Author: Haar, Selma van der
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CHAPTER 5

Investigating the relation between team learning and the team situation model[7]

Abstract

The development of a team situation model (TSM), a shared understanding of the current situation developed by team members moment by moment, and its impact on team effectiveness has received only minor attention in team research. This study investigates a moderated mediation model including the relationship between the team learning processes of co-construction and constructive conflict, the TSM, and team effectiveness. Forty-seven emergency management command-and-control teams participated in this field study. Their task was to manage a realistic emergency simulation developed and organized by field experts. The multi-rater approach included ratings of team members, researchers, and field experts. Results show that co-construction is related to the TSM under the condition of high constructive conflict. The TSM predicts team effectiveness in terms of the quality of actions at the scene of the incident.

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1. Introduction

Complex cognitive tasks are often conducted by teams (Cooke, Salas, Cannon-Bowers, & Stout, 2000). A team collectively possesses more knowledge and diversity in expertise than an individual alone, which can be beneficial for cognitively complex tasks. However, not all teams are able to benefit from this diversity (Jehn, Greer, & Rupert, 2008). To be able to solve problems, teams face the challenge of integrating the different knowledge, experiences, and values present. The capability of creating a shared mutual understanding among team members is assumed to be crucial (Salas & Fiore, 2004; Salas, Cooke, & Rosen, 2008).

During the last 20 years, diverse research efforts aimed to clarify the role of shared understanding of the task among team members for team performance (e.g. Cannon-Bowers, & Salas, 2001; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Smith-Jentsch, Mathieu, & Kraiger, 2005). Researchers have explored the value of both the *team mental model (TMM)*, which refers to collectively owned long-term task-relevant knowledge which team members bring to a situation, and the *team situation model (TSM)*, containing shared task-knowledge concerning the current situation, developed by the team members moment-by-moment (Canon-Bowers, Salas, & Blickensderfer, 1999; Cooke, et al., 2000). In this respect, we observe that while the TMM is widely studied, only a few studies so far have addressed the TSM (e.g. Cooke, Kiekel, & Helm, 2001).

This study aims to investigate the role of TSM for team effectiveness in the setting of emergency management teams which deal with disaster situations. These teams are characterized by a dynamic environment, high task demands, and a scarce amount of time available to communicate and strategize. Due to these circumstances, we expect the teams to benefit from a TSM, a shared understanding of the emerging situation and the collective actions that are required (Stout, Cannon-Bowers, & Salas, 1996), for a TSM could foster implicit coordination (Rico, Sánchez-Manzanares, Gil, & Gibson, 2008).

Several authors point at the value of team learning processes for teams to reach a mutual understanding and agreement within a team (e.g. Decuyper, Dochy, & Van den Bossche, 2010; Edmondson, 2003; Van den Bossche, Gijselaers, Segers, & Kirschner, 2006; Van den Bossche, Gijselaers, Segers, Woltjer, & Kirschner, 2011; Wilson, Goodman, & Cronin, 2007). However, given the time constraints emergency management teams face, we question if, compared to their role in establishing a TMM, team learning processes play the same role in predicting TSM and, in turn, team effectiveness. We investigate a moderated mediation model in the context of emergency management command-and-control teams (Figure 1). We first describe the main characteristics of emergency management command-and-control teams, and especially the multidisciplinary on-scene-command-team (OSCT) as an illustrative example, and the specific setting of this study.

2. Emergency management: The on-scene-command-team

When a community is severely shook by an incident, such as a traffic accident involving multiple cars and a truck containing flammable gas, multidisciplinary emergency management is required. Commanding representatives of the fire department, the police, and the medical assistance unit on call form an ad hoc multidisciplinary on-scene-command-team (OSCT).

The OSCT members are responsible for individually managing the mono-disciplinary actions of the own assistance unit and collectively coordinating the multidisciplinary cooperation of the different assistance units at the scene. The team members together create an overview of the emergency situation, determine the required actions at the scene, assign them to the person or unit responsible, and report on the actions (Helsloot, Martens, & Scholtens, 2010). The team exists for about two to eight hours and will be replaced by a new team if the incident requires continuing OSCT coordination (Helsloot, et al., 2010).

