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Experimental Evaluation of Collaborating Teams (EECT)

Tamera R. Schneider
Pamela Dowling
Gaea M. Payton

Wright State University
3640 Colonel Glenn Highway
Dayton OH 45435

Charlene K. Stokes

Air Force Research Laboratory
Sensemaking and Organizational Effectiveness Branch

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Anticipate & Influence Behavior Division
Sensemaking & Organizational Effectiveness Branch
Wright-Patterson AFB OH 45433-7604

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//SIGNED//
JOSEPH B. LYONS
Work Unit Manager
Sensemaking & Organizational
Effectiveness Branch

//SIGNED//
GLENN W. HARSHBERGER
Anticipate and Influence Behavior Division
Human Effectiveness Directorate
711th Human Performance Wing
Air Force Research Laboratory

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6. AUTHOR(S)

[1]Tamera R. Schneider, [1]Pamela Dowling, [1]Gaea M. Payton, [2]Charlene K. Stokes

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

[1]Wright State University
3640 Colonel Glenn Highway
Dayton OH 45435

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[2]Air Force Materiel Command
Air Force Research Laboratory
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Human Effectiveness Directorate
Anticipate & Influence Behavior Division
Sensemaking & Organizational Effectiveness Branch
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14. ABSTRACT

This report documents the results of research activities conducted as part of this task order. The Experimental Evaluation of Collaborating Teams (EECT) research effort sought to investigate psychosocial factors that might impact performance in virtual, distributed teams. Although computer-mediated interactions can limit the social context and depth of discussion about team tasks, their benefits include that they can obscure status differences, and increase team member participation and team coordination (83). The EECT research suggests that both selection of adaptable teammates and training skills in communicating certain information and shared mental models, as well as building team efficacy and cohesiveness can benefit team performance.

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PREFACE

The Experimental Evaluation of Collaborating Teams (EECT) research effort was sponsored by the Air Force Research Laboratory's (AFRL), Sensemaking and Organizational Effectiveness Branch (AFRL/RHXS) under Task Order #6 of the Technology for Agile Combat Support (TACS) contract (FA8650-D-6546). The period of performance for the research effort extended from 13 March 2007 to 2 July 2009. This report documents the results of research activities conducted as part of this task order.

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1.0 SUMMARY

The science and technology value of the Experimental Evaluation of Collaborating Teams (EECT) research effort is threefold. First, the research evaluated the relationship between established constructs and collaboration within teams (e.g., interpersonal trust, cohesion). Second, the research examined the predictive utility of team process variables, such as communication. Third, the research, by implementing a team-based socio-technical task, allowed for the experimental manipulation of technological variables (e.g., a breakdown in team communication), to examine the impact of this disruption on individual problem-solving situated within a team context. The EECT research effort involved a series of studies which assessed a myriad of psychological variables, some at the individual level (e.g., see Study 3), and most at the team level (e.g., collective efficacy, affective tone, etc.), to better understand their influence on individual and team effectiveness. Rather than embark upon a programmatic investigation of a few key variables that should impact individual and team performance in distributed networks, the EECT research explored a variety of psychosocial variables through different methods (i.e., communication, survey, and performance data) to fully utilize the capacity of the newly developed socio-technical task, and in part to establish its validity as a research tool.

The first two studies investigated variables evidenced in team communication and their relation to team performance. The first study found that positive forms of communication, such as trust, did not predict performance in newly formed virtual teams, which was unexpected. However, negative forms of communication which denoted help seeking and demoralizing reduced team performance, with the former being more beneficial over time than the latter. The second study found that although team stress appraisals were not related to coordination or performance, coordination was related to team performance, as expected. The third and fourth studies focused on self-report measures and their relation to performance. The third study found that cognitive and affective variables combine and operate through the process variables of self-efficacy and stress appraisals to influence adaptive performance (AP) at the individual level. Unexpectedly, the fourth study found that trust did not predict performance. However its close counterparts, collective efficacy and cohesion did predict better performance, as did lower levels of team negative affect. Together these findings have implications for training and selection in virtual teams. For example, training could emphasize key types of communication, such as requesting help when questions arise and anticipating others' needs, as well as skills such as reappraising situations in less threatening ways and improving self-efficacy beliefs. Selecting individuals who are more cognitively and emotionally adaptable will also facilitate adapting to the ever changing demands of military work. The use of distributed virtual military teams will likely continue to increase. These research findings suggest ways to bolster team effectiveness.

2.0 INTRODUCTION

Many jobs in the military domain require that individuals act rapidly, in a coordinated fashion, and often within teams. Teams are a vital part of many organizations, with virtual teams becoming more pervasive [1]. Despite their increasing prevalence, relatively little is known about distributed, virtual teams as work units [2]. Military teams often operate within advanced, interlinked information networks through which logistics activities, including crisis planning, dynamic re-planning, and command and control, are conducted. The purpose of this research effort was to examine psychological factors that influence individual and team performance using a newly developed computer-based laboratory task that requires team collaboration within a distributed logistics network. The laboratory task, Computer-based Aerial Port Simulation (CAPS), was developed by AFRL/RHXS as a logistics-based scenario and simulation framework to enable the investigation of factors that impact the performance of individuals and teams in real-time, distributed collaboration efforts [3].

3.0 STUDY 1

3.1 Introduction

Research has identified limitations in the dynamics of distributed, or computer-mediated, teams. These teams may experience barriers to team collaboration not faced by teams that engage in face-to-face communication [4]. Specifically computer-mediated teams experience more fragile trust [4; 5], inhibited communication [6], and reduced cohesion [4; 7]. These problems are exacerbated when one considers the domain of logistics, where teams are often characterized by geographic dispersion, ad-hoc membership, and brittle information exchange. In addition, collaboration science lacks consistent metrics to analyze collaboration [8]. Past research has identified some potential candidates for collaboration metrics, but these variables need to be validated through empirical research. Predictors of team process variables such as communication are touted as critical to team performance and cognition [9]. Many have investigated information sharing in teams, focusing on whether information was shared or not, not what kind of information was shared [10; 11]. This is the first study to our knowledge to investigate types of communication using conceptually-based content analysis and examining its relation with team performance. Study 1 of the present effort examined key process variables and whether they exist in spontaneous team communication, such as trust and cohesion, mentioned above, and their influence on performance in a distributed-logistics network.

Various psychosocial factors are postulated to predict better team performance, such as trust, cohesion, self-efficacy, and collective efficacy [4; 12; 13]. The present study contributes to the literature by exploring these process variables as they arise spontaneously in team communication. Trust refers to a psychological state comprising the intention to accept vulnerability based upon expecting positive intentions from another [14], and should predict better performance [11; 15]. Without trust, teammates may not keep their obligations to the team [16]. Cohesion refers to teammate acts of cohering, uniting, or sticking together [17], and should lead to better team performance [16]. Self-efficacy refers to judgments that individuals make concerning their ability to do whatever is required to successfully perform their jobs [18], and has been related to better individual performance which should hold for team performance. Collective efficacy refers to the beliefs that individuals hold concerning the ability of their group to successfully perform its work task [18]. It has been suggested that greater collective efficacy would facilitate team performance [12; 19]. Many of the above relationships have been hinted at, but have not been investigated empirically. The present study hypothesized that communicated trust, cohesion, self-efficacy, and collective efficacy would predict better team performance.

3.2 Method

3.2.1 Participants

Undergraduate students (N = 100) participated in this study in exchange for partial course credit. The average age was 19 (*SD* = 3). The majority were female (76 percent) and Caucasian (92 percent). Study 1 was a pilot study that commenced as the newly developed research platform was refined for use in empirical investigation. A total of 20 teams of five individuals participated in this preliminary research. Two teams were unable to perform the task due to software issues and their data were excluded from subsequent analysis. Of the 18 remaining teams, one team departed zero aircraft during session 1, but departed all aircraft during session 2, and two teams departed aircraft during session 1 (5 and 3 aircraft) but departed zero during session 2. Because these team problems were due to software issues rather than user error, these teams were included in analyses where possible.

3.2.2 Stimuli and Procedure

To provide an adequate research platform from which to study team collaboration, AFRL/RHXS researchers developed the Computer-based Aerial Port Simulation (CAPS) [3]. CAPS enabled a team of five interdependent individuals to simulate logistics operations associated with an aerial port squadron (e.g., movement of air cargo and passengers through the Defense Transportation System). The aerial port consisted of five primary functional sections: the air terminal operations flight (ATOF), passenger services, fleet services, cargo services, and ramp services. The ATOF was the section through which all information relating to airlift flow was received, processed, and dispatched to functional areas. Passenger services processed, embarked, and disembarked all passengers in the aerial port. Fleet services supplied transport aircraft with passenger and crew comfort items (including meals) and ensured that transport aircraft interiors were cleaned. Cargo services in-processed in-bound and out-bound cargo and sequenced palletized cargo for pick-up by ramp services. Ramp services downloaded in-bound palletized cargo and loaded out-bound cargo for the aerial port.

The interface operated in a point-and-click fashion, similar to the standard Windows configuration to reduce confusion among participants. Team members communicated using an instant messaging (IM) communication system, and all communication data were stored in an automated database for subsequent coding and analysis (see Appendix A for a snapshot of the graphical user interface). The communication interface modeled conventional instant messaging systems. Participants were told that they could use the IM to communicate as they would in conversations with friends when they were not performing their task-related activities. Participants were asked to respond to computer-generated information and messages sent by their teammates. The CAPS software recorded performance data relating to the actions of each team member in chronological order, including sequencing, and data relating to the actions of the team, including aircraft departure time (sec). CAPS allowed for an examination of performance in typical situations and the opportunity to manipulate key parameters to examine problem-solving in novel situations, such as the repurposing of an aircraft and a communication breakdown, both of which required the team to reformulate and execute new plans.

The procedure began with obtaining informed consent. Then, participants completed a background survey which included various trait measures, such as personality (described within the Materials section of the study in which they were examined), and demographics, such as age, gender, computer experience. After the background survey was completed by all participants, training commenced. The training session consisted of interactive PowerPoint slides for a general training of aerial port operations and job-specific training tailored to each station. Both training sessions were followed by brief quizzes where accurate feedback was provided for missed responses. Then, a practice session commenced where the team worked together on an aircraft and the experimenter answered any remaining questions. After the practice session, participants completed the post-training questionnaire. Then, the first of two 30-minute task sessions commenced. The first session included five aircraft which arrived one at a time and were separated by at least six minute increments with no disturbances during the session. Teammates had six minutes, from the time of the landing to departing an aircraft, to complete all activities required. If the participants failed to complete all of the required activities within the six minute time period, then the icon for the aircraft turned red to signal that it was late. A brief survey was presented between sessions one and two.

Compared to session one, the second session was more novel and complex, adding the repurposing of an aircraft and a subsequent communication breakdown. The second session involved three aircraft, but unlike the chronologically balanced spacing of aircraft in scenario one, two of the aircraft in session two arrived in close chronological proximity in the beginning of the second session. Upon the ATOF departure of the third aircraft, a system-generated IM was sent to all team members stating a destination change for that aircraft. Participants were instructed to re-accomplish the needed activities for a different destination (i.e., it was repurposed). That is, the passengers and cargo already loaded onto the aircraft had to be taken off and new passengers and cargo for the revised destination had to be uploaded. Two minutes after participants received the message about the repurposing, several of their communication windows were made unavailable (i.e., the communication breakdown). The unavailable communication windows were outlined by a red box and a message within the box that stated, "Communication Link is Down" in large red letters. Before this time, normal communication occurred throughout the first session and the first three disturbance-free aircraft of session 2. During normal communication ATOF was the hub responsible for the coordination, monitoring and directing of all activities among teammates. However, all teammates could communicate with each other. ATOF initiated the sequence of events when each aircraft landed by notifying all teammates of aircraft information (e.g., destination, number of passengers). First, passenger services (PS) was to remove passengers, followed by the removal of cargo by ramp services (RS), the cleaning of the aircraft by fleet services (FS), and cargo services (CS) and RS worked in union to get outbound cargo loaded, then PS was to load passengers, FS was to load meals and supplies, and finally, once ATOF confirmed all activities were complete, he or she was to depart the aircraft. There were numerous changes in communication links required by the team in light of the scheduled communication breakdown in the software. Each participant could still communicate with at least one other teammate, but the prior communication chain was disrupted. For example, ATOF lost communication links with all teammates except CS. In response, all information requiring task activities, of which ATOF must be informed to depart the aircraft, had to be directed through CS, whereas for all previous aircraft there was minimal communication with CS. With the communication link between cargo and ramp services down, the two team members had to convey needed information through third and fourth parties, specifically fleet and passenger services. Participants were not informed of the new options. Rather, they had to discover, or adapt to, the situation on their own. The intent of this scenario was to present participants with a novel situation to examine their ability to collaborate and problem-solve in new potentially distressing situations. A post-session questionnaire was then administered, followed by a paper-pencil version of an adaptive performance measure. Lastly, participants were debriefed and remunerated.

