the degree to which the overall missions and individual tasks were team tasks. The task interdependence job analysis variable was assessed with one item, measuring respondents' perceptions regarding the overall job (e.g., "Rate the importance and team relatedness of playing fleet command") (M = 3.64, SD = .98). The task interdependence task analysis (e.g., "Rate the importance and team relatedness of the task/activity") scale consisted of 18 items representing specific tasks that were necessary to complete each mission. SMEs identified the tasks considered similar in terms of relevance to mission completion. For the task interdependence task analysis variable, task-level ratings were aggregated across all tasks to present one value. Responses were made on 5-point scales for task interdependence, ranging from 1 ("Not required to work with team members for optimal performance") to 5 ("Very much required to work with team members for optimal performance") (M = 2.99, SD = .85; internal consistency = .92). The scale items are presented in Appendix D.

Mean team-level task interdependence perceptions refer to each team's average strength of task interdependence perceptions across individuals. For the job analysis variable, the team members' scores were aggregated (i.e., averaged) from the single-item measure (M = 3.59, SD = .63). For the task analysis variable, the team members' average individual-level value were aggregated (M = 2.97, SD = .55).

Homogeneity of task interdependence perceptions refers to the degree to which team members share similar perceptions of task interdependence. The variable was calculated as the within-group standard deviation from the individual-level task interdependence task analysis variable (M = .67, SD = .38). Therefore, higher values represented decreasing homogeneity.

Table 1 – Rater Correlations and the Effective Reliability for Each of the Communication Categories

Categories	**r**	**R**
Question	.99	.99
Answer	.99	.99
Response	.99	.99
Request	.98	.99
Acknowledgement	.85	.92
Statement	.99	.99
Non-task	.92	.96
Repetition	1.00	1.00
Total	.99	.99

Note.
All correlations were significant at $\alpha < .001$.

Individual workflow perceptions refer to team members' self-reports of the workflow patterns that characterize the tasks and overall job. Two workflow scales were constructed; one is measured at the job-level (job analysis), and one is measured at the task-level (task analysis). The scales were adapted from Arthur et al.'s (2005) team task analysis scales and were developed to assess team members' perceptions regarding the required workflow to complete the job and specific tasks of the team. The workflow job analysis variable was assessed with one item, measuring respondents' perceptions regarding the overall job (e.g., "Indicate the workflow pattern that is most descriptive of the work activities of playing fleet

command") (M = 3.48, SD = 1.13). The workflow task analysis (e.g., "Indicate the workflow pattern that best characterizes the performance of the task/activity") scale consisted of 18 items representing specific tasks that were necessary to complete each mission. For the workflow task analysis variable, task-level ratings were aggregated across all tasks to present one value. Responses were made on 5-point scales for workflow, ranging from 1 ("Not a team task/activity") to 5 ("Intensive interdependence"). Each workflow anchor was presented with a description and pictorial representation of the workflow pattern (M = 2.87, SD = .75; internal consistency = .90). The scale items are presented in Appendix D.

Mean team-level workflow perceptions refer to each team's average workflow perceptions across individuals. For the job analysis variable, the team members' scores were aggregated from the single-item measure (M = 3.26, SD = .83). For the task analysis variable, the team members' average individual-level value was aggregated (M = 2.85, SD = .42).

Homogeneity of workflow perceptions refers to the degree to which team members share similar perceptions of workflow. The variable was calculated as the within-group standard deviation from the individual-level workflow task analysis variable (M = 68, SD = .25). Therefore, higher values represented decreasing homogeneity.

Missing Data

All variables were analyzed to determine the frequency of missing data for each. One variable displayed missing data above the five percent threshold (Tabachnick & Fidell, 2007): individual workflow job perceptions. For workflow job perceptions, 10 of the 52 cases (19.23%) were missing. Independent samples t-tests were used to test for significant differences between respondents and nonrespondents for demographic (i.e., gender and age), contextual (i.e., member role and number of teammates), performance, and attitudinal variables (i.e., workflow and task interdependence perceptions). All tests were nonsignificant. For the task interdependence and workflow task analysis variables, mean values were calculated requiring at least 16 of the 18 items to have responses. However, all participants

responded to at least 17 items and there was less than 1% missing data across the 36 items combined (.002%).

For aggregation of the workflow job analysis variable to the team-level, two teams were excluded due to only one member response to the item. Correlations and partial correlations for the workflow job analysis variable were analyzed using the reduced sample of 12. In addition, the dominance analyses were tested using the reduced sample. The ten participants without performance scores were the fleet commanders for the ten four-person teams. For aggregation of the individual performance variable to the team-level, each team had three team members with individual performance values.

RESULTS

Analysis Strategy and Preliminary Analysis

Pearson's correlations were used to test Hypotheses 1 through 6, using both task and job analysis variables for task interdependence and workflow perceptions. In addition to being analyzed in Hypotheses 3 and 4, gaming ability and baseline performance were also used as control variables to further test Hypotheses 5 and 6 with multiple regression. Dominance analyses were performed to determine the relative importance of the hypothesized predictors of team performance and communication, enabling the testing of Hypotheses 7 and 8. Finally, multiple regression techniques were used to analyze the moderation effects proposed in Hypothesis 9. Task interdependence and workflow variables refer to task interdependence and workflow perceptions in the results and discussion sections, respectively.

Means, standard deviations, and correlations are presented in Table 2 for individual-level data and in Table 3 for team-level data.

Test of Hypotheses

Hypothesis 1a stated that mean team-level perceptions of task interdependence would be positively related to team communication. The relationship reached trend-level significance for the job analysis variable ($r = .53$, $p < .10$). The relationship was not significant for the task analysis variable ($r = .42$), though the correlation was in the expected positive direction. Thus, Hypothesis 1a was partially supported. Hypothesis 1b stated that mean team-level perceptions of workflow would be positively related to team communication. The relationship was neither significant for the task analysis ($r = .30$) nor the job analysis variable ($r = .46$). Although the correlations were positive, Hypothesis 1b was not supported. Hypothesis 2 stated that the frequency of communication would be positively related to team performance. The relationship was not significant, though the correlation was positive ($r = .26$), as predicted. Thus, Hypothesis 2 was not supported.

