Journal of Applied Psychology
2009, Vol. 94, No. 6, 1536–1543

0021-9010/09/$12.00 DOI: 10.1037/a0016903

The Benefits of Flexible Team Interaction During Crises

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Organizations increasingly rely on teams to respond to crises. While research on team effectiveness during nonroutine events is growing, naturalistic studies examining team behaviors during crises are relatively scarce. Furthermore, the relevant literature offers competing theoretical rationales concerning effective team response to crises. In this article, the authors investigate whether high- versus average-performing teams can be distinguished on the basis of the number and complexity of their interaction patterns. Using behavioral observation methodology, the authors coded the discrete verbal and nonverbal behaviors of 14 nuclear power plant control room crews as they responded to a simulated crisis. Pattern detection software revealed systematic differences among crews in their patterns of interaction. Mean comparisons and discriminant function analysis indicated that that higher performing crews exhibited fewer, shorter, and less complex interactions patterns. These results illustrate the limitations of standardized response patterns and highlight the importance of team adaptability. Implications for future research and for team training are included.

Keywords: crisis, adaptive behaviors, communication, team performance

A primary impetus underlying the increased use of teams in organizations is the belief that teams are especially proficient in responding to dynamic and complex situations (e.g., Burke, Stagl, Salas, Pierce, & Kendall, 2006). One such situation that requires teams to respond rapidly and accurately is a crisis. According to Gladstein and Reilly (1985), crisis situations are ambiguous and include unanticipated major threats to system survival coupled with limited time to react. Teams are charged with responding to life-threatening crises such as hostage standoffs and airplane malfunctions, as well as major organizational events including commercial Web site crashes (Killcrece, Kossakowski, Ruefle, & Zajicek, 2003) and sudden financial market surges (Garvey & Murphy, 2004).

While a mature literature exists on teamwork in general (for reviews, see Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Kozlowski & Ilgen, 2006), our collective knowledge concerning how teams effectively respond to crisis situations is somewhat murky. This may be due in part to an inability to generalize findings across settings, as crises, by definition, are unique, ambiguous, emergent events. However, recent work in this area (e.g., Tschan et al., 2006; Waller, Gupta, & Giambatista, 2004) suggests that *patterns of interaction* among team members during crisis events may prove to be consequential and more generalizable antecedents of team effectiveness. Accordingly, our objective in the current study is to examine the relationship between characteristics of team interaction patterns and team effectiveness during crisis events. Existing work on team crisis performance offers somewhat contradictory suggestions concerning this relationship. In the following article, we briefly review these competing ideas and then describe an exploratory study designed to empirically assess them. We close with a discussion of the implications of our results for future research and practice.

Crises and Team Performance

Yu and colleagues define crises as "low-probability, high-impact events that are characterized by time pressure and ambiguity and that have significant consequences for an individual, team, and/or organization" (Yu, Sengul, & Lester, 2008, p. 452). Empirical research examining the interaction patterns of teams in naturalistic crisis settings is scarce and primarily descriptive—for instance, a description of teams performing simulated neonatal resuscitation (Carbine, Finer, Knodel, & Rich, 2000) or responding to cardiac arrest incidents (e.g., Marsch et al., 2005; Tschan et al., 2006). Such research has shown that even highly trained teams vary considerably in their effectiveness and that many teams perform inadequately in such situations (e.g., Marsch et al., 2005). The current study extends this work by empirically evaluating two contradictory suggestions regarding the relationship between team patterns and team effectiveness during crises, both of which enjoy theoretical support in the literature.

Team Interaction Patterns

Team performance is not a static property or attribute, but emerges from a series of ongoing processes and actions that constitute recurring temporal cycles (McGrath, 1993). Marks and colleagues explicated a model of the rhythmic nature of team processes (Marks, Matthieu, & Zacarro, 2001), in which each cycle represents a performance episode, defined as "a distinguishable period of time over which performance accrues and feedback is available" (p. 359). Within each episode, teams repeatedly cycle between periods of team action, including processes such as team coordination and monitoring progress toward goals, and periods of team transition, including processes such as mission analysis and goal specification.

