Patterns of Information Technology (IT) Adaptation in Building Shared Mental Models for Crisis Management Teams

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ABSTRACT

One of the essential tasks of crisis management is to develop shared mental models (SMM) among teams and members about the crisis at hand, i.e. shared understanding of the task, process, technology and the teams. This is essential for developing an effective crisis management strategy. In this paper we draw lessons from our studies of distributed teams and their adaptation of IT capabilities to impact shared understanding. In particular, we discuss how patterns of the interplay between IT adaptation and SMM development have implications for crisis management teams.

Keywords

Shared mental models, information technology adaptation, crisis management, case study.

INTRODUCTION

Given the turbulent nature of the context in which businesses operate today, organizations are confronted with all kinds of crises as they grow and expand (McCray, Gonzalez, & Darling, 2011; Pearson & Clair, 1998). Although some researchers have argued that the outcomes of crisis response are always constrained by success and failure to some extent, a failure-dominant crisis response can close a firm or have severe long-term negative impacts on the firm (Boin, van Duin, & Heyse, 2001; Pearson & Clair, 1998).

Dealing with crisis is not an easy task. As Hermann has noted, crises are "devices of change" (C. F. Hermann, 1963, p.62). The occurrence of crises means that a breakdown in the organization's

traditional norms, values, and standard operating procedures has occurred (M. G. Hermann, 1979; Parker & Stern, 2002; Pauchant, Mitroff, & Lagadec, 1991; Pearson & Clair, 1998; Quarantelli, 1988). During crises, organizations can experience disruptive changes in shared meaning, institutionally-constructed relationships, collective beliefs, shared sense making, organizational culture, and decision and power structure (Cheng, Padgett, & Parekh, 2013; McCray, et al., 2011; Uriel Rosenthal & Kouzmin, 1991). All these phrases relate to facets of the development of a shared mental model among crisis teams and members of the task at hand ("the crisis"), processes ("crisis management practices"), technologies for coordination, information processing and control, and about each other ("team members").

In addition, the diversified background of crisis response team members makes it a challenge to deliver quality decisions. In practice, organizations will build a centralized crisis management team (CMT) consisting of decision makers, experts and advisers, and key stakeholders (Pearson & Clair, 1998). Often, the CMTs need to reconcile conflicts arising from CMT members' specific values, perspectives, and assumptions (Calderon, Hinds, & Johnson, 2013; Hart, Rosenthal, & Kouzmin, 1993; Pearson & Clair, 1998). CMTs are also trained to avoid "groupthink" that may result in biased decisions (M. G. Hermann, 1979).

Researchers have previously found that developing shared mental models (SMM), i.e. shared understanding of the goals, strategies, procedures, communication patterns, and team members' backgrounds, among crisis response team members can help organizations overcome the afore mentioned challenges (Cannon-Bowers & Salas, 1993; Lim & Klein, 2006; Mohammed, Ferzandi, & Hamilton, 2010).

Recent advances in information technologies (IT) offer immense promise for CMTs in coping with crisis events (Botterell & Griss, 2012; Lanfranchi, Mazumdar, & Ciravegna, 2014; Pottebaum, Marterer, & Schneider, 2014; Turoff, Chumer, Van de Walle, & Yao, 2004). For example, there has been much research conducted in exploring the best means of using social media, such as Twitter and Facebook in coping with crisis events (Hiltz, Kushma, & Plotnick, 2014; Sutton, et al., 2014). CMTs develop SMM through the adaptation of information technology (IT) capabilities that enable coordination, communication, interaction, and information processing during crisis (Davis, Murphy, Owens, Khazanchi, & Zigurs, 2009). Prior research suggests that communication channels will be reduced during crisis (Pauchant, et al., 1991). Further, CMTs may experience information overload and need to adapt to new communication and coordination schemes via information technology capabilities (McNeill, Gkaniatsou, & Bundy, 2014). Given the psychological, socio-political, and organizational influences on crisis management teams, we anticipate that these teams may exhibit varied patterns of IT capabilities adaptation when developing SMM for coping with crisis situations. Thus, the goal of this paper is to explore such patterns so that CMT's adaptation of IT capabilities can be better understood and/or potentially predicted during various stages of crisis. In addressing this goal, we will also discuss the rationale and implications of these patterns for the design of IT capabilities that could support CMTs in effectively responding to crisis. In view of the aforementioned discussion, our research addresses the following question: *what potential patterns of interplay between IT capabilities adaptation and SMM development are relevant in crisis management teams?*

