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Adaptability in Crisis Management: The Role of Organizational Structure

Topic 4 (Primary)
Collaboration, Shared Awareness, and Decision Making

Topic 5
Experimentation, Metrics, and Analysis

Topic 6
Modelling and simulation

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Teams performing in today's command and control (C2) environment are often faced with complex situations involving sudden and unexpected events that can modify the pace and demands of a situation to a great extent. To function effectively, these teams must adapt to a wide range of circumstances and be efficient in coordinating their actions. Adaptability can be described as undertaking effective actions when necessary, promptly responding to unforeseen circumstances, and effectively adjusting plans to take changes into account (Pulakos et al., 2000). We investigated how teams adapt in crisis management situations characterized by the occurrence of sudden events depending on their organizational structure. C^3Fire, a forest firefighting simulation, was used as task environment to compare functional (role-specific) and edge-like (decentralized and no specific role assigned) four-person teams. Various dimensions of teamwork and task performance were monitored, based on the occurrence of critical events during different scenarios. The results indicate that edge teams perform better prior to a critical event but that functional teams are able to adapt effectively shortly following the event. Also, the coordination of activities across edge-like teams appears to lose some consistency after critical events. The findings are discussed with regards to requirements for team adaptability and agility in complex C2 environments.

Introduction

Many organizations rely on teams to perform tasks that are complex and demanding. Of the various contexts in which collaborative work is required, the present study focuses on command and control (C2) in crisis management situations. Crisis situations of diverse natures can require the involvement of public safety or military teams, both domestically and abroad. Crisis management (CM) refers to the exercise of direction over resources in the accomplishment of specific goals and objectives in response to natural or human-made crisis events (e.g., environmental disaster, terrorist attack, health pandemic). CM can be seen to encompass a spectrum of activities and different notions that include C2 and emergency response. CM situations are most-often complex and dynamic, and require individuals to make optimal decisions under constraints of high risk, uncertainty, high workload, and time pressure (see, e.g., Brehmer, 2007). There is ample evidence that these conditions are cognitively demanding and heavily engage a variety of cognitive functions such as situation assessment, monitoring, problem solving, causal learning, and planning (e.g., Gonzales, Vanyukov, & Martin, 2005). In these safety-critical situations, teams are often faced with sudden and unexpected events that can modify the pace and demands of the situation to a great extent (e.g., Huey & Wickens, 1993). In order to function effectively, teams must adapt to such transitions and be efficient in coordinating their actions (e.g., LePine, 2005).

The expertise and resources required for the successful achievement of operational goals in CM generally extend beyond the capability of a single individual. However, the addition of individuals in the execution of the tasks represents in itself an element of complexity. Indeed, bringing people together as a team in order to accomplish interdependent tasks does not guarantee team effectiveness (see, e.g., Steiner, 1972) and can even hinder task execution (e.g., Allen & Hecht, 2004). Research from the past decades has shown that team cognition plays a critical role in team effectiveness (see Salas, Cooke, & Rosen, 2008, for a review). Cooke, Salas, Kiekel, and Bell (2004, p. 84) describe team cognition as emerging from the "interplay of the individual cognition of each team member and team process behaviors" (e.g., communication, coordination), and includes aspects of teamwork such as team situation awareness and team knowledge. In many safety-critical work settings, personnel usually operate as members of a team that distributes complex large-scale tasks among many individuals and sometimes over a large geographical area with the aim of avoiding CM situations. It is often crucial that the members be continually aware of the team's activities and intentions, if the team is to achieve the shared understanding that will make it more adaptable and responsive (e.g., LePine, 2005) and thus augment team performance (e.g., Cannon-Bowers & Salas, 2001).

There has been an ongoing interest in investigating how team structure influences the efficiency of responding to various situations (see, e.g., Artman, 1998; Diedrich et al., 2003; Hallam & Stammers, 1981). For instance, Hallam and Stammers (1981) showed that the impact of variations in task complexity on team performance differs as a function of the team's organizational structure. For their part, Diedrich, Entin, and their collaborators (Diedrich et al., 2003; Entin et al., 2003) examined the effectiveness of functional and divisional teams in a military C2 task environment. Diedrich et al. (2003) found that team effectiveness (as measured through output performance, communication, and perceived workload) varied as a function of resource allocation and coordination requirements. They showed that performance, perceived workload, and communication varied throughout task execution as a function of team structure.