Table 2 – Correlations, Means, and Standard Deviations (Individual-level Data)

Variables	N	Mean	SD	1	2	3	4	5	6
1. Baseline Performance	51	-1.65	8.72	--					
2. Gaming Ability	51	2.16	.67	.10	--				
3. Performance	42	-9.20	26.92	.08	.43**	--			
4. Task Interdependence (Task Analysis)	52	2.99	.85	-.04	.43**	.42**	(.92)		
5. Task Interdependence (Job Analysis)	50	3.64	.98	-.14	.33*	.22	.49***	--	
6. Workflow (Task Analysis)	52	2.87	.75	.04	.39**	.27†	.64***	.25†	(.90)
7. Workflow (Job Analysis)	42	3.48	1.13	-.13	.41**	.35*	.50**	.58***	.38*

Note.
N = 42-52.
†p < .10. *p < .05. **p < .01. ***p < .001.
The internal consistency reliability estimates for Task Interdependence (Task Analysis) and Workflow (Task Analysis) are presented on the diagonal in parentheses.

Table 3 – Correlations, Means, and Standard Deviations (Team-level Data)

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
1. Baseline Performance	-1.83	4.23	--								
2. Gaming Ability	2.14	.42	.12	--							
3. Performance	-9.20	27.15	.12	.81***	--						
4. Communication	3.53	3.42	.48†	.29	.26	--					
5. Task Interdependence (Task Analysis)	2.97	.55	.25	.59*	.65*	.42	--				
6. Task Interdependence (Job Analysis)	3.59	.63	.22	.53*	.32	.53†	.62*	--			
7. Workflow (Task Analysis)	2.85	.42	.06†	.44	.50†	.30	.73**	.47†	--		
8. Workflow (Job Analysis)	3.38	380	.01	.53†	.55†	.46	.60*	.47	.43	--	
9. Task Interdependence Homogeneity	.67	.38	-.14	.53†	.46†	-.21	.61*	.06	.57*	.33	--
10. Workflow Homogeneity	.68	.25	.26	.53†	.39	-.16	.51†	.15	.31	.19	.77**

Note.
N = 14. N = 12 for Workflow (Job Analysis).
†p < .10. *p < .05. **p < .01. ***p < .001.
Homogeneity variables are measured with Standard Deviation; thus, this is representing heterogeneity.

Hypothesis 3a stated that individual gaming ability would be positively related to individual performance. The correlation was significant ($r = .43$, $p < .01$), providing support for the hypothesis. Hypothesis 3b stated that individual baseline performance would be positively related to individual performance. The correlation was not significant, though it was in the hypothesized positive direction ($r = .08$, $p > .05$). Therefore, Hypothesis 3b was not supported.

Hypothesis 4a stated that mean team-level gaming ability would be positively related to team performance. The correlation was significant ($r = .81$, $p < .001$), providing support for the hypothesis. Hypothesis 4b stated that mean team-level baseline performance would be positively related to team performance. The correlation was not significant, thought it was in the hypothesized positive direction ($r = .12$, $p > .05$). Therefore, Hypothesis 4b was not supported.

Hypothesis 5a stated that individual-level perceptions of task interdependence would be positively related to individual performance. The correlation was significant for the task analysis variable ($r = .42$, $p < .01$); however, the relationship was not significant for the job analysis variable, though the correlation was in the predicted positive direction ($r = .22$).

Hierarchical multiple regression was also included to present the control (gaming ability and baseline performance) variables to determine the unique predicted variance for the task interdependence variables. Variance associated with the control variables was estimated using a hierarchical linear regression wherein ability and baseline performance are entered in Step 1, and the two task interdependence variables are entered separately in Step 2. Regression results are presented in Table 4. For individual performance, the initial model of control variables accounted for approximately 18 percent of the observed variance, $F(2, 37) = 4.17$, $p < .05$. The subsequent model with the task interdependence task analysis variable accounted for an increase in predicted variance of approximately 7% ($\Delta R^2 = .073$, $p < .10$). The model with the job analysis variable did not account for a significant increase in predicted variance ($\Delta R^2 = .014$, $p > .10$). Thus, Hypothesis 5a was partially supported, due to the observed

significant positive correlation and the trend-level significant regression coefficient between individual performance and the task analysis variable.

Table 4 – Regression Results for Task Interdependence Perceptions and Workflow Perceptions Predicting Performance (Individual-Level Data)

	Individual Performance		
	b	**ΔR^2**	**ΔF**
Step 1: Controls		.18*	4.17*
Gaming Ability	.42**		
Baseline Performance	.06		
Step 2: Task Interdependence			
Task Analysis	.30†	.07*	3.55†
Job Analysis	.13	.01†	.57
Step 2: Workflow			
Task Analysis	.13	.02*	.72
Job Analysis	.19	.03*	1.03

Note.
N = 30-39.
†p < .10. *p < .05. **p < .01.
Significant models are indicated under ΔR^2.

Hypothesis 5b stated individual-level perceptions of workflow would be positively related to individual performance. The correlation was significant for the job analysis variable (r = .35, p < .05); and the relationship reached trend-level significance for the task analysis variable (r = 27, p < .10).

Hierarchical multiple regression was also used to test Hypothesis 5b, entering the two workflow variables in Step 2 in a separate model. Regression results are presented in Table 4. Subsequent models with the workflow task analysis (ΔR^2 = .016, p > .10) and the job analysis (ΔR^2 = .028, p > .10) variables did not account for a significant increase in predicted variance. Thus, only marginal support was found

for Hypothesis 5b, as the correlation between individual performance and the workflow job analysis variable was significant but the variable's regression coefficient with control variables was not.

Hypothesis 6a stated that mean team-level perceptions of task interdependence would be positively related to team performance. For the task analysis variable, the relationship was significant ($r = .65$, $p < .05$); however the relationship was not significant for the job analysis variable, though the correlation was in the predicted positive direction ($r = .32$).

Applying the same model structure used to test Hypothesis 5, a hierarchical regression analysis introduced control variables in Step 1 to examine the team-level relationships excluding the effects of ability. Regression results for Hypothesis 6 are presented in Table 5. For team performance, the control variables accounted for 65 percent of the observed variance, $F(2, 11) = 10.87$, $p < .01$. Subsequent models with the task interdependence task analysis ($\Delta R^2 = .045$, $p > .10$) and the job analysis ($\Delta R^2 = .018$, $p > .10$) variables did not account for a significant increase in predicted variance. Thus, Hypothesis 6a received only marginal support. It was determined that the job analysis variable's negative regression coefficient was due to negative suppression by the gaming ability variable (Tabachnick & Fidell, 2007). With negative suppression, the suppressor enhances the magnitude of the other independent variable, though the sign of the regression weight changes (Tabachnick & Fidell, 2007). The coefficient was positive in all other models tested without gaming ability.

