TEAMWORK AND EMERGENT COGNITIVE STATES AS PREDICTORS OF ROUTINE AND ADAPTIVE PERFORMANCE IN FLIGHT DISPATCH CENTERS

Glenn E. Littlepage and Megan Wertheimer
Middle Tennessee State University
Murfreesboro, TN

This study examines relations between the emergent cognitive state of transactive memory, the emergent affective state of collective efficacy, teamwork processes, and team performance. Mediation is examined as well as comparison of states and processes related to performance in routine and non-routine situations.

Meta-analytic findings indicate that teamwork processes are related to team performance (Lepine, Piccolo, Jackson, Mathieu, & Saul, 2008). Meta-analysis has also shown that the emergent states of collective efficacy and transactive memory are known to relate to team performance (DeChurch & Mesmer-Magnus, 2010; Stajkovic, Lee, & Nyberg, 2009). Salas, Sims, & Burke, 2005 theorized that cognitive states provide a basis for teamwork processes. This suggests that teamwork processes serve as a mediator between cognitive states and team effectiveness. Based on previous research and theories of Marks, Mathieu, & Zaccaro (2001), and Salas and colleagues (Salas, Rosen, Burke, & Goodwin, 2009; Salas et al., 2005) we propose the following hypotheses:

H1: Teamwork processes are positively related to team performance
H2: Emergent states are positively related to teamwork. Specifically, H2a: Collective efficacy is related to effective teamwork, H2b: Transactive memory is related to effective teamwork.
H3: Emergent states are positively related to team performance. Specifically, H3a: Collective efficacy is related to team performance, and H3b: Transactive memory is related to team performance.
H4: Teamwork mediates relations between emergent states and team performance.

Routine vs. Adaptive Performance

Teams in aviation conduct many routine activities, but also must adapt to unexpected situations. Airline operations offer a context in which to study team performance in both routine and non-routine contexts. Performance during routine tasks and non-routine tasks can be markedly different. Cognitive ability is more critical on non-routine tasks and dependability (closely following existing protocols) facilitates performance on routine tasks while it may be dysfunctional on non-routine tasks where adaptation is needed (LePine, 2003). Likewise, effective teams modify interaction patterns (Stachowski, Kaplan, & Waller, 2009) and strategies (Randall, Resick, & DeChurch, 2011) to cope with non-routine situations. In addition, non-routine task contexts may require changes to the role relations between members (LePine, 2003). Furthermore, LePine (2005) observed only a moderate relationship (r = .38) between team performance on routine tasks and performance on non-routine tasks requiring adaptation. These findings suggest the relations between both emergent cognitive states and teamwork behaviors with team effectiveness may differ across routine and adaptive performance. These theories and findings suggest important differences between routine and adaptive performance. Based on the literature on team adaptation, we explore relations between emergent states and team processes with team performance separately for routine and non-routine tasks.

Method

Participants

Forty teams of senior-level aerospace students comprised this study. These students came from different aerospace specialties including flight dispatch, professional pilot, maintenance management, aerospace administration, and aerospace technology. Participants were assigned to specific positions in the flight operations center simulation (described below).

Procedure

The study was conducted in a high-fidelity simulation of an airline's flight operations center (FOCUS Lab). Positions in the lab include Flight Operations Coordinator, Flight Planning, Flight Scheduling, Maintenance Planning and Control, Crew Scheduling, and Weather and Forecasting. The center also externally coordinates with a Ramp Tower Coordinator, and Pilots. The team works together to release flights and overcome problems (i.e., "triggers") during the simulation. Each team completed two or three simulations, or "work shifts." Each simulation lasted approximately two and a half hours. During each simulation, participants came into the lab, worked on their specific job duties, and coordinated with team members to solve problems as they arose. During each simulation, the team collectively managed approximately 60 flight elements (takeoffs and landings). See Littlepage, Hein, Moffett, Craig, & Georgiou (2016) for a complete description of the lab and positions and duties within the simulations.

