A MULTILEVEL, CROSS-DOMAIN INVESTIGATION INTO ADAPTIVE TEAM PERFORMANCE

by

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May you never look too good, nor talk too wise.

In loving memory of Fred L. Wells.

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ABSTRACT

Three research questions were designed to investigate the relationship between individual team-member characteristics and team adaptability. The first found perceptual measures of self- and team-adaptability are related within persons. The second examined perceptual measures of adaptability using social combination models to compare individual members' perceptions of adaptability to the team-level construct of adaptability. Team adaptability was moderately related to the member with the highest self-perceived self-adaptability early in team formation but more strongly related to the average team member's self-adaptability later in training. Finally, team perceptions of adaptability were used to predict team adaptive performance on non-routine trials over time. Team perceptions of adaptability were not found to be related to adaptive team performance.

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CHAPTER I: INTRODUCTION AND LITERATURE REVIEW

Over the past several decades, the proliferation of technological advances, globalization, changing workforce demographics, rifts in the politico-economic climate, and presence of complex, ill-defined workplace problems have been impinging upon organizations (Burke, Stagl, Salas, Pierce, & Kendall, 2006; Ployhart & Bliese, 2006; Pulakos, Arad, Donovan, & Plamondon, 2000). Employees are increasingly faced with discontinuous working conditions characterized by complexity, unpredictability, instability, and novelty (Kozlowski, Gully, Nason, & Smith, 1999). Organizations' focus on restructuring to team-based work can be seen as one of many efforts to enable the flexibility needed in today's dynamic workplace environment (LePine, Hanson, Borman, & Motowidlo, 2000). This restructuring pushes problem-solving to a more proximal position relative to the source: the team (Kozlowski & Bell, 2008). Consequently, teams are increasingly becoming the unit of interest in organizational research (Kozlowski & Bell, 2013).

Teams do not merely function as merely a collection of individuals nor are they holistic entities independent of the characteristics of their members (Kozlowski & Bell, 2008). The attributes of individual team members must be considered when researching determinants of team task accomplishment (Steiner, 1972). Much research and theory on team member characteristics has explored deep-level composition variables (Bell, 2007; see also Devine, Clayton, Philips, Dunford, & Melner, 1999) such as cognitive ability (LePine, 2003), dispositional characteristics, such as personality (Barrick, Stewart, Neubert, & Mount, 1998), and teamwork knowledge (Morgeson, Reider, & Campion, 2005). Several empirical studies and recent review articles have called for researchers to investigate the nature of the relationship between individual team-member characteristics and team adaptability (e.g., Baard, Rench, & Kozlowski, 2014; LePine, 2005; Maynard, Kennedy, & Sommer, 2015). Three approaches will be taken to explore this relationship. The first explores theory as to why perceptual measures of adaptability are related at the individual- and team-level. The second examines how attributes of team adaptation determine how members' individual adaptabilities combines to produce the team-level outcome. Finally, shared team perceptions of adaptability will be used to predict adaptive performance over time.

Individual Adaptive Capacity as a Team Composition Variable

A team is defined as two or more individuals who interact socially, exist to perform organizationally relevant tasks, and operate within an organizational context that both constrains and influences exchanges with other units; members maintain and manage boundaries; and members share goals and exhibit task interdependencies, such as workflow, knowledge, and goal accomplishment (Kozlowski & Bell, 2013). Effective teams are composed of effective members (Driskell, Salas, & Hogan, 1987). Indeed, member composition is considered "*the most important* [emphasis added] condition affecting the amount of knowledge and skill members apply to their task" (Hackman, 1978, p. 326). The traits and dispositional characteristics of individual members influence the behavioral and affective responses of other members (Jackson & LePine, 2003), the overall quality of interactions among team members (Hackman, 1992), and can have direct effects on team outcomes (Bell, 2007; Heslin, 1964).

The field of team composition is research focused on "the attributes of team members, and the impact of the combination of such attributes on processes, emergent states, and ultimately outcomes" (Mathieu, Tannenbaum, Donsbach, & Alliger, 2013, p. 527). However, team member characteristics are often not seen as a direct cause of – but rather serve as ambient stimuli *for* instituting informational and affective states (i.e. beliefs and attitudes) as well as member discretionary behavior (Hackman, 1992). A major premise, therefore, of adaptability as an individual difference that influences team-level adaptation is that individual adaptability functions within teams as both an ambient and discretionary stimulus. The adaptability of individual members serves as an ambient stimulus for the team, creating a context for the development of team norms, affective states, and social inertia and informs team assumptions and expectancies. Additionally, individual adaptability impacts team informational and affective states through individual team members' discretionary behavioral contributions (see Hackman, 1992). That is to say, provided individual adaptability is an individual difference that shapes proactive and reactive behaviors (Ployhart & Bliese, 2006), it underlies behaviors that serve as stimuli directly informing other members' beliefs and attitudes about the team as a whole (Hackman, 1992). For example, the behavior(s) of a team member in response to a change in the environment provides information to other team members in their development of team efficacy judgements (i.e., a belief about whether the team as whole can be successful) and/or whether the necessary collaborative re-planning efforts are seen as favorable or unfavorable (i.e., an attitude).

The individual adaptability (I-ADAPT) theory (Ployhart & Bliese, 2006) defines adaptability as "an individual's ability, skill, disposition, willingness, and/or motivation, to change or fit different task, social, and environmental features" (p. 13). Drawing on previous research (Pulakos et al., 2000, 2002), the I-ADAPT framework identifies specific competency dimensions on which people vary: handling emergencies or crisis situations; handling work stress; solving problems creatively; dealing with uncertain and unpredictable work situations; learning work tasks, technologies, and procedures;

demonstrating interpersonal adaptability; demonstrating cultural adaptability; and demonstrating physically-oriented adaptability. In the I-ADAPT framework, individual adaptability is seen as “a reasonably stable, higher-order individual difference construct” that “has both direct and mediated […] effects on performance” (Ployhart & Bliese, 2006, p. 25). This line of research of adaptability as an individual difference construct has proven useful in further defining and conceptualizing adaptability as a *metacompetency* (Baard et al., 2014), or a set of knowledge, skills, and abilities that are influenced by – but sufficiently different from existing individual difference constructs (e.g., conscientiousness).

This approach is distinctly different from the view of adaptation as a performance construct because its focus is on characteristics of the individual(s) rather than on changes in task or environmental demands (Baard et al., 2014). However, research in this domain has been exclusively focused at the individual-level (Baard et al., 2014; e.g., Pulakos et al., 2002), leaving a gap in the literature pertaining as to how teams, like individuals, may also fundamentally differ in their ability and skill to adapt. Moreover, one criticism of the individual difference approach to adaptability is that adaptability is almost exclusively measured using self-report perceptual measures (Baard et al., 2014), yet perceptual measures of ability are intrinsically of interest because of their relationship with motivation (Bandura, 1982).

Team efficacy refers to a team’s “collective belief that it can successfully perform a specific task” (Lindsley, Brass, & Thomas, 1995, p. 648). Empirical evidence supports that, generally, teams are more successful on a task when they believe they will be successful (Gully, Incalcaterra, Joshi, & Beaubien, 2002; Tasa, Taggar, & Seijts, 2007). Perceptions of the team’s capacity (i.e., ability and skill) to adapt are analogous to a specific type of team efficacy, reflecting beliefs about the team's general capacity to change or fit different environmental features. Each individual's perception of the team's ability to adapt could be substantially raised or diminished by a single team member's attributes or behaviors (esp. adaptability). A synthesis of the research literature in this area supports that a single team member can greatly hinder the team (Felps, Mitchell, & Byington, 2006). Additionally, evidence has been found that supports the self-efficacy beliefs of a team leader are related to his or her collective efficacy beliefs, which are also strongly related to the team's collective efficacy beliefs (Hoyt, Murphy, Halverson, & Watson, 2003).

Currently, the nature of the relationship between shared perceived team adaptive capacity and individual perceptions of team adaptability remains unexplored, yet there are at least three reasons to argue for this area of research. First, an individual team member's personal efficacy beliefs are not unrelated to his or her beliefs about the team's efficacy (Bandura, 1982). Extending this argument, beliefs about the general adaptability of the self should then also be related within-persons to the beliefs about the efficacy of the team with regard to adaptation. Additionally, during task accomplishment, members share within-team experiences that influence individual members' perceptions of the team to converge over time (Hackman, 1992). Therefore, second, each team member's perception of the team's adaptability should also be related to the perception of the team's adaptability shared by all team members. Third, this shared perception of efficacy is theorized to drive the team's choice of action(s), effort, and persistence (Bandura, 1982). Because this area of research in the adaptability literature remains largely unexplored, the first research question (RQ) will address the relationship between self- and team-perceptions of adaptability.

RQ 1: At the individual team-member-level, how closely do the within-person self-perceptions of individual adaptability relate to the perceptions of team adaptability?

Several social combination models are used to justify the comparison of individual adaptability to a team-level phenomenon of adaptive team capacity. Social combination models focus on the rules and constraints that govern the production of group outcomes and were first explored with respect to differences in member ability (Steiner, 1972) and later applied to exploring individual member characteristics (see Bell, 2007). This concept is extended to meet a second purpose of this study, which is to investigate the relationship between perceptual measures of individual adaptability and team-level perceptions of team adaptive capacity.

Justifying Aggregation Strategies Using Social Combination Models

While team adaptation is a team-level phenomenon, consisting of team-level behaviors and shared perceptions (Rosen et al., 2011), teams are not independent of the characteristics of their members (Kozlowski & Bell, 2008) and, furthermore, these characteristics may not combine in a simple additive fashion (LePine, Hanson, et al., 2000). Compilation models are “a complex combination of diverse lower-level contributions” and, because of this, used to describe situations where the higher-level construct is something different than a straightforward average of member characteristics (Kozlowski & Klein, 2000, p. 17). The various social combination models, first laid out by Steiner (1972), have proven to be demonstrably useful as aggregation strategies when identifying how individual difference variables used in team composition research (e.g., personality, values, abilities, and intelligence) relate to team functionality in compilation models (Bell, 2007; Peeters, van Tuijl, Rutte, & Reymen, 2006). The major premise of the social combination model approach is that the characteristics of the task influence how the characteristics of the individuals can be combined to impact the team-level outcomes. In the formation of a team's perception of its adaptability, characteristics of the adaptation process may influence how individual members' self-perceptions are related to the team.

Permitted Process Models. The first kinds of social combination models are *permitted processes*. They include disjunctive and conjunctive tasks (Steiner, 1972). In a permitted process, the outcome is generated by one team member, or that a combination of individuals generate the outcome separately and then combine their inputs under the assumption that the characteristics of a single member can influence the task environment of the team (see Kenrick & Funder, 1988). Permitted process models are most suitable for situations in which a single member has an inordinate effect on the team's outcome (Barrick et al., 1998).

If the formation of a shared perception of team adaptability is *disjunctive*, then the team's adaptability will be best represented by the team member with the highest level of perceived individual adaptability. A task is disjunctive when a single team member's contribution must represent the team, and teams perform best if the most capable member's input represents the team's outcome. Some tasks are made disjunctive by being either-or decisions or when the team must accept one final decision-outcome (Steiner, 1972). Team performance on a disjunctive task is typically better than the average individual's performance. In this approach, a single, highly adaptable member can essentially adapt "for the team" by contributing the key responsive behaviors (e.g., back-up, directing coordination, etc.; Burke et al., 2006) and substantially increase the viability of the team's response.

If the formation of a shared perception of team adaptability is *conjunctive*, then the team's adaptability will be most linked to the team member with the lowest level of perceived individual adaptability. A task is conjunctive when the task rules or environmental constraints dictate that the team's outcome be tied to the "weakest link" or lowest-ability member (Steiner, 1972). The team can neither rely on selecting a single outcome nor has a single outcome represent the team. This approach is most suited to situations in which team members cannot compensate for one another with respect to task-relevant characteristics (LePine, 2003), or when every team member must contribute to the team's outcome (Steiner, 1972). One example in the literature of a conjunctive task is the assembly line. Technicians may be able to somewhat compensate for a poor performing member; however, because of the nature of the task, the poor performing technician can severely limit the performance of the line. A single poor performer could substantially diminish the team's ability to adapt. This is especially true when team members have low horizontal substitutability (i.e., non-redundant roles) and must rely on one another's specialized abilities (e.g., LePine, Hollenbeck, Ilgen, & Hedlund, 1997). The dynamic interdependencies required by the team-level adaptation processes (e.g., role-structure adaptation) suggests that in some teams, adaptation may be conjunctive.