Hypothesis 6b stated that mean team-level perceptions of workflow would be positively related to team performance. The relationship reached trend-level significance for the task analysis ($r = .50$, $p < .10$) and job analysis variables ($r = .55$, $p < .10$).

Using the hierarchical regression approach with the control variables in Step 1, subsequent models with the workflow task analysis ($\Delta R^2 = .024$, $p > .10$) and the job analysis ($\Delta R^2 = .015$, $p > .10$) variables did not account for a significant increase in predicted variance. Thus, only marginal support was found

for Hypothesis 6b, as the correlation between the workflow variables and performance reached trend-level significance but the regression coefficients with control variables did not.

Table 5 – Regression Results for Task Interdependence Perceptions and Workflow Perceptions Predicting Performance (Team-Level Data)

	Team Performance		
	b	**ΔR^2**	**ΔF**
Step 1: Controls		.65**	10.35
Gaming Ability	.81**		
Baseline Performance	.02		
Step 2: Task Interdependence			
Task Analysis	.27	.05**	1.50
Job Analysis	-.16	.02**	.56
Step 2: Workflow			
Task Analysis	.17	.02**	.73
Job Analysis	.15	.02*	.41

Note.
N = 14. N = 12 for Workflow (Job Analysis).
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.
Significant models are indicated under ΔR^2.

Dominance Analysis was utilized to test both parts of Hypotheses 7 and 8, using a series of multiple regression tests. Dominance analysis is a statistical technique that utilizes a series of regressions in order to determine the relative importance of three or more predictors by assessing each predictor in the model alone (i.e., direct effect), with other predictors in a series of all possible combinations (i.e., partial effects), and in the full model (i.e., total effect) (Budescu, 1993). Values of R^2 from the series of regressions were entered into a computer program developed by LeBreton (2002) in order to calculate relative importance weights, or dominance weights. Dominance analysis may serve as a more reliable technique in interpreting the relative importance of more than three predictors and when multicollinearity

among predictors exists; researchers have warned against the interpretation of standardized regression coefficients in these cases (e.g., Darlington, 1968; LeBreton, Ployhart, & Ladd, 2004).

In Hypothesis 7a, the task analysis variables for both task interdependence and workflow were expected to explain the greatest amount of predicted variance for team performance in relation to the corresponding job analysis variables. The task interdependence task analysis variable accounted for approximately 52 percent of the observed variance. The workflow task analysis variable accounted for about 17 percent, while the workflow job analysis variable accounted for the third greatest amount of observed variance with 23 percent. The task interdependence job analysis variable accounted for approximately 8 percent. Hypothesis 7a was only partially supported. Specifically, while the task interdependence task analysis variable accounted for a greater portion of the predicted variance than the corresponding job analysis variable, the workflow job analysis variable outperformed the task analysis variable. The results of the dominance analysis for predictors of team performance are presented in Table 6.

In Hypothesis 7b, the task analysis variables for both task interdependence and workflow were expected to gain the greatest amount of predicted variance for team communication in relation to the corresponding job analysis variables. For the prediction of team communication, the task interdependence job analysis variable accounted for the majority of the predicted variance (48%). The task interdependence task analysis variable, proposed as the most important predictor of team communication in this study, accounted for the large majority of the remaining variance (25%). The workflow job analysis variable (19%) also accounted for a greater portion of the predicted variance than the task analysis variable (8%). Therefore, Hypothesis 7b was not supported. The results are presented in Table 7.

Hypothesis 8a predicted that the task interdependence variables would account for a greater portion of the predicted variance for team performance in relation to the corresponding workflow

Table 6 – Dominance Analysis Results for Task Interdependence Perceptions and Workflow Perceptions Predicting Team Performance

			Additional Contribution of:		
Predictors	**R^2**	**A**	**B**	**C**	**D**
None		.49	.26	.11	.30
A	.49		.00	.02	.02
B	.26	.24		.01	.13
C	.11	.40	.15		.20
D	.30	.22	.09	.01	
A, B	.50			.02	.02
A, C	.51		.00		.03
A, D	.52		.00	.02	
B, C	.27	.24			.12
B, D	.39	.13		.00	
C, D	.31	.23	.08		
A, B, C	.51				.03
A, B, D	.52			.02	
A, C, D	.54		.00		
B, C, D	.39	15			
Total R-squared	.54				
(A, B, C, D)					
General Dominance Weights		.28	.09	.04	.13
Rescaled Weights		.52	.17	.08	.23

Note.
N = 12.
A = Task Interdependence (Task Analysis)
B = Workflow (Task Analysis)
C = Task Interdependence (Job Analysis)
D = Workflow (Job Analysis)

Table 7 – Dominance Analysis Results for Task Interdependence Perceptions and Workflow Perceptions Predicting Team Communication

			Additional Contribution of:		
Predictors	**R^2**	**A**	**B**	**C**	**D**
None		.27	.12	.37	.21
A	.27		.01	.13	.03
B	.12	.16		.26	.12
C	.37	.03	.00		.04
D	.21	.10	.03	.20	
A, B	.28			.13	.03
A, C	.41		.01		.02
A, D	.31		.00	.12	
B, C	.38	.04			.04
B, D	.24	.07		.18	
C, D	.41	.01	.00		
A, B, C	.41				.02
A, B, D	.31			.12	
A, C, D	.42		.01		
B, C, D	.41	.02			
Total R-squared	.43				
(A, B, C, D)					
General Dominance Weights		.11	.03	.21	.08
Rescaled Weights		.25	.08	.48	.19

Note.
N = 12.
A = Task Interdependence (Task Analysis)
B = Workflow (Task Analysis)
C = Task Interdependence (Job Analysis)
D = Workflow (Job Analysis)

variables. The hypothesis was only partially supported. While the task interdependence task analysis variable (53%) accounted for a greater amount of predicted variance than did the workflow task analysis variable (17%), the workflow job analysis variable (23%) accounted for a greater amount of predicted variance than did the task interdependence job analysis variable (8%) (see Table 6).