CONCEPTUAL FOUNDATIONS

In developing the ideas in this paper we hold four important assumptions: 1) individuals/teams have cognitive limitations, i.e. cognitive biases, which can be even strengthened under crisis, 2) individuals/teams' cognitive limitations can affect sense making and decision making during crisis, 3) emerging IT capabilities can be utilized to improve sense making and effect positive team outcomes; and 4) training can help CMTs overcome or minimize those limitations.

Figure 1 illustrates a conceptual framework that places our previous research on patterns of interplay between IT capabilities adaptation and SMM development in the context of crisis decision making. Drawing on previous literature in the crisis and information systems literature, we suggest an interplay relationship between SMM development and IT adaptation by crisis management teams.

Specifically, crisis management teams could adaptively use IT capabilities during CMT's communication, interaction, and information processing related activities, and therefore rely on IT adaptation to build shared understanding. CMTs' development of SMM can affect which IT capability will be used and for what purpose that particular IT capability is used.

Given the varied response behaviors by crisis management teams and their varied perceptions, experiences and habits of using information technologies, we also posit that there can be varied patterns of interplay relationship between shared mental models development and IT adaptation. Furthermore, the extent to which crisis management teams work under time pressure, severe threat and uncertainty can affect the paths following which IT capabilities interplay with SMM development.

In the next sections, we review key concepts and theories that provide the conceptual basis for our discussion.

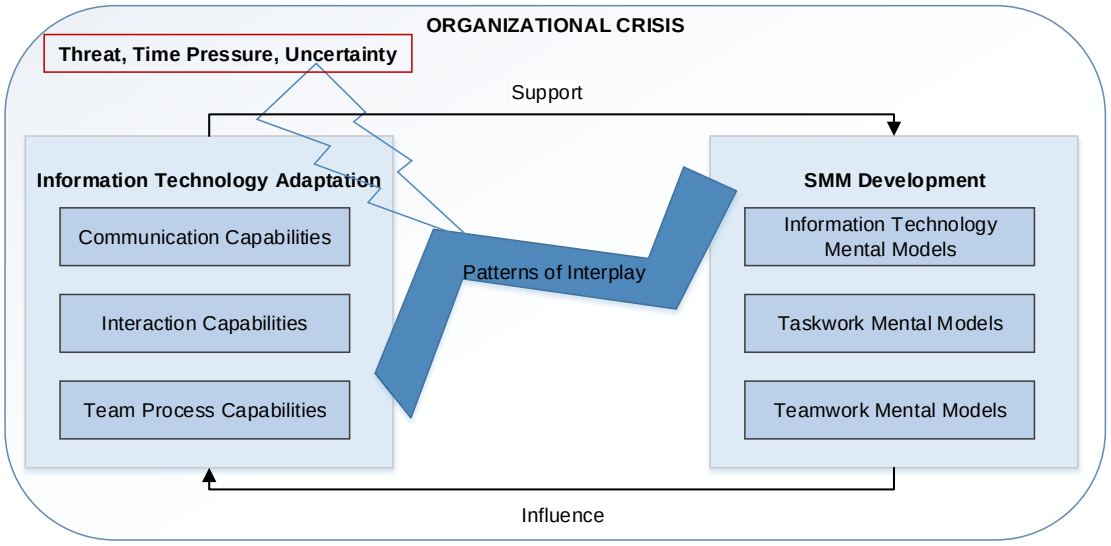

Figure 1. Conceptual Framework

SMM in Crisis Management Teams

Crisis is "a serious threat to the basic structures or the fundamental values and norms of a social system, which – under time pressure and highly uncertain circumstances – necessitates making critical decisions" (U. Rosenthal, Charles, & Hart, 1989, p.10). This definition reflects three prominent characteristics of crisis management, i.e. severe threat, time pressure, and high uncertainty (Brecher, 1979). Crisis management is seen as effective when "potential crises are averted or when key stakeholders believe that the success outcomes of short-and long-range impacts of crises outweigh the failure outcomes" (Pearson & Clair, 1998, p.62).