The multidisciplinary OSCT contains a representative of each assistance unit present at the scene and thus has high expertise diversity: team members are specialists in different knowledge and skill domains as a result of their work experience and education (Van der Vegt & Bunderson, 2005). The team has low team tenure since it is composed ad hoc; the officer on call is expected to show up. Furthermore, on many occasions, the team members may have never or rarely worked together before. The critical nature of the OSCT task implies working under time pressure (Baker, Day, & Salas, 2006; Helsloot, et al., 2010; Klein, Ziegert, Knight, & Xiao, 2006; Rasker, Post, & Schraagen, 2000; Salas, Wilson, Murphy, King, & Salisbury, 2008; Thorstensson, Axelsson, Morin, Jenvald, 2001), facing a regularly changing situation, and dealing with high task complexity requiring the input of different disciplines. In order to accomplish the task, the team members sequentially initiate OSCT meetings in between which they coordinate their own units.

Considering the OSCT consist of individuals who have high levels of skills and abilities, are specialized in their respective duties, and come together for a short period of time to work interdependently towards a common valued goal, it is a typical example of a command-and-control team (Salas, Burke, & Samman, 2001).

3. The value of the team situation model

The team mental model (TMM, shared long-term task-relevant knowledge applicable to multiple situations and which team members bring to a specific situation, Mohammed, Ferzandi, & Hamilton, 2010) and the team situation model (TSM, shared task-knowledge concerning the current specific situation developed by the team members moment-by-moment, Cooke, et al., 2000) are intertwined. The TSM develops while a team is engaged in a task and reflects the team's collective understanding of the specific situation at that moment (Cooke, et al., 2000), while making use of the preexisting TMMs (Cannon-Bowers, et al., 1999; Cooke, et al., 2001). Team members have been developing these TMMs containing preexisting and relatively long-lasting knowledge during former team training, earlier experiences, or team discussions. The TSM is the end-product of an integration of the TMM and shared situation awareness (SSA) in a specific situation, which involves the team's assessment (i.e. perception, comprehension, and projection) of the situation, including the surrounding, the task, and the team itself (Cooke, Stout, & Salas, 1997).

These constructs have in common that the members have a certain level of knowledge similarity: the extent to which the cognitive content of individuals is the same (Mathieu, Maynard, Rapp, & Gilson, 2008; Rentsch, Small, & Hanges, 2008). Such a shared mutual understanding among team members is assumed to be crucial for successful team performance (Salas & Fiore, 2004; Salas, et al., 2008). The value of similarity in task knowledge for team performance, merely the TMM, is studied across different types of field teams (Mohammed, et al., 2010), such as Air Force ROT teams (Cooke, et al., 2001), air traffic control teams (Smith-Jentsch, et al., 2005), military combat teams (Lim & Klein, 2006), community league basketball teams (Webber, Chen, Payne, Marsh, & Zaccaro, 2000), student teams performing a regular research task (Peterson, Mitchell, Thompson, & Burr, 2000), as well as in laboratories with student teams performing a simulated task (e.g. Edwards, Day, & Bell, 2006; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005; Van den Bossche, et al., 2011).

The research findings about the influence of shared knowledge in terms of a TMM and of a TSM are diverse (see Table 1). Whether there is an effect on team performance does not seem to depend on the number of teams involved, task characteristics in terms of complexity, time pressure, a changing situation, a field or a lab study, the TMM/TSM measurement method, or the team performance measurement. Lim and Klein (2006) explained why they found significant results in contrast with Mathieu et al. (2000, 2005) by arguing that the team context matters. Teams that have to perform under high stress and intense time pressure have very little time for explicit coordination and communication and therefore need a shared understanding of the emerging situation and collective action required far more than teams with ample time for discussion (Stout, et al., 1996).