Prescribed Process Model. Just discussed were two social combination models that can be categorized as permitted processes, wherein a single member's characteristics significantly influences the outcome because task characteristics permit this influence. An additional social combination model that argues for the significant influence of a single member's characteristics on the team's outcome is the *prescribed process* (Steiner, 1972). In the prescribed process model, task demands *prescribe* the processes required to achieve maximal success. Inherent to teams are team roles (Hackman, 1987). A core role is defined as encountering more team problems, having greater team-task exposure, and being more central to the workflow than other team roles (Humphrey, Morgeson, & Mannor, 2009). The adaptability of a core-role team member could significantly impact the team's formation of adaptability. The characteristics of a person directly responsible for handling adaptive performance episodes may significantly weigh on the team's ability to combine disparate inputs, problem-solve and make decisions, and handle overall team coordination.

Compensatory Model. If the formation of team adaptability is *compensatory*, then the mathematical average of the members' adaptive capacity scores will be the best representation of the team's adaptability because low-ability members will be compensated for by high-ability members (LePine et al., 1997; Steiner, 1972). The compensatory model is a compositional model, differing from the previously discussed compilational models, in that team members' contributions are equally weighted (Kozlowski & Klein, 2000). In the compensatory model, the team's performance should exceed a substantial number of the individual members' performance (Steiner, 1972). Using the mean presents its own problems, however. For instance, this approach assumes that increases in the adaptive capacity of any member will contribute to the overall team-level characteristic of adaptability and that more adaptive capacity is always better regardless of distribution across the team members (Barrick et al., 1998). Furthermore, it assumes that the similar constructs of individual adaptability and team adaptability operate equivalently despite being at different levels of analysis (Chan, 1998; LePine, Hanson, et al., 2000). Nevertheless, average member cognitive ability has been used to predict team performance (LePine, Colquitt, & Erez, 2000), and meta-analytic evidence suggests that the team average on composition variables, such as personality, provide useful insights (see Bell, 2007). Further, the composition model is plausible for team adaptability to the extent that the adaptation process is compensatory (Kozlowski & Bell, 2008).

Dispersion Model. On tasks in which team outcomes benefit from diverse inputs, the variability in a composition variable may be the best representation of the team-level construct (Barrick et al., 1998, p. 379). In the *dispersion model*, variability in within-team agreement is seen as the operationalization of the focal construct, as opposed to error variance (Chan, 1998, p. 239). The index of heterogeneity in scores is, by-definition, a team-level characteristic but may not be a team-level construct. Previous studies of within-group heterogeneity on a composition variable have included personality characteristics (Hoffman, 1959; Hoffman & Maier, 1961; Peeters et al., 2006) and member ability (Terborg, Castore, & DeNinno, 1976). In a team, if the distribution of adaptive capacity among team members is highly variable, meaning some members are fully capable of adapting while others are significantly less so, the team as a whole may not be able to fully adapt. As objectives or task strategies spontaneously change, an effective team-level response would be inhibited by the team's shared sense of uncertainty and by instability in the adjustment of individual members to uniformly meet new challenges.

The social combination models described above will be used explore the relationship between individual perceptions of self-adaptability and the overall team's perception of its ability to adapt.

> RQ 2: Which aggregation strategy of individual team members' self-perceptions of adaptive capacity shows the strongest relationship with the team's perceived adaptive capacity?

Using Perceptions to Predict Adaptive Team Performance

Despite theory suggesting adaptation as an unfolding dynamic process (Burke et al., 2006; Rosen et al., 2011), many studies in the adaptation literature fail to examine performance trajectories (Baard et al., 2014). An additional purpose of the present study is to examine adaptive team performance over multiple novel, non-routine trials using team-level perceptions of team adaptability as a predictor. The predictor, team adaptability, represents a team's willingness, skill, or ability to change or fit external features (Ployhart & Bliese, 2006). Adaptive team performance is the team-level outcome, which consists of team-level behaviors related to adaptation such as coordination, mutual monitoring, back-up behavior, and communication (Rosen et al., 2011). This study crosses multiple domains of adaptation research (Baard et al., 2014, namely adaptation as a dynamic process, performance construct, and a team-level difference), and is multilevel in nature, as the multiple observations of adaptive team performance over time are nested within teams.

Team members' self-judgements of their own capabilities influence their choice of task-specific actions, how much effort is to be expended, and persistence in task-completion (Bandura, 1982). This is true whether the self-judgements are accurate or fallacious. Additionally, before, during, and after transacting with the environment, these self-judgements influence attitudes (i.e., affective states) and beliefs (Bandura, 1982). When applied to the team, these principles would suggest that team self-perceptions have significant import in task accomplishment. Research on the efficacy-performance link strongly suggests that team-efficacy does for teams what self-efficacy does for individuals, driving team effort, degree of persistence, and guiding team behaviors (Kanfer, 1990). Team-efficacy refers to a team's "collective belief that it can successfully perform a specific task" (Lindsley et al., 1995, p. 648). Empirical evidence supports that, generally, teams are more successful on a task when they believe they will be successful (Gully et al., 2002; Tasa et al., 2007). If self-judgements on the ability and skill to adapt to novel situations is a specific kind of efficacy (Pulakos et al., 2002), then team self-judgements on adaptive capacity represent a task-specific team-efficacy judgement.

The *referent-shift consensus composition* model (Chan, 1998) is the preferred method and frequently used to measure collective efficacy (see Gully et al., 2002). This method follows recommendations made in the organizational behavior research literature to avoid model misspecification and bias in aggregation (Rousseau, 1985). The model has been used to examine team-level adaptive capacity (e.g., Marques-Quinteiro, Ramos-Villagrasa, Passos, & Curral, 2015) by modifying an individual difference measurement scale (Ployhart & Bliese, 2006). Using the domain-general approach (Baard et al., 2014), the construct of adaptability represents a team's "ability, skill, disposition, willingness, and/or motivation, to change or fit different task, social, and environmental features" (Ployhart & Bliese, 2006, p. 13). Within the content, the referent is changed from *self* to *team*, but the content of the original construct remains unchanged. At the individual-level, therefore, the new construct represents the individual members' perception of his or her team's adaptive capacity. Aggregation of the team members' perceptual scores to represent a team-level (i.e. task-specific team-efficacy) construct can then be justified using within-group consensus methods (Chan, 1998; see also Woehr, Loignon, Schmidt, Loughry, & Ohland, 2015).

This referent-shift consensus model of team adaptive capacity, using the theoretical definition of individual adaptability (Ployhart & Bliese, 2006), is consistent with other researchers' conceptualization of team adaptability (Gibson & Birkinshaw, 2004; Gorman, Cooke, & Amazeen, 2010; Marques-Quinteiro et al., 2015) in that teams must have the capacity (i.e. the ability and skill) to change or fit different task or environmental features. Furthermore, and by analogy, this conceptualization of team adaptive capacity is consistent with Bandura's (1982, p. 143) call to design measures of collective efficacy in the execution of specific strategies. Due to both the self-report nature and referent-shift consensus method, team adaptive capacity scores will be representative of a shared perception of the team's ability to adapt to a changed task or environment. This approach to a domain-general, team-level characteristic of a shared perception of the team's ability and skill to adapt is currently lacking in the research literature (see Baard et al., 2014), but may be a critical construct in determining team-level adaptive performance.

In sum, shared beliefs in the team's ability and skill to adapt to novel or changing situations are expected to influence both the individual team members' and team-level inputs through behavior selection, motivation to persist, and amount of effort. Teams with higher adaptive capacity should perform better, but it is unclear how the perceptual measure will be related to team adaptive performance over time. This leads to the research question (RQ):

RQ3: Can team-level perceptions of adaptability predict a team's ability to perform on novel tasks over time?

CHAPTER II: METHODOLOGY

Permission to obtain and analyze archival data previously collected under an approved protocol was granted by the institutional review board using a regular exempt form. The letter of approval is located in Appendix A.

Participants

Participants were recruited from a senior-level undergraduate aerospace course at a southeastern university. All data were collected with the participants' consent. Participation in the course was required for graduation, but participation in any research sessions was completely voluntary. All participants in the study had previously received extensive academic training in their respective aerospace concentrations (e.g., aviation management, flight dispatch, maintenance management, or professional pilot). Data were collected from all participating students who were enrolled during the academic semester. Data from 153 individuals are included. Each semester, incoming participants were assigned to teams by the course instructor based on their academic concentration and matched to a position within the research setting. Twenty-three teams were constructed in this way.

Task Apparatus

Overview. The flight operations center – unified simulation lab (hereafter referred to as the *lab*) is an interactive room that is an analog for a regional flight dispatch center, providing a highly realistic environment for team-training purposes. The lab incorporates participation from multiple physical locations and uses many software components. It is designed for ten-person teams. During a session in the lab, routine operational control is standard for all participating teams and requires the compilation of information from multiple aviation specialties to correctly (i.e., legally) dispatch digital flights that are simulated on a radar screen. Sessions in the lab are structured to last two and half hours. Following an onboarding training and completion of training modules, teams are given operational control of a simulated airline within lab for three 2.5-hour sessions during the academic semester. Each session in the lab is progressively more difficult than the previous in that participants are exposed to qualitatively more difficult simulated nonroutine trials and quantitatively more of these nonroutine trials (further discussed later). On average, during each session, teams dispatch about 40 flights with each one requiring decisions and inputs from multiple team members. See Figure 1 for a layout of the lab.

Positions. Seven participants are given operational control of the dispatch center and tasked with dispatching flights in accordance with Federal Aviation Administration (FAA) regulations. Two of the participants are located at a nearby airport and fly a simulated flight in a CRJ 200 aircraft simulator, which is linked to the dispatch center. The final team member is situated in a separate room that simulates a ramp tower. The positions are listed here:

1) Flight Operations Coordinator
2) Flight Operations Data 1 – Planning & Scheduling
3) Flight Operations Data 2 – Weight & Balance
4) Crew Scheduling
5) Weather & Forecasting
6) Maintenance Control
7) Hub Coordinator (Logistics)
8) Ramp Tower
9) CRJ – First Officer

10) CRJ – Captain

The positions within the lab are interdependent and each is provided with a wide array of data to consider. Some examples include: a plane maintenance issue may be problematic only if the plane's flight path comes near known icing conditions; or when weather conditions call for more additional fuel, requiring the plane's weight and balance to be recalculated, which could result in passengers and/or cargo being removed and rerouted. Verbal and electronic communication (via instant messenger service) are used by participants to communicate with one another.

Additionally, participants have access to lab staff both inside and outside the lab with the ability to verbally or electronically request help or seek advice. Lab staff would provide guidance regarding technical information but would not direct actions. The lab staff consists of both professors and graduate teaching assistants from the psychology and aerospace departments.

Due to the nature of the work conducted, data were only included from the first seven participant positions who are located in the dispatch center. These seven positions best fit the definition of a team (Kozlowski & Bell, 2013) and their adaptation and adaptive performance is of interest to the researchers.

Nonroutine Trials. Simulated environments are frequently used in safety-critical industries (e.g., aerospace and nuclear power) to train individual and teams to handle nonroutine situations by recreating and exposing teams to highly realistic scenarios (Stanton, 1996, p. 117). Simulation-based training environments, such as the lab, are ideal for studying the handling of nonroutine events (Gorman et al., 2010, p. 305; Maynard et al., 2015; Rosen et al., 2011, p. 114), especially over time (Baard et al., 2014). Numerous examples using laboratory settings can be found in the literature (e.g., Fowlkes, Lane, Salas, Franz, & Oser, 1994; Kozlowski et al., 2001; LePine, 2003, 2005; Marks, Zaccaro, & Mathieu, 2000; Resick et al., 2010).

Each team experiences a total of 11 nonroutine events, or *trails*, that are initiated by the research team, throughout their time in the lab during the academic semester. Two occur during the first session; four occur during the second session; and five occur during the third session. See Figure 2 for an overview. These nonroutine trials are designed based on real-world events and create coordination demands requiring team collaboration and problem-solving such as reallocating resources, which would be unsafe to test in a real operations center. Some examples of these trials include: a passenger having an in-flight heart attack, a pilot who falls off the gate bridge and breaks her arm right before take-off, and a security airport closure.