This model, as well as other temporal team models (e.g., Kozlowski, Gully, Nason, & Smith, 1999), imply that patterns of team

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Alicia A. Stachowski and Seth A. Kaplan contributed equally to this article. Order of authorship names was determined by a coin toss. We would like to thank Mike Cote for his assistance throughout the coding process. His input and cooperation were invaluable.

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activity can vary dramatically, as different teams may structure their actions within a given episode in discrepant ways. A corollary to this idea is that different patterns of activity may be more or less effective for team outcomes. We empirically address these two issues by examining how teams vary in their patterning of behavior and by linking this variability to differences in team effectiveness.

Specifically, we focus on interaction patterns, defined as “regular sets of verbalizations and nonverbal actions intended for collective action and coordination” (e.g., Zellmer-Bruhn, Waller, & Ancona, 2004). These actions, both verbal and nonverbal, serve a number of purposes, such as sharing knowledge, directing attention, and determining next steps, among others (Carvalho, Vidal, & de Carvalho, 2007). Figure 1 displays an example of patterned team interaction. The top and bottom portions of the figure exhibit the same set of molecular actions that occur over the course of the crisis episode. When these actions repeatedly co-occur, they are considered interaction patterns. Thus, Pattern 1, for instance, suggests that upon encountering a potential threat, members of this team respond in a consistent manner: Ron expresses a warning (Behavior A), Jill provides information (Behavior B), and Janet initiates a team briefing (Behavior C). Pattern 2 actually subsumes two smaller patterns. G–R represents one pattern of behaviors and G–V represents another. When these two sets of actions co-occur, they form a more complex pattern, which would be indicative of a high degree of structured interaction. When a behavior occurs in isolation, it does not form patterns (e.g., Behavior T).

Such patterns of team interaction, versus isolated behaviors, are especially important in crisis contexts. Because these events are cumulative and often nonlinear in their evolution (Perrow, 1984), team response tends to be fluid and exploratory; teams must monitor and adjust their actions as feedback regarding the environment and the team’s response gradually accrues (e.g., Marks et al., 2001; Waller et al., 2004). Thus, effectiveness during crises is not determined by a single action or utterance but is instead dependent upon teams’ patterns of interaction over the life of the event (e.g., Ziegert, Klein, & Xiao, 2001). In the next section, we review two central characteristics of interaction patterns in teams that relate to team effectiveness—the amount and the complexity of these patterns.

Frequency of Patterns

First, teams can vary in the number of patterns they exhibit. The team in Figure 1, for instance, exhibits two identifiable patterns, but other teams may display more or fewer within the same episode. The amount of patterned interaction is indicative of the degree to which the team operates in a structured and consistent manner. Teams that engage in consistent patterns of interaction behave in a more homogeneous manner over the course of the event, while those demonstrating less patterned interaction behave less consistently.

Existing work on team effectiveness suggests two opposing views of the relationship between the patterning of team interactions and team effectiveness. One possibility is that effective teams will engage in highly consistent patterned interaction during crises. Because crises are unique, low-probability events (Yu et al., 2008), teams cannot prepare for each specific contingency or situation. Instead of training for the details of various events, a more effective strategy may be to enact standardized patterns of communication that would be beneficial during various crises (Paraskevas, 2006). By adhering to structured and procedural responses (e.g., Argote, Turner, & Fichman, 1989), teams should be less susceptible to the confusion and distress that crises can entail (Zellmer-Bruhn et al., 2004). Similarly, teams who consistently maintain the same role structure and follow established interaction norms may avoid the ambiguity of having to determine the prioritization and distribution of tasks (Waller, 1999).

Thus, returning to Figure 1, Ron may play the role of team “watchdog,” and Jill may be the teammate who appreciates and responds to Ron’s warnings. Possessing and adhering to these prescribed roles and behaviors may provide for a more predictable and orderly team response. Indeed, these presumed benefits of a tightly prescribed role structure underlie the use of crisis training and organizational crisis planning (Pearson & Clair, 1998). In support of these ideas, Kanki and colleagues have consistently found that higher performing teams (e.g., air transport crews) demonstrated less variability in their communication patterns than did less effective teams (e.g., Kanki & Foushee, 1989; Kanki, Folk, & Irwin, 1991). These results imply that more effective teams, as a function of their predictable and consistent interactions, will exhibit more patterned interaction during their responses to crises than will less effective teams.