3.2.3 Materials

3.2.3.1 Communication coding

Various psychosocial factors, including trust, cohesion, self-efficacy and collective-efficacy, were coded from the team communication data obtained from participants' use of the IM system. A content analysis [20] of the communication data was conducted by two raters. Construct definitions were obtained from the literature and guided the content analysis. When noted in team communication, constructs were coded in two directions, positive and negative, to denote varied levels. A positive direction indicated that the construct was present at higher levels, whereas a negative coding indicated that the construct was present in the opposite direction. Examples from the communication data of positive trust, the intention to accept vulnerability, include, “RS will inform you when to clean,” “let me know when… so I can do my job,” and “I messed up…” Examples of negative trust include, “He didn’t tell me to…,” “they won’t respond to me,” and “you have to do it like I said.” In our codification, the presence of cohesion, or uniting, required two or more team members and included helping tasks and emotional support in response to statements, such as “LOL” (laughing out loud) and “ha ha.” Examples of positive cohesion include “lol” and “great job!” Examples of negative cohesion include “I don’t care if it gets done” and “that’s stupid.” Examples of positive self-efficacy, beliefs in one’s abilities, include, “ready to load, just waiting on RS” and “I’m supposed to download passengers.” Whereas the former self-efficacy utterances denoted job knowledge, the latter denoted times when the computer program may have disallowed a task, yet the participant knew how the task was supposed to be implemented. Examples of negative self-efficacy include “I don’t know what to do” and “I don’t know how to…” Examples of positive collective efficacy, beliefs about the team’s ability, include, “we can do this” and “waiting for cargo and then you can load.” Examples of negative collective efficacy include, “we can’t do this” and “we never leave on time.”

Inter-rater reliability was obtained by calculating proportion of agreement also know as Cohen’s Kappa, κ (http://faculty.vassar.edu/lowry/kappaexp.html). First we investigated agreement about the instances of communication that should be coded, exceeding 90 percent agreement across teams. The instances of agreement about the extent to which a phrase was coded in the same category (e.g., positive trust, negative self-efficacy) was .72 across seven teams (values were 70%, 80.3%, 81.5%, 82.1%, 60.5%, 74.2% and 57.8%), a low but acceptable level [20].

3.2.3.2 Performance

Performance during session one was assessed using three metrics: 1) the number of aircraft departed, 2) the accuracy of sequencing, and 3) the average time to depart aircraft, in seconds from aircraft landing to departure. To examine sequencing accuracy, teams were given one point for each of seven tasks completed in the correct order, which was: 1) passenger services disembarked passengers, 2) ramp services removed cargo, 3) fleet services cleaned the aircraft, 4) ramp services loaded outbound cargo, 5) passenger services uploaded passengers, 6) fleet restocked the aircraft with supplies and meals, and 7) ATOF departed the aircraft. Because of time constraints sequencing was not available for session two analysis.

3.3 Results

Table 1 shows a descriptive summary of the communication and performance data for sessions 1 and 2. On average, teams had 22 lines coded for session one and 14.5 for session 2. Overall there was less communication during session 2 (M = 166.7) compared to session 1 (M = 206.7). The decline could be due to increased task and teammate familiarity. Examining maximum values, negative self-efficacy had the highest frequency. This construct indicates communicating uncertainty about performing one’s task and as such might result in obtaining help from teammates. That is, we viewed negative self-efficacy as a request for help. Examining averages, communicating negative self-efficacy declined in session 2, suggesting more confidence in one's task performance. Negative self-efficacy, positive trust, positive cohesion, and positive self-efficacy were communicated most in session 1, as the team becomes a functional unit. In contrast, positive trust and positive cohesion were most communicated in session 2.

Table 1: Descriptive Statistics for Team Communication and Performance Data

	Mean	SD	Minimum	Maximum	Mode(s)
Session 1					
Positive trust	2.83	2.36	0	7	0
Negative trust	2.17	2.43	0	8	0
Positive cohesion	3.67	3.33	0	12	2
Negative cohesion	.50	.71	0	2	0
Positive self-efficacy	3.67	2.09	0	8	5
Negative self-efficacy	5.61	6.75	0	24	3
Positive collective efficacy	1.22	1.48	0	6	1
Negative collective efficacy	2.50	2.55	0	8	0,1
Number of lines coded	22.22	13.82	2	53.0	
Number of chat lines	206.67	74.54	88.0	427.0	
Planes departed	3.71	1.40	0	5	
Accuracy	3.91	1.40	1.20	7	
Time (sec)	917.00	342.38	458.00	1361.00	
Session 2					
Positive trust	2.38	2.24	0	8	1
Negative trust	.63	1.02	0	3	0
Positive cohesion	3.94	3.62	0	12	1
Negative cohesion	.81	1.33	0	5	0
Positive self-efficacy	1.63	1.93	0	6	0,1
Negative self-efficacy	2.25	4.89	0	20	0
Positive collective efficacy	1.25	1.53	0	4	0
Negative collective efficacy	1.69	1.78	0	5	0,1
Number of lines coded	14.63	9.65	3	39.0	
Number of chat lines	166.69	62.93	106	358.0	
Planes departed	2.53	1.01	0	3	
Time (sec)	490.20	124.07	304.0	772.0	

To reduce the communication data further and potentially enhance reliability even more, the extent to which these positive and negative communication variables coded during session 1 would load onto separate factors was explored using factor analysis. Variables that load onto one factor are interrelated, compared to those that load onto other factors, where each factor represents an underlying psychological construct [20]. An exploratory principal component factor analysis, with Varimax rotation, was computed. Factors were considered if their eigenvalue exceeded 1. Table 2 shows the rotated matrix pattern. Positive trust, self-efficacy, and collective efficacy loaded on the first factor (eigenvalue = 3.5; accounting for 31 percent of the variance), which we refer to as positive trust and efficacy. Negative self- and collective-efficacy loaded on the second factor (eigenvalue = 1.4; accounting for 29 percent of the variance), which we refer to as negative efficacy. Negative trust was the only uniquely contributing variable on the third factor (eigenvalue = 1.2; accounting for 16 percent of the variance), and as such it does not constitute a factor but was subsequently analyzed as a stand-alone variable. Interestingly, positive and negative cohesion did not load uniquely onto any one factor. They were subsequently analyzed as stand-alone variables. Bivariate correlations were calculated with these two communication factors, negative trust, the cohesion variables, and session 1 indicators of performance because more performance indicators were available for this session and it was disturbance free. Performance variables included number of aircraft departed, accuracy, and overall time to departure.

Table 2: Rotated Factor Matrix with Factor Loadings of Communication Variables

	Component		
	1	2	3
Positive trust	.63	.38	-.23
Negative trust	.12	.03	.87
Positive cohesion	.49	.39	-.57
Negative cohesion	.58	.45	.24
Positive self-efficacy	.76	.40	.22
Negative self-efficacy	.22	.91	-.14
Positive collective efficacy	.93	-.17	-.05
Negative collective efficacy	.06	.88	.01

Table 3 shows that positive trust and efficacy, positive cohesion, and negative trust were not related to performance. Negative communication and negative cohesion were related to performance in similar ways, although the findings were not uniformly statistically significant. Both were significantly related to fewer planes being departed, negative efficacy was related to less accuracy, and negative cohesion was related to the team taking more time to depart aircraft across the session.

Table 3: Correlations Among Team Communication Factors and Session 1 Team Performance

	Performance		
	# departed	accuracy	time
Positive trust and efficacy	-.05	.00	.04
Negative efficacy	-.65**	-.60**	.43
Negative trust	.23	-.01	.20
Positive cohesion	-.04	.03	-.29
Negative cohesion	-.54*	-.37	.57*

Note: *p < .05, **p < .01.

3.4 Discussion

Knowledge sharing in teams is critical, but virtual environments add complexity to team communication [11]. We expected that when teammates communicate enhanced trust, cohesion, and efficacy, the team would exhibit better performance. The findings of Study 1 show that trust does not always lead to better performance, which has been suggested in the past [21]. Findings suggest that constructs such as positive trust, self- and collective-efficacy, as demonstrated in team communication, are not related to better team performance. These constructs may be important for building team rapport. Although in newly comprised teams this sort of communication takes time away from task-related duties, communicating in these ways was not related to team performance. Results suggest that some `time may be needed to develop team trust to demonstrate its importance for performance, which has been found in the past [4]. The negative efficacy factor (comprised of negative self- and collective efficacy) predicted worse team performance, which could be due largely to the nature of these types of communication in the earlier periods of the team task. That is, stating that one is confused or that the team is working at its tasks in the wrong way are likely symptoms of teammates and teams in need of feedback or help.

Communications of negative cohesion, though the least communicated across both sessions, suggested that at least one teammate was demoralized and this negatively impacted team performance. Sharing sentiments of negative cohesion may lead to problems in teams, such as declining trust [16]. These findings suggest that communication is important for team performance - especially negative types of team communication. Though negative communications may be stated for different reasons – to get help or to state one's discontent with the team – they lead to worse performance in early stages of team work. The present research demonstrates that even early in the development of virtual teams, communication is related to team performance as teams begin to work toward common goals. Team communication is viewed as a critical aspect of team performance [15]. The next study investigated team communication further, by examining team coordination as evidenced in team communication, and whether it was related to team performance.

4.0 STUDY 2

4.1 Introduction

The purpose of Study 2 was to examine the role of stress evaluations and coordination on performance. Specifically, we further examined team communication, but in this study we focused on team coordination efforts as evidenced in team communication and its relation to performance, as well as its relation to stress evaluations. Stress is a process that unfolds over time [22]. Stress appraisals result from an interplay of primary and secondary appraisals, which refer to the personal stakes in a situation and the coping resources available, respectively [22]. Challenge appraisals occur when individuals evaluate their coping resources as commensurate with or exceeding the demands posed by a stressor, leading to expectations of mastery or growth. Threat appraisals occur when individuals evaluate their coping resources as insufficient for dealing with a stressful situation, leading individuals to anticipate harm or loss as a result of an encounter. A robust finding in past research is that threatened individuals perform more poorly than challenged individuals [23; 24; 25; 26]. What is less clear is whether these performance decrements are evident at the team level.

In addition to appraisals predicting differential performance, team-related behaviors such as coordination should predict team performance. Coordination is the process whereby teams organize their resources, activities, and responses in an effort to integrate, synchronize, and complete tasks within time constraints [27]. Overt communication directed toward another team member is referred to as explicit coordination [28]. Explicit coordination is required in all teams to maintain mutual mental models as situations change [29]. Implicit coordination can be found when transfers of information exceed requests for information because one party understands and anticipates the needs of another. Implicit coordination is denoted by a reduction of unnecessary communication during high workload or stress. This type of coordination depends upon the prior development of mutual mental models, which is often obtained through explicit coordination during relatively lower workload periods [28]. Team engagement in explicit and implicit coordination has been measured using an anticipation ratio [30]. The anticipation ratio is calculated by taking the number of subordinate communication transfers divided by team leader requests for information, actions, and planning or problem solving [28]. Anticipation ratios that exceed one demonstrate that subordinates anticipate and provide information, without being queried, that the team leader needs to facilitate completion of team tasks. Performance should be enhanced when teams experience a high anticipation ratio [31]. Study 2 investigated the relation of team stressor appraisals and coordination with team performance. We expected that threatened teams would demonstrate less coordination, evidenced by a lower anticipation ratio, and poorer performance, evidenced by lower accuracy and longer average departures, relative to challenged teams. We also expected that worse coordination (i.e., lower anticipation ratios) would predict worse team performance (i.e., lower accuracy and longer average departure times).