Adaptation Requirements. A pool of nonroutine trials, based on real-world events that have affected the aviation industry, were designed by the research team and intended to create team-level disruptions, inducing adaptation requirements such as collaborative re-planning. A final bank of 17 nonroutine trials was agreed upon by the research staff. Each of the trials was organized and standardized within one of six types based on the individual- and team-level required responses, which allowed trials within a given type equivalent and, therefore, interchangeable across sessions and between teams. Each type presents unique coordination obstacles to the team, but trials within the same type require the same responses even though the prompt may be different. See Figure 2 for a timeline of how the trails were presented to the teams throughout the academic semester.

Nonroutine scenarios were implemented by lab staff using a scripted process, which depended on the type of scenario. The six types are listed here:

- In-flight emergency involving a passenger
- On-the-ground maintenance issue arising immediately before take-off
- Flight crew member losing ability to fly
- On-the-ground weather-related maintenance problem arising after landing
- Airport or runways closures
- Plane experiencing an in-flight maintenance emergency

Data Collection

Data were collected throughout four academic semesters, beginning in the Fall semester of 2016 and ending in the Spring semester of 2018. Class and/or lab sessions were held once a week for each team. Participation within the academic semesters was broken down as follows:

A) onboarding class

B) online training period

C) in-class hands-on training period

D) session in the lab

E) performance feedback

D) and E) repeat two additional times during the semester. Participants were onboarded the first week of the academic semester, simulating the hiring process of a regional airline and increasing the psychological fidelity of the lab (Bowers & Jentsch, 2001). During onboarding, participants were notified of their assigned team and position for the lab. Assignment decisions were based on the participant's academic concentration. Over the next week, they participated in online training for their assigned positions. During the class meeting following the onboarding session, participants received hands-on training inside the lab. Following this training exercise, participants were asked to complete a series of questionnaires. During this post-training data collection session, participants were asked to self-report on their individual adaptability.

Following the training week, teams, as an in-tact unit, participate in three 2.5-hour sessions per academic semester, during which the teams are given operations control of a simulation small regional airline. On average, during those sessions, teams dispatch about 40 flights. Teams receive performance feedback after each session as an in-tact team from a trained facilitator. Performance feedback sessions provide participating teams with information such as financial data and qualitative information regarding team processes. (For more information about the team training process and performance feedback see Littlepage, Hein, Moffett, Craig, & Georgiou, 2016). At the conclusion of each performance feedback session, teams moved from a conference room to a computer lab, and participants individually completed an online survey in the presence of a lab staff member.

Measures

Participants completed an online questionnaire to capture adaptability. Members of the research staff served as subject matter experts (SMEs). They provided ratings on each team's adaptive performance on multiple nonroutine trials.

Adaptability. The individual adaptability measure (I-ADAPT-M) was designed to assess an individual's "ability, skill, disposition, and/or motivation to change or fit different task, social, and environmental features" (Ployhart & Bliese, 2006, p. 13) through the measurement on a constellation of dimensions previously identified as required to do so (Pulakos et al., 2000; 2002). Previous research supported the eight-factor structure of the I-ADAPT-M was a good fit and found the reliabilities of the subscales to be acceptable (Ployhart, Saltz, Mayer, & Bliese, 2002). Forty-one items reflecting the six dimensions we believe to be most relevant to the research setting were included. They are a) ability to deal with crisis situations (e.g., “I think clearly in times of urgency”), b) ability to deal with work stress (e.g., “I usually over-react to stressful news”), c) ability to deal with uncertainty (e.g., “I need for things to be ‘black and white’), d) ability to deal with interpersonal issues (e.g., “I try to be flexible when dealing with others”), e) creative problem-solving ability (e.g., “When resources are insufficient, I thrive on developing innovative solutions”, and f) ability to learn from experience (e.g., “I often learn new information and skills to stay at the forefront of my profession”). A full list of items for the I-ADAPT-M and their dimensions is located in Appendix B. Although the authors of the I-ADAPT-M and I-ADAPT theory encourage the measurement of all eight dimensions, the omission of task-irrelevant dimensions is consistent with previous research (e.g., Griffin & Hesketh, 2003; Stokes, Schneider, & Lyons, 2010). Participants self-reported using a Likert scale (1 = *strongly disagree*, 5 = *strongly agree*) after completing the in-lab training session (see Figure 2).

Team adaptability was measured by modifying the I-ADAPT-M using the referent-shift consensus approach (Chan, 1998; for an example, see Marques-Quinteiro et al., 2015). This measure was completed individually by participants after the first performance feedback session. For each of the 41 items, the referent was changed to the participants’ team (i.e., changing “I” to “Our team” and making necessary changes in the body of text). See Appendix C for a list of the items for the T-ADAPT-M. The referent-shift was deemed a more appropriate approach than aggregating team members’ perceptions of their own individual adaptability because the latter approach only provides information about how the average team member perceives his or her adaptability. When aggregated, the team adaptability measure (T-ADAPT-M) reflects the collective perception of the team's ability, skill, disposition, willingness, and/or motivation to adapt. An example of a work stress item would be "Our team is usually stressed when we have a large workload." Participants gave their responses using a Likert scale (1 = *strongly disagree*, 5 = *strongly agree*). Team adaptability was collected twice: once after Session 1 and once after Session 3.

Adaptive Performance. Teams' adaptive performance on multiple nonroutine trials was evaluated based on select behaviors in which team members engaged in when responding to the trial. During each session, lab staff members (i.e., SMEs) took notes on the team's performance, recording qualitative performance data. Following each session, the SMEs met for a structured research meeting to provide ratings on how effectively teams adapted to each of the nonroutine trials. During these meetings, each nonroutine trial was discussed in sequence, and SMEs notes were combined. The team's performance was discussed openly (and sometimes frankly) to identify discrepancies, share additional performance information with one another, and further notes were made. During the meeting, the meeting notes were displayed for the team of SMEs to reference. After a thorough discussion of the team's performance on a particular nonroutine trial, each SME provided an individual rating on how effective the team was at handling the nonroutine trial before moving on to the next trial. Ratings were provided using a 7-point behaviorally-anchored rating scale (BARS; 1 = *extremely ineffective*, 7 = *extremely effective*). The format and details for the BARSs for each type of nonroutine trial are located in Appendix D. The behavioral anchors describe (either implicitly or explicitly) individual-level markers of the adaptive performance process as it emerges (Rosen et al., 2011; e.g., cue recognition, coordination, back-up behavior, mutual monitoring, team communication, and meaning ascription).

BARS have used by researchers evaluating how individuals and teams meet adaptation requirements (e.g., Chen, Thomas, & Wallace, 2005; Entin & Serfaty, 1999). Behaviorally-anchored rating scales have also been found to reduce rating errors (Campbell, Dunnette, Arvey, & Hellervik, 1973), and have been previously identified as an ideal way to capture bottom-up changes in team performance (see Rosen et al., 2011). In this study, the BARS focused on specific behaviors in which any one team member could engage (e.g., requesting emergency services). Additionally, the BARS contained some position-specific behaviors that only one team member could perform, but any team member could identify as being required (e.g., requesting maintenance after a bird-strike on an engine).

Analytic Approach

Research Questions 1 and 2 will be explored via null hypothesis significance testing using the Pearson product-moment correlation coefficient. The aim of Research Question 1 is to examine how closely self-perceptions of adaptability are related to perceptions of the team's adaptability within each person, so perceptions of self-adaptability (I-ADAPT-M) will be correlated with perceptions of team adaptability (T-ADAPT-M) within each person (at the individual-level). Research Question 2 seeks to determine which aggregation strategy of individual members' adaptability demonstrates the strongest relationship with the team-level team adaptability: several different models using self-report adaptability of team members (I-ADAPT-M) will be used to represent the team and will be correlated with the aggregated perceptions of the team's adaptability (T-ADAPT-M).

Research Question 3 explores the relationship between team-level perceptions of team adaptability and adaptive team performance. Research Question 3 will be explored using repeated measures multiple regression (RMMR, Cohen, Cohen, West, & Aiken, 1983; Hollenbeck, Colquitt, & Gully, 1998; Hollenbeck, Ilgen, & Sego, 1994; for an example, see Marks et al., 2000). RMMR is a multilevel data analysis technique that can examine the longitudinal effect of continuous predictors on a continuous outcome. RMMR will be used to test the simultaneous and incremental influences of time (i.e., chronological trial number) and team-level perceptions of adaptability (T-ADAPT-M) on adaptive performance (i.e., SME ratings on BARS). Since the research question involves predicting adaptive performance scores of teams over time, performance scores on trials are located at Level 1. A summary of the longitudinal model used to predict adaptive team performance is provided in Appendix E.

To begin, Eq. (1) is proposed:

$$\text{Level} - 1: \quad perform_{ij} = \beta_{0j} + \beta_{1j} time + \varepsilon_{ij} \tag{1}$$

Here, a level-1 predictor, *time*, is introduced and is operationalized by the chronological trial index. This index represents time because the trials occur in a sequence throughout the sessions (see Figure 2). Eq. (1) states that the predicted adaptive performance score on the i^{th} trial within the j^{th} team ($perform_{ij}$) will be a function of a) the average adaptive performance score of team j when time is equal to zero (β_{0j}) plus b) the effect of time on adaptive performance scores for team j (β_{1j}) plus c) the variation in performance for the i^{th} trial within the j^{th} team after controlling for the effect of time (ε_{ij}).

Level 2 has two equations using a single predictor. The first allows team adaptability (*adapt*), as a level-2 (or team-level) predictor, to have an effect on the starting point of team performance (i.e., the intercept). Conceptually, when time is equal to zero, this represents an average baseline measure of adaptive team performance. Eq. (2) allows for a team's adaptability to have an effect on the baseline adaptive team performance score. Essentially, the baseline level of adaptive team performance for team *j* is predicted to be related to team *j*'s adaptability. The second Level 2 equation allows team *j*'s adaptability (*adapt*) to strengthen (or weaken) the relationship between time and its performance score (i.e., the slope). To model the baseline adaptive performance score for the *j*th team, Eq. (2) is proposed:

$$\text{Level} - 2: \quad \beta_{0j} = \quad \gamma_{00} + \gamma_{01} adapt + u_{0j} \tag{2}$$

Eq. (2) predicts the baseline performance for team j, or average performance when time is equal to zero. The predicted baseline for team j (β_{0j}) will be a function of a) the overall average of adaptive performance across all trials and all teams (γ_{00}) plus b) the effect of team adaptability on adaptive performance (γ_{01}) plus c) team *j*'s specific variation in the average trial performance (u_{0j}). This implies teams higher (or lower) in adaptability will have higher (or lower) starting levels of adaptive performance. The usefulness of using team adaptability to predict the baseline levels of adaptive team performance will be tested for significance.

Eq. (3) models the impact of team adaptability on the relationship between time and performance:

$$\text{Level} - 2: \quad \beta_{1j} = \gamma_{10} + \gamma_{11} adapt + u_{1j} \tag{3}$$

Eq. (3) allows for the relationship between time and performance to be modeled and vary between teams depending on their adaptability (*adapt*). Adaptability is added, again, as a level-2 predictor, The predicted relationship between time and adaptive performance for team j (β_{1j}) will be a function of a) the estimated overall relationship between time and performance (γ_{10}) plus b) the effect of team adaptability on the time-performance relationship (γ_{11}) plus c) team j's specific variation in the time-performance relationship (u_{1j}). This implies that a team's rate of change (or "slope") for trial performance over time can be predicted using the team's adaptability.

Eq. (4) is created by beginning with Eq. (1) and substituting values from the two Level 2 equations. The combined equation, Eq. (4), is comprised of Eq. (1) through Eq. (3), with the β_{0j} value (representing the predicted baseline measure of adaptive team performance) in Eq. (1) being substituted by Eq. (2). Similarly, the β_{1j} (representing the predicted time-performance relationship) in Eq. (1) is substituted by Eq. (3). The fixed effects (γ-values) are presented on the first row with the random effects (i.e., the u- and ε -values) presented on the second row:

$$perform_{ij} = \gamma_{00} + \gamma_{10}time + \gamma_{01}adapt + \gamma_{11}adapt(time) + u_{1j}time + u_{0j} + \varepsilon_{ij} \quad (4)$$

The model will be estimated using full information maximum likelihood, so the best fitting model, as determined by an analysis of variance on the fit statistics (and AIC, BIC, and χ^2 goodness-of-fit), can be identified through model comparison. An alpha of .05 was selected for all analyses.