However, an alternative possibility exists. Because crises change and evolve (Perrow, 1984), teams who fail to alter their interaction patterns with the shifting situation may be relatively less effective (Gersick & Hackman, 1990). These routinized interaction patterns, while normally beneficial, may preclude adequate responses to changing situations (Hollenbeck, Ilgen, Tuttle, & Sego, 1995). This recognition underlies the growing focus on team adaptation, which highlights the functional benefits of teams altering their responses to meet changing situational demands

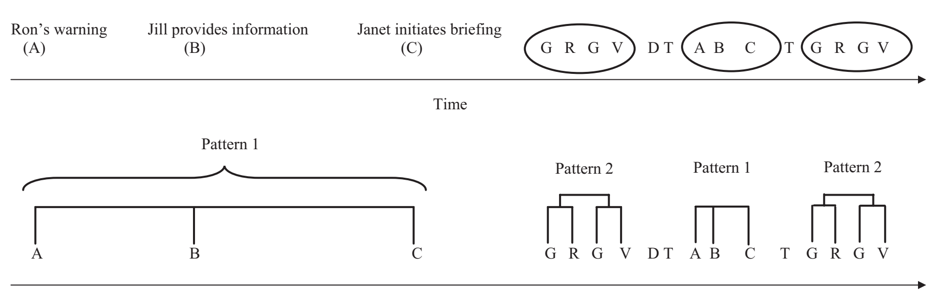

Figure 1. Example illustrating patterns of team interaction.

(Burke et al., 2006). According to this work, teams should not necessarily adhere to a set of prescribed roles and norms over the course of the episode but instead should adopt norms and role structures that are most suitable to the dynamic circumstances. Consistent with the idea that this increased flexibility is functional, Driskell and Salas (1991) found that team members, including leaders, become more, not less, receptive to each others' input under stressful situations. More direct support for this idea comes from LePine's (2003) finding of a positive relationship between role structure adaptation and team decision-making accuracy. This idea is also the basis for the presumed benefits of shared leadership (e.g., Burke, Fiore, & Salas, 2003), wherein various team members may assume the leadership role when such becomes necessary or appropriate. Thus, in contrast to the first possibility that we described, this latter notion suggests that effective teams should exhibit greater flexibility by employing less patterned interaction.

Complexity of Patterns

In addition to the *amount* of patterned interaction, the *complexity* of interaction patterns also can vary. First, patterns can be longer or shorter with respect to the number of behaviors they subsume. That is, some patterns may include a single pair of covarying behaviors (e.g., a question and an answer), while others may encompass several behaviors (e.g., the patterns in Figure 1). Second, patterns can vary in the number of actors involved in the interaction. Some patterns may involve all of the team members while others only include a subset of members. Third, interaction patterns can differ in terms of the number of actor or "floor" switches involved (see Burgoon, Dillman, & Stern, 1993). For example, one pattern could involve two team members with a high number of actor switches, indicating a two-way exchange of information, whereas another contains fewer switches, indicating more one-way communication. Finally, patterns can be more or less hierarchically complex, consisting of a single set of behaviors (e.g., Pattern 1 in Figure 1) or multiple sets of behavior (e.g., Pattern 2). Similar to the competing expectations regarding amount of patterned interaction, pattern complexity also could relate to team effectiveness in one of two ways. First, complex patterns may be associated with greater effectiveness. Because of the ambiguity of crises and the need to gather and share information (e.g., Stanton, 1996), effective team performance may be associated with complex and participatory patterns of information exchange. During these scenarios, team members must continually update their understanding of the unfolding situation and of the team's response in order to act in a coordinated manner (e.g., Waller & Uitdewilligen, 2008; Weick & Sutcliffe, 2001). Accordingly, studies reveal the benefits of teams engaging in open and continuous patterns of information sharing during nonroutine events (e.g., Prince & Salas, 2000). These results suggest that teams with patterns involving more team members may fare best. For instance, teams in which each member delivers information in turn during team briefings might outperform teams with briefer interactions dominated by a single individual.