4.2 Method

4.2.1 Participants

Data on 73 teams, each including five individuals, were collected (N = 365). The average age was 21 (*SD* = 4.41), the majority of participants were female (64 percent) and Caucasian (63 percent). Graduate students and undergraduate psychology students from a Midwestern university participated in this study in exchange for partial course credit or monetary remuneration ($30).

4.2.2 Materials

4.2.2.1 Stressor Appraisal Scale (SAS)

Stress appraisals were measured using a six-item stressor appraisal scale [25]. Participants rated three primary appraisal items (e.g., “How threatening do you expect the upcoming task to be”) and three secondary appraisal items (e.g., “How able are you to cope with this task”) on a 5-point scale (1 = ‘not at all’ and 5 = ‘extremely well’). Reliabilities were good, exceeding .80 for both scales. The average primary and secondary appraisal scores, obtained just before session 1, were calculated as a ratio primary appraisal/secondary appraisal (PA/SA) to create appraisal scores, and these were averaged across teams.

4.2.2.2 Communication Coding

Individual chat utterances [32] or single lines of chat, such as “How are you?” were coded. Utterances that assisted in team coordination were examined in terms of requests and transfers of 1) information, 2) actions, and 3) planning or problem solving [30]. Information requests and transfers consisted of communications about needed information or updates on the progress of a task. Action requests asked that tasks be completed, whereas transfers involved telling a teammate that a task was completed. Planning or problem solving requests and transfers were communications about the sequence of events or teammate problems with their tasks. Incidences of each type of request and transfer in communication data were tallied for each teammate [30]. The proportion of agreement indexed inter-rater reliability and exceeded .90 (http://faculty.vassar.edu/lowry/kappaexp.html), which was acceptable. The anticipation ratio was calculated from the tallies of teammate transfers to ATOF requests (i.e., transfers/ATOF request) [30].

4.2.2.3 Performance

Team performance was indexed by sequencing accuracy and aircraft departure time during session 1, which was selected as it did not include task disturbances which would interfere with interpreting performance data. Aforementioned, there were seven steps for accurate sequencing: 1) PS unloaded passengers, 2) RS unloaded cargo, 3) FS cleaned the aircraft, 4) RS loaded cargo, 5) PS loaded passengers, 6) FS loaded supplies, and 7) ATOF departed the aircraft. Each step followed in this order gained one point toward team sequencing accuracy. Each aircraft could receive seven points, for a total up to 35 points across the five aircraft. Departure times, in seconds, were provided by CAPS which gave the time when an aircraft landed in the scenario and when an aircraft was departed. This period denoted the amount of time the aircraft was on the ground and available for processing by the team. Shorter departure times index better performance. In addition to individual aircraft times, an average departure time was created by averaging across aircraft times.

4.3 Results

Preliminary analyses revealed that the ATOF age and reported frequency of using instant messaging (IM) were correlated with coordination and performance scores. Subsequent analyses controlled for these variables. Table 4 presents correlations of team stressor appraisals with sequencing accuracy and aircraft departure times. Though there were negative correlations with stressor appraisals and sequencing in that threat was seemingly indicative of worse sequencing, these correlations were not statistically significant. The correlations of stressor appraisals with departure times suggest that greater threat was indicative of longer departure times, although these correlations were not statistically significant. To test whether threatened teams would engage in less coordination, team stressor appraisals scores were correlated with team anticipation ratios (r = .06, *ns*). The correlation suggests that more threat was linked to less coordination, but the relationship was not significant.

Table 4: Correlations of Stressor Appraisals with Sequencing and Departure Times, Controlling for ATOF Age and IM Experience (*df* = 68)

	Aircraft					
	1	2	3	4	5	
Sequencing						Total
Team Appraisals	-.02	-.09	-.05	-.12	-.14	-.13
Departure Times						Average
Team Appraisals	.08	.17	.20	.13	.08	.16

Note. † $p < .10$, * $p < .05$, ** $p < .01$

To test the hypothesis that teams who coordinate less would perform worse, anticipation ratios were correlated with performance scores. Table 5 shows that as sequencing accuracy increased the anticipation ratios also increased over time, but this relationship was only marginally significant for the last aircraft alone. Total sequencing across the five aircraft appeared to be related to better coordination, but not significantly. Table 5 also presents the correlations of coordination with departure times. Anticipation ratios were increasingly negative correlated with departure times across the task session. These negative correlations suggest that as teammates anticipated and relayed information to the ATOF, aircraft departed more quickly. The pattern of correlations increased in magnitude over the course of the task session, demonstrating a marginally significant relationship with aircraft three, significant relationships with aircraft four and five, and a significant relationship with the average departure time for the session.

Table 5: Correlations of Coordination with Sequencing and Departure Times, Controlling for ATOF Age and IM Experience (df = 68)

	Aircraft					
	1	2	3	4	5	
Sequencing						Total
Anticipation Ratio	-.06	.11	.05	.19	.23†	.17
Departure Times						Average
Anticipation Ratio	-.09	-.19	-.23†	-.33**	-.30*	-.26*

Note. † $p < .10$, * $p < .05$, ** $p < .01$

4.4 Discussion

These findings suggest that examining stressor appraisals in teams is not related to team performance, which is contrary to much research on individuals showing that threatened individuals perform worse than their challenged counterpart [23; 24; 25; 26]. It is likely that aggregating individual stressor appraisals within teams lost variability in appraisal scores, preventing statistically reliable findings.

However, some of the findings support past research showing that implicit coordination is related to better team performance [28; 30]. Though the relationship of coordination with sequencing accuracy was not reliable, the trend was in the right direction, with coordination seeming to bolster sequencing accuracy across the task and reaching marginal significance by the last aircraft. Coordination did reliably speed up aircraft departure time over the course of the task session, and during the session on average. Although virtual environments add to the complexity of communication amongst a team work unit [11], the present study shows that it is coordination efforts in communication that bolster some types of team performance. Teams who perform well include team members who anticipate the needs of their teammates and enable the team to switch between explicit and implicit coordination; this adaptive mechanism facilitates team performance [33]. The next study also examined adaptation for teammates as teams experienced increased task difficulty.

5.0 STUDY 3

5.1 Introduction

The increased need for adaptability is a fundamental demand associated with many novel performance environments, particularly for military teams operating in distributed settings [34]. Ultimately, research on adaptability requires a systems perspective as it permeates across multiple levels of analysis. Although all levels are relevant and most appropriately considered in union, the present study investigated the fundamental building block for all other approaches, the individual level of adaptive performance.

Adaptability was defined as altering behavior to meet the demands of the environment [35]. The demands that require adaptive performance are often novel and ill-defined problems occurring in work [36]. Allworth and Hesketh [37] were among the first to critically examine adaptive performance. They validated a performance rating scale based on extensive job analyses. Their intent was to distinguish adaptive performance as a unique performance dimension from the dimensions of task and contextual performance initially identified by Borman and Motowidlo [38]. All three dimensions are conceptualized as broad, overarching dimensions of performance that are generalizable to most jobs. Pulakos and colleagues [35] also validated a preliminary taxonomy serving as an 8-dimension model of Adaptive Job Performance (AJP), as well as a behaviorally-based measure to assess adaptive performance. Similar to Campbell and colleagues' [39] widely adopted performance model, the 8-dimension AJP model is intended to reveal the latent structure of the performance construct at a general level of abstraction, and includes: 1) solving problems creatively; 2) dealing with uncertain and unpredictable work situations; 3) learning work tasks, technologies, and procedures, 4) demonstrating interpersonal adaptability; 5) demonstrating cultural adaptability; and 6) demonstrating physically oriented adaptability; 7) handling emergencies or crisis situations, and 8) handling work stress. Adaptive performance captures an area beyond the models of Borman and Motowidlo [38] and Campbell et al. [39] - the ability to quickly alter behavior and transfer learning to meet changing environmental demands.

Numerous predictors of adaptive performance have been examined [37; 40; 41; 42]. Much of the previous research used objective task scores following a task disruption as the criterion for adaptive performance. The present study examined a predictor model of adaptive performance that used both objective task performance scores and subjective performance ratings which were theoretically derived and empirically validated [35; 43].

Borman and Motowidlo [38] assert that cognitive ability and personality differentially predict separate dimensions of task and contextual performance, respectively. A similar assertion seems plausible with the dimensions of adaptive performance. Considering Pulakos and colleagues' [35] model of adaptive performance, the cognitive component relates to the *application of learning and problem solving skills*, and the affective component relates to the attitudinal or emotional adjustment that is required to *cope with changing environments and task requirements*. Unlike Borman and Motowidlo who propose greater independence of cognitive-task performance and personality-contextual performance, it is likely that the cognitive and affective components are inseparable such that a high level of adaptive performance requires abilities to transfer knowledge and skills (cognitive) and emotional (affective) coping with increased demands and stress imposed by a dynamic work environment.

At first glance the distinction between cognitive and affective components to adaptive performance may appear to reflect an overlap with the task and contextual components of performance proposed by Borman and Motowidlo [38]. However, Allworth and Hesketh's [37] research suggests that although adaptive performance may overlap with task and contextual performance, being adaptable within the boundaries of a dynamic job is a distinct aspect of performance relative to performing a static job well. As such, there are likely distinct predictors of, or a distinct predictor model for adaptive performance. Prior research has examined distinct predictors of adaptive performance, such as change-related self-efficacy; however, a distinct path model for the prediction of adaptive performance has yet to be specified. The present research examined a model that includes mechanisms that link the cognitive and affective components that should result in improved adaptive performance.

A National Atlantic Treaty Organization (NATO) research team attempted to profile the adaptive worker, and has found a three-factor structure for predicting adaptive performance [44]. Although an adaptive performance scale such as Pulakos et al.'s [35] was not used as a criterion in the study, the data collection sites were chosen for their high fidelity in requiring adaptive performance on the job. Svenson et al.'s [44] intent was not to predict adaptive performance as a distinct dimension, but to identify latent factors which profile adaptive workers. The present research effort supplemented the NATO efforts by using a criterion measure of adaptive performance to examine the predictive validity of their identified adaptive profile.

Svensson et al. [44] examined indicators of adaptability, including personality, and affective and cognitive variables. Following the use of data reduction and modeling efforts, they found that most indicators loaded on one of three factors: 1) Instability, 2) Adaptability, and 3) Need for Structure. *Instability* was composed of Fear of Invalidity and Neuroticism. *Adaptability* was composed of Emotion Regulation and Cultural Adjustment. *Need for Structure* was composed of Personal Need for Structure and Need for Cognitive Structure. Each indicator is explained in detail below.

In the NATO research adaptability was designated as a predictor. Wheaton and Whetzel [45] noted that constructs can be designated as "predictors" or "performance" measures, depending on the research intentions and study design. For example, performance scores at the end of a training program can be outcome measures of training or as predictors of transfer. In the present study adaptability as a predictor and adaptive performance as an outcome are operationalized as two separate constructs, each with their own measurement tool. *Adaptability* was assessed as a predictor, measured by emotion regulation and cultural adjustment, and *adaptive performance* was assessed as an outcome measured by Pulakos et al.'s [35] scale and by objective task performance following a task disruption. Svensson and colleagues' [44] work identified several indicators of adaptability; however, given the dispositional nature of these indicators, they are more likely to exert a distal influence on the behavioral indices of adaptive performance. Rarely has previous research examined proximal indicators of adaptive performance. Therefore, the present research examined proximal mediators, stress appraisals and self-efficacy, of the relationship between dispositional indicators and adaptive performance [46; 47].