Hypothesis 8b predicted the same in prediction of team communication. The hypothesis was supported. Both the task interdependence task and job analysis variables (25 and 48%, respectively) accounted for greater amounts of predicted variance than did the workflow task and job analysis variables (8 and 18%, respectively) (see Table 7).

Hypothesis 9a stated that the relationship between mean team-level perceptions of task interdependence and team performance would be moderated by within-group homogeneity of task interdependence perceptions. The task interdependence variable was first centered to reduce measurement error and multicollearity (Aiken & West, 1991; Baron & Kenny, 1986). The homogeneity variable was not centered, since this variable had a meaningful zero value (within-group standard deviation). The interaction term was then created by multiplying the task interdependence variable with the corresponding homogeneity variable. Team gaming ability and baseline performance were entered as control variables in the first step, followed by the centered task interdependence and homogeneity variables in the second step. The interaction term was entered in the third step. The standardized regression coefficient of the interaction term was significant ($\beta = -.68$, $p < .10$). Previous researchers have suggested $\alpha = .10$ as an appropriate level for moderation (Aguinis, 1995; McClelland & Judd, 1993). Thus, Hypothesis 9a was supported.

Due to the limitations regarding the study's sample size and the low statistical power of moderation tests, moderation effects were tested without the control variables (Aguinis, 2004; Aguinis & Stone-Romero, 1997; Cohen, 1988). The standardized regression coefficient of the task interdependence interaction term was significant ($\beta = -.78$, $p < .10$), thus providing further support for Hypothesis 9a. The

graph of the interaction effect is presented in Figure 3. The interaction effect is graphed using one standard deviation above and below the mean as low and high within-group homogeneity of perceptions, respectively. The same approach was used for task interdependence perceptions. Steep, positive slopes were present for both teams with stronger and weaker homogeneity of perceptions, suggesting that performance increased as mean perceptions increased. Teams with weaker task interdependence perceptions and higher homogeneity showed higher performance than comparable teams with lower homogeneity of perceptions. Teams with stronger task interdependence perceptions and less homogeneity of perceptions showed the highest performance, overall. Performance was lowest for teams with weaker task interdependence perceptions and low homogeneity. Thus, the slope for the task interdependence perceptions-performance relationship was steeper for teams with high homogeneity of perceptions. Therefore, while the interaction effect was significant, the proposed nature of this effect was not supported.

Hypothesis 9b stated that the relationship between mean team-level perceptions of workflow and performance would be moderated by within-group homogeneity of workflow perceptions. The test followed the same procedure used to test Hypothesis 9b. The interaction term coefficient did not reach significance. The regression coefficient remained nonsignificant in the regression model without the control variables. Thus, Hypothesis 9b was not supported. Results are presented for task interdependence and workflow in Tables 8 and 9, respectively.

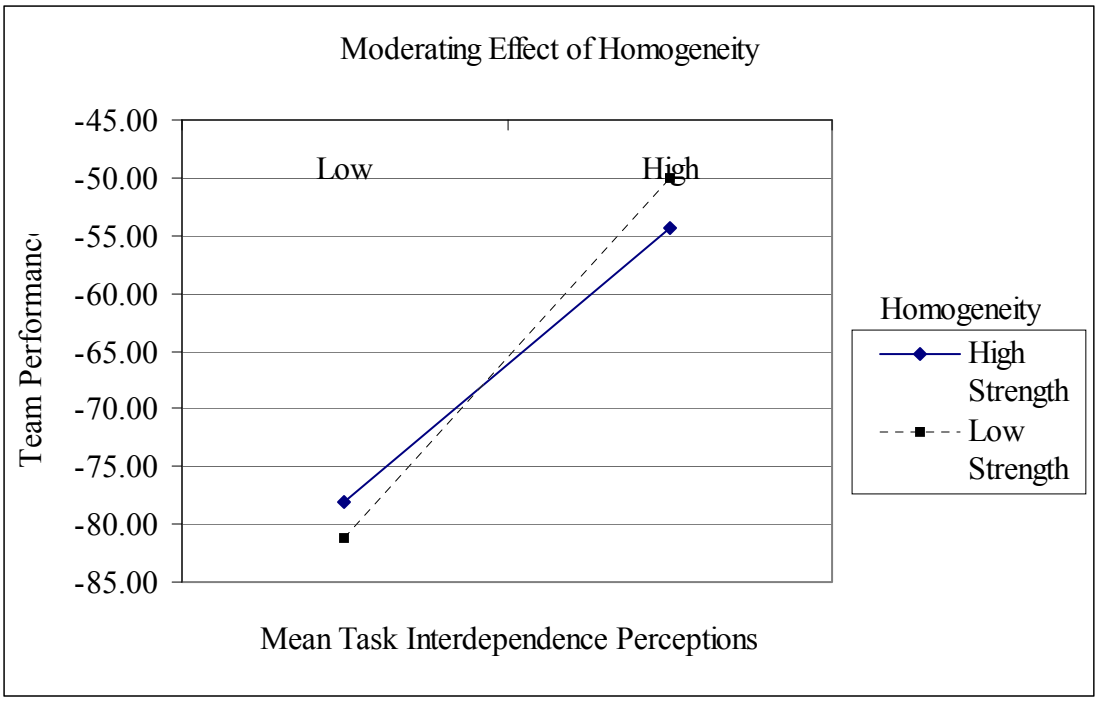

Figure 3 – Interaction of homogeneity of task interdependence perceptions and mean-team level perceptions on team performance

Table 8 – Regression Results for Testing of Moderating Effect of Homogeneity of Task Interdependence Perceptions

	b	**ΔR^2**	**ΔF**
Step 1: Controls		.66**	10.87**
Gaming Ability	.80**		
Baseline Performance	-.11		
Step 2: Task Interdependence		.04*	.59
Task Analysis (Centered)	.28		
Homogeneity	-.08		
Step 3: Interactions		.10*	3.74†
Interaction Term	-.68†		
Interaction Term	-.78†		
(Without Controls)			
Overall Model		.80*	6.31*
(df)			(5, 8)

Note.
N = 14.
†p < .10. *p < .05. **p < .01.
Interaction term (without controls) represents variable in the regression equation without the control variables presented in Step 1.
Significant models are indicated under ΔR.