Organizations often form crisis management teams, which may consist of decision makers, experts and advisors, key stakeholders, peer members of the high-policy elite, and military, and even members from competing elites and interest group (Brecher, 1979; Pearson & Clair, 1998).

Building shard mental models (SMM) in CMT is important for constructively solving conflict among members so that CMT members can collaborate effectively when coping with crisis. Shared mental models (SMM) are formally defined as "knowledge structures held by members of a team that enable them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behavior to demands of [their unique domain]" (Cannon-Bowers & Salas, 1993, p.228). Research has shown that teams with shared mental models have stronger adaptability than teams that do not (McNeill, et al., 2014; Turoff, et al., 2004).

Studies have also suggested that teams can form three types of mental models, i.e. information technology mental models, taskwork mental models, and teamwork mental models (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Thomas & Bostrom, 2007; Dominic M. Thomas & Robert P. Bostrom, 2010). A team's IT mental model is the knowledge structure and beliefs held by the team about the information technology capabilities and the usage of these capabilities (Thomas & Bostrom, 2007). A team's taskwork mental model is the knowledge structure and beliefs held by the team about the task goals, steps to accomplish the tasks, and the technologies used to accomplish the tasks (Mathieu et al. 2000). The teamwork mental models refer to the knowledge structure and beliefs held by the team about the team interaction and team members' roles, skills, and knowledge (Mathieu et al. 2000). Assessment of shared mental models' convergence is mostly focused on measuring the degree to which knowledge structures overlap or are similar among the team members, i.e. the SMM similarity (Mohammed et al. 2010).

Adaptive Use of IT Capabilities

Adaptive use of IT capabilities (AUITC) refers to the process when CMTs either proactively or passively adapt a variety of IT capabilities to the environment in the team process (Yu and Khazanchi, 2014a). CMTs have to build the capability of using IT effectively, sometimes even creatively so that positive CMT ("Introducing an Agile Process to an Organization,") outcomes can be attained. Researchers have shown that during crisis, CMTs often experience information overload, thus, quick, accurate, and direct information dissemination is critical to successful CMTs management (McNeill, et al., 2014; S.Tucker, et al., 2012). Similarly, researchers suggest that the ability of organizations in sending out information to the targeted audience in the right time important to crisis preparedness and

crisis prevention (Appelbaum, Keller, Alvarez, & Be´dard, 2012). Further, researchers have shown that using different communication technologies for crisis situation is critical to CMTs (Aman, Irani, & Liang, 2012). CMTs can rely on IT for searching for alternative choices and making evaluations during the decision making process (S.Tucker, et al., 2012).

The above discussion illustrates the critical role that IT plays in crisis management. There are many ways of characterizing IT. We adopt the characterization of IT developed by Davis et al (2009), which is built upon work in the Group Support Systems (GSS) domain by Zigurs and Buckland (1998). Based on Davis et al's characterization, IT capabilities include communication, interaction, and team process (Davis, et al., 2009). IT capabilities refer to "distinctive features of a specific technology that include various technological functionalities and offer an undeveloped potential that is dynamic, representing a starting point that can change through interaction in the environment" (Davis et al., 2009, p. 95). A formal definition of three categories of IT capabilities is as follows:

- IT communication capabilities: any capabilities that support a virtual team's communication and collaboration.
- IT interaction capabilities: any capabilities that support the process of people working with others and engaging with the virtual collaborative environment.
- IT team process capabilities: any capabilities that support team processes, such as process structure, information processing, appropriation support, and socialization/community building (adapted from (Davis, et al., 2009; Zigurs & Buckland, 1998).