Aforementioned in Study 2, stress appraisals can result when individuals evaluate their skills and abilities (secondary appraisal) in relation to the personal importance of a situation (primary appraisal). Challenge appraisals differentially affect performance, affective outcomes, and physiological responses, such that threatened individuals perform worse, feel more negative and less positive, and have increased vascular rather than cardiac responding, compared to challenged individuals [23; 25; 26]. Adaptive individuals tend to be low in need for structure, embracing the uncertainty and spontaneous nature of changing situations [44], and they are typically of higher cognitive ability. This low need for structure decreases the potential threat of adaptive situations (primary appraisal), and the higher cognitive ability serves as a coping resource (secondary appraisal). Adaptive individuals should be challenged in response to adaptive situations and perform better than less adaptive individuals.

Research has generally found that self-efficacy is a proximal predictor of performance, while other individual attributes and situational influences tend to be distal, or antecedent to self-efficacy [48; 49]. Self-efficacy has been consistently related to adaptive performance [37; 43; 48; 50; 51; 52]; thus, the examination of a mediated relationship is warranted.

Previous research has established a relationship between cognitive ability and adaptive performance [37; 40; 52]. Given the dual influence of cognitive and affective factors, the present research also investigated cognitive ability. Figure 1 presents a full model of the relationships aforementioned. The order of associations specified in the model was conceptually derived considering a continuum of proximity associated with the indicators examined and their relation to adaptive performance. Moving from distal to proximal influences on adaptive performance, the latent factors included in the adaptive profile capture dispositional characteristics (distal), stress appraisals are task specific capturing relationships with *general* performance, and self-efficacy (proximal) which in the present study is specific to beliefs regarding *adaptive* performance.

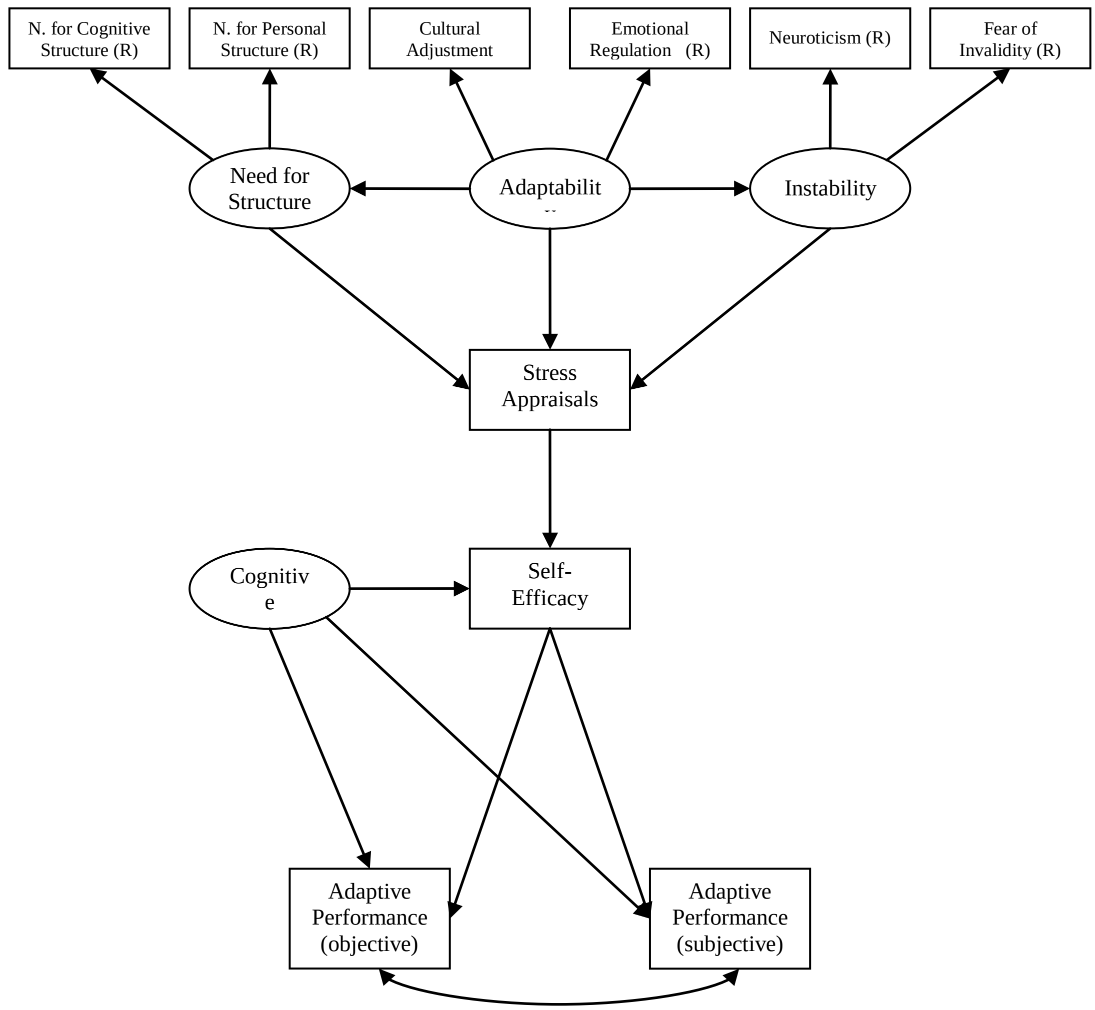

Figure 1: Conceptual Model of Distal and Proximal Indicators of Adaptive Performance

5.2 Method

5.2.1 Participants

Thirty teams of 5 individuals participated in this study (N = 150; 58 percent were female; age range was 18 to 42, M = 20). This sample was culturally diverse with 59 percent Caucasian, 15 percent African American, 18 percent international students, primarily from India, and 8 percent other.

5.2.2 Materials

5.2.2.1 Adaptive Profile

The NATO team's validated measures were used in this study to assess cognitive and affective indicators of adaptive performance. The measures of Neuroticism, Need for Cognitive Structure, Personal Need for Structure, Personal Fear of Invalidity, Cultural Adjustment, and Emotion Regulation were used in the present study. As depicted in Figure 1, these measures were intended to serve as indicators of the aforementioned factor structure that captures the adaptive profile of an individual.

5.2.2.1.1 Neuroticism

Personality was assessed with the 10-item neuroticism subscale of Goldberg's [53] International Personality Item Pool – Five-Factor Model (IPIP-FFM) (see http://ipip.ori.org/) [54]. Participants rated their item agreement on 7-point scales (1 = strongly agree, 5 = strongly disagree). This same 7-point response scale was used for all measures for the adaptive profile. The reliability was acceptable, α = .82.

5.2.2.1.2 Need for Cognitive Structure (NCS)

The 20-item NCS scale assessed an individual's tendency to use cognitive structuring for decision-making, especially if the situation involves uncertainty [44; 55]. An example item is "I prefer things to be predictable and certain." The reliability was acceptable, α = .86.

5.2.2.1.3 Personal Need for Structure (PNS)

The 12-item PNS assessed the degree to which individuals prefer structure and clarity and dislike ambiguity in situations [56]. An example item is "I find a well ordered life with regular hours tedious" (reversed scored). A single composite score was created. The reliability was acceptable, α = .84. A preference for structure was assessed by both the NCS and PNS scales, but the NCS is specific to decision-making, whereas the PNS is a more general measure of preferences [44].

5.2.2.1.4 Personal Fear of Invalidity (PFI)

The 14-item PFI measured *concern* with committing errors when confronted with decision-making [56]. To avoid mistakes, those high in PFI vacillate between options and resist commitment, resulting in delayed responses [44]. An example item is "I wish I did not worry so much about making errors." The reliability was acceptable, α = .79.

5.2.2.1.5 Cultural Adjustment (CA)

The 22-item Intercultural Adjustment Potential Scale [ICAPS, 57] taps underlying psychological skills (i.e., openness, flexibility, and creativity) purported to be necessary for effective intercultural adjustment. There are three factors, including openness, flexibility, and creativity. Openness is similar to the personality factor openness to experience (10 items, example: "I enjoy hearing new ideas"). Flexibility assessed beliefs about traditional ideas and social roles (6 items, example: "I think women should have as much sexual freedom as men").

Creativity (or critical thinking) assessed desire for self-direction and freedom from arbitrary constraint (6 items, example: “The average citizen can influence governmental decisions”). The reliability was acceptable, α = .75.

5.2.2.1.6 Emotion Regulation (ER)

The 9-item ER scale assessed general experience of negative emotions and overly emotional reactions to the environment (example item: “I get angry easily”). The reliability was acceptable at .77, after deleting one item: “People should not care what other people do.”

5.2.2.2 Stressor appraisal scale (SAS)

The 6-item SAS was administered following training and following the first task session, to account for changes in appraisals due to continued task experience. The reliabilities for both were acceptable (Time 1: primary appraisals α = .74, secondary appraisals α = .86; Time 2: primary appraisals α = .82, secondary appraisals α = .88). A ratio (primary/secondary) indexed appraisals with high scores denoting more threat.

5.2.2.3 Self-efficacy

This 14-item measure assessed beliefs pertaining to confidence in being able to achieve adaptive self-efficacy behaviors [43] and was developed to match dimensions of the adaptive performance taxonomy [35]. Items were modified in the present study to align with the task. An example item is: “Rate your level of confidence in being able to adjust to new processes or procedures” and “…form good relationships with people of different cultures.” Items were rated on 5-point scales (1 = not at all confident, 5 = certain). The scale was administered twice, after training (α = .94) and after the first session (α = .95).

5.2.2.4 Cognitive ability

The Wonderlic Personnel Test [58] assessed general cognitive ability. It is a 12-minute timed test of general verbal, math, and analytical abilities. Test-retest reliability ranges from .82 to .94, and internal consistency ranges from .88 to .94 [58]. Scores are the sum of total correct items.

5.2.2.5 Adaptive performance requirements (manipulation check)

Three aspects of the CAPS platform emphasized adaptability: 1) repurposing of aircraft, 2) communication breakdown, and 3) task interdependence. Participants were not informed of the potential of a repurposing event or communication breakdown that occurred during the second session of CAPS, and had to adapt to the situation on their own. Interdependent tasks require an individual to be flexible in response to others to coordinate their efforts. Manipulation checks were created for the present study to ensure the adaptability requirements of the task were perceptible to participants. The scale was administered twice, after each task session. Participants rated items using a 5-point scale (1 = not at all, 5 = extremely) to rate two items concerning evaluations of task adaptability requirements: 1) In your opinion, how difficult was this task? 2) To what degree do you feel you had to adjust or adapt your behavior to cope with the task demands? And two items assessed perceived task interdependence: 3) To what degree do you feel your performance on this task was dependent on the performance of your teammates? 4) To what degree do you think your teammates' performance would have suffered if you did not perform your job?

5.2.2.6 Objective task performance scores

Individual task performance scores were calculated for each station based on requisite duties. For example, the calculation of the performance score for Fleet Services was based on (a) whether the aircraft was cleaned, (b) whether meals were delivered, (c) whether duties were performed in the appropriate sequence in relation to teammates' duties, and (d) whether the required information was communicated to teammates. Individual task performance scores were calculated for each aircraft *or* each discrete adaptive event in a session. Ten individual performance scores were calculated: five aircraft in session 1, three aircraft in session 2, one repurposing event in session 2 (associated with the departure of aircraft 3), and one communication failure in session 2 (two minutes into the repurposing event). Scores were standardized to allow comparison across aircraft and adaptive events. Performance scores for the first eight aircraft (five in session 1 and first three in session 2, prior to repurposing) were considered standard performance because the situation was static and consistent with the training scenario. Based on the eight individual aircraft scores, composite scores were created for each session to represent standard performance. Conversely, the performance scores for the repurposing and communication failure events were considered adaptive and a composite score was created to represent adaptive performance.