Traditionally, CM is associated with a functional organizational structure whereby tasks and roles are clearly assigned to each team member. FIRESCOPE, a commonly used crisis intervention plan developed in California (Office of Emergency Services, 2007) is a good example of such a structure. However, explicit and a priori allocation of roles could potentially limit a team's ability to adapt to changing demands of a crisis situation. One concept that has been put forward as the panacea to the challenge of enhancing shared understanding in teams and augmenting team performance is that of Edge Organizations (EO; Alberts & Hayes, 2003). EOs consist in the flattening of more traditional hierarchical organizations and team structures. It is assumed that this decentralization is associated with empowerment, shared awareness, and freely flowing knowledge, which are deemed by many practitioners as necessary for more informed decision making and competent action (e.g., Alberts, 2007; Alberts & Hayes, 2003). The notion of EOs is not new. Indeed, in organizational psychology and management sciences very similar concepts – for example, empowered self-management, self-regulating work group – have been investigated and documented over the last 30 years or so (see Cooney, 2004, for a review). Most of the research comes from observation and questionnaire-based studies in a range of work environments – manufacturing, engineering, business, and civil service – mostly at the mid-to-large scale organizational level. Despite the obvious key differences with CM, the same benefits are attributed to less traditional and flatter organizations. However, there is still limited empirical research on the concept of EOs (e.g., Duncan & Jobidon, 2008; van Bezooijen et al., 2006) and the evidence remains somewhat inconclusive as to whether such organizations do significantly increase productivity and quality of work.

Role assignment is intrinsically linked to organizational structure. Indeed, on one hand organizational structure can determine or constrain the allocation of roles among team members, while on the other hand the organizational structure can stem from requirements for coordination, communication, and distribution of information (Hollenbeck, 2000; Waern, 1998). From the team literature, it appears that explicit role allocation allows team members to develop knowledge of their own and others' roles, and has been associated with improved team planning process and shared situation awareness, and overall better team performance (e.g., Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995). Although planned role allocation can be important, when dealing with dynamic and complex situations such as CM teams need to be able to adjust their roles as needed during the execution of a task (e.g., Rousseau, Aubé, & Savoie, 2006), a function that can be referred to as online task balancing (see Jobidon, Tremblay, Lafond, & Breton, 2006). A potential issue of EOs with regards to flexible role allocation is the notion of role ambiguity, which suggests that lack of clarity on team roles and responsibilities can act as a major hindrance to performance (e.g., Klein et al., 2009; LePine, LePine, & Jackson, 2004). Spontaneous coordination or adoption of roles might be a means for how self-synchronization manifests itself; however, the question remains as to whether role adoption is beneficial, and, if so, under which conditions the potential hindrance of role ambiguity becomes organizational flexibility that can make a military team more efficient and responsive (see Alberts & Nissen, 2009).

Adaptability

Providing teams with the flexibility to adapt to evolving complex situations is at the core of EOs. Pulakos, Arad, Donovan, and Plamondon (2000) describe adaptability as undertaking effective actions when necessary, promptly responding to unforeseen events or circumstances, and effectively adjusting plans or courses of actions to take changes into account. This description is particularly relevant with regards to how efficiently teams coordinate their activities when faced with the vagaries of C2 environments in general and CM in particular. Adaptability has been identified not only as a key teamwork competency (e.g., Rousseau et al., 2006; Salas, Sims, & Burke, 2005) but as a critical component of what Uitdewilligen, Waller, and Zijlstra (2010) refer to as 'action teams'; that is, "teams that face unpredictable, dynamic, and complex task environments" (p. 295). Teams working in such environments cannot afford to pause and take stock of unforeseen events and changing demands, and how to deal with them in a timely manner; rather, they need to adapt on the fly (LePine, 2005).