The alternative possibility is that less complex interaction patterns predict greater team effectiveness. In support of this view, several studies suggest that effective communication in nonroutine situations is efficient, not necessarily greater in quantity (e.g., Rouse & Morris, 1986). For instance, Stout, Cannon-Bowers, Salas, and Milanovich (1999) found that accurate shared mental models allowed team members to anticipate the needs of their team members and to provide information without explicit requests. More recently, Sauer, Felsing, Franke, and Rüttinger (2006) found that specialized teams with a deep level of understanding of a small number of possible scenarios engaged in less within-team communication and superior performance compared with nonspecialized teams that possessed superficial knowledge about a broad number of different scenarios. In addition, Urban, Bowers, Monday, and Morgan (1995) revealed that during periods of high workload, better performing teams made significantly fewer requests for information than lower performing teams. Finally, Waller and colleagues (2004) found that better performing nuclear crews engaged in less information exchange and interacted for less time than lower performing crews during a simulated crisis. These studies suggest that patterns characterized by briefer and less complex interactions predict higher team effectiveness.

The Current Study

In sum, we argue that the relevant literature can be construed as offering alternative predictions regarding the relationship between interaction patterns and team effectiveness during crises. To examine these predictions, we conducted an exploratory study examining both the frequency and complexity of interaction patterns. Specific hypotheses are not offered. As detailed in the following section, we observed 14 nuclear power plant crews as they engaged in a high-fidelity training simulation that required the teams to respond to a dynamic crisis situation.

Method

Participants

Fourteen intact nuclear power plant (NPP) control room crews working at a NPP in the northeastern United States participated in the study (61 NPP licensed operators, all of whom were men). Their average age was 43.18 years (SD = 3.60), average tenure as an operator was 8.83 years (SD = 3.47), and average tenure with one's crew was 2.36 years (SD = 0.77). The average size of the crews was 4.36 members, with team size ranging from 3 to 6. The two 3-person crews were composed of 1 unit supervisor and 2 licensed board operators. The other crews contained between 1 and 3 additional members (a shift manager, additional board operator, and/or a shift technical advisor). Each crew member had a specific role in his crew. For instance, the unit supervisor, who is the crew leader, coordinates the entire crew's actions, and 1 board operator is responsible for controlling the reactor core, cooling systems, and emergency systems.

Procedure

The 14 crews participated in a regularly scheduled training simulation. The simulator was an exact replica of the control room in which the crews operate on a daily basis. In general, during a simulation, the crews respond to several crisis events designed to portray realistic scenarios that are often based on events that have recently occurred at other plants. If not contained in a timely and correct manner, these events cascade, ultimately resulting in severe outcomes. We focused on the first simulated crisis event in order to avoid the possibility that earlier performance would impact subsequent reactions and performance. Each crew faced an almost identical scripted scenario. The scenario was written by the NPP training staff and followed industry-standard training protocols. The successful management of the crisis event required interdependent and coordinated crew actions and the sharing of information among crew members as the situation unfolded.

Data Coding and Performance Categorization

Data coding. The simulation was recorded using four digital video cameras (including audio recording) positioned throughout the control room. A member of the research team watched all the video recordings and coded all team member interactions during the 15-min period following the inception of the crisis. In addition, a second researcher also coded 7 of the 14 recordings to allow for assessment of interrater agreement. Following the onset of warning signs, teams followed a set of written procedures. As such, only volitional behaviors beyond those involved with the procedure were recorded. Coders recorded the actor, the specific behavior, and the time at which the behavior occurred (e.g., "the unit supervisor called a focus brief at 7:10:05"). Past research on NPP crews suggests that this 15-min period following the crisis onset is characterized by high perceived workload, increased time pressure, and heightened emotionality (e.g., Sebok, 2000) and is especially significant in distinguishing higher from average-performing crews (Waller et al., 2004).