Measures

Participants completed a 10-item *collective efficacy* scale based on Quinones (1995). Items were rated on a five-point scale from strongly disagree to strongly agree. *Transactive memory* was assessed using a 15 item self-report scale (Lewis, 2003). These items were rated on a five-point scale from strongly disagree to strongly agree.

Self-rated teamwork was assessed using a teamwork scale developed by Mathieu and Marks based on Marks et al. (2001). The scale comprised 30 items rated from 1 (not at all) to 10 (a very great extent) and measured the extent to which team members engaged in certain teamwork behaviors. The scale assesses a broad array of teamwork behaviors including planning activities such as analysis of goal specification, coordination, backup behavior, and conflict management. *Observer-rated teamwork* was assessed using a locally developed ten-item behaviorally anchored scale. This scale included three subscales: problem solving, coordination, and information utilization. These items were measured on a seven-point scale from 1 (trainee level) to 7 (professional level).

Both objective and subjective measures of team performance were collected for this study. *Delay loss* was measured in dollars and is a consequence of flight delays during the simulation. Delay loss is conceptualized as a measure of routine performance with lower delay loss representing more effective performance. *Trigger effectiveness* measured the team's performance solving problems that arose during the simulation. Examples include: pilot illness, mechanical issues, severe weather, and passenger issues. Triggers not only require adaptation to the current situation, they may also require actions to prevent or minimize disruptions to other flight segments and to accommodate passengers who are stranded or miss connections. Trigger Effectiveness was measured on a seven-point scale from 1 (highly ineffective) to 7 (highly effective) by observers upon the completion of a simulation.

Results

Data analyses were conducted at the team level. See Table 1 for means, standard deviations, Cronbach alpha, and correlations.

Table 1.
Descriptive statistics and correlations.

Measure	Mean	SD	α	1	2	3	4	5
1. Collective Efficacy	2.91	.19	.70					
2. Transactive Memory	3.76	.12	.73	.08				
3. Observer-rated Teamwork	4.54	.90	.97	-.12	.37*			
4. Self-rated Teamwork	4.10	.30	.97	-.20	.61**	.58**		
5. Delay Loss	$25K	$14K		.10	-.00	-.51**	-.14	
6. Trigger Effectiveness	4.93	.67		.07	.45**	.66**	.48**	-.01

Note. *$p < .05$; **$p < .01$

Teamwork and Team Effectiveness (H1).

Observer-rated teamwork was significantly related to both team effectiveness measures: delay loss, where low scores indicate better performance (*r* (37) = -.51, *p* <.01) and trigger effectiveness (*r* (31) = .66, *p* <.01). Self-rated teamwork was significantly related to trigger effectiveness (*r* (31) = .48, *p* <.01) but not to delay loss. These findings provide partial support for H1. Self-rated teamwork was related to observer-rated teamwork, *r* (38) = .58, *p* <.01, providing some evidence of the construct validity of these measures of teamwork behavior.

Emergent States and Teamwork (H2).

Collective efficacy was not significantly related to either teamwork measure, thus hypothesis 2a was not supported. Transactive memory was positively related to both self-rated teamwork, *r* (38) = .61, *p* <.01, and observer-rated teamwork, *r* (38) = .37, p <.05. These results provided support for hypothesis 2b.

Emergent States and Team Performance (H3).

Collective efficacy was not related to either delay loss or trigger effectiveness. Transactive memory was related to trigger effectiveness, *r* (31) = .45, *p* = .01, but not to delay loss. This pattern of results does not support hypothesis 3a (collective efficacy), but provides partial support for hypothesis 3b (transactive memory).

Teamwork as a Mediator (H4).

Based on the pattern of correlations, three relationships showed the potential for mediation. Direct and indirect effects were identified as described by Hayes (2013). See Figure 1-3 for a visual depiction of the mediation analyses and standardized regression coefficients. In each figure, the top relationship represents the overall effect of the predictor on the criterion and the lower relationships represent direct and indirect paths. As indicated in Figure 1, observer-rated teamwork mediated relations between transactive memory and trigger effectiveness (z = 2.09).