5.2.2.7 Subjective task performance scores.

Griffin and Hesketh's [43] 20-item adaptive performance rating scale assessed subjective performance scores, which were based on seven of Pulakos et al.'s [35] eight dimensions. In the present study the eighth dimension, physical adaptability, was excluded because it was irrelevant to task requirements. Two items assessed *handling crisis situations* (e.g., was able to take an alternate course of action to deal with a new and urgent priority), and were correlated, $r = .58$, $p < .001$. The remaining six dimensions were assessed by three items each. Example items and subscale alphas are as follows: *problem solving* ($\alpha = .93$) - Was able to look at problems from many different angles; *new learning* ($\alpha = .93$) - Learned new skills, knowledge or ways of doing things to keep up to date with the changing situation; *interpersonal adaptability* ($\alpha = .95$) - Was flexible and open-minded when dealing with teammates; *cultural adaptability* ($\alpha = .92$) - Integrated well with teammates of a different background or culture; *copes with uncertainty* ($\alpha = .94$) - Was able to function in the face of uncertainty or ambiguity; *copes with stress* ($\alpha = .94$) - Remained calm and composed when faced with demanding workloads. Participants rated their own and their four teammates' performance using a 7-point scale (1 = performed very poorly, 7 = performed very well). A single-factor analysis of variance (ANOVA) confirmed similarity in ratings across self and peers, $F(5, 1125) = 2.22$, $p = 0.16$, thus ratings were collapsed across a participant.

The dimensions did not hold psychometrically. An exploratory factor analysis was conducted to determine factor structure. Entering all 20 items, a principal axis factor analysis with promax rotation suggested only one factor, with 89 percent of the variance explained. The eigenvalue of the second component did not exceed .3. Findings did not psychometrically support Pulakos et al.'s [35] dimensions. Thus, a composite score based on the full scale was used to test hypotheses. The reliability of the full scale was acceptable at .97.

5.3 Results

5.3.1 Manipulation Check

The adaptability required for responding to the repurposing and communication breakdown introduced in session 2 were perceived by participants. Participants reported session 2 was more difficult (M = 3.03, SD = 1.15) than the first session (M = 2.81, SD = 1.23; $t(230) = -2.57$, $p < .01$), and session 2 required more adaptive behavior (M = 3.55, SD = 0.96) than the first (M = 3.09, SD = 1.07; $t(226) = -5.78$, $p < .001$). A high degree of task interdependence was noted in both sessions (session 1: M = 4.15, SD = 0.84; session 2: M = 4.13, SD = 0.84; $t(226) = 0.27$, *ns*). Consistent with task design, participants reported that the second session was more difficult than the first session and required an adaptive response.

5.3.2 Adaptive Profile

A confirmatory factor analysis (CFA) was conducted using the Alpha Micro Operating Systems (AMOS) program to verify Svensson and colleagues [44] posited 3-factor measurement model for the adaptive profile. Results indicated that the 3-factor structure did not fit the data well: N = 263, $\chi^2(6) = 41.89$, $p < .001$; CFI = .94, SRMR = .09 (Figure 2). Given the strong correlation ($r = .81$, $p < .001$) and conceptual similarity of Matsumoto et al.'s [57] emotional regulation measure and the FFM personality measure of neuroticism, it is theoretically plausible that these two measures tap the same latent factor, instability. In addition, the standardized residual covariance matrix indicated a high degree of covariance of cultural adjustment with need for personal structure (-5.14) and with need for cognitive structure (-4.52), both exceeding the cut level of 2.58 [59]. These results suggest that switching the loading for cultural adjustment to the need for structure latent variable would be more representative of the population data. Based on the above results, the measurement model was redesignated as a second-order model (Figure 3).

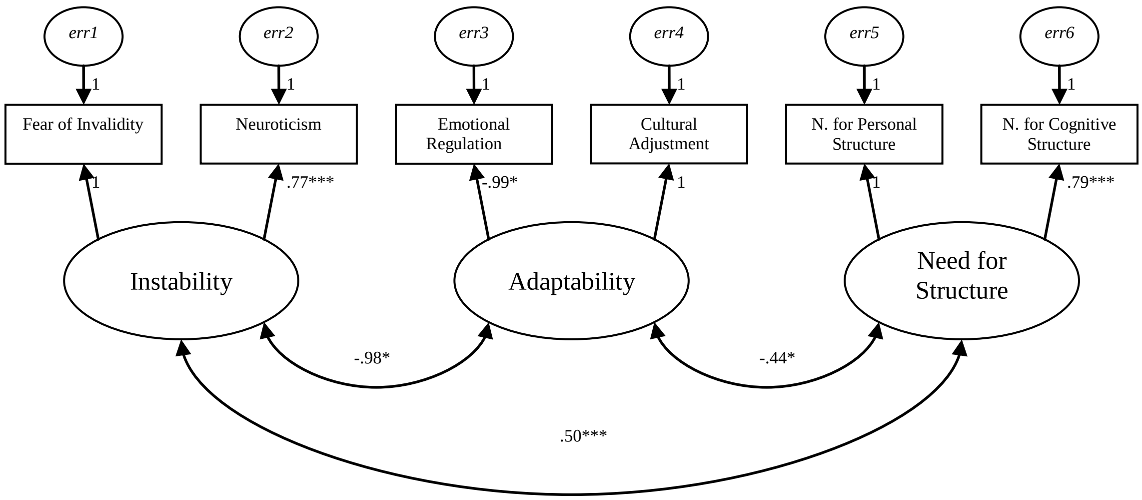

Figure 2: CFA for Proposed Three-factor Measurement Model (standardized)

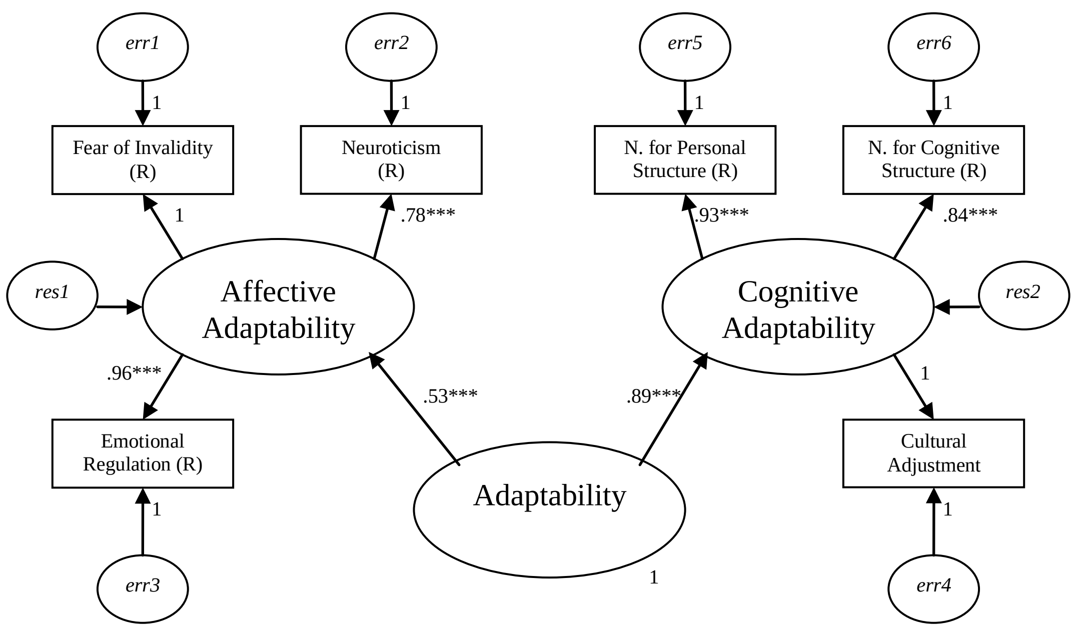

Figure 3: Redesignated Second-order Measurement Model (standardized estimates reported). Reverse Scores (R) used for Several Indicators to Permit Positive Loadings on Latent Factors

In line with the previously mentioned distinction between cognitive and affective influences on adaptive performance, need for structure was reconceptualized as ‘cognitive-oriented adaptability’ and instability was reconceptualized as ‘affective-oriented adaptability.’ Both factors in turn are indicators of the second order construct of adaptability, which represents general adaptive tendencies. Need for cognitive structure and need for personal structure were reverse scored, with positive scores denoting less preference for structure, to align with the cultural adjustment scale and load positively on ‘cognitive adaptability.’ Similarly, neuroticism, fear of invalidity, and emotional regulation were reverse scored so as to load positively on ‘affective adaptability.’ To ensure the higher order structure was identified, equality constraints were placed on the higher order residuals after verifying their similarity: discrepancy of .01 in estimated variances with a critical ratio < 1.96, suggesting the two residual variances are equal in the population. The fit indexes for the redesignated model were superior and indicated good fit: $N = 263$, $\chi^2(8) = 9.52$, $p = .30$; CFI = .99, SRMR = .03. Although the difference between the two models cannot be tested for significance as they are not nested, the fit indexes reflect a clear advantage for the redesignated model.

5.3.3 Full Predictor Model

To test the mediating relationship of self-efficacy, the statistical program AMOS [60] was used to analyze the proposed hybrid (measurement and path) structural equation model. A few modifications and underlying model specifications should be noted. For the measurement portion, the redesignated measurement model (Figure 3) was used as opposed to the proposed measurement model depicted in Figure 1. Both subjective and objective measures of adaptive performance were included in the hybrid model. As the two measures are intended to capture the same underlying construct their disturbances were permitted to covary [61]. If a single measure is modeled as an observed exogenous variable, it is assumed to be measured without error; an assumption usually violated [61]. Therefore, the alternative approach of modeling a single observed variable as an indicator of a single latent factor was used for cognitive ability. This approach permits an error term with an a priori specified variance to be included for the observed variable. Finally, a path from cognitive ability to cognitive-oriented adaptability was included.

With the above model specifications established, a theoretically and empirically based iterative process of model comparison examined the mediating relationships between the individual difference variables and adaptive performance. The initial model represents a baseline model and includes direct and indirect relationships with both measures of adaptive performance (Figure 4). The overall fit indexes for this model suggest acceptable fit: $N = 114$, $\chi^2(34) = 40.3$, $p = .21$; CFI = .99, SRMR = .06. However, with the exception of cognitive ability (subjective AP: $\beta = .20$, $p < .05$; objective AP: $\beta = .26$, $p < .01$), several of the direct relationships with adaptive performance were not significant. According to Kline [61], non-significant direct effects in the presence of significant indirect effects in the structural equation model (SEM) indicate strong support for mediation. Thus, this statistical evidence aligned with the theoretical proposition of self-efficacy’s mediating effect. Consequently, the non-significant paths were eliminated in the analysis of a second, parsimonious model (Figure 5). As expected, with several paths trimmed from the model, the χ^2 statistic for the parsimonious model increased: $N = 114$, $\chi^2(39) = 46.5$, $p = .21$; CFI = .98, SRMR = .07. However, as indicted by the χ^2

difference test in Table 6, the model fit did not significantly depreciate under the more parsimonious model. Thus, the latent factor of adaptability was fully mediated by stress appraisals, which are in turn, fully mediated by self-efficacy. Cognitive ability was only partially mediated by self-efficacy.