Table 1. The relevance of similarity in the task-understanding among team members

Author and year	Team type	Task dynamics	Lab / field	TMM / TSM	Method TMM/TSM	Performance indicator	Value similarity for team performance
Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers (2000)	56 two-person student teams; flight simulator task	Time pressure, changing situation.	Lab	TMM	Paired comparisons ratings / Pathfinder; UCINET	Points per mission objective	n.s.
Webber, Chen, Payne, Marsh, & Zaccaro (2000)	24 five – twelve person basketball teams; community league	Time pressure, task complexity.	Field	TMM	Critical incidents questionnaire / Cue-strategy associations	Winning percentage and points	n.s.
Peterson, Mitchell, Thompson, & Burr (2000)	26 two-eight-person student teams; research project	Task complexity	Field	TMM	Concept mapping	Project grade	β= -.43, $p < .05$ (disagreement).
Cooke, Kiekel, & Helm (2001)	11 3-person Air Force ROT teams; synthetic task of controlling an uninhabited air vehicle (UAV).	Task complexity, time pressure, changing situation.	Field	TSM	Answering two queries during the task concerning the current moment.	Result of mission variables	r = .72, p =< .05
Cooke, Kiekel, Salas, & Stout (2003)	36 three-person student teams; cross-training and a military team task	Task complexity, time pressure, changing situation.	Lab	TMM	Relatedness ratings / Pathfinder	Mission completion rate	β=.35, $p < .05$
Mathieu , Heffner, Goodwin, Cannon-Bowers, & Salas (2005)	74 two-person student teams; flight simulator task	Task complexity, time pressure, changing situation.	Lab	TMM	Paired comparisons ratings / Pathfinder; UCINET	Points per mission objective	n.s.
Smith-Jentsch, Mathieu, & Kraiger (2005)	47 air traffic control tower teams	Task complexity, time pressure, changing situation.	Field	TMM	Critical incidents questionnaire / Cue-strategy associations	Safety and efficiency	n.s.

Author and year	Team type	Task dynamics	Lab / field	TMM / TSM	Method TMM/TSM	Performance indicator	Value similarity for team performance
Lim & Klein (2006)	71 seven- or eight-person military combat teams; small unit operations	Task complexity, time pressure, changing situation.	Field	TMM	Paired comparisons ratings / Pathfinder	Externally rated team efficiency measure	β=.32, p < .01
Edwards, Day, & Bell (2006)	83 two-person student teams; space fortress video game	Task complexity, time pressure, changing situation.	Lab	TMM	Paired comparisons ratings / Pathfinder	Average of the total scores	Time 1: β=.20, p < .05; Time 2:n.s.
Resick, Dickson, Mitchelson, Allison, & Clark (2010)	67 three-person student teams; simulated search and capture task	Task complexity, time pressure, changing situation.	Lab	TMM	Mental model questionnaire	Goal accomplishment (total number of points)	n.s.
Van den Bossche, Gijselaers, Segers, Woltjer, & Kirschner (2011)	27 three-person student teams; business simulation game	Task complexity.	Lab	TMM	Concept mapping	Mean equity and goodwill	Varying from β = 0.43, p<.05 to β = 0.51, p<.01.

In this respect, Waller, Gupta, and Giambatista (2004) as well as Comfort (2007) theorize that such teams are served by developing a shared idea of the situation and its risks, a shared idea of the team goal that follows from this situation, and a shared idea of how to act towards this goal together in an efficient way. 'Knowing what is going on' is important for decision making in complex situations such as emergencies, that are often uncertain, unpredictable, and stressful (McGuiness, 2007). It is about developing a common view of what is happening, what is likely to happen next, why it is happening, and what needs to be done. In this respect, the study of Cooke, Kiekel, and Helm (2001) is interesting. The TSM of eleven teams (consisting of three interdependent members) who had to deal with a dynamic task (a simulated Air Force's Predator uninhabited air vehicle (UAV) operation) was measured. Results showed that the TSM played a significant role for team effectiveness.