Studies have found that users engage in a cycle of adaptive technology use once they adopt the technology (Bhattacherjee, Limayem, & Cheung, 2012; Limayem, Hirt, & Cheung, 2007; Ortiz de Guinea & Markus, 2009; Sun, 2012; D. M. Thomas & R. P. Bostrom, 2010). In each cycle of adaptive IT use, users start with learning about the technology to develop their own ways of using the technology or eventually abandoning the technology (Jasperson, Carter, & Zmud, 2005).

There are a variety of reasons that can influence teams' adaptation of IT, such as perceived usefulness, perceived ease of use, prior usage experience, habits, interactions among users, leader/experts' opinion, collective beliefs on technologies, and other contingent factors (Limayem, et al., 2007; Sarker, Valacich, & Sarker, 2005; Venkatesh, Morris, Davis, & Davis, 2003; Zigurs & Buckland, 1998).

RESEARCH DESIGN

Study Setting

We utilized a mixed research longitudinal multiple case study embedded with a survey design to explore IT adaptation and its influence on SMM development in virtual teams (Yu and Khazanchi, 2014b). Participants were students enrolled in an asynchronous, Internet-mediated undergraduate-level course taught at a mid-size university in Midwestern U.S.A. A total of seventeen participants were assigned into five teams of three to four. Participants had no face-to-face meeting during the study. Gmav (i.e. customized email), Blackboard (BB), and Google Sites were the collaborative technologies used in this study. The team task required the development of an e-commerce business plan. Interim

deliverables provided structure to the task, but each team had to determine its own process for completion of the task. The deliverables were submitted through a customized website in Google Site.

Our study included teams that share characteristics associated with crisis management teams in that 1) team members had little to no experience with their co-workers, 2) teams were assigned a relatively complex task that needed to be completed in a certain time, and 3) team members had to develop shared mental models through communication and collaboration by adapting to a variety of IT capabilities.

Data Collection and Data Analysis

We collected both qualitative and quantitative data in the study. The qualitative data was collected from: 1) the weekly individual-based self-reports regarding perceptions of a team member's technology-usage experience, 2) text of team communication in emails, BB discussion board posts, BB blog posts, BB wiki posts, BB journal posts, and Google Sites-enabled communication. In addition, quantitative data was collected using a survey of all team members. The survey consisted of measures for IT capabilities adaptation and SMM development. In addition, the technology usage logs from Google Site were quantified to describe each team's interactions with Google Site features. Following are examples of data that was collected and coded.

> Example 1: Quote from the individual-technology usage report.
>
> *[Mary]: This technology will be used to keep all of the final information for our project. My goal is to have this page fully utilized by all team members. I also want to keep this as clutter free as possible. … I brainstormed some ideas on how it can be used for the project. Once we finalized our overall theme, I'm hoping to put my research into action.*
>
> Example 2: Logs in Google Site:
>
> *Nov 4, 2012 5:53 PM XXX edited an item in Tasks*
> *Nov 7, 2012 8:54 PM XXX edited an item in Tasks*
> *Nov 7, 2012 7:36 PM XXX edited Welcome to Webcolamities*
> *Nov 7, 2012 7:42 PM XXX edited Welcome to Webcolamities*

The overall data analysis strategy in our study was to use a case study approach to identify major themes in the data and to use survey data analysis as a supplementary quantitative assessment of our constructs and the relationships among the constructs.

Specifically, all of the qualitative data was organized into three documents about the technology usage, team communication, and Google Site activities respectively. The three documents had a total of 146 pages. Then one of the authors read through the documents several times to get a sense of the data and then discussed with the second author about the data for further refining the coding scheme. We then coded qualitative data into coding categories for major concepts on AUITC and SMM. We categorized the initial team interaction into high and low based on the number of days of team interaction observed (Yu & Khazanchi, 2014b). We also used a time-ordered matrix for each of the five teams to better visualize the interplay between AUITC and SMM. In each time-ordered matrix, the columns were arranged by week, from the first week to the last week of the case study project. The rows were

sub-dimensions of two major components, the AUITC and SMM.