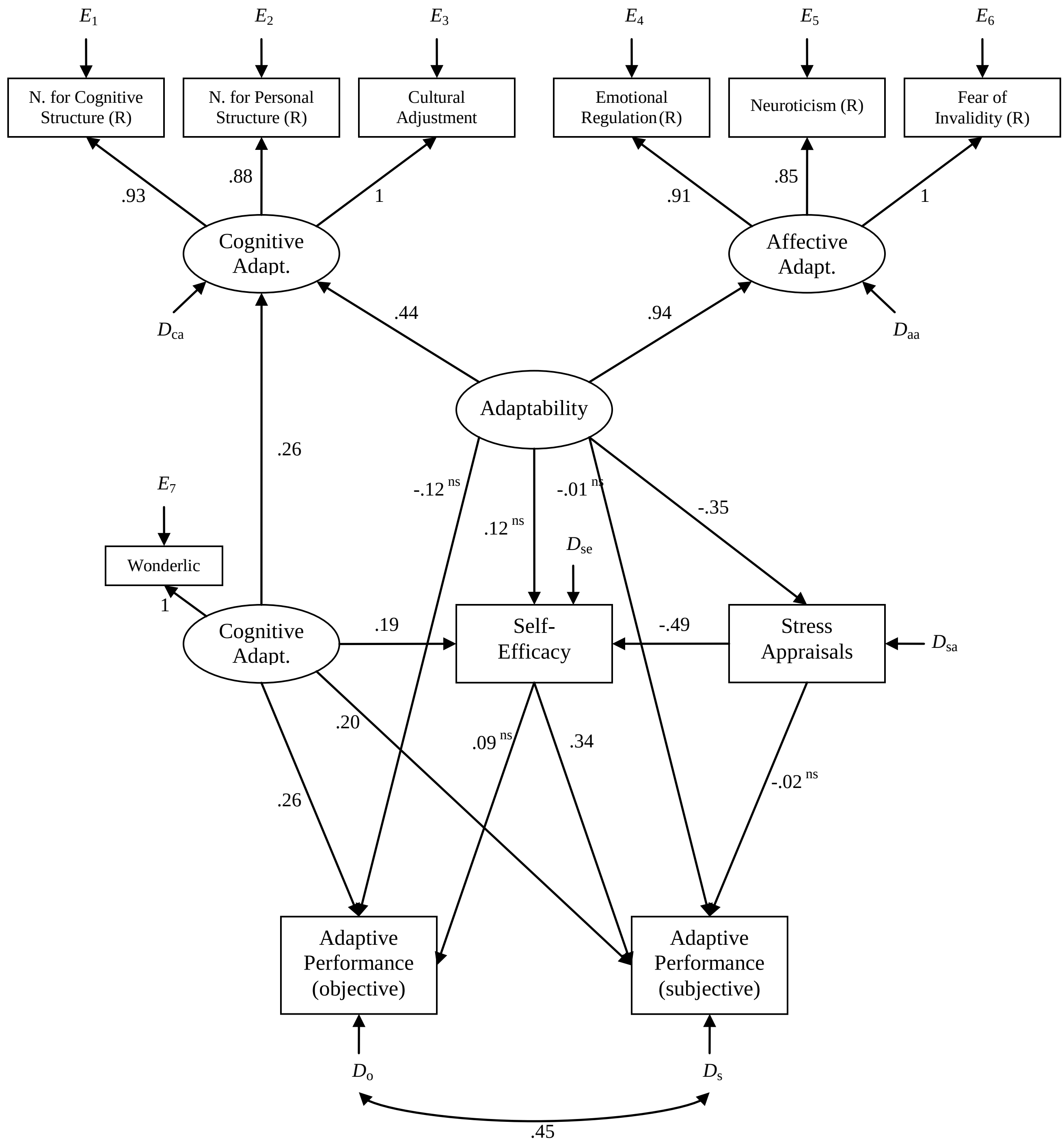

Figure 4: Results for the Baseline Path Model of Adaptive Performance. Unless Specified (ns), all Paths are Significant at $p < .05$. Standardized Regression Coefficients Reported. $N = 114$, $\chi^2(34) = 40.3$, $p = .21$; CFI = .99, SRMR = .06

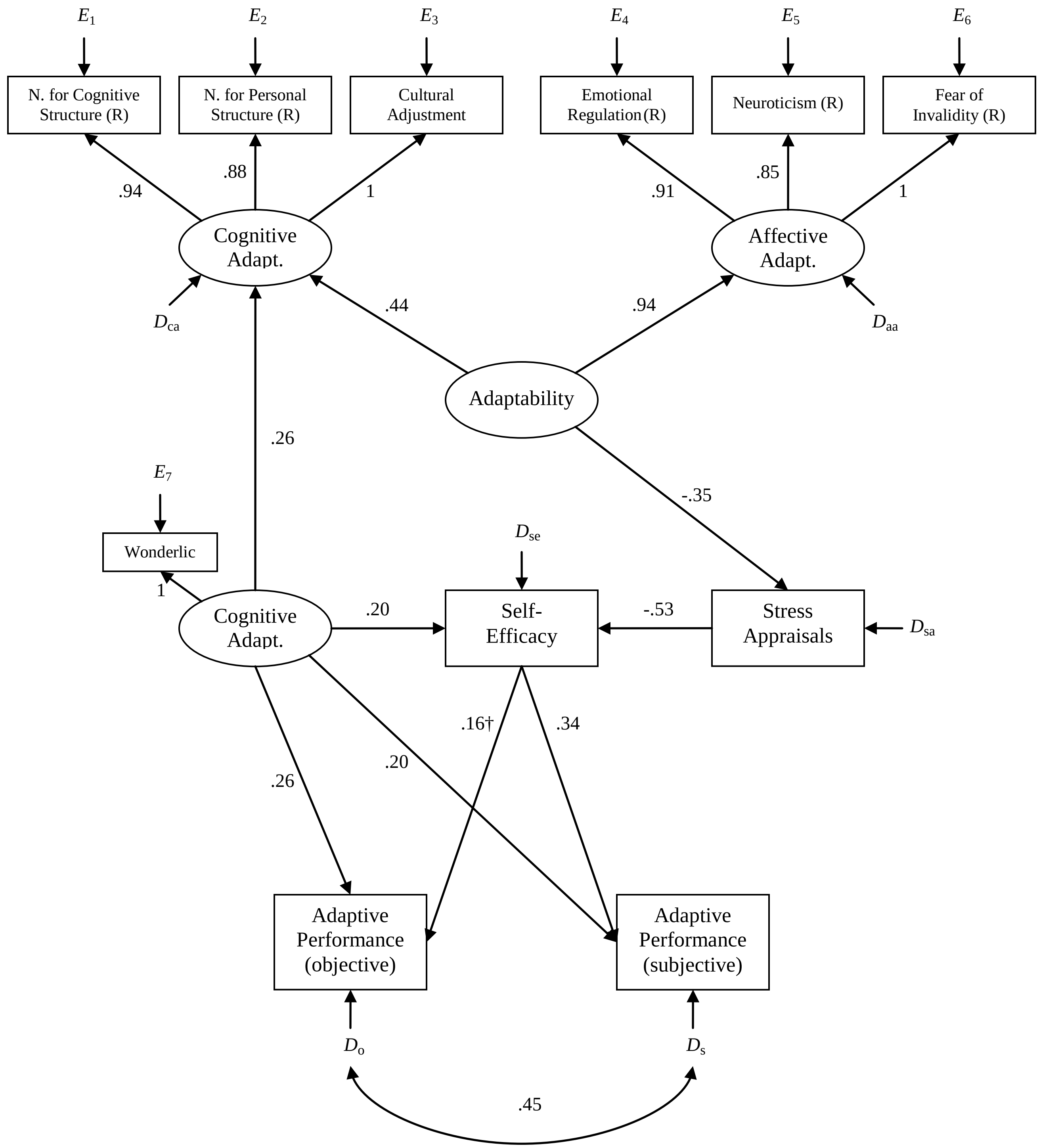

Figure 5: Results for a Parsimonious Path Model of Adaptive Performance. All Paths are Significant at *p* < .05 with the Exception of Self-Efficacy to Objective AP, which is Marginally Significant at *p* = .07 (†). Standardized Regression Coefficients Reported. $N = 114$, $\chi^2(39) = 46.5$, $p = .19$; CFI = .98, SRMR = .07

Table 6: $\chi 2$ Difference Test

Model (N = 114)	χ^2	*df*	Contrast with baseline model		CFI	SRMR
			$\chi^2_{difference}$	$df_{difference}$		
Baseline model (Fig. 7)	40.3*ns*	34	n/a	n/a	.99	.06
Parsimonious model (Fig. 8)	46.5*ns*	39	6.2*ns*	5	.98	.07
Exploratory model (Fig. 9)	40.5*ns*	33	n/a	n/a	.98	.06

Note. ***$p < .001$. N = 140 for *minus cognitive ability* model. Desired fit indexes: non-significant χ^2; CFI > .95; SRMR < .10 (61). The $\chi^2_{difference}$ test did not apply to the exploratory and baseline model comparison as they are non-hierarchical.

Although the above results support the mediating role of self-efficacy and stress appraisals, tests of significance were conducted separately for the indirect effects associated with subjective AP and objective AP. Following Kline's [6] procedure, results indicated that only the indirect effects associated with subjective AP were statistically significant. The non-significant results for indirect effects associated with objective AP are likely due to the fact that the path loading for self-efficacy to objective AP is only marginally significant: $\beta = .16$, $p = .07$ (Figure 5). Given the high degree of technical performance reflected in objective AP task scores relative to the self- and peer-rating format used for subjective AP, cognitive ability is likely accounting for a greater degree of variance in objective AP, thereby reducing the effect of self-efficacy on objective AP. Therefore, for exploratory purposes a third model was analyzed excluding cognitive ability (Figure 6). With the exclusion of cognitive ability, the indirect effects associated with both subjective and objective AP were significant (Table 7). Furthermore, the exclusion of cognitive ability did not depreciate model fit. See Table 8 for a comparison of all models analyzed. Thus, the effect of the latent factor adaptability on both subjective and objective AP is fully mediated by stress appraisals and self-efficacy, as expected.

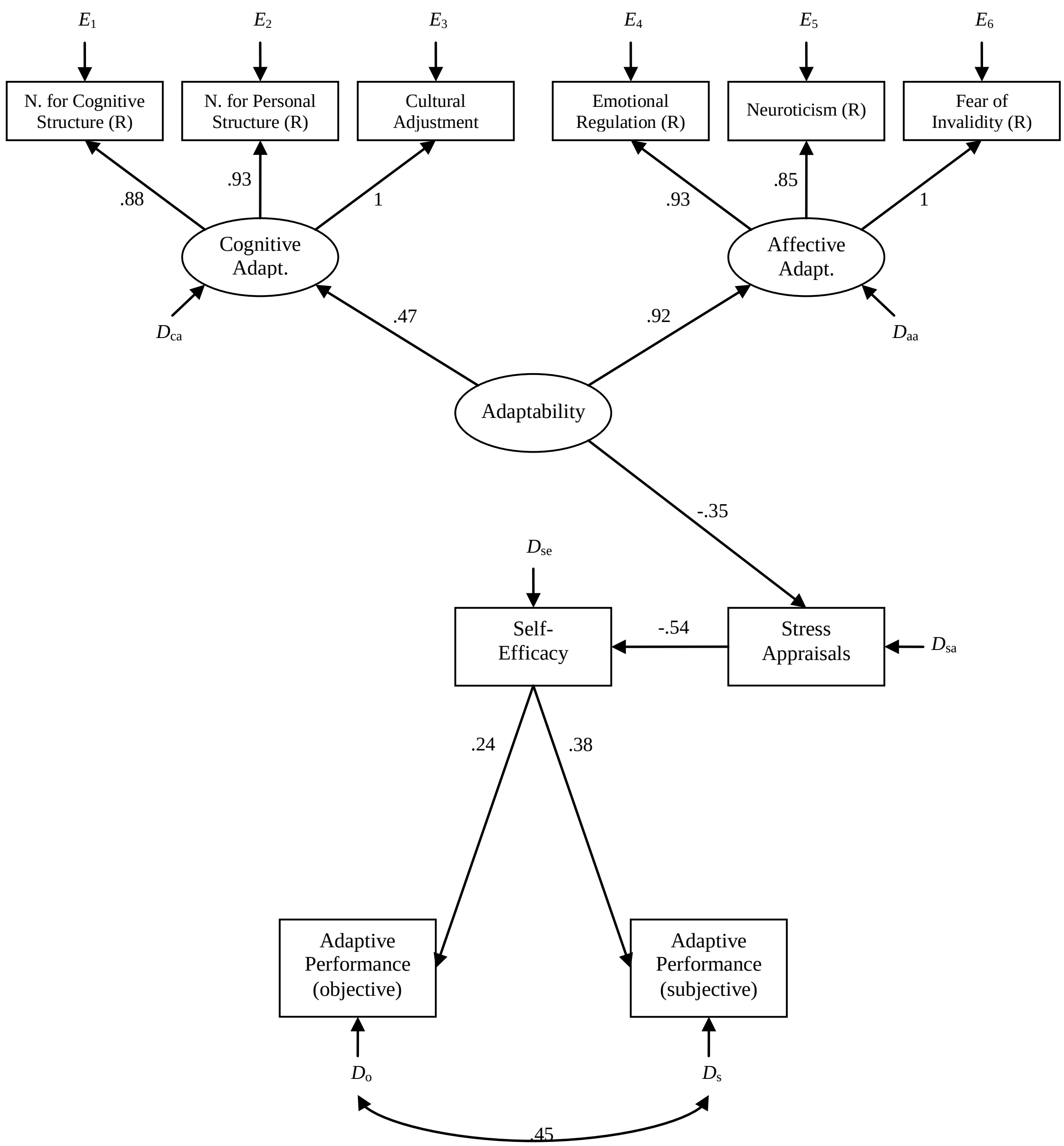

Figure 6: Results for Exploratory Path Model of Adaptive Performance Excluding Cognitive Ability. All Paths are Significant at $p < .01$. Sample Size Larger ($N = 140$) due to the Exclusion of Cognitive Ability. Standardized Regression Coefficients Reported. $N = 140$, $\chi^2(33) = 40.5$, $p = .17$; CFI = .98, SRMR = .06

Table 7: Significance Tests for Indirect Effects

Indirect Effect Paths	Parsimonious Model		Minus Cognitive Ability	
	Objective AP	Subjective AP	Objective AP	Subjective AP
Cognitive ability				
via self-efficacy	.03	.07*	--	--
Stress appraisals				
via self-efficacy	-.09	-.18***	-13**	-.20***
Adaptability				
via stress appraisals and self-efficacy	.03	.06*	.05*	.07*

*Note.** $p < .05$, ** $p < .01$, ***$p < .001$. Standardized coefficients reported. Kline's [61] procedure for calculating significance tests of indirect effects was used.