Based on the aforementioned studies, we expect that teams with a complex task, such as coordinating the emergency management processes at the scene of an incident, will benefit from the shared knowledge stored in a TSM since it supports the use of implicit coordination (i.e. "when team members anticipate the actions and the needs of their colleagues and task demands and dynamically adjust their own behavior accordingly, without having to communicate directly with each other or plan the activity", Rico, et al., 2008, p. 164). Implicit coordination is extremely useful in situations where teams have little or no time for explicit coordination. The TSM is the basis for anticipating and executing actions (Kozlowski & Ilgen, 2006). It enables teams to adapt to novel elements in the situation, and the actions or needs of the colleagues at the scene (Uitdewilligen, Waller, & Zijlstra, 2010) and thus influences team effectiveness.

Team effectiveness in the context of emergency management command-and-control is a multidimensional concept (cf. Guzzo & Dickson, 1996; Hackman, 1987; Tannenbaum, Beard, & Salas, 1992). It reflects the results of the response at the scene of the incident in terms of the quality of actions (e.g. justified, coordinated, safe), the level of goal achievement (e.g. control, stabilization of the situation), and the error rate concerning the victims and the damage as well as the nature of the media's reports on the process and results (Van der Haar, Segers, & Jehn, 2013). This is a team performance effectiveness outcome, not a behavioral outcome (e.g. absenteeism) or attitudinal outcome (e.g. team member satisfaction) (Cohen & Bailey, 1997).

4. Relating team learning, the team situation model, and team effectiveness

With this study, we intend to add to the experimental research of Cooke et al. (2001) by testing whether the significant effect of the TSM on team effectiveness they found in a synthetic task environment with 11 teams could be confirmed in 47 realistic emergency management teams dealing with high task complexity, time pressure, high risks, and a continuously changing situation in a realistic simulation exercise environment. While the queries used by Cooke et al. (2001) investigated the TSM in terms of expected success on the task and the person(s) to communicate with, we focused on the TSM in terms of the emergency management processes required at the scene of the incident. Moreover, Cooke and colleagues (2001) studied the direct effect of team processes and the TSM on team effectiveness separately. We investigate the indirect effect of team processes on team effectiveness through the TSM (Figure 1).

The TSM emerges as a result of interaction processes between team members, such as exchanging information, affect and resources, sharing ideas, and communicating feelings and moods (Rico, et al., 2008) while the team is engaged in the task (Cooke, et al., 2000). In this respect, Mohammed & Dumville (2001) refer to the role of team learning for the development, modification, and reinforcement of sharedness. Team learning is a dynamic behavioral process of interaction and exchange among team members (Kozlowski & Ilgen, 2006) that generates change or improvement for teams, team members, organizations, etc. (Decuyper, et al., 2010). In this case, the change concerns the development of similarity among team members' knowledge as stored in the TSM.

Earlier empirical research has shown the value of team learning processes for team mental models (TMMs) and, in turn, for team effectiveness (Van den Bossche et al., 2006, 2011). More concretely, Van den Bossche and colleagues (2006, 2011) refer to co-construction and constructive conflict as two supportive team learning processes. Co-construction is the process in which team members share facts that they know and ideas that they have and build meaning by refining, further developing, or modifying the original input; it facilitates the exchange of information and ideas (Van den Bossche, et al., 2006, 2011). Being an interaction process, co-construction incorporates process behaviors such as describing the problem situation, sharing information and ideas, active listening and tuning into other team members, and trying to understand explanations and intentions.

Constructive conflict refers to the critical but constructive behaviors of handling differences of opinions by addressing them directly, acting on comments given on ideas, and verifying opinions and ideas of team members by asking each other critical questions (see Appendix A; Van den Bossche, et al., 2006, 2011). As such, constructive conflict is different from task, process and relationship conflict (Jehn, 1997) which reflect the perceptual state of tension, disagreement, and conflict of ideas as an outcome of team interaction (DeChurch, Mesmer-Magnus, & Doty, 2013). In addition to Van den Bossche et al. (2006, 2011), other researchers such as Bolstad and Endsley (1999) point to the relevance of questioning assumptions and checking each other's input on conflicting information or perceptions. In addition, when teams experience process conflict and manage to solve their disagreements on how to approach the task, this is beneficial for the experienced trust, respect, and cohesion (Jehn, et al., 2008) which, in turn, enhances team effectiveness (Jehn, Greer, Levine, Szulanski, 2008).