The primary coder met for 2 days with the training supervisor to develop the coding scheme and then contacted him with any additional questions that arose during the actual coding process. In addition, the primary coder became familiar with control room functioning and training simulations by reading relevant material from the human factors literature and nuclear industry, as well as reports furnished by the organization.

As our focus was on patterns of team interaction, we coded instances in which a team member verbally communicated with 1 or more teammates (e.g., Kanki & Foushee, 1989). Eleven behaviors were coded to characterize the crews' patterns of interaction (see Table 1 for examples). These behaviors represent the primary substance of team communication during nonroutine and complex situations (e.g., Stout et al., 1999; Weick & Sutcliffe, 2001). Each of these behaviors serves the various essential functions that determine team effectiveness in such circumstances (e.g., situation assessment, plan execution; see Burke et al., 2006; Salas, Rosen, Burke, Nicholson, & Howse, 2007). Providing temporal information, for instance, is a common behavior in nonroutine scenarios that is indicative of the team's task prioritization and ultimate performance outcomes (Waller, 1999). Furthermore, the few studies that have explicitly examined control room interactions have examined similar (and some of the same) behaviors, suggesting the current coding scheme reflected common and important behaviors for crews handling nuclear crises (e.g., Patrick, James, & Ahmed, 2006; Reinartz & Reinartz, 1989).

To ensure adequate intrarater agreement, the primary researcher recoded 3 of the 14 recordings at a later time (approximately 1 year after the initial coding). Cohen's kappa for those 3 recordings was .88, .92, and .90, respectively. In addition, interrater agreement between the two coders averaged .64 across the 7 recordings they both coded. After the coders had discussed disagreements in coding, their interrater agreement rose to .73, which represents adequate agreement (LeBreton & Senter, 2008).[1] Thus, the primary coder's record was used for all analyses.

Team effectiveness. To operationalize team effectiveness, we used the *anticipation ratio* (e.g., Entin & Serfaty, 1999), which was derived from our coding. This ratio represented the proportion of coded information transfers to coded information requests. Information transfers were considered to be the provision of information (see Table 1) in which a crew member voluntarily and without solicitation provided descriptive information regarding system status (e.g., the reading of a particular instrument panel), announced his actions (e.g., "I am closing the valve"), or acknowledged another crew member's actions. Information requests were instances in which a team member needed to explicitly request information because it had not been provided or had been provided in an untimely, incomplete, or confusing manner. We also considered communication errors in which operators addressed each other using the incorrect name or role as indicating a lack of awareness, since such an error should have, but did not always, generate a clarification (i.e., information request) from the recipient.

Higher ratios indicate that team members are anticipating their teammates' information needs and "pushing" them this information prior to their requesting it, signifying higher implicit coordination and shared situational awareness (e.g., Entin, Serfaty, & Deckert, 1994). Conversely, lower ratios represent a lack of anticipation, thereby resulting in the team members needing to "pull" information from one another. Thus, lower ratios represent less coordination and shared awareness. Because operators used standardized three-way communication (i.e., statement, repeat, acknowledge), deviations from correct communication were generally overt and straightforward for a coder to detect in the video recordings. Using this effectiveness index, we classified five crews as high performing and nine as average performing. This treatment is consistent with other research in this area (e.g., Waller, 1999; Waller et al., 2004) and also consistent with the distribution of the anticipation ratios, which appeared to be bimodal, with the two clusters significantly differing in performance (for high performers, $M = 27.00$, $SD = 6.19$; for average performers, $M = 12.28$, $SD = 3.94$), $t(12) = 3.62$, $p = .03$.

To ensure the appropriateness of the anticipation ratio as a measure of team effectiveness, we also asked the unit supervisors (i.e., crew leaders) to rate crew performance in the simulation by marking an "X" on a rating scale containing 21 gradations. Collecting data on this other measure was especially important because the anticipation ratio arguably is more a measure of team process than team effectiveness, per se. As seen in Table 2, the self-report measure strongly correlated with the anticipation ratio measure. In addition, the two clusters of teams significantly differed with respect to these supervisory ratings (for high performers, $M = 17.40$, $SD = 2.07$; for average performers, $M = 11.00$, $SD = 5.79$), $t(12) = 2.35$, $p = .04$. Given the convergence between these measures, we felt confident in using the anticipation ratio as the primary measure of effectiveness.