Table 9 – Regression Results for Testing of Moderating Effect of Homogeneity of Workflow Perceptions

	b	ΔR^2	ΔF
Step 1: Controls		.66**	10.87**
Gaming Ability	.80**		
Baseline Performance	-.11		
Step 2: Task Interdependence		.02*	.28
Task Analysis (Centered)	.14		
Homogeneity	-.10		
Step 3: Interactions		.01*	.38
Interaction Term	-.64		
Interaction Term	-1.17		
(Without Controls)			
Overall Model		.84*	3.70
(df)			(5, 8)

Note.
N = 14.
$^{\dagger}p < .10$. $*p < .05$. $**p < .01$.
Interaction term (without controls) represents variable in the regression equation without the control variables presented in Step 1.
Significant models are indicated under ΔR.

DISCUSSION

Summary of Purpose and Major Findings

The present study examined the relationship between team members' task interdependence and workflow perceptions, as well as team communication and performance. In general, the results suggest that participants' impressions of their dependency upon one another were a factor that influenced their intentions toward and ultimate execution of teamwork behavior. Furthermore, the results suggest that the execution of teamwork behaviors may have played a role in how well an individual and team performed (see Figure 1). These findings provide initial support in favor of the hypotheses and the theoretical framework for these hypotheses (see Appendix E). Specifically, while most studies have focused on objective task interdependence, this study shows that task interdependence and workflow perceptions were positively related to team communication and performance. In addition, different approaches to measuring team-level constructs and analyzing these perceptions yielded important results with implications for the measurement of team cognition. Specifically, task interdependence perceptions regarding specific tasks served as the strongest predictor of team performance, while task interdependence perceptions regarding the overall job served as the strongest predictor of team communication. Thus, while perceptions of the overall mission most strongly related to communication, perceptions of the mission's tasks most strongly related to performance. This suggests that additional teamwork behaviors may have been present that more strongly related to performance than communication.

Initial support was found for the relationship between task interdependence perceptions and team communication. Task interdependence perceptions exhibited a clearly stronger relationship with communication than did workflow perceptions. This suggests that members' perceptions of task interdependence are more influential in determining the frequency of communication. It is important to note that the present study's sample size served as a major weakness in the ability to detect significant relationships. It was surprising to find that teams' perceptions of task interdependence regarding the

overall mission accounted for the greatest amount of predicted variance for team communication (approximately 63 percent). This suggests that perceptions regarding the overall mission were more important in relation to communication than more specific perceptions regarding the missions' tasks. Still, task interdependence perceptions regarding the overall missions and perceptions directed toward the mission's tasks accounted for nearly 86 percent of the observed variance-far outperforming perceptions of workflow. The exploratory analyses conducted regarding the relationship between task interdependence perceptions regarding the overall job and specific types of communicate yielded several interesting findings. Specifically, teams with stronger task interdependence perceptions regarding the overall job were more likely to make statements ($r = .56$, $p < .05$), respond to requests ($r = .56$, $p < .05$), and engage in asking behavior ($r = .57$, $p < .05$). This supports the theoretical framework, as team members with stronger perceptions may be more likely to announce facts and the mission's progress (statements), ask teammates questions and request information and aid (asking behavior), and respond to their teammates requests (responses) through teamwork intentions.

The nonsignificant relationship between communication frequency and team performance stymies the practical significance of the perception-communication relationship. Specifically, it was expected that in the present study communication was the main component of teamwork mediating the relationship between perceptions of task interdependence and performance. This result may have been due to the use of a narrowly-defined measure of team communication (e.g., communication within one representative mission) and a broadly-defined measure of performance (e.g., performance across all missions). A more broadly-focused measure of communication may show a stronger direct relation to team performance. For instance, two of the top-three performing teams were below the mean for communication frequency. An assessment of team communication across the entire study may have yielded more consistent results regarding the communication-performance relationship. Post hoc analyses examined potential nonlinear relationships between communication frequency and performance, but these findings were not significant.

The frequency of statements was most strongly related to team performance ($r = .30$). As expected, repetitions exhibited the smallest correlation with performance ($r = .03$).

With respect to individual- and team-level perceptions of task interdependence and workflow, initial support was found for the hypothesized perceptions-performance relationships. However, these effects did not extend beyond the effects of gaming ability. Therefore, these hypotheses should be re-examined. For example, the positive relationship between gaming ability and individual's perceptions of task interdependence and workflow suggests that individuals' self-reported gaming ability may extend beyond aspects of actual game performance. Specifically, more experienced gamers (and teams with more experienced gamers) may also be better at judging computer simulation task characteristics, such as task interdependence and workflow. Finally, the partial correlations were also examined to determine the unique contribution of each predictor in relation to team performance when partially out the predicted variance attributed to gaming ability. At the individual level, the partial correlation between task interdependence task perceptions and performance reached trend-level significance ($pr^2 = .28$, $p < .10$). At the team level, partial correlations were not significant.

The dominance analysis confirmed the expectation that members' task interdependence perceptions directed toward the mission's specific tasks would most strongly relate to team performance. Thus, these perceptions were the most important in relation to team performance. This finding contradicts the overarching proposition that task interdependence perceptions directed toward the mission's tasks would most strongly influence team communication and subsequent performance. Specifically, task interdependence perceptions regarding the overall mission most strongly related to team communication while perceptions regarding the mission's tasks most strongly related to team performance. This suggests that additional teamwork variables may have played a role in the present study. For example, members may have aided teammates who were in need of resources without communicating this over the headsets.

Thus, task interdependence perceptions regarding the mission's tasks may have more strongly related to additional teamwork behaviors.

Though significant, the nature of homogeneity of task interdependence perceptions' moderation effect on the mean perceptions and team performance relationship was unexpected. Specifically, homogeneity only increased performance when mean perceptions were less intensive. However, this increase in performance above teams with less homogeneity was still lower than performance for groups with high mean task interdependence perceptions. Furthermore, previous research has suggested that consensus may be beneficial to teams, irrespective of the nature of that consensus. For example, Schyns (2006) found consensus regarding Leader-Member Exchanges (LMX) to be positively related to job satisfaction and commitment, suggesting that consensus at both the high and low ends of LMXs produced a positive relationship. The nonsignificant moderation by homogeneity of workflow perceptions may be attributed to the low sample size and problems with the statistical power of moderation tests (Aguinis, 2004; Aguinis & Stone-Romero, 1997; Cohen, 1988).