The question is whether the aforementioned findings hold for emergency management command-and-control teams as well. The continuously changing situation that these teams face and the multiple perspectives the team members have on the complex task, force the team members to share relevant information and collectively create an idea of what is going on and what needs to be done (TSM). Since the task is full of risks, the members cannot afford to make mistakes. Therefore, sharing what they know is not enough (co-construction); they need a critical attitude towards individual contributions and collectively developed ideas (constructive conflict). Only then can team members develop a TSM that supports task completion in terms of emergency control and prevention of victims and damage. We therefore hypothesize:

> *Hypothesis 1 (moderation hypothesis): Constructive conflict moderates the positive relationship between co-construction and the TSM, such that if constructive conflict is high, the relationship between co-construction and the TSM is positively strengthened.*

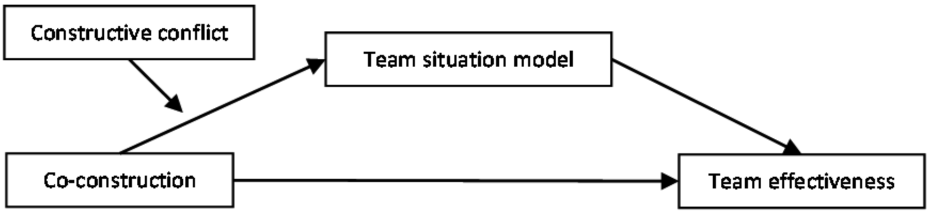
Former research has shown that team learning directly influences team performance. In her field study at a manufacturer of office furniture (including functional teams in sales, manufacturing, and staff services, self-managed teams in manufacturing and sales, cross-functional product development teams, and cross-functional project teams), Edmondson (1999) evidenced that teams using team learning behaviors such as seeking information, discussing errors, and seeking feedback from each other and customers, perform better as a team than teams that don't. Van der Vegt and Bunderson (2005) confirmed this finding for a setting with multidisciplinary teams in the oil and gas industry, composed of scientists, engineers, and technicians and responsible for research and development functions. The researchers of both studies used a comparable perception measure for team learning and external ratings for team performance.

In addition, the research of Van den Bossche and colleagues (2006, 2011) with student teams performing a business game indicated the existence of an indirect effect of team learning on team effectiveness through mutually shared cognition. They found that team mental models (TMM) partially mediated the relationship between team learning processes and the perceived performance (Van den Bossche, et al., 2006, 2011), as well as the actual performance in terms of goodwill (Van den Bossche, et al., 2011). The question is if these findings are also valid for the team situation model (TSM) and for emergency management command-and-control teams.

We propose that the complex and risky task of multidisciplinary emergency management command-and-control teams and the discipline-specific perspectives of the different team members necessitates them to integrate the perspectives and bridge the differences in order to be effective in the response to the incident. To create a TSM that benefits team effectiveness, they need to co-construct knowledge about the present changing situation and deal with differences in perspectives constructively (constructive conflict). In line with our earlier argumentation, we propose that constructive conflict has a strengthening effect on the positive relationship between co-construction and the TSM (Figure 1). Therefore, we propose a moderated mediation model (Figure 1):

Hypothesis 2a: The TSM mediates the positive relationship between co-construction and the quality of actions, in which the relationship between co-construction and the TSM is moderated by constructive conflict.
Hypothesis 2b: The TSM mediates the positive relationship between co-construction and goal achievement, in which the relationship between co-construction and the TSM is moderated by constructive conflict.
Hypothesis 2c: The TSM mediates the positive relationship between co-construction and the error rate, in which the relationship between co-construction and the TSM is moderated by constructive conflict.

Figure 1. Moderated mediation model of the relations between team learning processes, the team situation model (TSM) and team effectiveness.