CHAPTER III: RESULTS

Analyses were conducted using SPSS version 23 and *R* "Single Candle" version 3.4.1. The reliability of the I-ADAPT-M was found to be acceptable, with an internal consistency reliability estimate of .95 (i.e., Cronbach's α = .95), and McDonald's (1999) omega, which represents the general factor saturation of a test, estimated at .76. The T-ADAPT-M also demonstrated acceptable levels of internal consistency reliability (α = .94), but because of its multilevel nature, general factor saturation was not estimated.

Team-level perceptions of adaptability represents the criteria in Research Question 2 and is the predictor variable in Research Question 3. Because the approach selected was the referent-shift consensus method, the T-ADAPT-M measure was evaluated based on estimates of interrater reliability and team member agreement. Intraclass correlation (ICC) coefficients were used to determine reliability. ICC1 (also ICC in the mixed-effects model literature) represents the percentage of (overall) variance in ratings due to team membership. When ICC1 is calculated for a dependent variable, it is typically used to determine the whether the data are nested, or if the variable is affected by its membership in a group. Conversely, when ICC1 is calculated for an independent variable, it is used to measure interrater reliability (Bliese, 2000). In both cases, the more similar team members to one another than to members of other teams, the higher the ICC1 value will be. ICC2 is conceptualized as a between-team measure of reliability, or whether the teams can be reliably differentiated based on average score (Bliese, 2000). The general consensus for regarding ICC2 values within the team research literature is that ICC2 values should be > .70, but recommendations for ICC1 vary due to the effect of team size on ICC1 and even the nature of the construct (Woehr et al., 2015).

ICCs were calculated using the *multilevel* package in *R*. Overall, the T-ADAPT-M demonstrated some degree of interrater reliability, ICC1 = .10, ICC2 = .41, $F(22, 114) = 1.69$, $p < .05$. A value of .10 is consistent with a medium effect of group membership on scores (LeBreton & Senter, 2008). Additionally, about half of the teams *did* demonstrate moderate within-team agreement or better on their ratings of the team adaptability, $\text{Median}_{rwg(j)} = .70$ (James, Demaree, & Wolf, 1984; LeBreton & Senter, 2008). The mean of the T-ADAPT-M will still be used to represent teams' adaptability because it accurately represents the average team member's perception of the team.

Research Question 1: Within-Person Self-Perceptions of Adaptability

To answer the first research question, within-person perceptions of individual adaptability ($M = 3.95$, $SD = 0.42$) before training were correlated with perceptions of team adaptability ($M = 3.83$, $SD = 0.62$) after the first lab session. Due to missing values, the sample size for this Pearson bivariate correlation was limited to 128. A moderately strong, statistically significant relationship between the two perceptual measures was found, $r(126) = .44$, $p < .05$. These results support that a person's perception of his or her own ability to adapt are indeed related to that person's perception of his or her own team's ability to adapt, but the two constructs are sufficiently different.

Research Question 2: Social Compilation Models of Individual Adaptability

Table 1 shows the summary statistics for the aggregated data. Exploratory comparisons between aggregated perceptions of team adaptability and the various social composition models was conducted using Pearson correlations. The relationship between team adaptability and the best member's individual adaptability was statistically significant but not the worst member's, $r(21) = .47$, $p = .023$ versus $r(21) = -.18$, $p = .413$. The relationship of the team's adaptability with the core member's, the average member's, and the variability in team members' adaptability were not statistically significant, $r(19) = -.17$, $p = .461$, $r(21) = .29$, $p = .182$, $r(21) = .36$, $p = .092$, respectively. These results suggest that the disjunctive model is informative and viable, $r(21) = .47$, $p = .023$. This correlation of .47 indicates that average team-member perception of the team's ability to adapt is moderately-to-strongly associated with the perception of the team's member who has the highest view of his or her own ability and skill to adapt. In other words, about 22% of the variation in team-level perceptions of adaptability is being predicted by the level of perceived individual adaptability of each team's best individual member (or the member with the highest self-view of his or her own ability and skill to adapt).

Supplemental Analyses. A visual inspection of the scatterplots comparing the various social comparison models with team adaptability led to the identification of an anomalous data point. Figure 3 contains both the dispersion and compensatory model scatterplots as examples. One team's data did not follow the same pattern as the other teams'. This led to the consideration of other, non-parametric methods of correlation as opposed to deleting an entire team from the dataset. The correlational analyses from above were rerun using Spearman's rho (ρ). Results suggest that the disjunctive, compensatory, and dispersion model are variable, $\rho(21) = .597$, .517, and .437, p-values = .003, .012, and .037, respectively. No support for the conjunctive model was found, $\rho(21) = .008$, $p = .970$. Additionally, the data again failed to support the prescribed process model, $\rho(19) = -.045$, $p = .847$.

Research Question 3: Adaptive Team Performance

Table 2 contains descriptive statistics, correlations, and estimates of reliability coefficients for adaptive team performance on the non-routine trials, along with team adaptability (which is repeated from Table 1). Scores given by SMEs were averaged per trial so that each team had nine scores, one for each of the nonroutine trials occurring after Session 1 (see Figure 2). This allowed a period of time for member perceptions of team adaptability to develop. Subject matter experts' (SME) ratings of adaptive team performance on nonroutine trials demonstrated a high degree of interrater reliability, with at least 50% of the variation in scores within each trial being attributable to teams. ICC2 indicates that teams could be reliability distinguished based on their trial score ($ICC2_{min}$ = .89). Figure 4 contains histograms of adaptive team performance segmented by trial number. Interestingly, adaptive team performance across the nine non-routine trials were uncorrelated ($r_{average}$ = .11), indicating that performance on trials was generally unrelated. Additionally, the analyses did not find a statistically significant relationship between team adaptability and adaptive team performance on any of the trials.

See Figure 5 for a visual representation of adaptive team performance grouped by trial number on the *x*-axis and an ordinary least squares fit-line superimposed for each team. Adaptive team performance scores at the disaggregate-level and chronological trial number were correlated to determine if, on average, scores increased or decreased over time – regardless of team. Results suggest that adaptive performance scores do not change significantly over time, $r(197) = .09$, $p = .203$.

Variance partitioning was first conducted (Hollenbeck et al., 1998). Total variance for all observations of adaptive team performance is 2.64 ($M = 4.73$, $SD = 1.62$, $SE = 0.14$). An average adaptive performance score across the nine trials was calculated for each team, so that each team had a single score representing average adaptive performance. The between-team variance was calculated by dividing the variance of the performance scores after they were averaged by team (.47) by the total variance (of 2.64), which demonstrates only 17.9% of the variance in total scores being due to between-team differences in adaptive team performance scores and 82.1% being due to within-team differences. This suggests that most of the variability in adaptive performance is at the trial level.

Next, the random intercept and random slope model, as hereinbefore described in the analytic approach section, was run using the *lme* package in *R*. Both team adaptability and time were entered as fixed effects on random intercepts, allowing team adaptability and time to predict different baselines or starting levels of adaptive performance for each team. The interaction of time and adaptability was entered as a fixed effect on random slopes of performance, which tests for the multiplicative effect of adaptability over time. This allows for the time-performance to vary between teams based on team adaptability, such that teams higher in adaptability will have higher rates of change in performance over time. Time was also entered as a random effect, which allows for performance to vary within-teams after controlling for the effect of adaptability. See Table 3 for model estimates for the model proposed in the analytic approach.

Fit and model comparison statistics are contained in Table 4. Models were compared using the *anova* function in *R*. The proposed model did not significantly improve the null model, which had no predictors. Furthermore, none of the fixed effects were statistically significant. The proposed model explained 2% of the total within-team variation in adaptive team performance, or 2% of 17.9%, $R^2_{within-team} < .01$. The estimated intercept for the model was not significant, γ_{00} = 5.75, $F(1, 174) = 2.10$, p =

.149. Time did not have a significant effect on teams' performance, γ_{10} = -0.09, $F(1, 174) = 0.03$, $p = .722$. Additionally, the effect of team adaptability on adaptive team performance was not significant, γ_{01} = -0.37, $F(1, 20) = 0.13$, $p = .859$. This finding is consistent with the previously reported Pearson correlations (see Table 2) that suggest team adaptability is not related to performance scores on any of the trials. And, finally, the multiplicative relationship between team adaptability and time with performance was also non-significant, γ_{11} = 0.04, $F(1, 174) = 0.09$, $p = .770$. None of the random effects' confidence intervals included zero (see Table 3), which suggests that each is statistically significantly greater than zero. At the trial-level (Level 1), trial performance does differ significantly within teams. At the team-level (Level 2), the adaptive team performance does differ significantly between teams even after controlling for the effect of Level 1. The variation in team-level slopes (u_{1j}) suggests that performance trajectories are positive and significantly different from zero, but the variation in this effect across all teams is small.

Supplemental Analyses. Subject-matter experts also provided ratings on trial difficulty. The trial difficulty scores were negatively correlated with adaptive team performance scores, $r(197) = -.311$, $p < .001$. Suggesting that as trial difficult ratings increased performance by teams on the trials decreased. Additionally, at the end of the academic semester, the T-ADAPT-M was re-administered to see if student's perceptions of the team's adaptability had increased. A paired-sample *t*-test was used to compare the mean ratings of team adaptability after one session in the simulator ($M = 3.84$, $SD = 0.35$, $SE_{Mean} = 0.07$) with perceptions of adaptability after two additional session in the simulator ($M = 3.91$, $SD = 0.31$, $SE_{Mean} = 0.07$). Results suggest that team-perceptions did not increase, $t(21) = 0.89$, $p = .382$, but estimates of reliability increased, ICC1 = .35, ICC2 = .74, $F(21, 93) = 3.87$, $p < .05$.

The social composition models from Research Question 1 were revisited using team adaptability measured after training. See Table 1 for the correlations. The findings were such that the compensatory model demonstrated the only statistically significant relationship, $r(21) = .71$, $p < .05$. Both the disjunctive and conjunctive model produced correlations over .35, but neither were statistically significant. This suggests that team perceptions of adaptability are strongly related to the perceptions of individual adaptability of the average team member after some time. This relationship between individual- and team-adaptability is likely bidirectional. However, taken together, the results from the supplemental analyses suggest that within-team perceptions of team adaptability do converge over time, as Hackman (1992) predicts. Additionally, after exposure to multiple non-routine trials, perceptions of team adaptability do not increase (or decrease) but rather shift from being associated with highest member to the average member, in terms of members' self-perceived adaptability.

CHAPTER IV: DISCUSSION

General Discussion

Self-perceptions of general adaptability were measured before bringing students together in teams to have them work together. After some initial experiences in a simulated environment solving two team-level non-routine problems, each student reported on perceptions about his or her team's adaptability. Our findings suggest self-perceptions of adaptability are strongly related to perceptions of the team's ability to adapt within a person early in team development. Furthermore, member composition in *self-perceptions* of adaptability is strongly related to the average team member's perceptions of the team's adaptability through the disjunctive model. In our sample, a team's perception of its ability to adapt was strongly associated with the team member having the highest score on a self-rated measure of individual adaptability.

The compensatory model also had evidence to support its viability in the development of team perceptions of adaptability. Early in team development, the average individual adaptability score and the average team adaptability score were moderately correlated, but the parametric correlation was not statistically significant. However, the average individual adaptability score (from the beginning of the semester) was highly correlated with the average team adaptability score at the end of the semester of training. The substantial three pieces of evidence found are that a) the best member's adaptability was correlated with the team's adaptability early in training but not at the end, and b) teams agree more about their own adaptability at the end of training but c) adaptability does not increase significantly with additional task and team experience. Taken together, these suggest that multiple exposures to non-routine events shifts the expectations about the team's abilities to be more in-line with the average member (as opposed to the best).