In the last fifteen years, theoretical and empirical work on adaptability has been undertaken with the aim of better understanding the role and implications of adaptability in relation to other aspects of teamwork and team effectiveness, for instance team cognition (e.g., shared mental models, shared situation awareness, transactive memory; e.g., Uitdewilligen et al., 2010), leadership (e.g., Zaccaro, Banks, Kiechel-Koles, Kemp, & Bader, 2009), training (e.g., Entin & Serfaty, 1999; Priest, Burke, Munim, & Salas, 2002), and team learning (e.g., Kozlowski & Bell, 2008). Particularly relevant for the purpose of this paper, some researchers have focused their effort on role allocation and team structure (e.g., Dubé, Tremblay, Banbury, & Rousseau, 2010; LePine, 2003). Burke, Stagl, Salas, Pierce, and Kendall (2006) propose that team adaptability is evidenced by the development or the modification of structures, capabilities, behaviours, and/or cognitive activities. In that context, LePine (2003) investigated role structure adaptation; that is, "reactive and nonscripted adjustments to a team's system of member roles that contribute to team effectiveness" (p. 28). The findings show that role structure adaptation mediated the relationship between team composition (e.g., cognitive ability, openness) and team effectiveness in task environments where teams were faced with unforeseen changes. It is noteworthy that LePine (2005) emphasizes the importance of considering team adaptability over time, through different phases of activity, to take into account the uncertain and unpredictable nature of task environments.

In another take on role allocation and adaptability, Dubé et al. (2010) compared two team structures: functional (each team member is allocated one specific role and appropriate resources) and cross-functional (each team member is allocated a variety of the resources available to perform the task). When analysing teamwork before and after an unforeseen event in a CM task environment, cross-functional teams showed better coordination and process gain (a measure of performance) and communicated less than functional teams. However, the two types of structure did not significantly differ in terms of adaptability.

Purpose of the Study

In this paper, we investigate how teams respond to sudden and unforeseen events in a CM situation and assess the extent to which such events affect adaptability in different organizational structures. Although a cross-functional structure as described in Dubé et al. (2010) offers more flexibility for coordination of roles, built-in constraints remain as there is an explicit allocation of resources to each team member. The aim of this study is to compare functional (role-specific) to edge-like four-person teams. In the edge-like structure, there is no explicit allocation of roles and resources. Team members must determine amongst themselves how to distribute resources and how to go about achieving their mission. This team structure allows for greater flexibility, and possibly adaptability in the face of unexpected events and changing demands. However, as mentioned above it could also come at a cost of role ambiguity and decreased team effectiveness.

Microworld Simulation

The study reported here uses an approach that offers a good compromise between ecological and internal validity by creating controlled experiments in realistic simulations of CM. Applying this approach requires a microworld within which a scenario representing a typical task is implemented. The method is to perform a microworld experiment using a simulated CM task for teams. Microworlds (also referred to as functional simulations or synthetic environments) are task environments that are used to study behaviour under simulated conditions within a laboratory setting (Brehmer, 2004). They provide a certain real-word, ecological validity while permitting researchers to establish causal, rather than associative, relationships and to rule out the effects of alternate factors. They retain the basic or essential real-world characteristics while leaving out other aspects deemed superfluous for the purposes at hand. Microworlds offer the great advantages of experimental manipulation and control, without stripping away the complexity and the dynamic nature of the task.

Microworlds are highly configurable environments. Developing customized scenarios allows inserting cognitive stressors and investigating their impact on teamwork and team effectiveness. Time pressure and workload were selected as stressors to study adaptability and coordination in CM. These stressors are pervasive characteristics of crisis situations and are therefore highly relevant for the purpose of this study. The C^3Fire microworld (Granlund, 1998, 2003), a forest firefighting simulation, is used to reproduce a complex and dynamic C2 situation.

Method

Participants

One hundred and ninety-two participants, 78 male and 114 female (*M* = 25.2 years old, *SD* = 8.7 years) were recruited on the Université Laval campus in Québec City, Canada. They were divided into 48 four-person teams. Each person was randomly assigned to one position in the team. Participants received an honorarium in exchange for their participation.

Material

The C^{3}Fire microworld is a computer-controlled simulation of forest firefighting (e.g., Granlund, 1998, 2003; Tremblay, Lafond, Gagnon, Rousseau, & Granlund, 2010; Tremblay, Lafond, Jobidon, & Breton, 2008). The C^{3}Fire interface consists of a geospatial map, displayed on a 40×40 cell grid, built up by a set of four interacting simulation layers: fire, geographical objects, weather, and intervention units (see Figure 1). The *fire layer* defines five different states for each cell of the map: clear, firebreak, on fire, extinguished, or burned out. A clear cell is a cell in which no fire has started yet, but that can be ignited if an adjacent cell is already burning. A cell turns red when on fire, and brown when extinguished. If a cell is not extinguished within a certain time interval after ignition, it turns black and is considered burned out. A burned-out cell cannot be extinguished or reignited. A firebreak can be built on a clear cell, which turns grey and can no longer be ignited.