5. Method

5.1 Setting

We collected data during realistic on-scene-command-team (OSCT) simulation exercises organized by five different safety regions in the Netherlands. Such multidisciplinary exercises are frequently organized by the disciplines (i.e. fire department, police, and medical assistance unit) to prepare team members for emergency management tasks. Regular participation is required.

The task for the OSCT members was to individually manage the mono-disciplinary actions of their assistance unit and to collectively manage the multidisciplinary cooperation of the different assistance units at the scene, following realistic procedures. The members were provided with relevant information about the development of the incident and were expected to coordinate their cooperation themselves, using regular team meetings.

The exercises were realistic in the way that the teams had a representative team composition. Each team consisted of at least a representing officer from the fire department, the police, and the medical assistance unit. Depending on the severity of the incident, a team leader was expected to be invited by the key members to join the team as a new member from the second team meeting onward. The members were not informed about their team composition or about the incident scenario beforehand. The incident scene was projected using virtual reality and the scene could be explored by every team member using a joy stick. Communication with the OSCT colleagues was done face-to-face or with a walkie-talkie. The team members got additional information about the development of the incident in the form of a response to their actions from response trainers during the exercise. These raters gave information about the incident development from the perspective of a key player, such as the first ambulance driver or the fire department commander at the scene. In this way, they developed an opinion about the effectiveness of the emergency response during the simulation.

5.2 Procedure

First, the members got a face-to-face exercise briefing by the training staff. Then, at the start of the exercise, they each received the initial on-call notice after which they had to call in using a walkie-talkie to receive additional general as well as discipline-specific information. The team members immediately started coordinating the assistance at the scene by collecting information through exploring the projected virtual reality and from the role-playing trainers, and giving orders to the own unit. After about 20 minutes the team members were expected to initialize their first face-to-face meeting with an average duration of 8 to 10 minutes. Each team had time for two or three meetings during the exercise, depending on how the team organized their processes. After each meeting they returned to the coordination of the own unit and they received new information about the development of the incident. The training staff gave the call for the end of the exercise when the exercise time of on average 75 minutes ran out.

The team members as well as the external raters filled out a questionnaire before the exercise started, after each meeting during a short time-out, and right after finishing the exercise. In this study, we focused on the second team meeting, which we viewed as a transition moment (Marks, Mathieu, & Zaccaro, 2001). While in the first meeting the three key members shortly come together to share their first impressions and share information about mono-disciplinary actions (e.g. fire extinction or traffic management) that might affect other disciplines, the second meeting is more elaborate. The focus shifts to the multidisciplinary dilemmas and approach. The members share relevant information about their mono-disciplinary actions, evaluate this information from a multidisciplinary perspective, explore different possible scenarios and their consequences, decide on actions, and divide them. For this meeting and the following, the team often invites a team leader. So the TSM development starts with a more mono-disciplinary oriented TSM in meeting 1 to a more multidisciplinary TSM in meeting 2. This is why we consider meeting 2 as a transition from mono-disciplinary first reactions to a multidisciplinary structured approach.

5.3 Participating teams

Seventy-four teams participated in this field study with a total of 206 team members (3 to 7 members per team, 4 members per team on average, 19% women). Each team participated in a simulation exercise organized by one out of five different safety regions in the Netherlands. The local organizers put the teams together and did not inform the team members about the participants beforehand. Each team had a representative team composition, including the fire department, the police, and the medical assistance unit. Two teams lacked a person from the medical unit due to practical circumstances (i.e. illness). In sum, 23 teams had a formal team leader participating from meeting 2 onward. Table 2 gives an overview of the present disciplines and composition per team. The team members had a mean age of 45 years (*SD* = 8.95) and 64 % had a higher education level. The average experience with real-life emergencies of the participants was 13 times (SD = 17.32; range 0 – 150). The average number of emergency simulation exercises that participants had already done was 13 as well (SD = 17.32; range 0 – 75).