Despite the moderate correlations between the task interdependence and workflow variables, there was a clear difference in the relative importance of the two types of perceptions in predicting team communication and performance. These findings are similar to Arthur et al.'s (2005) findings in that they both suggest that workflow should not be used as a proxy assessment of task interdependence perceptions. There are differences between the two sets of results, as well. They reported a much smaller correlation (mean r = .25) between workflow and task interdependence perceptions, while the correlations were larger in the present study (mean r = .51). Furthermore, workflow perceptions showed the strongest relationship with team performance in their study, while task interdependence perceptions correlated most strongly with performance and communication in this study. One potential difference between the studies lies in the measurement of performance, as Arthur et al. (2005) used multiple factors to determine team performance, while one mean mission effectiveness score was calculated for each team in the present

study. Second, though the tasks were both military simulations, there were differences in the nature of teamwork required to complete the missions. Specifically, there were two distinct dyadic working relationships within the four-person teams in Arthur et al.'s study, while no such arrangement existed in the present task.

It was not surprising that individual and team gaming ability showed a strong, positive relationship with performance, especially at the team-level. The team-level relationship was examined further, considering the overall structure of each team's make-up of member's abilities. Only one team consisted of all novices, and this three-member team was the lowest performing team in the sample. The team with the highest performance consisted of three average-level members and one expert. Participants' performance in relation to their ability within their own team was also examined. Specifically, the distance between each individual's gaming ability and the average gaming ability of their respective team members was calculated, with negative values indicating a member's ability that was below their teammates' average ability. However, this distance was not significantly correlated with performance. In contrast, baseline performance showed only a weak relationship with individual and team performance. Interestingly, though baseline performance was not strongly related to gaming ability, it was significantly correlated with team communication. Thus, teams' performance when not relying on each other within their respective team (during individual sessions) was strongly related to the team's amount of communication during the team sessions. In addition, baseline exhibited a negative (though nonsignificant) correlation with the strongest predictor of team communication, task interdependence job perceptions. The partial correlation between task interdependence job perceptions and team communication when controlling for baseline performance still reached trend-level significance ($pr^2 = .47$, $p < .10$).

Limitations and Directions for Future Research

Several limitations of the present study are acknowledged. First, the sample size presented limitations to the statistical power to detect significant relationships and the capacity to interpret the findings. Therefore, findings from this study should be examined with caution, and require replication and extension. The small sample size of the team-level data makes it difficult to obtain significant findings via hypotheses tests with the significance level set at .05 ($p < .05$) due to the limitations with respect to power. A debate has surfaced in recent years regarding significance testing (see Cohen, 1994; Krueger, 2001). Krueger (2001) argued in favor of significance testing, while emphasizing the importance of replication. Additionally, an argument can be made that in the case of theory building, the researcher may be more concerned with committing a Type 1 error (e.g., failing to reject the null hypothesis when it is, in fact, false). Finally, Cohen (1990) contends that the most important index of research is the effect size. Cohen (1988) set guidelines for small, moderate, and large effect sizes for product-moment correlations as .10, .30, and .50, respectively, and .02, .15, and .35 for multiple correlations. It is important to note that several correlations reached moderate and large effects, while not reaching statistical significance. This was most likely to occur when analyzing team-level data, as the small sample served as a barrier to power. Using power of .80, an alpha of .05, and a medium effect size for multiple correlations (.15) with three independent variables, a sample size of 76 would be required.

Another limitation is that all teams were subjected to the same procedure and team missions, thus within- and between-group variance in perceptions of task interdependence and workflow were restricted. Future research may be useful in comparing different missions with varying levels of task interdependence required, as well as varying required workflow processes. The team performance measure used in the current study is an additional weakness. Specifically, the individual and team performance variables did not take into account variability. Therefore, within-group variability across missions was not taken into account. Furthermore, between-group variability across team performance

was large, as evidenced by the large standard deviation of the performance measure. This may be especially problematic at the team-level, due to the small sample size. Specifically, the small sample size at the team-level yields results that are especially prone to outliers. In addition, there are multiple dimensions of performance (Gilboa, Shirom, Fried, & Cooper, 2008), making it necessary to use multiple performance measures in any study of performance. Finally, the present model suggests a mediating role of teamwork behaviors on the task interdependence perceptions-team performance relationship. However, only team communication was considered in the present study as a teamwork variable. Further, a mediation relationship was not tested, and communication was not significantly related to team performance. Therefore, additional teamwork variables must be identified in future studies that may account for additional variance in the hypothesized relationship.

Further limitations to the generalizability of the current study are presented by the task and simulation. While the current task produced a simulated virtual team experience, the actual proximity of team members differed from the reality of virtual teams. Since teams were in the same room during the study, generalizability to virtual military teams is not assumed. Thompson (1967) noted that teams that are physically close communicate more often and usually rely upon one another to a greater extent, thus increasing task interdependence. Therefore, proximity may have augmented the communication among team members, though this should be at the same level for every team. Still, Thompson's assertion should be noted in the discussion of generalizability to virtual teams. In addition, the participants were college students with no military experience.

Finally, while there is partial support for the theoretical framework providing the basis for these hypotheses, the Theory of Planned Behavior also takes into account perceived control. Perceived control is a variable that should also be included in future discussions of the team perceptions-communication relationship. In addition, individual differences in variables such as motivation and goal attainment must be taken into consideration. With respect to goal attainment, it is important to note that team members

may have differed in what they intended to receive by participating in this study. Monetary gain and personal enjoyment are two possible goals for participation in the present study. Indeed, participants with different goals for participation may have had differing levels of motivation to perform to the best of their ability, regardless of whether they perceived the activities to be team-based and requiring intensive workflow.

In the present study, the team performance variable was an average of each team's performance across all missions for each team. As discussed above, one problem with this approach is that it does not take into account variability in performance. Thus, performance variability is an additional variable that should be taken into account in future analyses. Furthermore, the temporal aspect of performance was not factored into the present study. It is possible that teams differentially improved their performance over time, thus making time an important issue to consider.