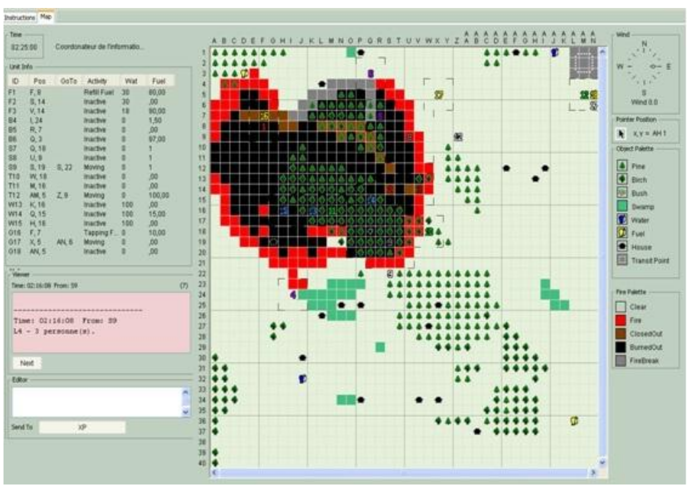

Figure 1. C^{3}Fire interface.

The *geographical objects layer* corresponds to the different types of physical entities displayed on the map (houses, transit point, water tanks, fuel tanks, birches, pines, and swamps). The content of a cell directly influences its ignition time. Swamps, transit point, water tanks, and fuel tanks cannot ignite. The *weather layer* determines the strength and direction of the wind. The stronger the wind, the faster the fire spreads to adjacent cells in the same direction as the wind blows. The *unit layer* refers to the six types of intervention units under the control of the operators: firefighter (FF), firebreakers (FB), water tankers (WT), fuel tankers (FT), search units (S) and rescue units (R), each represented by a numbered icon. Each type of unit is colour-coded and has a specific role: FF extinguish fire, FB create firebreaks to control the spread of fire, FT and WT supply water and fuel to the other units, S explore the map in order to find new fires and survivors, and R collect the survivors and bring them to a transit point. To move a unit, operators must click on the unit and drag it to the desired destination cell. FF extinguish fire by moving to a burning cell. Their reservoir contains only a limited quantity of water, and they are refilled by moving a WT to an adjacent cell. Similarly, FF, FB, WT, and R have a limited fuel reservoir, which is refilled by moving a FT to an adjacent cell. Finally, WT and FT have a limited tank, and have to be refilled by moving respectively to water tanks and fuel tanks distributed on the map.

Throughout each C^3Fire scenario that teams completed for this study, the Morae software (TechSmith, Okemos, MI) recorded every event that happened in the microworld (e.g., keystrokes) and performed continuous screen capture. Team members could speak to each other via headsets by holding down the Control key. All communications were transmitted and recorded using the Teamspeak software (TeamSpeak Systems, Krün, Germany).

Design

The study was based on a 2 (team structure) × 2 (time pressure) × 2 (workload) mixed design, with team structure as the between-subject variable (functional, edge), and time pressure and workload as within-subjects variables. In the context of C^3Fire, time pressure was operationalized as the tempo at which the fire spreads (slow, fast) and workload was operationalized as the number of fires teams have to manage (one or two fires). The combination of the two within-subjects variables created the four test scenarios, each with different dynamics (see Table 1). Scenarios were presented in a counterbalanced order.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tempo	slow	slow	fast	fast
Fires	two	one	one	two

Table 1. Combinations of the two independent variables in each test scenario.

Procedure

Teams were assigned randomly either to the functional or edge condition. In the functional condition, participants were assigned randomly to one of four roles: *operation chief*, responsible for three FF and three FB; *search and rescue chief*, responsible for three R and three S; *resources chief*, responsible for three WT and three FT; and *planning chief*, who did not control any units. The planning chief saw the position and the information about the units of his or her team members. This role also required to send a message to the media every two minutes to make an assessment about the fire propagation and the rescue of the civilians. In the edge conditions, participants were given information on the different units, and were instructed to allocate the roles and the units amongst themselves as they saw fit. Three goals were given to participants: 1) to save civilians in houses from the fire, 2) to prevent houses from burning, and 3) to limit fire propagation.