Support was not found for the conjunctive model, which is recommended when team members have low horizontal substitutability (LePine, 2003), despite team members having specialized knowledge and skills within the team. This suggests that high levels of team adaptability could be developed even with a few members who are poor at adapting as long as the team has members who can stand-in and perform the necessary functions or behaviors required by the task environment or at least the team will perceive itself as being adaptable. No support was found for the prescribed process model, which suggests that someone in a core role would have a larger impact on the perceptions about the team than other members. During non-routine events, the team may collectively turn to the member who "steps up" to engage in the required adaptation behaviors (e.g., team communication and back-up behavior) rather than to the member in a core role who is more central to the routine workflow.

Interestingly, the direction of the relationship for the dispersion model was opposite of what was predicted. Higher variability in perceptions of individual-level adaptability was associated with higher average team member perceptions of team adaptability. This relationship could be spurious, of course. However, a team that is highly variable in its members capabilities to adapt may consistently rely on or defer to a select few (or one) of the more adaptable members to perform the necessary team-level functions (e.g., team monitoring and back-up behavior, coordinating resources, and monitoring events) all while performing individual tasks. If this member is consistently successful, the team's self-perceptions could be increased. Future research should investigate the nature of this relationship.

Aggregated data is associated with having lower power, and the team-level sample size is relatively small for the correlational analyses. Considering this, although the disjunctive model was the most supported, with a larger sample size further, stronger support for some of the other models might be found as well. More specifically, results from the dispersion and compensatory model merit further investigation, as the non-parametric correlations were statistically significant.

For Research Question 3, team adaptability was used to predict adaptive performance over time. In this analysis, adaptability is conceptualized as a a) team-level difference in ability and skill to change and also b) a performance construct. This is the cross-domain aspect of this study. However, the findings were such that team adaptability was not predictive of adaptive team performance on any of the non-routine trials that teams faced during the academic semester. Adaptive team performance scores on these trials were uncorrelated. Further, results from the multilevel (i.e., longitudinal) analyses suggest the majority of the variability in adaptive team performance is due to variability in performance on the trials themselves within teams. Together, these suggest that there may be trial-level moderating variables that control the relationship between team adaptability and adaptive performance. Additionally, trials themselves may be too different in their required team-level responses to be compared across time.

Limitations

The T-ADAPT-M is a measure adapted from the individual adaptability theory (I-ADAPT; Ployhart & Bliese, 2006). This measure was the criterion variable in Research Question 1 and Research Question 2, and it was the predictor variable in Research Question 3. As measured by the T-ADAPT-M, perceptions of team adaptability are theorized to drive team action(s), effort, and persistence during non-routine performance episodes (Bandura, 1982). Evidence of the use of this approach to team differences in shared beliefs about adaptability is sparse in the literature (Baard et al., 2014). However, the approach used in this study meets the criteria established by researchers to capture team-level constructs, namely the *team* must be the referent, the measure must discriminate between teams (Chan, 1998), and members must show agreement on the items (Guzzo, Yost, Campbell, & Shea, 1993; Woehr et al., 2015).

The estimated relationship between the perceptual measures of self- and team-adaptability may be downwardly biased. Individual adaptability was measured early in the semester prior to any sessions in the simulator (or exposures to non-routine trials), while team adaptability was measured several weeks later, after Session 1 (and two non-routine trials) and after performance feedback was provided to the team for Session 1. It is possible that participation in Session 1, and/or the exposure to the non-routine trials during the session, and/or the performance feedback received could have had an impact on self-perceptions of adaptability. If perceptions of individual- and team-adaptability were measured at the same time, or closer together in time, confidence in the comparisons of the two measures may be increased and a higher correlation may be observed. However, according to I-ADAPT theory (Ployhart & Bliese, 2006), adaptability is a relatively stable construct, therefore, any anticipated changes would be small.

It remains unclear whether simulations and laboratory tasks accurately replicate *real world* adaptation process (Baard et al., 2014). However, the case for the use of simulations in training and adaptive performance research have been made by many researchers and argued to be appropriate settings because of the provided environmental controls and safety concerns (Baard et al., 2014; Gorman et al., 2010; Rosen et al., 2011).

It is possible that the teams' performance on the nonroutine trials was impacted by events outside of the laboratory. Even though each team was formed at the same time, and every effort was made by the research team to keep the team experiences standardized across sessions, due to time and human resource constraints, teams began their first session at different points in the semester (about one week apart). Therefore, individual team members and teams as a whole could have been exposed to performance information about other teams (from classmates). Every effort was made to reduce this type of potential contamination. For example, the research team developed a series of comparable trials that are interchangeable, so that no two teams in a given semester have the exact same experience within the simulation. The nature of the correct response to the interchangeable trials is exactly the same, but the wording of the prompts is different.

Previous research has suggested that the relationship between surface-level composition variables (e.g., sex, age, functional diversity) and team effectiveness is complex and may vary across team type (Devine et al., 1999). The nature of the relationship between surface- and deep-level composition variables (Bell, 2007) and effectiveness are different. This study made no attempts to measure or control for deep- or surface-level composition variables during the selection of students or assignment of students to teams. The teams are not considered to be equal on expected team differences for these variables. For example, it is reasonable to assume that some teams are higher on team-level intelligence, and team-level intelligence may be a more significant predictor or be confounded with the operationalization of perceptions of adaptability.

The researchers could display systematic bias in the ratings provided. The strong situation of the research laboratory or the ambiguity of the adaptability construct could lead to systematic bias in the researchers’ rating of each team’s adaptive performance. Researchers may have (un)conscious expectations of teams to improve on the nonroutine trials over time, which could mean the behavioral anchors do not function the same across time. In other words, performance criteria on each trial could change over time due to the researchers' (un)conscious expectations of maturation. This problem is related to rater leniency on the first session and rater severity on the last session. Researchers do receive frame of reference training, which is designed to combat leniency and severity in ratings. Furthermore, the inter-rater reliability on the performance ratings for the trials were acceptable, suggesting that ratings were more similar to one another within teams than between teams.

Practical Implications

The first practical implication is regarding team composition. The perceptions of the team's adaptability to adapt are at least moderately related to the perceptions of the member with the highest adaptability early in training. Selecting individuals with high self-efficacy to adapt should be considered when creating teams that may need to perform non-routine tasks or experience disruptions in their work. These findings may have implications for the development of individual- and team-level efficacy spirals pertaining to adaptive performance, as highly adaptable members could substantially raise other member's (self-)expectations about the team's ability to adapt.

The second practical implication is the development of shared team-level perceptions of adaptability. The administration timing of instruments using the referent-shift consensus method need to consider the time it takes for these perceptions to develop and become shared. Perceptions about the team *should* converge over time (Hackman, 1992), but it is unclear how long it takes for teams to reach an acceptable level of within-team consensus. Measurement of team adaptability after Session 1 did not meet the recommended cut-off guidelines for referent-shift consensus methods provided by Woehr et al. (2015). Their recommendations are that ICC1 and ICC2 be used as an initial hurdle for justifying aggregation and values should be greater than .21 and .66 respectively. In the supplemental analyses, team adaptability met these requirements, but the measurement was after teams completed all the non-routine trials for the semester. To draw causal inferences, the cause must precede the effect. However, to measure a more specific team-efficacy construct regarding perceived ability and skill to adapt, the team may need multiple exposures to non-routine events. In this study, two trials over three hours appears to be insufficient but, after eleven trials over nine hours of training, team adaptability eventually did meet the criteria for being a reliable team-level construct (Guzzo et al., 1993; Woehr et al., 2015). Researchers and practitioners should consider and measure the training time it takes to develop a shared sense of ability to adapt as a team in training settings. A few hours and a couple of short drills is likely not enough time for teams to develop a shared sense of adaptability.

Future Research

Future research should also attempt to replicate this research using different measurement methods. For example, using peer or subject matter expert ratings of adaptability to predict the overall team's adaptability. Additionally, team adaptability should be measured using different methods as well such as direct consensus of team members or subject matter experts' ratings of team adaptation processes. Additionally, the research literature is unclear on how quickly teams develop – and what boundary conditions exist for the development of perceptions of team adaptability. Some teams may develop these perceptions and arrive at a consensus on these perceptions more quickly than others. In this study, perceptions of team adaptability were measured just twice. Future research should examine the temporal dynamics of developing shared team perceptions of adaptability using methods laid out by Lang, Bliese, and de Voogt (2018).

The referent-shift approach taken to measuring adaptability assumes that dimensions of team adaptability are qualitatively equivalent to individual adaptability but occurs at a higher level (see Chan, 1998). For example, team adaptability requires teams to have the ability to deal with work stress and uncertainty in a similar manner – but at a level higher – than individuals. This may be an acceptable assumption for some dimensions (e.g., crisis situations) but not for others (e.g., interpersonal). Further, the substantive wording of the items may need to be further modified for some items beyond shifting the referent to the team. For example, “I become frustrated when things are unpredictable” is aiming to capture how the *dealing uncertainty* dimension of adaptability. This item becomes “*Our team* becomes frustrated when things are unpredictable.” Teams themselves do not become frustrated, but the individuals within them can become frustrated. Future research should investigate if the dimensions of individual adaptability can be better mapped onto team adaptability, and how these newly team-level dimensions of adaptability may differ slightly in their conceptualizations and operationalizations to better align measurement instruments with construct validity.

The I-ADAPT-M and T-ADAPT-M ask participants to respond to items tapping perceptions and attitudes towards their own and their team capabilities to adapt in a similar manner to self- and collective-efficacy, respectively. In I-ADAPT theory (Ployhart & Bliese, 2006), types of performance behaviors are not distinguished (e.g., contextual performance versus adaptive performance versus task performance), but rather adaptability is conceptualized as impacting all performance behaviors through mediating constructs such as behavior regulation and strategy selection. While adaptability is a more distal predictor of performance, these mediating processes are more proximal to performance and explain how adaptability impacts behaviors. Many team processes are directly observable and, therefore, more ratable by teammates (Carter, Carter, & DeChurch, 2018). Therefore, future investigation into team-level adaptability as a team efficacy-like construct should include mediating team processes that are more proximal to performance itself (see Rosen et al., 2011).

Conclusion

The methods used in this study follow the suggestion of recent review articles (Baard et al., 2014; Maynard et al., 2015) to further explore the relationship between team-level adaptability and member characteristics. Furthermore, they answer Bandura's (1982) call to explore additional task-specific forms of efficacy by exploring a new conceptualization of a team-level construct of team adaptability. This construct of team adaptability operationalized as a perceptual measure was not related to adaptive team performance on non-routine trials, nor was it predictive of linear improvements in adaptive team performance over time; however, this particular finding could be because the various types of non-routine trials used in the lab are too dissimilar in their adaptation requirements. The considerable variability within teams on trial performance supports this assertion.

The findings also suggest that member composition in terms of individual adaptability is related to team adaptability differently at different times during team training. Early in team development, team adaptability is most related to the member with highest individual adaptability, but most teams do not agree sufficiently on adaptability for it to be considered a shared team-level construct. Later in training, teams do agree on their adaptability and the average individual adaptability is highly correlated with team adaptability. These findings may have implications for the development of individual- and team-level efficacy spirals relating to adaptive performance. Statistical power is a limitation of this study and future studies are needed to assess the replicability and generalizability of these results.

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Tables

Table 1.

Individual-level Perceptions of Self Adaptability Correlated with Team-level Precepts of Adaptability at Two Times

Model	*M*	*SD*	1	2	3	4‡	5	6
1. Team Adaptability	3.83	0.35	1	.47*	-.18	-.17	.29	.36
2. Disjunctive Model	4.46	0.30	.37	1	-.14	.23	.64*	.84*
3. Conjunctive Model	3.46	0.27	.38	-.14	1	.31	.50*	-.57*
4. Prescribed Process‡	4.07	0.37	.09	.23	.31	1	.33	.02
5. Compensatory Model	3.96	0.18	.71*	.64*	.50*	.33	1	.24
6. Dispersion Model	0.38	0.14	.11	.84*	-.57*	.02	.24	1

Note. $N = 23$. * = significant at the .05 level (2-tailed). Models are specific aggregation strategies of the individual-level data correlated with the combined team-level perceptions. ‡Due to missing data from core team members, correlations between core team members and team perceptions can only be calculated for 21 teams. Correlations above the diagonal are various models using I-ADAPT-M scores correlated with team T-ADAPT-M scores from early in the semester (after one session in the simulator). Correlations below the diagonal are various models using I-ADAPT-M scores correlated with T-ADAPT-M scores from the end of the semester (after three total sessions in the simulator).