Table 8: Summary of Fit Indexes and Chi-Square Difference Tests for all Models Examined

Model (N = 114)	χ^2	df	Contrast with baseline model		CFI	SRMR
			$\chi^2_{difference}$	$df_{difference}$		
Baseline model (Fig. 7)	40.3*ns*	34	n/a	n/a	.99	.06
Parsimonious model (Fig. 8)	46.5*ns*	39	6.2*ns*	5	.98	.07
Exploratory model (Fig. 9)	40.5*ns*	33	n/a	n/a	.98	.06

Note. ***$p < .001$. N = 140 for *minus cognitive ability* model. Desired fit indexes: non-significant χ^2; CFI > .95; SRMR < .10 (61). The $\chi^2_{difference}$ test did not apply to the exploratory and baseline model comparison as they are non-hierarchical.

5.4 Discussion

The results of Study 3 offer empirical support for the prediction of adaptive performance; a performance domain that is of critical importance to successful collaboration and coordination in distributed team environments. The present study coupled the findings of previous research regarding dispositional factors [44] and self-efficacy [43; 52] into a coherent model that elucidates the mediating mechanisms through which adaptive performance is influenced. Moreover, a theoretically supported measure of adaptive performance was used, which supplemented the often relied on measure of objective task performance. The present research confirmed the association between the disparate measures of adaptive performance and ensured relatively equal predictive validity for the predictors examined.

Compelling results were found for the newly examined role of stress appraisals as a valid predictor of adaptive performance. Although previous research has yet to examine this association and therefore replication studies should follow, the present research found support for a direct relationship between stress appraisals and adaptive performance (subjective and objective). Results indicated that challenge appraisals were associated with higher adaptive performance whereas threat appraisals were associated with lower adaptive performance. These results are consistent with findings in regard to stress appraisal's relationship with other types of individual-level performance [23; 24; 25; 26]. Furthermore, as discussed in the next section, stress appraisals played an integral role in explicating potential causal associations between other variables examined.

6.0 STUDY 4

To further investigate factors that facilitate performance during situations that are relatively static and those which require adaptation, the present study investigated individual and team-level factors that should impact team performance. The present study investigated a host of variables that should predict team performance such as trust [16] and team or collective efficacy [12], which were examined in communication in Study 1, and variables that have focused on predicting individual-level performance such as stress appraisals and affect [25], which are extended to the team domain in the present research, as well as other key variables such as leadership [62].

Trust, the intention to accept vulnerability based upon expecting positive intentions from another [14], predicts more organizational citizenship behaviors and individual-level performance, as well as fewer counterproductive work behaviors [63]. Beyond facilitating individual-level performance, trust in teammates should predict better team collaboration and performance as teams must work toward common goals [64; 65]. However, trust often develops over time as people interact [66]. Distributed teams typically lack prior interactions, which can hinder the development of trust [67]. This study investigated this speculation.

In addition, individual characteristics that teammates bring to team work, such as personality (e.g., agreeableness, openness to experience), might be related to being more trusting of teammates in newly formed virtual teams [68; 69]. Past research has found that both agreeableness and conscientiousness predict better team performance [70]. Specifically, agreeableness was related to better teammate ratings and conscientiousness was related to higher supervisor ratings; both were related to better product concepts and product outcomes. Like personality, transient situation-related factors should predict team performance, such as leadership and stress responses. Leaders who ensure cohesiveness in a group promote better team performance [2]. Stashevsky and Koslowsky [62] found that transformational leadership, an empowering type of leadership, was related to greater team cohesiveness and performance. Greater trust in teammates should extend to leaders, particularly when they are more transformational in nature. Other situation variables such as team stress appraisals and team affect were expected to serve as a psychological resource to reduce team distress and facilitate team performance, as they have been found to do for individual-level data [25]. Specifically, trusting teammates should facilitate challenge appraisals (see Study 2) as teammates would be considered a resource (i.e., increase coping options in particular), and would facilitate more positive affect and less negative affect. We expected that trust toward teammates would be related to stable personality characteristics such as agreeableness and openness, and be related to leaders who were more transformational in nature, as well as foster beneficial stress responses to the novel team task.

6.1 Method

6.1.1 Participants

Data on 71 teams of 5 individuals (N = 355) were analyzed for this study. The average age was 20 (*SD* = 3.53), most were female (61 percent) and Caucasian (56 percent), followed by African American (27 percent). Both graduate and undergraduate students from a midwestern university participated in this experiment in exchange for partial course credit or monetary remuneration ($30).

6.1.2 Materials.

6.1.2.1 Interpersonal Trust

Trust was measured using a modified version of the 11-item Organizational Trust Inventory (OTI) [71]. Modified versions of this scale have been used reliably in past research [14]. Participants rated items on the degree of trust they felt toward their teammates during the task using a 7-point agreement scale (1 = strongly disagree, 7 = strongly agree). Example items included “I feel that other team members performed the task with me honestly,” and “I think other team members took advantage of my problems.” Interpersonal trust was reliably assessed after session 1 ($\alpha = .85$) and session 2 ($\alpha = .89$). These scores were highly correlated ($r = .77$, $p < .01$), and their relationships with other variables were similar. Scores were aggregated across teammates within a team for all variables.

6.1.2.2 Personality

Goldberg’s [53] 50-item IPIP-FFM (see materials Study 3) assessed personality in the pre-training survey. Participants rated their agreement with items using a 7-point agreement scale. The reliabilities were acceptable: agreeableness = .74, conscientiousness = .81 and openness = .69.

6.1.2.3 Baseline state affect

Participants rated their feelings at the moment of assessment [72], using a 5-point scale (1 = not at all, 5 = extremely). Ten items assessed *positive* affect (interested, excited, enthusiastic, strong, proud, active, attentive, alert, inspired, and determined) and 10 assessed *negative* affect (distressed, guilty, nervous, hostile, scared, upset, irritable, ashamed, jittery, and afraid). The reliability of the positive affect and negative affect scales was acceptable (alphas .83 and .70, respectively).

6.1.2.4 Team affect

Positive and negative team affect were measured with the positive affect negative affect schedule (PANAS) by asking participants to rate their team’s affect at the time of the rating. As with baseline state affect, positive affect (e.g., interested) and negative affect (e.g., nervous) each had 10 items. Reliability was acceptable with post-session 1 alphas of .91 and .83, respectively.

6.1.2.5 Stressor Appraisal Scale (SAS)

Stress appraisals were measured using a six-item stressor appraisal scale [25]. Three items assessed primary appraisals (e.g., How threatening do you expect the upcoming task to be) and three items assessed secondary appraisals (e.g., How able are you to cope with this task). Responses were recorded on a 5-point scale (1 = ‘not at all’ and 5 = ‘extremely well’). The average primary appraisal score and secondary appraisal score were put in a ratio (PA/SA) to create an appraisal score. The alphas for appraisals assessed after training and just before session 1 were .81 for primary and .91 for secondary appraisals.

6.1.2.6 Leadership

Six items were adapted from the Multifactor Leadership Questionnaire (MLQ) [73] to assess transformational leadership. Participants first rated the leader who they believe emerged during the scenario. If participants chose themselves or ‘none’ they were not given subsequent items. Example items included: displayed optimism about our future work, and was enthusiastic about what needed to be accomplished. These items formed a reliable scale with an alpha of .99. Team aggregates were calculated, averaging across the five teammates. This is a justified approach because if one teammate rates that there was a team leader besides him or herself and gives that leader an average transformational rating of 4.5, but the other four teammates rate themselves as leader or state that there was no leader, leadership for this team is clearly in peril and the average score would be .90. However, if there was a team where one person rated that he or she was the leader and thus contributed to the average a score of zero, and the other four teammates had an average transformational leadership average of 5.0, 4.83, 4.67, and 4.33, then the team average would be 4.71, demonstrating high agreement among teammates that there was a leader who demonstrated transformational qualities. Ratings were obtained at the end of session 2.

6.1.2.7 Collective efficacy

Seven items assessed beliefs that individuals hold concerning the ability of their group to successfully perform its work task [18]. An example item was the team I am working with has above average ability. Cronbach’s alpha for post-session 1 was .89.

6.1.2.8 Cohesion

Seven items assessed cohesion, defined as teammate acts of cohering, uniting, or sticking together [17]. An example item was the team members all get along well. Reliability was acceptable with a post-session 1 alpha of .83.

6.1.2.9 Performance

Team performance was indexed by number of aircraft departed during session 1, which was related to communication variables in Study 1, and average departure times (sec).

6.2 Results

Interrelationships among interpersonal trust, agreeableness, conscientiousness, openness to experience, baseline positive and negative affect, the teams’ positive and negative affect, stressor appraisals, transformational leadership, collective efficacy, cohesion, and session 1 performance were examined. Table 9 shows that interpersonal trust was, unexpectedly, not related to personality, however it was related to various state-level variables. Teams higher in interpersonal trust had higher team positive affect and lower team negative affect, challenge appraisals, and departed their aircraft more quickly. Surprisingly, team interpersonal trust levels were very highly correlated with collective efficacy and cohesion so much so that their independence is questionable. Further, the correlation of collective efficacy and cohesion are very high and their pattern of correlations with other variables is similar to that for trust, with the exception that both higher collective efficacy and cohesion predicted greater number of aircraft departed and for this reason predicted performance better than trust. Team negative affect predicted worse performance in that greater team negative affect was related to slower departure times and also fewer aircraft departed. This variable was also related to most other variables. Leadership, unexpectedly, was not related to team trust, collective efficacy, or cohesion ratings.

Table 9: Intercorrelations among Variables for Study 4 (*df* ranges from 66 to 70)

	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Session 1 Trust	.11	-.11	.24	-.04	-.16	.45**	-.54**	-.31*	.06	.73**	.79**	.23	- .28*
2. Agreeableness		.33**	.27*	.13	-.31**	.14	-.09	-.14	.08	.13	.11	-.04	.07
3. Conscientiousness			.13	.13	-.12	-.13	.25*	.01	-.06	-.15	-.12	-.07	.05
4. Openness				.34**	-.18	.20	-.06	-.16	-.10	.08	.07	.08	.00
5. Baseline Positive Affect					-.11	.42**	.11	.07	-.12	-.05	.08	-.12	.12
6. Baseline Negative Affect						-.09	.23	.31*	-.07	-.10	-.13	-.02	.04
7. Team Positive Affect							-.34**	-.22	-.08	.47**	.53**	.11	.08
8. Team Negative Affect								.34**	-.06	-.69**	-.65**	-.42**	.31*
9. Appraisals Post-training									-.08	-.28*	-.16	-.08	.09
10. Leadership										.07	.03	-.10	-.09
11. Collective Efficacy											.80**	.48**	-.08
12. Cohesion												.33**	-.27*
13. Session 1 # of departures													-.66**

Note: *p < .05, **p < .01. Variable 14 above is Session 1 Average Departure Time (sec) is Session 2 average time.