The experiment consisted of a single testing session that lasted between 2.5 and 3 hours. The timeline of the experiment is represented in Figure 2. In the tutorial phase, participants read a tutorial describing the simulation and goal of their mission, and watched a demonstration of the software. Following these instructions, participants completed two familiarization scenarios. The first scenario lasted 15 minutes and was played individually to allow participants to familiarize themselves with the basic C[3]Fire functionalities. The second familiarization scenario lasted 10 minutes and was played with the other team members allowing them to learn to play C[3]Fire as a team. Then, each team completed a 5-minute unsupervised (but recorded) planning session. This was followed by a short questionnaire session that aimed to assess shared mental models and quality of planning. Then, all participants performed four 10-minute test scenarios, each followed by questionnaires (post-scenario questionnaires took 5-7 minutes completing). The experiment ended with a final set of questionnaires that addressed the overall experiment, which took participants between 20 and 30 minutes to complete.

Figure 2. Experiment timeline.

Metrics

A set of cognitive and teamwork metrics was developed to assess team adaptation to unexpected events. These included measures of performance, coordination effectiveness, and level of activity. For each metric, an adaptability score was calculated comparing two minutes before the discovery of the second fire with two minutes following this unexpected event. As teams were aware of the first fire (although they did have to find its location), the discovery of the second fire represented the unexpected event of interest in this paper. Therefore, the adaptability score focused on that event. The following formula was used:

$$Adaptability\ Score = \frac{Score\ after\ the\ unexpectec\ event}{Score\ before + after\ the\ unexpected\ event} \div 0.5$$

An adaptability score greater than 1 means that the score after the unexpected event is greater than the score before the unexpected event. This formula was used in order to prevent scores of 0 from creating false missing data. Therefore, if the scores before and after the unexpected event are null, the adaptability score will be 1. This formula was applied to measures of performance, coordination, and activity level.

Performance

Performance was measured through firefighting efficiency. In the C[3]Fire scenarios, the teams' main task was to extinguish the fire in order to achieve their objectives. A team that can extinguish fire at a greater pace will generally be able to control the threat to civilians, houses, and forest better. The number of extinguished cells was used as a firefighting efficiency index, which was calculated as follows:

$$\frac{\textit{Total number of cells extinguished}}{\textit{2 minutes}}$$

If a team achieved the objectives and completed the task or if the mission ended before the post-event two-minute period elapsed, the denominator of the formula reflected the actual duration rather than the maximum two-minute period. The same denominator and logic were used to calculate coordination effectiveness and activity level scores.

Coordination Effectiveness

Coordination effectiveness was based on the time each unit spent without resources (i.e., water or fuel) to function. This is a measure of the effectiveness of resource-oriented coordination. This type of coordination refers to processes that serve primarily to manage dependencies between activities or resource dependencies (Crowston, 1997). It provides an excellent indicator of the efficiency in performing the water and fuel refill process, which requires coordination between the various units. It was calculated as follows:

$$\frac{\textit{Total time without resources for all units}}{\textit{2 minutes}}$$

Based on this formula, a score of 0 represents optimal coordination effectiveness, as a unit would never have an empty water or fuel tank during the period of interest.

Activity Level

The activity level was assessed by measuring the number of commands given to all the units during a given period. An active team is deeply involved in the execution of their task, while a less active team could be in a planning phase or not focused on the task. The ratio of actions performed before and after the beginning of a second fire represents adaptation in terms of taskwork adaptation; that is, adaptation with regards to the task and goals to be achieved by the team. A high ratio suggests efficient adaptation. This measure was calculated as follows:

$$\frac{\textit{Total number of commands}}{\textit{2 minutes}}$$

Results

Based on the design, C^3Fire logs and Teamspeak recordings yielded a considerable set of data. As the focus of the paper is on teams' adaptability to an unexpected event, a subset of the data was considered for statistical analysis. The discovery of the second fire represented that unexpected event so only scenarios with two fires (high workload) were included in the analyses as scenarios with only one fire (low workload) were not relevant for the purpose here. Also, seeing as we were mainly interested in comparing adaptability of the two team structures for this paper and that only teams that discovered the second fire could be considered for analysis, the two levels of time pressure were collapsed in order to maximize statistical power. Therefore, analyses of variances (ANOVAs) were conducted on the various metrics with team structure as a between-subject variable. A total of 72 completed scenarios (out of 96 high-workload scenarios) were included in the analyses used to compare team structures; 31 of those missions were completed by teams in the functional condition and 41 by teams in the edge condition. An alpha level of .05 was used for all statistical analyses.