Mason (2006) asserted that homogeneity of within-group perceptions, in general, has lead to improvements in communication and coordination. This is an interesting topic to delve into further. First, the present research looks only at the frequency of communication and does not investigate the effectiveness of communication. Still, it is not surprising to find a positive correlation between homogeneity of task interdependence perceptions and communication. Second, the importance of communication effectiveness should be considered for its predictive utility above and beyond communication frequency. Moreover, teamwork characteristics (e.g., communication, coordination, and cooperation) are important in gaining similarity between mental structures related to teamwork (Klimoski & Mohammed, 1994). It would be expected that the homogeneity of task interdependence and workflow perceptions would increase over time through communication. However, it is not expected that mean team-level task interdependence perceptions would be influenced by communication over time in any one direction. Specifically, groups are likely to become homogeneous over time, but the direction this process takes is dependent upon initial levels of interdependence perceptions within the group. For example,

group polarization suggests that group interaction facilitates more extreme group decisions (irrespective of direction) than those made by individuals, based on members' attitudes before interaction with other members (Moscovici & Zavalloni, 1969).

As discussed above, several variables investigated in the present study are expected to be influenced by time. These include performance, communication, and homogeneity of perceptions. Indeed, these variables may interact with one another in a longitudinal fashion. In addition, time may indirectly influence task interdependence and workflow perceptions via the variables listed above. Furthermore, the Theory of Planned Behavior inherently assumes a temporal aspect.

While it is still plausible to assume that the proposed model here is correct and task interdependence and workflow perceptions do influence performance via communication, additional variables may play a role. For instance, there was a significant positive correlation between individual gaming ability (e.g., novice, average, or expert) and perceptions of task interdependence and workflow, such that individuals with increased gaming ability tended to report stronger perceptions of task interdependence and workflow. This relationship suggests that expert gamers may be better judges of task interdependence and workflow or at least more likely to be "team players." The gaming ability variable essentially measured self-efficacy generalized to video and computer gaming. It may be useful in future studies to look at a more reliable measure of gaming self-efficacy, or one's expectancy that effortful performance will be high. In addition, future researchers may find it useful to increase the specificity of the measure to the task under study. For example, an examination of self-efficacy of military combat simulations may have yielded stronger relationships with the variables of interest. However, researchers should use caution when increasing the specificity of such a measure, as it may restrict the range of responses.

Additional workflow variables, such as centrality and criticality, reveal less about task interdependence and instead focus on the structural components of the workflow[3]. Specifically, the focus is on structure (e.g., team member position) rather than process (e.g., flow of information). Brass (1981) listed centrality, criticality, and transaction alternatives as indicators of the structural relationships of team member positions. While these variables are less important in the context of task interdependence, they are important when the focus is on team member position. Ellis et al. (2005) determined the criticality of one's role in the team's workflow to be important in emphasizing the benefits of declarative teamwork knowledge. In addition, Brass (e.g., Brass, 1985; Brass, 1984) investigated the importance of employees' positions within the workflow and networks for its importance in perceptions of influence. It may be useful to determine this effect under the conditions of the present study, where a central character (e.g., the fleet commander) may serve a more (or less for that matter) critical role than others.

In the present study, participants should have held similar views regarding task interdependence and workflow since all participants completed the same tasks. However, each member within the team held a specific position, different from the other members of the team. Team members may differ in their perceptions of task interdependence and workflow as a function of the particular role each holds within the team. Thus, the structural perspective should be kept in mind when investigating the causes of disagreement among team members' perceptions concerning task characteristics (e.g., task interdependence & workflow). Though team member position did not appear to be important in predicting differences between team members' perceptions of task interdependence and workflow, this variable may be important in other ways. For instance, team members' perceptions of one another may be influenced by the role they hold within the team, as well as the perceived criticality and centrality of those roles by the team members.

[3] Gosselin (1985) distinguished between interdependence in the flow of work (workflow) and process interdependence. The distinction made between process and structural components of workflow in the present paper is independent of the notion of process interdependence, which focuses on enriching knowledge and improving skills.

Practical and Research Implications

The main question that may arise from the findings of the present research is, "What are the implications for organizational teams?" Though the generalizability of these findings to nonmilitary teams is questionable, there are some practical implications. First, it must be taken into account that team members may disagree in their perceptions of the degree to which their team should work together and process information and work on different tasks. Additionally, the present findings suggest that within- and between-team differences in these perceptions have consequences for team communication and performance. Therefore, it may be necessary to establish consistent views regarding task interdependence and workflow within work teams. While this research relates specifically to military teams, it is assumed that additional types of work teams may also need this type of training, especially those that perform in projects in which the level of task interdependence may not be easily determined. The point of training in this case is to convert subjective perspectives of team members regarding task interdependence and workflow to one unanimous, objective perspective.

It has been noted here and in previous research regarding teamwork mental models (Smith-Jentsch, Campbell, Milanovich, & Reynolds, 2001) that homogeneity, accuracy, and members' perceptions must all be taken into account when investigating team cognition's role in influencing team performance. Thus, the goal of any training directed toward the development of task interdependence and workflow perceptions is to produce homogeneous (within-group and across tasks) and accurate perceptions. Furthermore, task interdependence and workflow training, along with performance training, may produce more positive effects (Salas et al., 2008; Smith-Jentsch et al., 2001).

Though related, perceptions of task interdependence and workflow regarding missions' tasks or the overall job yielded differential results in their relationship with performance and communication. It would be interesting to determine other perceptions regarding team design features that are subject to differing perceptions at the job- and task-level. The findings of the present study suggest that team

members may perceive task interdependence and workflow differently from one another, as well as differently for the overall job and individual team tasks.

General Conclusions

In conclusion, the present findings provide support for the idea that perceptions of task interdependence and workflow are important in relation to teamwork and performance. Further, the present findings regarding the relationship between individual-level perceptions and individual performance may suggest that teamwork doesn't just contribute to the effectiveness of the team, but to the effectiveness of the individual, as well. In addition, perceptions about the overall job and individual tasks resulted in relationships of different strength with outcomes. Specifically, perceptions of task interdependence regarding the overall job served as the strongest predictor of team communication, while perceptions regarding the specific tasks served as the strongest predictor of team performance. Within-group agreement of interdependence-related perceptions was also important in influencing the relationship between mean team-level perceptions of task interdependence and performance, with agreement leading to higher performance for teams with less intensive perceptions. These findings, taken together, serve the purpose of providing a framework for future research directed toward the measurement of task interdependence and an argument for team training directed toward interdependence perceptions.

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APPENDIX A

RECRUITMENT FLYER

UT STUDENTS:
EARN MONEY PLAYING VIDEO GAMES
THIS FALL!