PATTERNS OF IT ADAPTATION AND SMM DEVELOPMENT IN DISTRIBUTED TEAMS

Drawing on the results of this research, we found that the dynamic interplay between the IT adaptation and SMM development in distributed teams shapes how teams execute tasks and build relationships. Additionally, a team's adaptation of IT capabilities also influences the method and quality of the SMM development in distributed teams. Teams vary in their patterns of such interplay. We identified three distinct patterns of the interplay between IT capabilities adaptation and SMM development that has direct implications for crisis management teams and crisis decision making. Table 1 summarizes the key characteristics of these patterns and the following paragraphs elaborate further on their unique characteristics (Yu & Khazanchi, 2014b).

Table 1: Patterns of the Interplay between IT Capabilities Adaptation and SMM Development (adapted from Yu and Khazanchi, 2014a)

SMM-driven Pattern
1. Early and active initial interactions
2. Relatively low time pressure in the beginning of the teams' life cycle
3. Inclusive and creative exploration of IT capabilities
4. Early convergence of SMM on IT capabilities usage for supporting team interaction and task completion
5. Relatively high level of IT capabilities adaptation evidenced by quality IT usage, diversity of IT capabilities used, and fit between technology and task
6. Effective information exchange and process accompanied by high SMM convergence
AUITC-driven Pattern
1. Late and inactive initial interactions
2. Relatively low time pressure in the beginning of the teams' life cycle
3. Limited and conservative use of IT capabilities
4. Dominant by IT capabilities enabled task-oriented and problem-solving activities
5. Increasingly adapt to new IT capabilities or new purposes of using those IT capabilities
6. SMM convergence is contingent on if teams identify a fit between technology capabilities and task
Struggle Pattern
1. Early and active initial interactions
2. Relatively low time pressure in the beginning of the teams' life cycle
3. Inclusive but mindless exploration of IT capabilities
4. Struggle at coping with some individual's "inactive" coping behavior
5. Low to moderate level of IT capabilities adaptation evidenced by low degree of fit between technology and task

6.	Ineffective information exchange and process accompanied by low to moderate degree of SMM convergence

SMM-driven Pattern

Teams following this pattern initiate their interaction early and actively so they experience relatively low time pressure when accomplishing tasks. We have labeled these teams as "IT sensitive" teams. What has become increasingly clear from our research is that one of the clearest factors that distinguish the SMM-driven pattern from the other two patterns is the early convergence of teams' shared mental models on what IT capabilities they would use and how these IT capabilities were going to be used.

Members of "IT sensitive" teams do not take viewing and exploring new IT capabilities as a cost. Rather, they view exploring IT capabilities and making adaptation according to specific team needs as a strategic necessity. Specifically, these teams recognize the importance of establishing mechanisms for information processing and communication. Further, these teams appreciate the potential of exploiting IT capabilities in supporting their goals.

The early decision on choice of IT capabilities and how these capabilities will be used is also very important for teams to achieve high convergence on SMM about taskwork mental models and teamwork mental models. That is because the teams can effectively use IT capabilities to manage the building, storing, accessing, and applying of their team knowledge well. Clearly, this pattern is ideal for CMTs dealing with solving challenges consistently under time pressure and uncertainty.

AUITC-driven Pattern

One of the distinguishing characteristics of the AUITC-driven pattern is that teams start their initial team interaction very late in the process of managing their tasks and establishing an effective collaboration with each other. Because of this delay, teams in this pattern feel high time pressure in accomplishing the tasks on time.

One of the consequences of the perceived high time pressure is that members tend to follow the "ideal" sequence of completing project or tasks, from opportunity identification or goal attainment, problem solving, interaction, to execution (Mcgrath 1991). However, teams in this pattern pay little to no attention to relationship building among team members and rarely explore the potentials of using IT capabilities to enhance team interaction (Yu & Khazanchi, 2014b).

Furthermore, teams in this pattern tend to increasingly adapt a diverse set of IT capabilities and the members' convergence on SMM is contingent on whether there is a fit between the technology capabilities in use and the requirements for building a particular type of mental model.