One-way ANOVAs were run on the adaptability ratio for performance, coordination effectiveness, and activity level (see Figures 3 to 5). The results on the performance metric revealed that edge teams had a significantly lower adaptability score than functional teams for firefighting efficiency, $F(1,70) = 7.904$, $p < .01$. However, the adaptability scores for the two team structures did not significantly differ for coordination effectiveness, $F(1,70) = 1.305$, $p = .257$) and for activity level, $F(1,70) = 1.470$, $p = .229$.

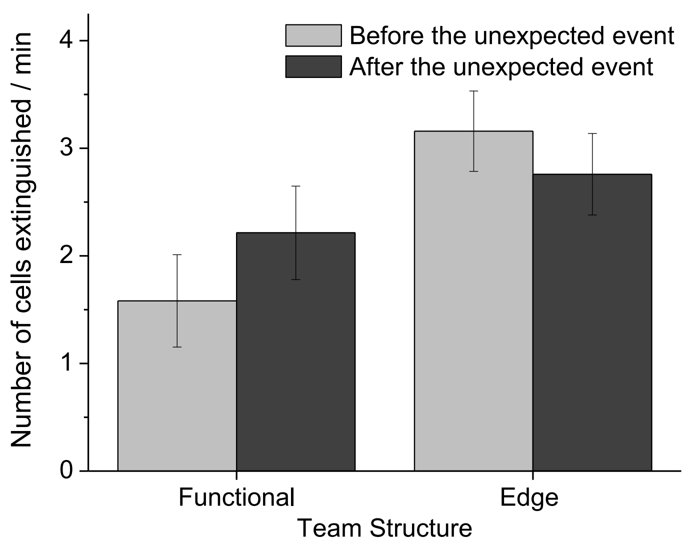

Figure 3. Mean performance as a function of the discovery of the second fire and team structure. Error bars represent standard errors.

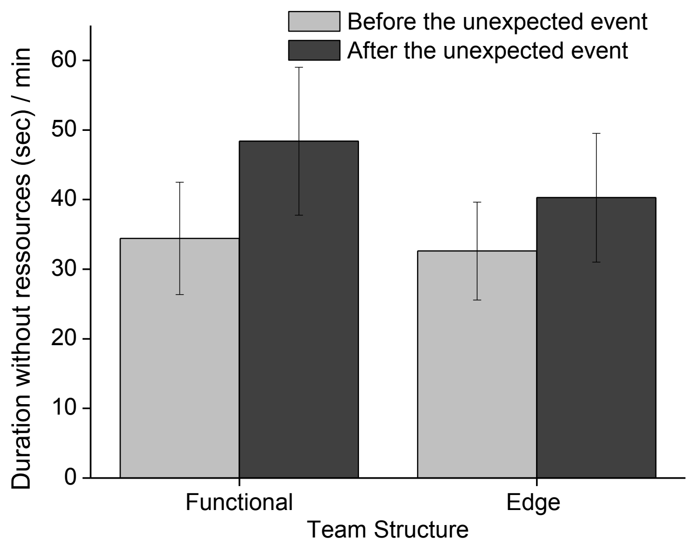

Figure 4. Mean coordination effectiveness as a function of the discovery of the second fire and team structure. Error bars represent standard errors.

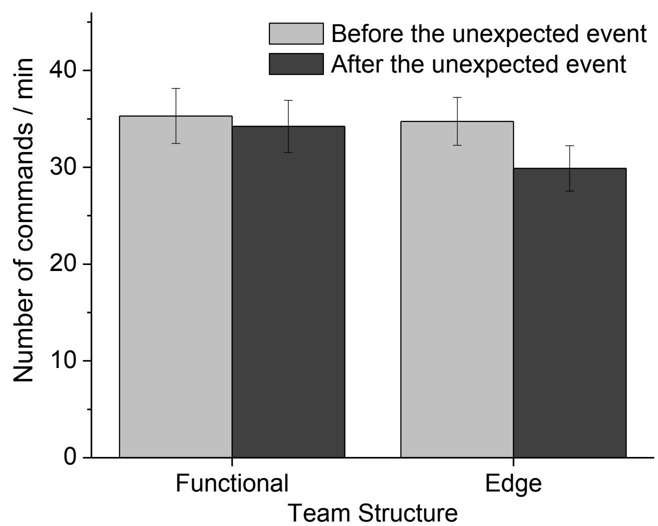

Figure 5. Activity level as a function of the discovery of the second fire and team structure. Error bars represent standard errors.