Results

Table 2 displays the relationships between demographic variables and the two measures of effectiveness. Notably, crews with

[1] The disagreements largely concerned whether a behavior was part of a standardized response protocol or was "volitional." These discrepancies reflected the primary coder's greater familiarity with the context.

Table 1
Mean Frequency, Standard Deviations, and T Tests of Coded Behaviors for Average- and High-Performing Crews

Behavior	Example	Average *M*	Average *SD*	High *M*	High *SD*	*t*	*p*
Provides information	"I am closing the valve."	17.89	5.46	20.80	4.21	−1.12	0.29
Provides summary/recap	"OK, we've completed the first 7 steps."	1.11	0.60	1.00	0.71	−0.31	0.76
Provides feedback	"Nice job, Jim."	0.67	1.00	1.00	1.22	0.51	0.63
Makes command	"Bill, trip main board 7."	1.11	0.78	1.20	0.84	0.58	0.58
Offers opinion	"We may have to consider initiating procedure X."	0.67	0.71	0.40	0.55	−0.90	0.39
Begins procedure	Opens procedural handbook and begins first step.	1.56	1.13	1.00	0.71	−1.15	0.27
Expresses warning	"RCS pressure is 1,900 lbs and lowering."	5.22	3.15	4.00	3.16	−0.84	0.42
Pacing comment	"We need to hurry up."	1.78	1.48	2.20	1.64	0.62	0.55
Requests opinion	"Do you think we should move on a few steps?"	0.44	0.73	0.60	0.89	0.33	0.75
Shift manager returns	Shift manager returns to control room.	0.56	0.73	0.20	0.45	−1.15	0.27
Begins/ends focus brief	"Focus brief"/"End-of-focus brief."	3.44	1.81	3.00	2.00	−0.39	0.71

Note. $N = 14$ crews. We conducted t tests after controlling for scenario in which the crew participated. RCS = reaction control system.

older power plant operators tended to be better performing crews. While these correlations were not statistically significant, they are of substantial magnitude and consistent across the two measures.

Our primary interest was to determine whether average- versus high-performing teams could be differentiated on the basis of the nature of their interaction patterns. As an initial step, we conducted a two-tailed t test comparing the two sets of teams in terms of how frequently they exhibited the coded behaviors. The difference in total behaviors between average- ($M = 33.75$, $SD = 2.92$) and high-performing ($M = 39.60$, $SD = 10.36$) teams was nonsignificant, $t = 1.54$, $p = .15$, Furthermore, separate t tests on each of the 11 behaviors also revealed no differences between average- and high-performing teams in terms of how frequently they exhibited the individual behaviors (see Table 1).

Frequencies, however, do not reveal the quality or patterning of interactions over time (e.g., Waller, 1999). To investigate possible differences in the interaction patterns of the two sets of crews, we submitted the data for our 11 coded crew behaviors to THEME, a pattern recognition software algorithm that identifies patterns of sequential interactions or behaviors (see Magnusson, 2000; also Ballard, Tschan, & Waller, 2008). The algorithm has been used in several areas of inquiry to detect time-based behavioral patterns that are otherwise difficult for human observers to discern (Magnusson, 2000).

The algorithm identifies patterns through a series of three steps. The program first uncovers two behaviors that occur in succession more often than would be expected by chance (i.e., T patterns; e.g., Behaviors A, B, and C in Figure 1). These patterns contain a combination of behaviors that occur in the same order, with real-time differences between the characteristics of the pattern remaining invariant (Borrie, Jonsson, & Magnusson, 2002). Next, the program constructs more complex hierarchies of behaviors by combining together the simpler T patterns of two behaviors to make more complex patterns (e.g., Patterns 1 and 2 in Figure 1). Finally, the algorithm removes less complete versions of patterns created earlier in the sequence.