Struggle Pattern

Like the SMM-driven pattern, teams in the struggle pattern start their initial interaction early and consequently experience low time pressure. In addition, the teams using this pattern also explore diverse IT capabilities; however, the teams tend to not be reflective and thoughtful about using and adapting IT capabilities effectively. This mechanical use of IT capabilities inhibits teams from adapting

IT capabilities to the team and task over time and therefore has a negative impact on teams' development of SMM through communication and interaction.

Another notable characteristic of the struggle pattern is the negative impacts of team members' coping behaviors on teams' development of SMM through IT capabilities adaptation. In our research, we found that there are individuals who show "distancing" or "inactive" coping behavior during task activities. Unlike the other two patterns when teams can accommodate such unfavorable individuals' coping behaviors, the team using struggle patterns show intolerance of these coping behaviors (e.g. late or no response to someone else's requests). The intolerance of the other members' inactive coping behaviors leads to the delay in task accomplishment and low level of convergence on SMM.

DISCUSSION

The results of our study suggested three patterns of interaction that have direct relevance to CMTs' SMM development and adaptive use of IT capabilities. As elucidated earlier, these three patterns are different in terms of teams' perceived time pressure during all stages of task management, the path teams follow to develop shared understanding (i.e. shared mental models) about technology capabilities, task work and team interaction, and consequently, on the quality of SMM convergence and the characteristics of IT capabilities used.

Drawing on insights gained from our research study, we identified three group-level factors that can account for CMTs' varied patterns of interactions between AUITC and SMM (Yu & Khazanchi, 2014b). These are as follows: 1) pre-existing knowledge and experience shared by CMTs regarding task, team and technology, 2) CMT's shared perceptions of the role of IT in supporting the development of SMM, and 3) CMTs' group dynamics, such as team members' coping behaviors.

First, CMT members' initial overlapping knowledge and experience on task, team, and technology can positively influence CMTs in task accomplishment, team building or technology adaptation, and vice versa.

Second, two extremes exist regarding CMTs' shared perceptions of the role of IT in crisis management. One extreme is to think of IT as an essential means of facilitating effective teamwork evidenced by willingness to take substantial time to explore diverse IT capabilities, and at the same time, being reflective of developing a shared understanding on the pros and cons of a specific IT capability. The second extreme is to think of IT as no more than a set of basic tools, evidenced by passively adapting IT capabilities. This can be associated with an unwillingness of teams to deliberatively and reflectively try new features.

Finally, crisis teams' coping behaviors can greatly influence the teams' IT adaptation and SMM development. Coping behavior involves the individual's strategies for dealing with threats and uncertainty (Rosenthal et al. 1989). One type of coping behavior is to avoid the threatening situation by withdrawing him/herself psychologically from the scene. Our study revealed that such "distancing" coping behaviors can cause mistrust among team members and therefore can negatively affect teams' collective effort in developing SMM using technology capabilities. Another type of coping behavior is to confront the situation by increasingly engaging in problem-solving activity or by aggressively participating in the team task. When teams exhibit such "confronting" coping behaviors, the team may

experience success in converging on the team goals, strategies, and the outcome. However, it should be noted that when few members of the CMT exhibit such "confronting" coping behaviors, one should be careful about the danger of "groupthink" (Hermann 1979).

Figure 2 illustrates how these patterns of interplay apply during crisis coping behaviors. The horizontal axis in this picture refers to the teams' shared perceptions about IT adaptation with two simple anchors. The vertical axis refers to teams' varied coping behaviors. The diagram illustrates the dynamic, emergent and interdependent relationship between IT capabilities adaptation and SMM development in crisis situations as reflected in these patterns of team behavior.