Table 2.

Descriptive Statistics and Correlations for Ratings of Effectiveness on Nonroutine Trials

	Variable	*M*	*SD*	ICC2	1	2	3	4	5	6	7	8	9	10
1	Team Adaptability	3.83	0.35	.41	*.10*	-.09	.03	.03	-.26	.01	.40	-.15	-.33	.33
2	Trial 3: Runway 1	5.67	1.28	.89		*.50*	.29	.24	.13	.21	.17	-.16	.27	-.07
3	Trial 4: In-Flight	4.14	1.43	.96			*.74*	.37	.38	.29	.09	.26	.04	-.15
4	Trial 5: Pilot 1	4.15	1.23	.92				*.58*	.29	.29	.03	.14	.22	.15
5	Trial 6: Whiffle 2	4.98	1.97	.98					*.84*	-.15	-.11	.15	.06	-.12
6	Trial 7: Runway 2	3.96	1.34	.94						*.66*	.39	.11	.26	-.03
7	Trial 8: Pilot 2	4.05	1.54	.93							*.64*	-.25	.13	.19
8	Trial 9: Maint. 2	5.06	1.45	.95								*.70*	.23	.01
9	Trial 10: Wx Mx	4.48	1.79	.96									*.78*	.01
10	Trial 11: Whiffle 3	6.05	1.21	.95										*.72*

Note. $N = 22$. Trials 3 through 6 occur during Session 2. Trials 5 through 9 occur during Session 3. The intra-class correlation coefficient (ICC) 1, for interrater reliability, is along in italics along the diagonal. ICC2 is an estimate of the team-level reliability. Where numbers are present after the trial name, then a comparable trial is administered some time during the semester. Runway = airport runway closure or airport closure; in-flight = a serious in-flight emergency; pilot = pre-flight pilot emergency; whiffle = an in-flight emergency involving a passenger that requires a diversion; maint. = pre-flight, on-the-ground maintenance issue arising immediately before take-off; wx mx = weather-sensitive maintenance issue for a plane immediately before take-off. See Appendix D for details about trail BARSs.

Table 3.

Multilevel Model Estimates for Proposed Model

		Coefficients	*s.e.*	*p*-value	95% CI
Fixed Effects					
Intercepts	Intercept, γ_{00}	5.75	3.96	.149	
	Adaptability, γ_{01}	-0.37	1.03	.859	
Time	Intercept, γ_{10}	-0.09	0.50	.722	
	Adaptability, γ_{11}	0.04	0.13	.770	
Random Effects					
Level 1 (Trial)	ε_{ij}	2.40			(1.39, 1.72)
Level 2 (Team)	u_{0j}	0.46			(0.12, 3.92)
	u_{1j}	< 0.01			(0.00, 0.78)[‡]

Note. Model was estimated using full information maximum likelihood. CI = Confidence Interval. 95% Confidence Intervals are for the standard deviations of the random effect, while point estimates are of the variance of the random effects. Adaptability = team adaptability measure (or T-ADAPT-M). [‡] = The lower-bound 95% confidence interval is equal to .004.

Table 4.

Model Fit and Comparison Statistics for the RMMR Models

Model	***df***	**AIC**	**BIC**	**Likelihood Ratio**	***p*-value**
Null Model	6	761.15	780.88		
Random Intercepts and Slopes	8	765.01	791.32	0.14	.935

Note. Model comparisons made using the *anova* function in *R*.

Figures

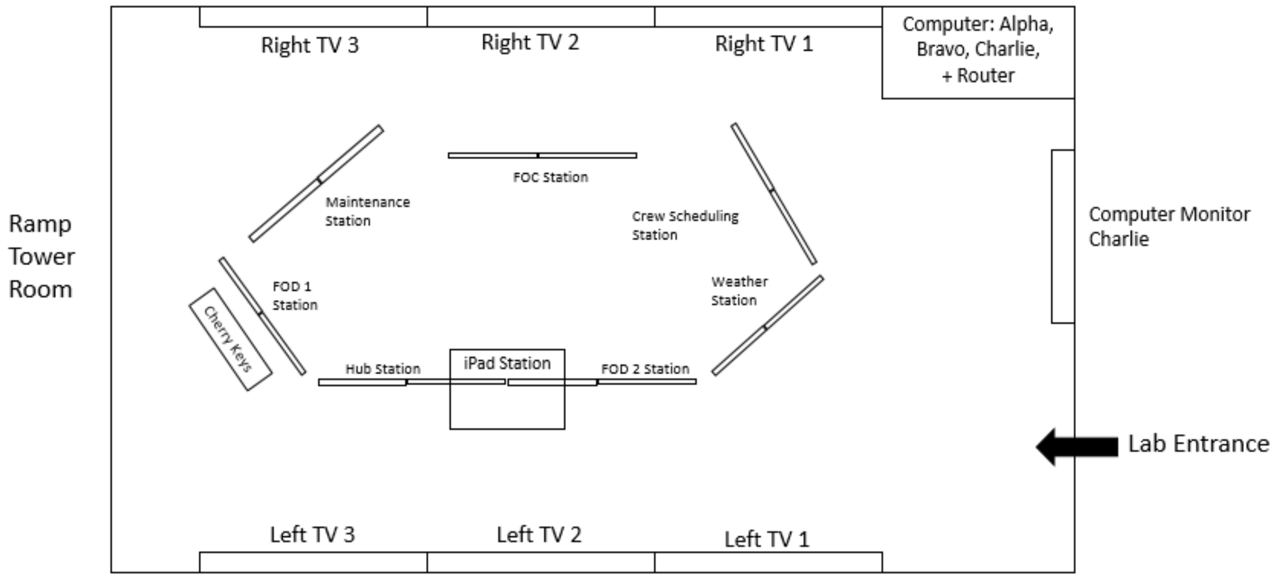

Figure 1. Overview of the Flight Dispatch Center Simulator.

Within the lab, participants in seven positions have extensive use of technology and access to multiple displays.

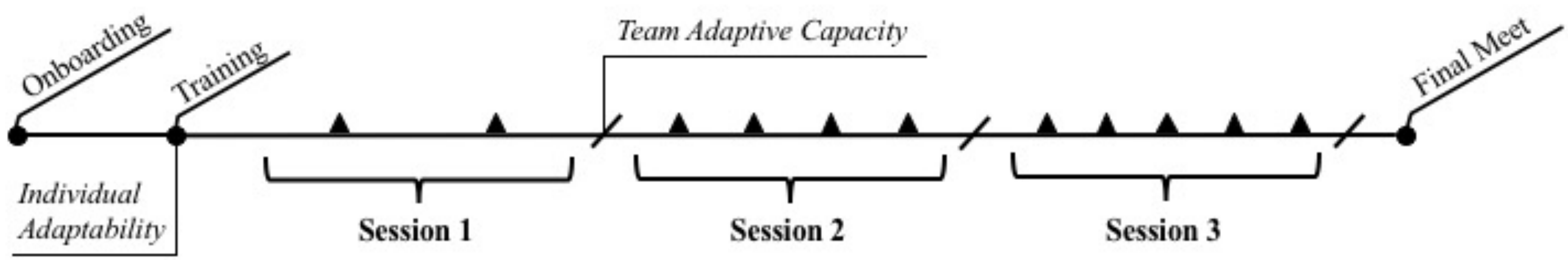

Figure 2. Academic Semester and Session Timeline.

Each team experienced 11 total nonroutine trials (▲). Nine of these trials occurred after the team's perceptions of its own adaptability was measured. Some of the class meetings (●) were focused on either preparing students for their experiences within the lab and the final class meeting recapped the experiences with an emphasis on students' professional development. Feedback and action planning sessions (/) were held the week after a team participated in the lab and provided students with team-level performance feedback and structured goal setting.

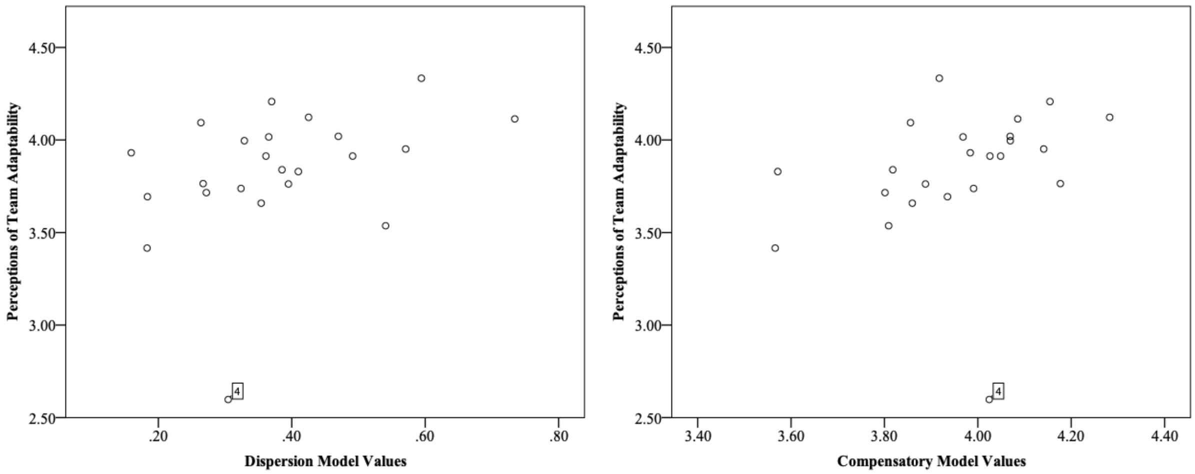

Figure 3. Scatterplots of Social Combination Models.

Scatterplot of dispersion model (standard deviation of individual-level adaptability within a team) and compensatory model (average of individual-level adaptability) values on the *x*-axes with aggregated values of team adaptability on the *y*-axes. A visual inspection lead to the identification of potential problematic data-point, labeled here as #4.

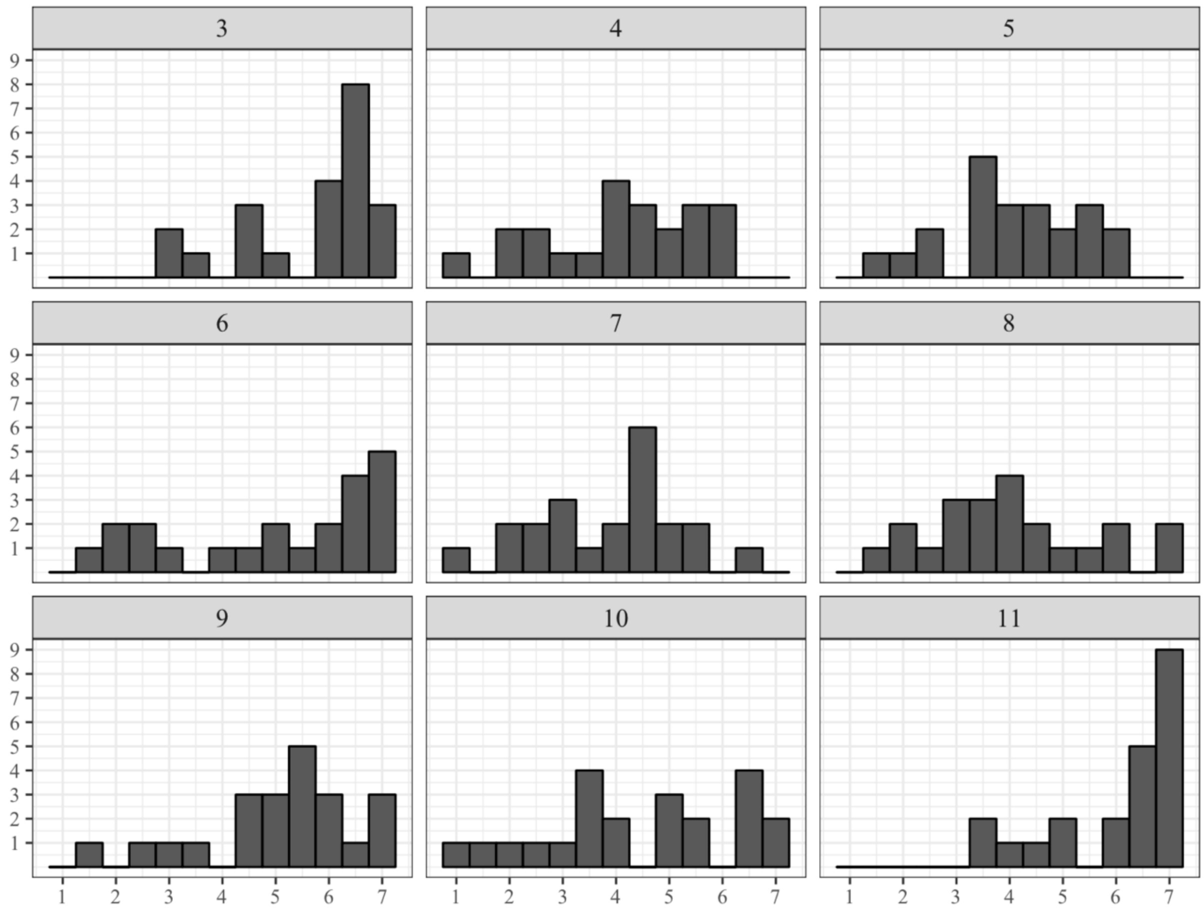

Figure 4. Histograms of Adaptive Performance Segmented by Trial Number.