Further analyses examined whether the two team structures differed before and after the unexpected event, separately. The ANOVAs showed that edge teams had a greater firefighting efficiency than functional teams before the discovery of the second fire, $F(1,70) = 7.696$, $p < .01$). However, firefighting efficiency was not significantly different after the unexpected event, $F(1,70) = 0.890$, $p = .349$. Coordination effectiveness and activity level both before and after the unexpected event did not differ significantly between functional and edge teams (all *p*s > .228).

One of the linchpins of edge organizations is that team members are free to adopt the structure and patterns of interaction that they think best suit them and/or the situation. A corollary to that flexibility is that there is a greater potential for variability across teams in the edge condition than in the functional condition. To explore that assumption, standard deviations were analysed in order to look for patterns that mean analyses may not have revealed (see, e.g., Devine & Phillips, 2001; Peeters, van Tuijl, Rutte, & Reymen, 2006). Applying the same logic as the analyses performed on mean scores, ANOVAs were run first on standard deviations of the adaptability ratio for the three metrics, and then on standard deviations of scores before and after the discovery of the second fire separately.

With regards to the adaptability ratio, ANOVAs revealed that standard deviations for the level of activity were greater for edge teams than for functional teams, $F(1,70) = 5.755$, $p < .05$). No significant differences in variability were found for firefighting efficiency, $F(1,70) = .618$, $p = .434$, and coordination effectiveness, $F(1,70) = .015$, $p = .903$.

When variability was analysed before and after the event, respectively, results indicated that standard deviations for firefighting efficiency were significantly higher for edge teams than for functional teams after the event, $F(1,70) = 6.680$, $p < .05$ but not before, F(1,70) = 2.545, $p = .115$. Neither the variability for coordination effectiveness, $Fs(1,70) < 1$, $ps > .82$, nor activity level, $F(1,70) = 2.000$, $p = .162$ and $F(1,70) < 1$, $p = .582$, were significantly different across team structures before or after the discovery of the second fire.

Discussion

Natural or human-made crisis situations can require the involvement of public safety and military teams, both domestically and abroad. CM is complex and dynamic by nature, and puts high demands on teams in a context of high risk, uncertainty, high workload, and time pressure (e.g., Brehmer, 2007; Gonzalez et al., 2005). As such, teams in CM situations need to be adaptable in the face of sudden and unexpected events (LePine, 2005; Uitdewilligen et al., 2010).

The purpose of this paper was to investigate teams' response to unexpected events in CM situations and the extent to which such events affect adaptability in different organizational structures, namely functional and edge teams. The flexibility of edge teams with regards to role and resource allocation is theorized to allow greater potential for adaptability in the face of unexpected events and changing demands (e.g., Alberts, 2007; Alberts & Hayes, 2003). However, this could come at a cost of role ambiguity and decreased team effectiveness.

In the context of C^3Fire, the unexpected event that teams had to manage was the occurrence of a second fire in the area of operation. In the same vein as LePine (2005) and Jobidon, Breton, Rousseau, and Tremblay (2006), team adaptability was assessed over time, with the discovery of the second fire as the critical moment, and two minutes before and after the discovery as the periods of interest for the analyses.

The findings indicate that functional teams adapted more efficiently than edge teams in the short term (i.e., two minutes after the discovery of the second fire), as shown by a greater adaptability in firefighting efficiency in terms of number of extinguished cells. Indeed, edge teams had a lower adaptability ratio with regards to performance; that is, they exhibited a better performance before the discovery of the second fire than after. As edge teams were fighting the fire significantly more efficiently than functional teams before the discovery of the second fire but not after, this suggests that the unexpected event had a greater impact on edge teams than functional teams. A likely explanation for that finding is that task and resources allocation in edge teams is less explicit and potentially less specific than in functional teams, and the potential role ambiguity could lead to greater confusion when unexpected events occur and have to be dealt with, leading to a loss of performance for edge teams in the time period following the discovery of the event.