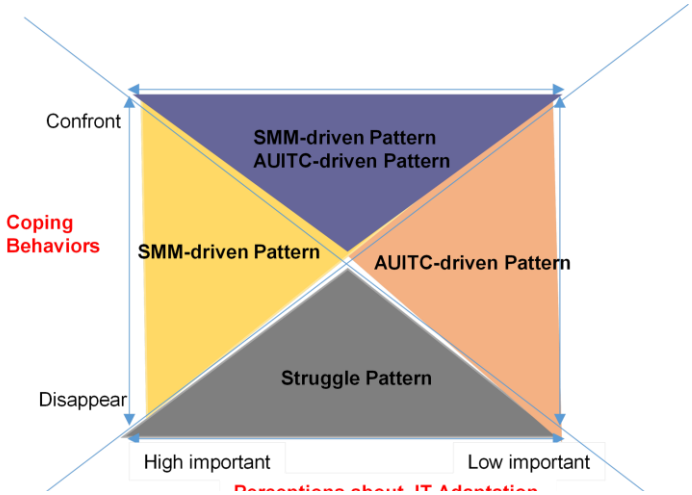

Figure 2. Three Patterns of IT Adaptation and SMM Development

The patterns of IT capabilities adaptation and SMM development have critical implications for crisis management teams. First of all, it should be noted that CMTs should avoid the "struggle pattern", which was observed to have comparatively low convergence on SMM and ineffective CMT performance in our research study. Specifically, "inactive" coping behaviors by team members, evidenced by late or no response to members' requests, can lead to negative feelings by other members and therefore cause ineffective team collaboration. Therefore, organizations could provide training that emphasizes individual differences in coping behaviors under crisis so team members can be better prepared. In addition, it is recommended that organizations adopt information technologies with enhanced features for facilitating the "visible" interaction among members.

Second, our research revealed different paths and the related conditions by which teams may follow to develop SMMs through using IT capabilities. Therefore, in the crisis response stage, leaders of CMTs might predict the possible path by which teams develop their SMM based on the assessment of the teams' initial conditions. Accordingly, leaders or managers of CMTs can make decisions on IT choice and utilize managerial interventions to facilitate the efficiency and accuracy of information sharing among the team members (Ley, Pipek, Reuter, & Wiedenhoefer, 2012).

Third, crisis management is not just managing the crisis and fixing the problem, rather, crisis management is a procedure and involves stages, such as pre-crisis stage, acute crisis response stage,

and the post-crisis stage (Deverell & Olsson, 2010; McCray, et al., 2011). Findings of our study have implications for management effectiveness of CMTs in all three stages of crisis. During each stage of the crisis, CMTs may experience varied combinations of types of tasks (i.e. simple task, complex task, decision making task, problem solving task, and fuzzy task) (Zigurs & Buckland, 1998). These situations then require CMTs to adapt IT capabilities to the task needs. In addition, CMTs may have varied quality of SMM development across different stages of crisis requiring the adaptation of different IT capabilities. For example, during the crisis preparedness and crisis prevention stages when the time pressure is relatively low, CMTs can spend more time on team mental model building rather than during the crisis happening stage. In addition, during the crisis happening and post-crisis stages, CMTs can draw on their established SMM to develop their task mental models efficiently. For SMM development during each stage of crisis, CMTs could benefit from an active, thoughtful, and creative adaptation of IT capabilities.

Finally, our research also indicates that the quality of SMM convergence is contingent on the ability to find a match between technologies and the needs of the task as perceived by CMTs ("ideal profiles"). However, when teams are under time pressure and uncertainty as is common in crisis situations, teams' ability to find a "fit" is limited by negative psychological feelings (e.g. deep level of anxiety, stress) and cognitive biases. Therefore, it is important for organizations to provide training that emphasizes the development of employees' knowledge and skills relating to creative and reflective use and adaptation of information technology. Finally, our findings can provide some rationale for the design of information technologies, such as knowledge sharing systems that aim to promote the efficiency of CMTs under highly dynamic situations (McNeill, et al., 2014).

CONCLUSION

Advances in information technologies have provided crisis management teams with a variety of IT capabilities to address challenges associated with communication, interaction, and team process. Successful adaptation of such IT capabilities by CMTs can significantly enhance the teams' shared mental models development as well as the overall coordination effectiveness, information processing capability, and decision making quality.

This paper explores the emergent and dynamic interplay between IT capabilities adaptation and shared mental models development in CMTs. Drawing on findings of our research relating to the patterns of the interplay between IT adaptation and SMM development in distributed teams, we argue that these patterns have interesting implications for crisis management.

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