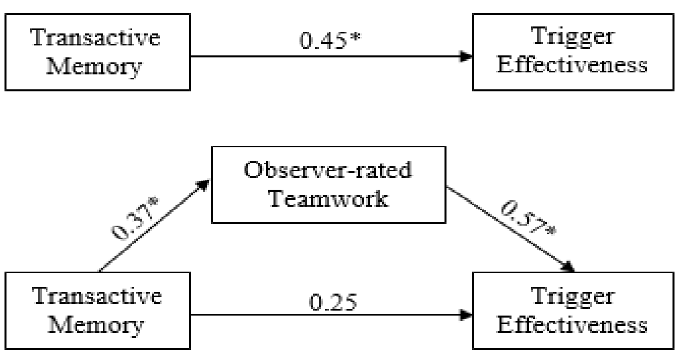

Figure 1. Testing observer-rated teamwork as a mediator between transactive memory and trigger effectiveness.

Although zero-order correlations indicated that self-rated teamwork was related to both transactive memory and trigger effectiveness, additional analyses did not confirm mediation (See Figure 2). Both transactive memory and self-rated teamwork were directly related to trigger effectiveness, but no mediation was observed.

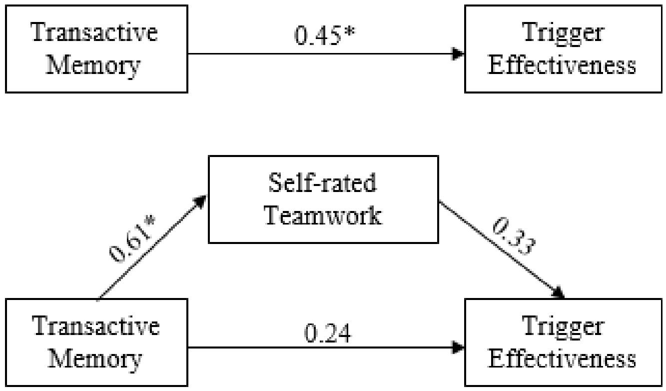

Figure 2. Testing self-rated teamwork as a mediator between transactive memory and trigger effectiveness.

The correlation between transactive memory and delay loss was extremely small (r = -.004). Nevertheless, mediation analysis indicated an indirect effect of transactive memory on delay loss. (z = - 2.06). The effect of transactive memory on delay loss was indirect and operated through observer-rated teamwork. This is explained by the existence of a suppressor variable. A variable with a positive relationship with the predictor and a negative relationship with the criterion can suppress the observed relationship between the independent and dependent variable (Schwab, 2005, p. 57). This is the pattern observed in the indirect relationship between transactive memory and delay loss. Transactive memory was positively related to observer ratings of teamwork and those ratings were negatively related to delay loss. Note that delay loss is an indicator of poor team performance. This relationship is shown graphically in Figure 3.

The overall pattern of mediation results provides mixed support for hypothesis 4. Two of the four analyses suggested that teamwork mediated the relationship between transactive memory and team performance. In both cases, teamwork was operationalized via observer ratings of teamwork. Mediation was not observed when self-ratings were used to operationalize teamwork.

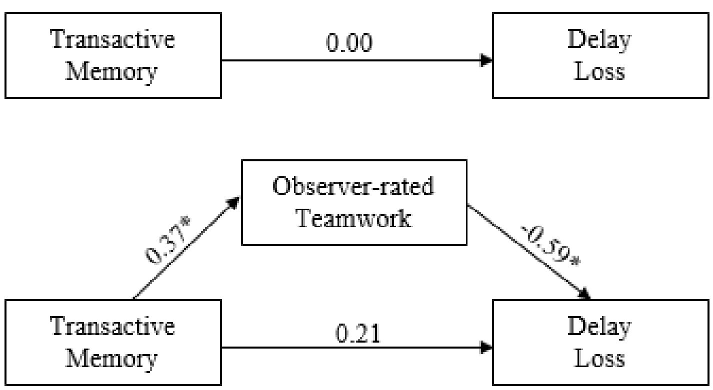

Figure 3. Testing observer-rated teamwork as a mediator between transactive memory and delay loss.