To be conservative, we retained in our data set only those patterns identified by the algorithm that occurred at a less than 5% probability level relative to chance. The algorithm accounted for the total number of behaviors observed in each crew, rather than simply requiring that a given pattern be exhibited with a certain frequency. As an example, a pattern of behaviors that occurred twice was more likely to be kept for a crew who exhibited only 20 total coded behaviors than for a crew who exhibited 100 behaviors.

Table 3 displays the descriptive statistics and the independent samples t tests for each of the five variables of interest: the frequency of patterns and the four indexes of pattern complexity. Note that Levene's test for equality of variances (Levene, 1960) revealed significant differences between the two groups for all three comparisons. Thus, the t tests reported in Table 1 are the more conservative results that do not assume equal variances.

Results indicate that the higher performing crews exhibited fewer interaction patterns than did the less effective crews ($p = .08$). Results concerning the complexity of interaction patterns

Table 2
Descriptive Statistics and Intercorrelations Between Demographics and Team Effectiveness

Variable	*M*	*SD*	1	2	3	4	5
1. Avg. crew tenure	2.36	0.77	—				
2. Avg. tenure as NPPO	8.83	3.47	−.29	—			
3. Avg. age	43.18	3.60	−.08	.67**	—		
4. Anticipation ratio	20.75	6.69	.16	.27	.52	—	
5. US perf. ratings	13.00	5.45	−.22	.35	.28	.65*	—

Note. $N = 14$ crews. Avg. crew tenure = average tenure as part of that crew among crew members. Avg. NPPO tenure = average tenure as a licensed nuclear power plant control room operator. Avg. age = average age among crew members. US perf. ratings = Unit supervisors' performance ratings.
$^{*}p < .05$. $^{**}p < .01$.

Table 3
Descriptive Statistics and T-Test Results Comparing Average- Versus High-Performing Crews

Outcome variable	*M*	*SD*	*t*	*p*
No. of interaction patterns				
High-performing crews	0.32	1.81	2.26	.08
Average-performing crews	2.19	0.31		
No. of actor switches				
High-performing crews	0.16	1.15	2.76	.05
Average-performing crews	1.30	0.38		
No. of team members in patterns				
High-performing crews	0.16	0.28	2.76	.05
Average-performing crews	2.14	1.59		
Pattern length				
High-performing crews	0.52	2.08	2.26	.08
Average-performing crews	2.67	0.59		
Pattern hierarchy				
High-performing crews	0.10	0.30	2.07	.11
Average-performing crews	1.51	1.51		

Note. The *t* test results reported are corrected for unequal variances. Degrees of freedom differed across models, depending on the extent of nonequivalence of variances.

indicate that the more effective crews engaged in less actor-switching ($p = .05$), involved fewer team members in their patterns ($p = .05$), and engaged in shorter, more concise interaction patterns that contained fewer behaviors than the patterns of less effective crews ($p = .08$). Higher performing crews also demonstrated patterns characterized by fewer hierarchical levels of behavior, although that difference was not statistically significant ($p = .11$). In sum, there were significant differences in four of the five pattern characteristics between the high- and average-performing crews at the .10 or .05 level.

Finally, to assess the extent to which each of these five characteristics distinguished the two sets of crews, we conducted a discriminant function analysis, predicting crew performance on the basis of these pattern variables. In combination, the five characteristics significantly differentiated the high- from average-performing crews, Wilk's $\lambda = .22$, $\chi^2(5, N = 14) = 14.41$, $p < .05$). Using these variables, we were able to correctly predict all of the crews as being average or high performing. The standardized coefficients indicated that the degree to which patterns contained more versus fewer hierarchical levels of behavior most strongly differentiated the crews (discriminant function coefficient = 7.67), while the number of patterns was the relatively weakest variable in distinguishing crew performance (discriminant function coefficient = .64). In sum, the results revealed that superior crews exhibited fewer, shorter, less complex, and more flexible patterns of crisis response than did average-performing crews.