In order to further explore the flexibility afforded to edge teams compared to functional teams, variability in performance, coordination, and activity level across teams was assessed. The findings show that the adaptability ratio related to activity level was more variable in edge teams than functional teams. This suggests that the adaptability of edge teams in the face of a second fire, as reflected by the activity level, varied across teams (with some teams being more active shortly following the fire while others are less active) whereas functional teams seemed to maintain a more consistent level of activity when adapting to the discovery of the second fire. This finding is consistent with the assumptions associated with EOs (e.g., Alberts & Hayes, 2003; Cooney, 2004); that is, edge teams took advantage of their flexibility and different teams behave differently during the completion of their task. The greater variability observed with adaptability of activity level in edge teams as well as their greater variability in terms of performance following the second fire are also in line with the hypothesis of role ambiguity mentioned above. Indeed, role and resource allocation being vaguer in the edge condition than in the functional condition, it is plausible that as a result adaptability to an unexpected event would vary more across edge than functional teams, with an impact on performance.

Interesting comparisons arise with Dubé et al. (2010) who compared functional and cross-functional teams. Indeed, they observed that cross-functional teams coordinated more efficiently overall than functional teams in situation with an unexpected event, while the present study indicates that functional and edge teams did not differ in that regard. However, different time periods were considered in both studies – overall scenario in Dubé et al. and two minutes before and after the event here – so further analyses should inform us on overall coordination effectiveness across edge and functional conditions and lead to a more direct comparison of the two studies. In the context of the present study, the findings suggest that the differences observed with performance and activity level are not related to variations in coordination effectiveness as characterized by the time spent without water or fuel resources, at least in the short term following the unexpected event. Also, contrary to Dubé et al.'s comparison of adaptability in functional and cross-functional teams, we did observe significant differences in adaptability between functional and edge teams, with the latter seemingly having more difficulty to adapt to the discovery of the second fire and displaying greater variability in their activity level when adapting to the event.

Conclusion and Future Work

Overall, the present paper provides evidence that the flexibility afforded by the edge structure can indeed lead to variances in how teams go about completing their task. However, this seems to come at a cost when edge teams are faced with an unexpected event, at least in the short term. Tremblay, Vachon, Lafond, and Kramer (2012) observed that recovery from an unexpected event can take place over various phases (in their case, recovery from unexpected task interruption), therefore it would be interesting to investigate functional and edge teams' response to the discovery of the second fire on later time periods and the overall scenario. In addition, examining the content of communication and other teamwork indicators (e.g., cluster analysis, see Duncan & Jobidon, 2008) would be interesting to explore whether trends or patterns emerge in how edge teams organize their roles and resources during a scenario. Such analyses should help further our understanding of the current findings, and more generally of how functional and edge-like team structures respond to unexpected events in CM situations. Another interesting avenue would be to investigate the impact of education and/or training of strategies to adapt to various types of events, in both functional and edge structures. In the current study, participants were not given information on potential strategies that could be used to deal with an expected event such as the occurrence of the second fire. Giving teams information about possible ways to adapt to unexpected events may enhance team response and team performance in these situations.

Agility, adaptability and related concepts are increasingly prominent in public safety and military organizations. Teams and organizations must be able to adapt to a wide range of circumstances in dealing with situations characterized notably by high risk, time pressure, and uncertainty. EOs have been put forward as a more decentralized, flexible and presumably efficient alternative to traditional functional or hierarchical structures. However, in line with previous studies (e.g., Dubé et al., 2010; Duncan & Jobidon, 2008; LePine, 2003), the present study suggests that flexible structures are not a straightforward solution to the constraints of traditional structures. Furthermore, it could be argued that the ramifications of edge structures may be compounded in underdeveloped, degraded, and denied operational environments that military organizations are increasingly susceptible to face. Indeed, deployment in these environments may be plagued by unavailable and/or unreliable capabilities and infrastructures, which can hinder elements important for collaboration and mission success, such as coordination, communication, and shared situation awareness. On one hand, it is possible that the costs of EOs be worse under these circumstances – for instance, an unreliable or disrupted communication network leading to increased difficulty in clarifying roles and planning courses of actions to react to unexpected events. On the other hand, the flexibility and adaptability potentially afforded by EOs could emerge to be assets under some of these degraded conditions. Therefore, while edge-like structures may have clear advantages, more empirical work is required to determine their drawbacks and under what circumstances flexible structures are best.

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