- PARTICIPANTS NEEDED -

Details of study:
- Game will be played in teams
- Participants may earn up to $14/hr for up to 14 hrs total

Participants must be able to participate for 7 consecutive workdays for the same two-hour period each day. If you are interested, please come to an information session during one of the following times:

- Tuesday, Sept. 6th – UC Room 223 – 2pm, 3pm and 4pm
- Monday, Sept. 19th – UC Room 223 – 2pm, 3pm and 4pm
- Tuesday, Sept. 20th – UC Room 220 – 2pm, 3pm and 4pm

If you cannot attend an information session, please email orl@utk.edu prior to the session's date.

APPENDIX B

TIMELINE FOR STUDY'S SESSIONS

Week 1	Week 2
Monday: Pre-session I	**Monday: Team Session I**
Study introduction	Training Overview
Sign-up	Introduction to team member roles
Wednesday: Pre-session II	1: Practice & Test
Consent forms	**Tuesday: Team Session II**
Individual differences questionnaire	2A: Practice & Test
Thursday: Individual Session I	2B: Practice & Test
1A: Baseline assessment	**Wednesday: Team Session III**
1B: Instruction	3A: Practice & Test
1C-D: Practice & Test	3B: Practice & Test
Friday: Individual Session II	**Thursday: Team Session IV**
2A: Instruction	4A: Practice & Test
2B-C: Practice & Test	4B: Practice & Test
3A: Instruction	**Friday: Team Session V**
3B-C: Practice & Test	5A: Practice & Test
	5B: Practice & Test

APPENDIX C

DEFINITIONS AND EXAMPLES OF CODED COMMUNICATION UNITS

Behavior	Definition	Example
Question	Requesting Information	"What are the coordinates of the enemy ship?"
Answer	Providing information in response to a question	"The coordinates of the enemy ship are…"
Request	Requesting resources, assistance, or specification	"Send out all of your helicopters."
Response to request	Responding to request for resources, assistance, or other specific action	"My helicopters are now in the air."
Answer forming request	Offering a request for resources as an answer to a question	"No, I don't have enough ammunition to sink the enemy ship."
Acknowledgement	Indicating having heard a previous utterance or action of another team member	"Thanks for the help." "Roger."
Statement	Providing information about the status of the task or the status of a team member (including self)	"I've destroyed the enemy's base"
Other	Speaking about nontask-relevant matters	"When do we get to go to break?"
Repetition	Representative of inefficiency; Repeating or asking another team member to repeat what was just said	"What did you say?" "I said I have all of my ships in the air."

APPENDIX D

MEASUREMENT SCALES

Task Interdependence and Workflow Perceptions

1. Playing fleet command [Job Analysis]
2. Completing mission goals
3. Planning mission tactics
4. Monitoring mission progress
5. Maneuvering platforms to maximize strike potential
6. Maneuvering platforms to maximize defense potential
7. Concealing fleet from enemy detection
8. Jamming enemy RADAR
9. Identifying unidentified platforms
10. Monitoring sensors
11. Selecting the appropriate platform for an engagement
12. Selecting the appropriate weapon for an engagement
13. Detecting enemy platforms
14. Destroying enemy platforms
15. Launching weapons
16. Launching aircraft
17. Managing weapons supply
18. Monitoring platform damage
19. Responding to task messages

APPENDIX E

SUMMARY OF HYPOTHESES

1. a) Mean team-level perceptions of task interdependence will be positively related to the frequency of team communication (marginally supported); b) Mean team-level perceptions of workflow will be positively related to the frequency of team communication (not supported).
2. The frequency of communication will be positively related to team performance (not supported).
3. a) Individual gaming ability will be positively related to individual performance (supported); b) Individual baseline ability will be positively related to individual performance (not supported).
4. a) Mean team-level gaming ability will be positively related to team performance (supported); b) Mean team-level baseline ability will be positively related to team performance (not supported).
5. a) Individual-level perceptions of task interdependence will be positively related to individual performance (marginally supported); b) Individual-level perceptions of workflow will be positively related to individual performance (marginally supported).
6. a) Mean team-level perceptions of task interdependence will be positively related to team performance (marginally supported); b) Mean team-level perceptions of workflow will be positively related to team performance (marginally supported).
7. a) The task analysis approaches to measuring task interdependence and workflow will serve as more important predictors of team performance than will the job analysis approaches (supported); b) The task analysis approaches to measuring task interdependence and workflow will serve as more important predictors of team communication than will the job analysis approaches (partially supported).
8. a) The task interdependence variables will serve as more important predictors of team performance than will the corresponding workflow variables (partially supported); b) The task

interdependence variables will serve as more important predictors of team communication than will the corresponding workflow variables (supported).

9. a) Mean team-level perceptions of task interdependence will moderate the relationship between homogeneity of perceptions and team performance, such that as mean team-level perceptions of task interdependence increase across teams, homogeneity of perceptions will more strongly relate to team performance (supported); b) Mean team-level perceptions of workflow will moderate the relationship between homogeneity of perceptions and team performance, such that as mean team-level perceptions of workflow increase across teams, homogeneity of perceptions will more strongly relate to team performance (not supported).

VITA

Jared LeDoux was born in Kinder, Louisiana, on August 12, 1982, to James LeDoux and the late Jennifer Manuel LeDoux. His mother passed away on May 20, 1996. He graduated from Kinder High School in 2001 and received a Bachelor of Science degree in psychology in 2005, from McNeese State University. He completed one year of graduate studies at the University of Tennessee and one year of graduate studies at McNeese State University before enrolling in the Industrial-Organizational Psychology Program at Louisiana State University (LSU) in 2007. He is currently in his second year as a doctoral student and hopes to finish his doctorate in 2011.

He has made presentations at a number of conferences, including the Society for Industrial and Organizational Psychology annual conference, the Southwestern Psychological Association annual conference, the Industrial Organizational/Organizational Behavior graduate student conference, and the Southeastern Association for Education Studies annual conference. His work with Dr. Tracey Rizzuto and Dr. John Paul Hatala was recently published in the Social Psychology of Education Journal. His primary research interests include team cognition and intervention, trainee reactions and comprehensive training models, and issues related to aging in the workplace.

He has two children, Cameron Allen LeDoux and Carson Dean LeDoux, who reside with him in Baton Rouge, Louisiana. He has been a member of Christ the King Catholic Church since 2007, and received confirmation in 2008.