Data from the nine trials included in the analyses are presented here and labeled above each histogram is the chronological trial number. The *x*-axes represent the adaptive performance score. The *y*-axes represent the number of teams achieving a particular score.

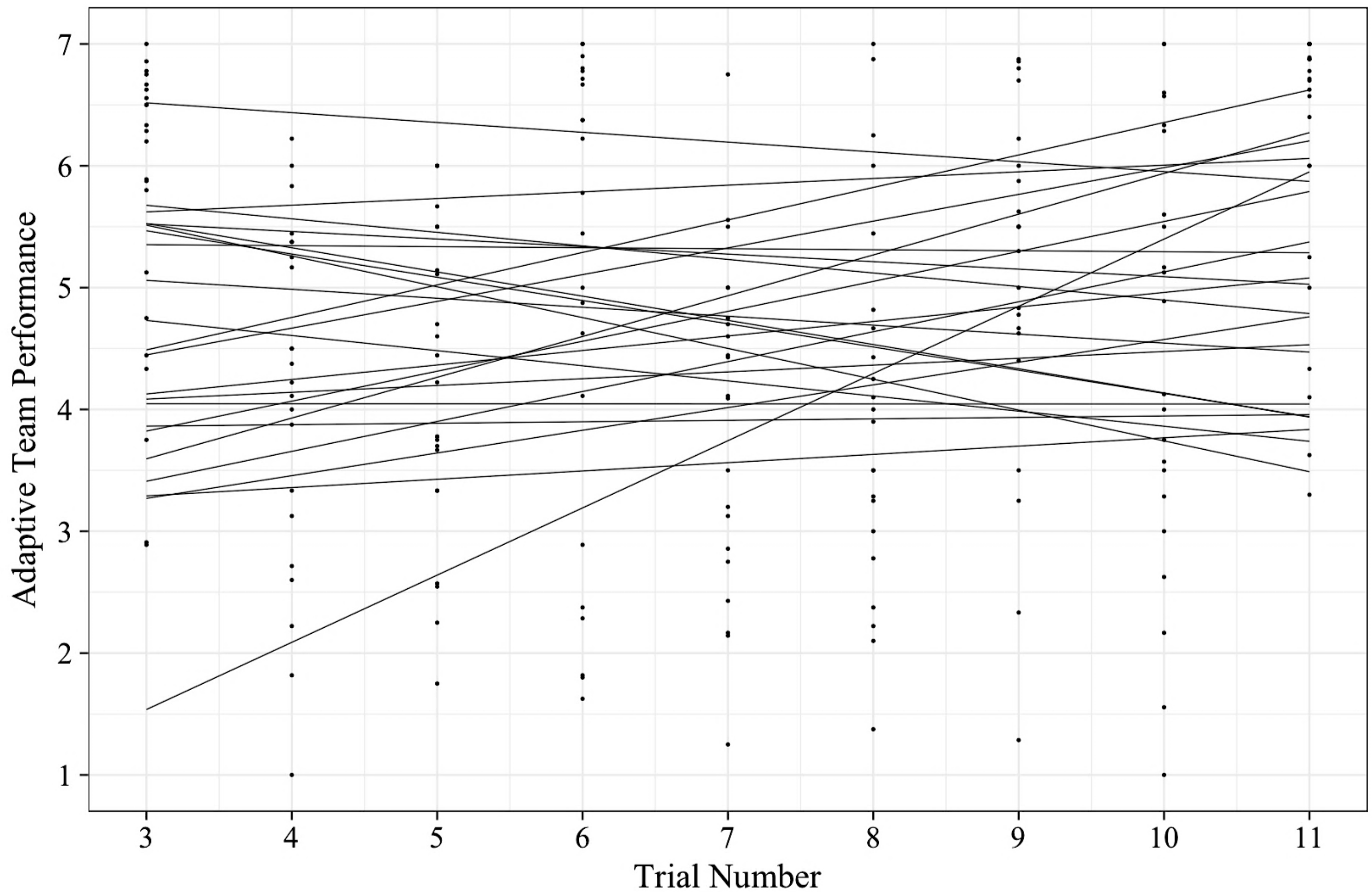

Figure 5. Adaptive Team Performance Scores Plotted by Trial Number.

Adaptive team performance ratings by trail number (*x*-axis) with an ordinary least squares fit-line superimposed for each team.

APPENDICES

APPENDIX A: IRB Approval Letter

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129

IRBN007 – EXEMPTION DETERMINATION NOTICE

Monday, February 11, 2019

Principal Investigator	**Christopher R. Bearden** (Student)
Faculty Advisor	Glenn Littlepage
Co-Investigators	Michael Hein and Alex Jackson
Investigator Email(s)	*crb3g@mtmail.mtsu.edu; glenn.littlepage@mtsu.edu*
Department	Psychology
Protocol Title	***A multilevel cross-domain investigation into adaptive team performance***
Protocol ID	**19-1164**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review Board (IRB) through the **EXEMPT** review mechanism under 45 CFR 46.101(b)(2) within the research category *(4) Study involving existing data* A summary of the IRB action and other particulars in regard to this protocol application is tabulated as shown below:

IRB Action	**EXEMPT from furhter IRB review*****	Date	**2/11/19**
Date of Expiration	NOT APPLICABLE		
Sample Size	500 (FIVE HUNDRED)		
Participant Pool	**Non-Human Subject - analysis of students data collected using the NASA FOCUS Lab (17-2008)**		
Exceptions	NONE		
Mandatory Restrictions	1. Participants must be 18 years or older 2. Informed consent must be obtained from the participants 3. Identifying information must not be collected		
Restrictions	**1. All restrictions for exemption apply.** **2. Mandatory disclosure of the exclusion criteria.** **3. Approved for data analysis; Not approved for participant enrolment**		
Comments	NONE		

***This exemption determination only allows above defined protocol from further IRB review such as continuing review. However, the following post-approval requirements still apply:

- Addition/removal of subject population should not be implemented without IRB approval
- Change in investigators must be notified and approved
- Modifications to procedures must be clearly articulated in an addendum request and the proposed changes must not be incorporated without an approval
- Be advised that the proposed change must comply within the requirements for exemption

- Changes to the research location must be approved – appropriate permission letter(s) from external institutions must accompany the addendum request form
- Changes to funding source must be notified via email (irb_submissions@mtsu.edu)
- The exemption does not expire as long as the protocol is in good standing
- Project completion must be reported via email (irb_submissions@mtsu.edu)
- Research-related injuries to the participants and other events must be reported within 48 hours of such events to compliance@mtsu.edu

Post-approval Protocol Amendments:

The current MTSU IRB policies allow the investigators to make the following types of changes to this protocol without the need to report to the Office of Compliance, as long as the proposed changes do not result in the cancellation of the protocols eligibility for exemption:

- Editorial and minor administrative revisions to the consent form or other study documents
- Increasing/decreasing the participant size

Only THREE procedural amendment requests will be entertained per year. This amendment restriction does not apply to minor changes such as language usage and addition/removal of research personnel.

Date	Amendment(s)	IRB Comments
NONE	NONE.	NONE

The investigator(s) indicated in this notification should read and abide by all applicable post-approval conditions imposed with this approval. Refer to the post-approval guidelines posted in the MTSU IRB's website. Any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918 within 48 hours of the incident.

All of the research-related records, which include signed consent forms, current & past investigator information, training certificates, survey instruments and other documents related to the study, must be retained by the PI or the faculty advisor (if the PI is a student) at the sacure location mentioned in the protocol application. The data storage must be maintained for at least three (3) years after study completion. Subsequently, the researcher may destroy the data in a manner that maintains confidentiality and anonymity. IRB reserves the right to modify, change or cancel the terms of this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:
Click here for a detailed list of the post-approval responsibilities.
More information on exmpt procedures can be found here.

APPENDIX B: I-ADAPT-M

This survey asks a number of questions about your preferences, styles, and habits at work. Read each statement carefully. Then, for each statement indicate the number that best represents your opinion. There are no right or wrong answers.

1 = Strongly Disagree
2 = Disagree
3 = Neither Agree nor Disagree
4 = Somewhat Agree
5 = Strongly Agree

No.	Item	Dimension
1	I am able to maintain focus during emergencies	Crisis Situations
2	I usually over-react to stressful news*	Work Stress
3	I believe it is important to be flexible in dealing with others	Interpersonal
4	I take responsibility for acquiring new skills	Learning
5	I tend to be able to read others and understand how they are feeling at any particular moment	Interpersonal
6	In an emergency situation, I can put aside emotional feelings to handle important tasks	Crisis Situations
7	I see connections between seemingly unrelated information	Creative
8	I enjoy learning new approaches for conducting work	Learning
9	I think clearly in times of urgency	Crisis Situations
10	I feel unequipped to deal with too much stress*	Work Stress
11	I am good at developing unique analyses for complex problems	Creative
12	I am able to be objective during emergencies	Crisis Situations
13	My insight helps me to work effectively with others	Interpersonal
14	I am easily rattled when my schedule is too full*	Work Stress
15	I usually step up and take action during a crisis	Crisis Situations
16	I need for things to be ‘‘black and white’’*	Uncertainty
17	I am an innovative person	Creative
18	I make excellent decisions in times of crisis	Crisis Situations
19	I become frustrated when things are unpredictable*	Uncertainty
20	I am able to make effective decisions without all relevant information	Uncertainty
21	I am an open-minded person in dealing with others	Interpersonal
22	I take action to improve work performance deficiencies	Learning

No.	Item	Dimension
23	I am usually stressed when I have a large workload*	Work Stress
24	I am perceptive of others and use that knowledge in interactions	Interpersonal
25	I often learn new information and skills to stay at the forefront of my profession	Learning
26	I often cry or get angry when I am under a great deal of stress*	Work Stress
27	When resources are insufficient, I thrive on developing innovative solutions	Creative
28	I am able to look at problems from a multitude of angles	Creative
29	I quickly learn new methods to solve problems	Learning
30	I tend to perform best in stable situations and environments*	Uncertainty
31	When something unexpected happens, I readily change gears in response	Uncertainty
32	I try to be flexible when dealing with others	Interpersonal
33	I can adapt to changing situations	Uncertainty
34	I train to keep my work skills and knowledge current	Learning
35	I am continually learning new skills for my job	Learning
36	I perform well in uncertain situations	Uncertainty
37	I take responsibility for staying current in my profession	Learning
38	I adapt my behavior to get along with others	Interpersonal
39	I easily respond to changing conditions	Uncertainty
40	I try to learn new skills for my job before they are needed	Learning
41	I can adjust my plans to changing conditions	Uncertainty

Note. *Indicates reversed scored items.

APPENDIX C: T-ADAPT-M

This survey asks a number of questions about your FOCUS Lab team's preferences, styles, and habits. Read each statement carefully. Then, for each statement indicate the number that best represents your opinion of how the statement reflects your FOCUS Lab team. There are no right or wrong answers.