Routine and Adaptive Performance

Delay loss was conceptualized as a measure of routine performance while trigger effectiveness was conceptualized as a measure of adaption to non-routine conditions. Results indicated that the two performance measures were uncorrelated (r = -.01). Predictors such as transactive memory and teamwork ratings showed a more consistent pattern of relationships with trigger effectiveness than with delay loss. As previously indicated, trigger effectiveness was related to transactive memory (r = .45), observer-rated teamwork (r = .66), and self-rated teamwork (r = .48). Delay loss was related only to observer-rated teamwork (r = -.51).

Discussion

Results indicate partial support for hypothesis 1. Three of the four relations between measures of teamwork and measures of team performance were significant and moderate or strong in magnitude. Positive relationships between teamwork and team performance are consistent with theory (Marks et al., 2001; Salas et al., 2009; Salas et al., 2005) and findings from LePine et al. (2008).

Hypothesis 2 and 3 received partial support. Consistent with hypothesis 2b, transactive memory showed moderate to large correlations with both measures of teamwork. In partial support of hypothesis 3b, transactive memory was related to one of the two measures of team performance (trigger effectiveness). The positive relationships with teamwork and performance are consistent with meta-analytic findings (DeChurch & Mesmer-Magnus, 2010). Contrary to hypotheses 2a and 3a, collective efficacy was not related to any measure of teamwork or performance. This is surprising given that meta-analysis indicates the importance of collective efficacy (Stakovic et al, 2009). While we cannot offer a definitive explanation, the varied roles in the simulation may provide a clue. Some positions within the simulation (e.g. flight operations coordinator) are especially critical and represent core roles (Humphrey, Morgeson, & Mannor, 2009). Perhaps on this task where one person performs a coordinating role, the level of efficacy possessed by the person in this core role is more critical than the overall degree of collective efficacy. While this potential explanation is speculative, it may be worth exploring.

Partial support was found for hypothesis 4 that teamwork processes mediate the relationship between emergent states and team performance. No support was found for the mediating role of collective efficacy. One of the two teamwork measures (observer-rated teamwork) mediated the relationship between transactive memory and measures of both routine and adaptive performance.

The two measures of teamwork were highly related (r = .58). In some cases they showed consistent patterns of relations with other variables. This includes significant relationships with transactive memory, and trigger effectiveness. But observer-rated teamwork was related to delay loss while self-rated teamwork was not. In addition, observer-rated teamwork mediated relationships between transactive memory and team performance while self-rated teamwork did not. It is unclear whether these differences represent differing perspectives of the two rating sources or whether they represent differences in the facets of teamwork rated by the two types of raters. Self-rated teamwork utilized scales designed to measure the Marks et al. (2001) teamwork model that reflects a broad range of teamwork behaviors including transition, action, and interpersonal processes. The observer-rated teamwork examined a narrower set of teamwork processes including problem solving, coordination, and information utilization.

The two measures of team performance, delay loss and trigger effectiveness, were not related. These measures were representative of two different aspects of team effectiveness. While delay loss tends to capture routine performance, trigger effectiveness captures adaptive performance. Our finding that the two performance measures are unrelated is consistent with theoretical positions that distinguish between routine and adaptive performance (e.g., Burke, Stagl, Salas, Pierce, & Kendall, 2006; Rosen et al., 2011) and are relatively consistent with previous findings that routine and adaptive performance are not highly related (LePine, 2005). The lack of a close relation between measures of routine and adaptive performance and the differing pattern of relations with predictors suggests the need for research that distinguishes between factors related to performance under routine and non-routine conditions. This is especially true for aviation research because aviation requires performance in both routine and non-routine situations.

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