6.3 Discussion

There has been much discussion in the literature of the benefits of trust on team performance [64; 65]. Much of that discussion and subsequent research has focused on teams who meet face-to-face or have meetings over time. Swift trust develops quickly, as team members entrust others with specific tasks; it is sustained by proactive and enthusiastic actions [74], openness, fairness, timely responses, providing feedback [75]. Swift trust is more pertinent to virtual teams as often there is no face-to-face interaction or numerous meetings. In this type of environment, Study 4 found that trusting ones' teammates was not related to performance. It is may be that the brief nature and virtual interactions involved with the scenario precluded a relationship of trust with performance [66; 67]. Interestingly, collective efficacy and cohesion were both very highly related to trust, and they did predict better team performance. These paradoxical findings for trust and its two related variables warrant future research.

Past research has found that transient stress-related factors predict individual level performance. Team negative affect predicted worse performance, as might be expected from individual level findings [25]. A potentially new avenue of interest is the finding that higher stress appraisals (i.e., threat appraisals) were related to lower team collective efficacy. It could be that confidence in the group's ability to do their job is a coping resource that lowers threat appraisals and allows task focus. However, appraisals were not related to performance in the present study, although collective efficacy was.

Leadership was unrelated to all other variables measured in this study. It was expected to be related to cohesiveness and better performance as has been found in past research [2; 62]. It may be that the scale used for this study, which was adapted from the MLQ, is not a valid representation of transformational leadership, although it was a reliable measure. That is, it is quite possible that the present survey used to measure transformational leadership did not measure that construct well.

7.0 GENERAL DISCUSSION AND IMPLICATIONS

Relatively little is known about distributed, virtual teams as work units [2]. However, these are just the type of units in which military personnel often find themselves. This research effort examined psychological factors that influence individual and team performance using a newly developed computer-based laboratory task requiring team collaboration within a distributed logistics network, so we could investigate factors that impact performance of individuals and teams in real-time, distributed collaboration efforts [3].

The studies reported above have much to tell us about team performance generally. The first study showed that although team performance was not related to positive communication, such as demonstrating trust toward other teammates in communication, performance was impacted by negative communication including negative efficacy and cohesion. In the present research, a lack of self- and collective- efficacy comprised negative communication. Given the examples noted in the Method of Study 1, it is likely that team performance, in terms of both the number of aircraft that were departed and sequencing accuracy, were hampered because teammates needed help with their tasks. When teammates did not understand their tasks their team's work suffered. This team process could be remedied with teammate intervention such as providing information or help. Negative cohesion also predicted worse team performance, as has been found in past research on virtual teams [4; 7]. This variable is likely a symptom of team conflict, which can be relatively more difficult to resolve. In summary, negative efficacy involved requests for help, whereas negative cohesion may have caused teammates to become less inclined to want to work with other because they were demoralized. This speculation could easily be examined in future research. The second study revealed that although team performance is not impacted by team stress appraisals, it is impacted by team communication efforts, as was found in Study 1. Anticipatory communication involved understanding the kinds of information teammates needed and offering it before teammates had to request it [30]. This type of communication increased team performance. Coordination in this fashion suggests that teammates have a shared understanding of what the overall team task requires and they collaborate well with teammates, which increases performance [28; 30]. It may be that during periods of higher distress than was found in the present task, that appraisals mediate the link between coordination and team performance. Team members could be trained to communicate effectively, by anticipating the needs of teammates and avoiding comments that foster negative cohesion. Training should include a focus on gaining shared meaning rather than trying to reach agreement should increase performance [76].

Study 3 offered support for the predictive validity of Svensson et al.'s [44] adaptive profile of dispositional tendencies. The adaptive profile information could be used to identify those most likely to perform well in teams in turbulent environments such as military settings. Supplementing selection based on dispositional tendencies, training interventions can be targeted at improving adaptive performance. Specifically, the path model supported in the present research offers stress appraisals and self-efficacy as targets for training interventions. Stress appraisals and self-efficacy are malleable beliefs about the task or situation at hand. In regard to self-efficacy, individuals must first have confidence in their ability to adapt before they can perform adaptively [43; 51]. Training or exposure to previous successful experiences in dealing with change can help to increase self-efficacy. Gist et al. [77] provided empirical evidence indicating that augmenting content approaches to skill training with process oriented self-management training (e.g., stress appraisals and self-efficacy) facilitates the generalization of adaptive behavior to new settings. Kozlowski et al. [78; 79] have suggested several such self-management training techniques that enhance adaptive performance through the improvement of self-efficacy beliefs: advance organizers, analogies, guided discovery, error-based training, metacognitive instruction, learner control, and self-sequenced mastery goals. In addition to and related to the improvement of self-efficacy, these training techniques also facilitate other learning outcomes such as deep comprehension, flexible knowledge structures, self-regulatory and metacognitive skills. Although empirical evidence is needed, given such learning outcomes in training, individuals will also be less likely to be threatened by a situation when they have developed the abilities to cope with the changing situation. Future research should investigate other adaptive scenarios, such as introducing a new teammate midway through the scenario, and investigate its influence in adaptive performance as well as communication and other psychosocial variables found in this research effort, to be related to team performance.

In Study 4 we found that interpersonal trust was not related to performance as might be expected and has often been speculated. The brief amount of time the team works as a unit and their inability to experience peripheral information, such as nonverbal cues, might delay the development of trust in the short term [80]. Other factors highly related to trust, collective efficacy and cohesion, predicted performance. Enhancing both factors might benefit trust immensely. Trust was related to higher team positive affect and lower team negative affect. This finding suggests that emergent affective properties of teams may foster the early development of trust. This speculation requires follow-up investigation. Trust emerges over time from teammate demonstrations of competence in team work [81]. It may be that preliminary information provided to teammates about the skills and ability of their work mates would foster ‘swifter’ trust. Though there were no stable or individual difference variables that predicted trust, openness was marginally significantly related to more trust, as might be expected [75]. Overall, though, collective efficacy and cohesion were the best predictors of team performance.

8.0 CONCLUSION

Literature reviews have suggested that teams are beneficial for performance [82]. The EECT research effort sought to investigate psychosocial factors that might impact performance in virtual, distributed teams. Although computer-mediated interactions can limit the social context and depth of discussion about team tasks, their benefits include that they can obscure status differences, and increase team member participation and team coordination [83]. The EECT research suggests that both selection of adaptable teammates and training skills in communicating certain information and shared mental models, as well as building team efficacy and cohesiveness can benefit team performance.

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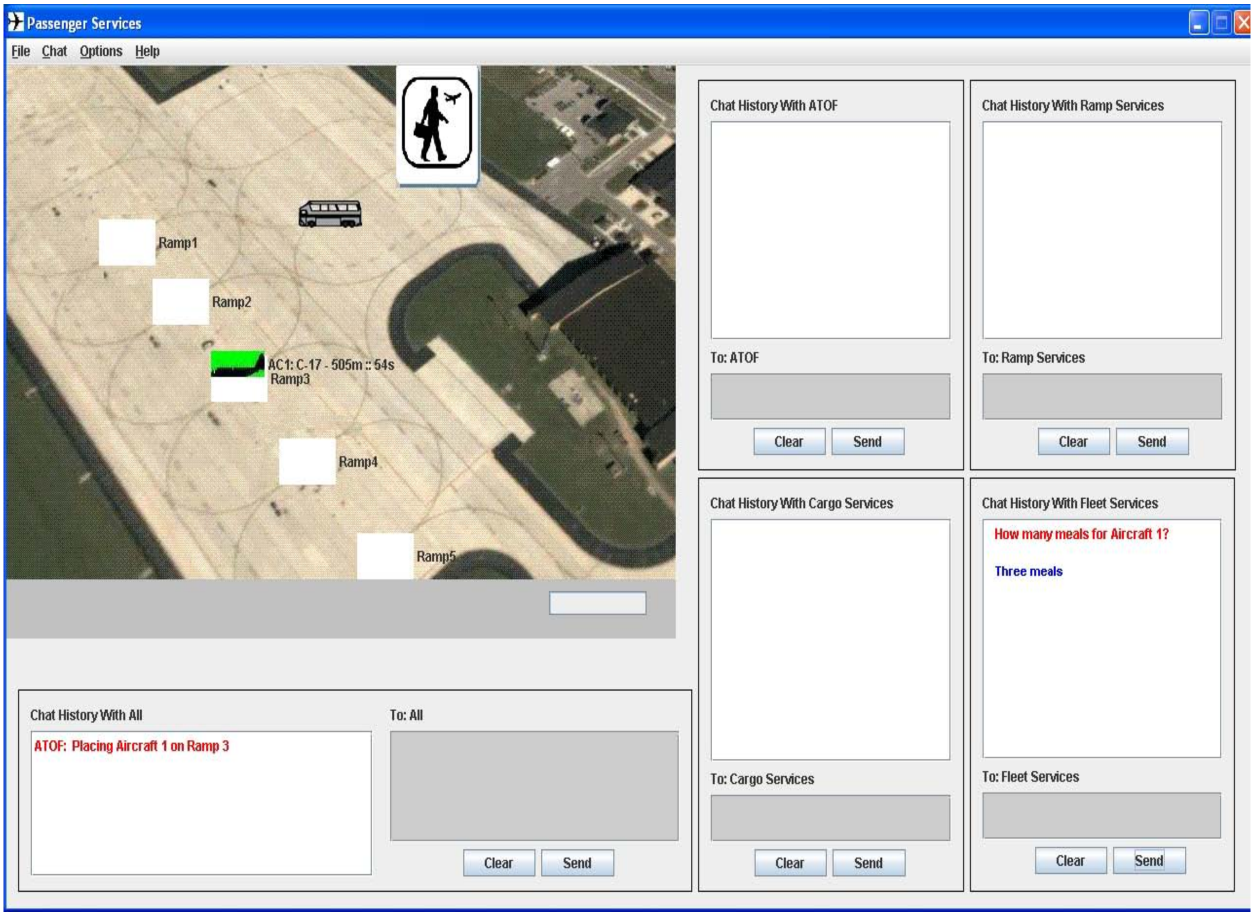
APPENDIX A: EXAMPLE CAPS INTERFACE



LIST OF ACROYNMS

AFRL	Air Force Research Laboratory
AMOS	Alpha Micro Operating System
ANOVA	Analysis of Variance
AP	Adaptive Performance
ATOF	Air Terminal Operations Flight
AJP	Adaptive Job Performance
CA	Cultural Adjustment
CAPS	Computer-based Aerial Port Simulation
CFA	Confirmatory Factor Analysis
CS	Cargo Services
EECT	Experimental Evaluation of Collaborating Teams
ER	Emotion Regulation
FFM	Five-Factor Model
FS	Fleet Services
ICAPS	Intercultural Adjustment Potential Scale
IM	Instant Messaging
IPIP-FFM	International Personality Item Pool/Five-Factor Model
MLQ	Multifactor Leadership Questionnaire
NATO	National Atlantic Treaty Organization
NCS	Need for Cognitive Structure
OTI	Organizational Trust Inventory
PANAS	Positive Affect Negative Affect Schedule

PA/SA	Primary Appraisal/Secondary Appraisal
PFI	Personal Fear of Invalidity
PNS	Personal Need for Structure
PS	Passenger Services
RHXS	Sensemaking and Organizational Effectiveness Branch
RS	Ramp Services
SAS	Stressor Appraisal Scale
SEM	Structural Equation Model
TACS	Technology for Agile Combat Support