1 = Strongly Disagree
2 = Disagree
3 = Neither Agree nor Disagree
4 = Somewhat Agree
5 = Strongly Agree

No.	Item	Dimension
1	Our team is able to maintain focus during emergencies	Crisis Situations
2	Our team usually over-react to stressful news*	Work Stress
3	Our team believes believe it is important to be flexible in dealing with others	Interpersonal
4	Our team takes responsibility for acquiring new skills	Learning
5	Our team tends to be able to read others and understand how they are feeling at any particular moment	Interpersonal
6	In an emergency situation, our team can put aside emotional feelings to handle important tasks	Crisis Situations
7	Our team sees connections between seemingly unrelated information	Creative
8	Our team enjoys learning new approaches for conducting work	Learning
9	Our team thinks clearly in times of urgency	Crisis Situations
10	Our team feels unequipped to deal with too much stress*	Work Stress
11	Our team is good at developing unique analyses for complex problems	Creative
12	Our team is able to be objective during emergencies	Crisis Situations
13	Our insight helps us to work effectively with each other	Interpersonal
14	Our team is easily rattled when our schedule is too full*	Work Stress
15	Our team usually steps up and takes action during a crisis	Crisis Situations
16	Our team needs for things to be ‘‘black and white’’*	Uncertainty
17	Our team is innovative	Creative
18	Our team makes excellent decisions in times of crisis	Crisis Situations
19	Our team becomes frustrated when things are unpredictable*	Uncertainty

No.	Item	Dimension
20	Our team is able to make effective decisions without all relevant information	Uncertainty
21	Our team members are open-minded in dealing with each other	Interpersonal
22	Our team takes action to improve work performance deficiencies	Learning
23	Our team is usually stressed when we have a large workload*	Work Stress
24	Our team members are perceptive of others and use that knowledge in our interactions	Interpersonal
25	Our team often learns new information and skills to perform at a professional level	Learning
26	Our team members often cry or get angry when under a great deal of stress*	Work Stress
27	When resources are insufficient, our team thrives on developing innovative solutions	Creative
28	Our team is able to look at problems from a multitude of angles	Creative
29	Our team quickly learns new methods to solve problems	Learning
30	Our team tends to perform best in stable situations and environments*	Uncertainty
31	When something unexpected happens, our team readily changes gears in response	Uncertainty
32	Team members try to be flexible when dealing with others	Interpersonal
33	Our team can adapt to changing situations	Uncertainty
34	Our team trains to keep our work skills and knowledge current	Learning
35	Our team is continually learning new skills for the job	Learning
36	Our team performs well in uncertain situations	Uncertainty
37	Team members take responsibility for maintaining a high level of job-related knowledge	Learning
38	Team members adapt their behavior to get along with each other	Interpersonal
39	Our team easily responds to changing conditions	Uncertainty
40	Our team tries to learn new skills for our jobs before they are needed	Learning
41	Our team can adjust our plans to changing conditions	Uncertainty

Note. *Indicates reversed scored items.

APPENDIX D: Nonroutine Trial BARS

All Wiffleballs (passenger heart attack, peanut allergy, unruly passenger)						
1 **Extremely Ineffective**	**2**	**3**	**4**	**5**	**6**	**7** **Extremely Effective**
- Ignored the Pseudo Pilot's notice of the on-board emergency - Didn't call for support services (e.g. EMT or Law Enforcement Personnel) - Didn't resolve any downstream consequences (e.g. refueling, missed connections, future leg delays) - Left passengers on the aircraft for more than 1.5 hours		- Arranged for support services, but took no further action - **Didn't re-release** plane to continue the flight - Didn't resolve any downstream consequences (e.g. refueling, missed connections, future leg delays) - Left passengers on the aircraft for more than 1.5 hours		- Arranged for support services - Recalculated fuel and refueled as necessary - Re-released plane to continue the flight - Completed in an **untimely** manner - Didn't address downstream consequences (e.g. missed connections, future leg delays)		- Arranged for support services - Recalculated fuel and refueled as necessary - Re-released plane to continue the flight - Completed in a **timely** manner, which prevented any downstream consequences

Maintenance

(engine oil leak, flaps won't operate, and cargo door won't close)

1 Extremely Ineffective	2	3	4	5	6	7 Extremely Effective
- Released plane without fixing the maintenance issue - Left plane on the ground (either fixed the issue or did not) - Didn't resolve any downstream consequences (e.g. missed connections, future leg delays) - Left passengers on plane for more than 1.5 hours		- Flew Universal E-Line's maintenance personnel down to fix the issue that caused a significant time delay and wasted resources - Released flight once the maintenance issue was fixed, **but not immediately** - Didn't resolve any downstream consequences (e.g. missed connections, future leg delays) - Left passengers on plane for more than 1.5 hours		- Called contract maintenance, but not in a timely manner - Released flight once the maintenance issue was fixed, **but not immediately** - Resolved less than **50%** of the missed connections - Didn't get a spare plane and reserve crew at the destination to continue later legs		- Called contract maintenance **in a timely manner** (less than 15 minutes) - **Released flight immediately** after the maintenance issue was fixed - Resolved more than **75%** of the missed connections - Got a spare plane and reserve crew at the destination to continue later legs **without any future delays**.

Runways

(Suspicious package in terminal, ATC fire, and security airport closure)

1 **Extremely Ineffective**	2	3	4	5	6	7 **Extremely Effective**
- Released plane before the airport/terminals were re-opened or ATC fire issue resolved, or at least attempted to do so - Didn't address any downstream consequences (e.g. missed connections, future leg delays) - Left passengers on plane for more than 1.5 hours - Did not divert flights to the nearest approved airports and allowed flights to land at the intended destination		- Never released flights from their diversion or departure airports, even after the airport/terminals were re-opened or ATC fire issue resolved - Didn't address any downstream consequences (e.g. missed connections, future leg delays) - Less than 25% of inbound planes were diverted to the nearest approved airports or held from taking off - Left passengers on plane for more than 1.5 hours		- Poor communication with Pseudo Pilot/Administrator regarding the resolution of the issue (needed to be prompted about diverting/releasing flights) - 25- 75% of inbound planes were diverted to the nearest approved airports or held from taking off - <u>Did not</u> complete fuel calculations **AND** communicate with crew scheduling prior to the airport/terminal reopening or the ATC fire issue being resolved, leading to a **delay in releasing the plane** - Resolved less than **50%** of the missed connections - Didn't get a spare plane and crew at the destination to continue later legs		- Communicated regularly with Pseudo Pilot/Administrator to see when issue is resolved - More than 75% of inbound planes were diverted to the nearest approved airports or held from taking off - <u>Completed</u> both the fuel calculations **AND** communicated with crew scheduling prior to the airport/terminal reopening or the ATC fire issue being resolved, preventing further delays - Resolved more than **75%** of the missed connections - <u>Got a spare plane and reserve crew</u> at the destination to continue later legs **without any future delays**.

Crew Scheduler Issue

(Captain broken arm, Drunk FO, Sick Pilot, Pilot Fatigue)

1 **Extremely Ineffective**	2	3	4	5	6	7 **Extremely Effective**
- Didn't call for a reserve crew to take over the flight (no action) - Released flight with the original crew - Didn't address any downstream consequences (e.g. missed connections, future leg delays) - Left passengers on plane for more than 1.5 hours		- Called for a reserve crew - Arranged for a flight to transport the reserve crew to the location of the original crew in an inefficient and costly method (e.g. chartered a plane, ground transportation, etc.) - Released flight after the reserve crew arrived, but not immediately - Didn't address any downstream consequences (e.g. missed connections, future leg delays) - Left passengers on plane for more than 1.5 hours		- Called for a reserve crew - Arranged for a flight to transport the reserve crew to the location of the original crew, **but** <u>not on the soonest flight</u> - Released flight after the reserve crew arrived, but not immediately - Resolved less than **50%** of the missed connections - Didn't get a spare plane and reserve crew at the destination to continue later legs		- Called for a reserve crew - Held the **soonest hub flight**, in order to transport the reserve crew to the location of the original crew (bumped passengers if needed) - Released the flight immediately after the reserve crew arrived - Resolved more than **75%** of the missed connections - <u>Got a spare plane and reserve crew</u> at the destination to continue later legs **without any future delays**.

In-Flight Maintenance

(Rapid decompression, Bird strike, Landing Gear won't retract)

1 **Extremely Ineffective**	2	3	4	5	6	7 **Extremely Effective**
- Did NOT divert plane upon receiving the Pseudo Pilot's notice of problem - Diverted but didn't resolve any downstream consequences (e.g. stranded passengers, missed connections, future leg delays) - Left passengers on the aircraft for more than 1.5 hours		- Diverted plane upon receiving the Pseudo Pilot's notice of problem - Called contract maintenance - Bussed passengers (or obtained other inefficient mode of travel) to their next destination - Didn't resolve any downstream consequences (e.g. missed connections, future leg delays) - Left passengers on the aircraft for more than 1.5 hours		- Diverted plane upon receiving the Pseudo Pilot's notice of problem - Used Universal Elines resources and obtained a crew, MX personnel, necessary parts/equipment, and a spare aircraft to pick up passengers and complete remaining legs. There was a delay in this process. - Resolved less than **50%** of the missed connections - Contacted emergency services to meet the plan after it lands (as needed)		- Diverted plane upon receiving the Pseudo Pilot's notice of problem - Used Universal Elines resources and obtained a crew, MX personnel, necessary parts/equipment, and a spare aircraft to pick up passengers and complete remaining legs. This was done in a timely manner. - Resolved more than **75%** of the missed connections - Contacted emergency services to meet the plan after it lands (as needed)

Weather-Related Maintenance

(Wing anti-ice valve inop and weather radar inop)

1 **Extremely Ineffective**	2	3	4	5	6	7 **Extremely Effective**
- Weather and Maintenance positions did **not** communicate - Released plane without fixing the maintenance issue (weather required a fix) - Left plane on the ground (either fixed the issue or did not) - Didn't resolve any downstream consequences (e.g. missed connections, future leg delays) - Left passengers on plane for more than 1.5 hours		- Weather and Maintenance positions did **not** communicate - Released plane with or without fixing the maintenance issue (and weather did **NOT** require a fix) - Flew Universal E-Line's maintenance personnel down to fix the issue that caused a significant time delay and wasted resources - Released flight once the maintenance issue was fixed, **but not immediately** - Didn't resolve any downstream consequences (e.g. missed connections, future leg delays)		- Weather and Maintenance positions communicated - Called contract maintenance, but not in a timely manner (weather required a fix) OR released flight because weather did not require a fix - Released flight once the maintenance issue was fixed, **but not immediately** - Resolved less than **50%** of the missed connections - Didn't get a spare plane and reserve crew at the destination to continue later legs		-Weather and Maintenance positions communicated - Called contract maintenance **in a timely manner** (less than 15 minutes – weather required a fix) OR released flight because weather did not require a fix - **Released flight immediately** after the maintenance issue was fixed - Resolved more than **75%** of the missed connections - Got a spare plane and reserve crew at the destination to continue later legs **without any future delays**.

APPENDIX E: Longitudinal Model of Adaptive Performance

Longitudinal Model

Level 1 : $perform_{ij} = \beta_{0j} + \beta_{1j} time + \varepsilon_{ij}$

Level 2 : $\beta_{0j} = \gamma_{00} + \gamma_{01} adapt + u_{0j}$

$\beta_{1j} = \gamma_{10} + \gamma_{11} adapt + u_{1j}$

$perform_{ij}$ trial performance score for the i^{th} trial in j^{th} team

β_{0j} trial performance of the j^{th} team when time = 0 (random)

γ_{00} average trial performance across all trials for all teams when adapt = 0 (fixed)

γ_{01} relationship for adaptability to predict average trial performance of teams (fixed)

u_{0j} team-specific variation of the average trial performance (random)

β_{1j} relationship between time and performance (random)

γ_{10} overall relationship between time and performance (fixed)

γ_{11} relationship for adaptability to predict the varying slopes for time (fixed)

u_{1j} team-specific variation in this relationship (random)

ε_{ij} variation in performance for the i^{th} trial for the j^{th} team after controlling for the effects of time and within each team (random)

Combined Model

$zperform_{ij} =$

$\gamma_{00} + \gamma_{10} time + \gamma_{01} adapt +$ Fixed

$\gamma_{11} adapt(time) +$ Interaction

$u_{1j} time + u_{0j} + \varepsilon_{ij}$ Random

The adaptive performance on trial *i* for team *j* is being predicted by time. We are modeling the effects of 1) team-level adaptability on average trial performance (i.e. varying/random intercepts) and 2) the time-performance relationship (i.e. varying/random slopes) across teams.