Discussion

The purpose of this study was to further understanding of the temporal patterns that underlie differences in team effectiveness during crises. Findings indicated that team effectiveness was associated with shedding established patterns of interaction, as the better performing crews exhibited fewer systematic patterns of interaction. In addition, these crews also engaged in less complex interaction, exhibiting patterns that encompassed fewer behaviors (e.g., verbal statements), involved fewer actors, and incorporated less back-and-forth communication.

In our view, a particularly important implication of these findings is in regard to crisis management training. In particular, these results highlight the limits of training teams to respond in a highly procedural fashion or to adhere necessarily to an established pattern of interaction. While necessary to a degree, training that emphasizes adherence to specific procedures also may attenuate trainees' awareness of the need to deviate from those patterns and prevent them from acquiring skills that would foster such deviation (Gersick & Hackman, 1990).

Anecdotal evidence for the drawbacks of overemphasizing standardized procedures derives from our post hoc observation of the less effective crews. Upon revisiting the video recordings, we noted that several crews seemed to allow the standardized response protocol to "drive" their interpretation of, and response to, the crisis. This reliance appeared to result in the crews becoming passive information recipients, not active information seekers and processors (Louis & Sutton, 1991). Conversely, the more effective crews used these protocols as tools but did not permit them to guide their patterns of interaction. These latter crews instead interacted in ways (i.e., patterns) that were not outlined or stipulated in the written procedures.

Underscoring the importance of this finding is the recognition that current high-reliability training largely focuses on developing awareness and adherence to such procedural responses. For instance, the Department of Homeland Security, in providing guidelines for the development of emergency response training, emphasizes reliance on "Incident Action Plans" and on "chain of command" and "unity of command" among other training characteristics (see U.S. Department of Homeland Security, 2007). Current findings, however, suggest that less, not more, standardized responses may be effective and that training should emphasize such flexibility. Future research should address how effective teams manage to balance adhering to and deviating from standard interaction patterns and when such teams should shift between these states. Efforts to develop and evaluate programs that foster these proficiencies may be useful as well (see Salas, Nichols, & Driskell, 2007; Zellmer-Bruhn et al., 2004). Also instructive would be studies examining when and how teams transition back to established patterns and how teams change patterns as a result of what they learned during the crisis.

Furthermore, the current study also suggests that such training should foster team interaction that is briefer and involves fewer actors and less back-and-forth communication (see also Waller, 1999, for similar findings). This notion seemingly runs counter to the idea that team decision making generally should include all team members. Training designed to teach teams to engage in these briefer, more directive, and less inclusive interactions without sacrificing shared team knowledge would seem useful.

With regard to other future research, it would also be beneficial to examine such patterns in other contexts to shed light on the generalizability of the patterns and results obtained in our study. These patterns should be examined for teams facing less safety-oriented consequences. Perhaps effective patterns of interaction would differ in crises that are not high reliability (e.g., responding to drastically changing market conditions or to an attempted hostile takeover) due to dissimilarities in the nature of concerns or to the longer time periods over which these events unfold.

The current investigation has some limitations that warrant mention. First, we had access to only a small sample of NPP teams. However, we had considerable data (i.e., 15 min of video recorded data) for each crew, which somewhat countered the small sample size. Given practical constraints, research examining relatively few teams in high reliability contexts is common (e.g., Waller, 1999). Second, we had access only to crews responding during crises. As an anonymous reviewer appropriately noted, this precluded our being able to distinguish patterns of effective crisis interaction from patterns of effective interaction during routine circumstances. While other research indicates that the nature of and requirements for effective team performance vary as a function of the typicality and complexity of the scenario (e.g., Waller, 1999), research explicitly comparing patterns of interaction across circumstances would be valuable.

Overall, our study supports the argument that effective teams are able to shed routinized, rigid interaction patterns and are thus better able to adapt to emergent crisis situations. Teams charged with monitoring complex systems spend the majority of their time carrying out complex but routine tasks. While crisis events that damage such systems do not necessarily pose a threat to safety, such events are nonetheless crises for the organizations involved, and understanding how teams deal with them effectively remains an important area for future study.

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Received August 2, 2008
Revision received April 20, 2009
Accepted June 8, 2009 ■