5.4 Measures

Team learning processes. The rating scale with a response scale ranging from 1 (“strongly disagree”) to 7 (“strongly agree”) consisted of the nine items of Van den Bossche et al.’s (2006) Team Learning Beliefs and Behavior scale. The scale was externally rated by three different educational researchers, of which one (34 teams) or two (13 teams) were present with each team (1.28 raters per team on average). The researches were 27, 32, and 34 years old and all three had completed an academic education. The results of the exploratory factor analysis (maximum likelihood, direct oblimin) revealed a two factor model with all items loading above .4: co-construction (six items, e.g. ‘During this meeting, all relevant information and ideas were shared’; M = 5.91, SD = .77, α = .91), and constructive conflict (three items, e.g. ‘The team members’ opinions and ideas are verified by asking each other critical questions’; *M* = 4.85, *SD* = .86, *α* = .79). We aggregated the individual scores to determine a team score (Table 3 contains aggregation indices).

Team situation model. We used team member similarity ratings of predefined categories of emergency management processes (e.g. rescue and technical support , traffic control, medical assistance; see Appendix A) for the measure of the TSM (DeChurch & Mesmer-Magnus, 2010). We asked each team member of 34 out of the 47 teams (due to practical reasons we could not include all teams) to individually mark the emergency management processes on a list of at least 15 choices[8] that should get priority at the scene after the second OSCT meeting. This task-specific and task-embedded measure was short enough to minimize fatigue or boredom effects and to prevent disturbing the flow of the task (Cooke, Salas, Kiekel, & Bell, 2004).

As this list of processes is commonly used in reality and training situations, OSCT members are trained to know them by heart. The processes can be approached as categories of main activities which could be executed by the fire department, the police, or the medical assistant unit. They make it clear to all members which assistance unit has which responsibilities in general and, accordingly, which discipline has which expertise and needs which information. During their meetings, the OSCT members discuss the situation, the possible consequences, and decide on the required actions. These actions are related to the different processes, but are not the same. Actions are explicitly mentioned during meetings, whereas the processes they relate to are not necessarily. The idea that each team member has about which processes are and will be occurring at the scene is thus a result of the integration of the discussed situation, decisions made, and required actions. At the end of a team meeting, this understanding is reflected in the emergency management processes that the team members expect to be started or continued at that moment. The processes thus characterize the understanding of the specific situation at that moment (Cooke, et al., 2000). Therefore, we approach our initial measure as the individual situation model.

To create a team level TSM measure, we aggregated the individual data (situation models) by determining the level of dispersion (Cooke, et al., 2004). First, we determined to what extent members of a team marked the same emergency management processes as relevant. To this end, we transformed individual team members' selected processes into a dichotomous matrix (1 indicated "given priority", and 0 indicated "not given priority"). Second, we calculated the diversity scores per process at the team level using the Blau's Index (Harrison & Klein, 2007). Third, we reversed the results to gain similarity scores. Fourth, we added the similarity scores of all processes per team and transformed them into percentages of the maximum possible similarity score (a score of 100% indicated that all team members indicated the exact same processes having priority at the scene after the meeting). The TSM measure thus indicates to what extent team members had a TSM reflecting the processes they thought had priority and they expected to be executed at the scene in the phase following the team meeting. (M = 0.79, SD = .11)

[8] Whether a team receives a checklist of 15, 16, or 17 choices depends on its safety region. We present the checklist and measures of the other variables in Appendix A.

Table 2. Team member roles and compositions

No. of teams	Fire	Police	Medical	Team leader	Local government	Plotter / information manager	Public relationships	Advisor on chemical substances	Military on scene commander	National Police Services Agency commander	Professional role player	Missing	No. of members
20	x	x	x										3
1	x	x	x	x									4
1	x	x	x						x				4
1	x	x		x								x[a]	5
3	x	x	x						x	x			5
7	x	x	x	x	x								5
1	x	x	x	x			x						5
1	x	x	x	x				x					5
2	x	x	x	x	x		x						6
4	x	x	x	x	x	x							6
1	x	x	x	x	x							x	6
2	x	x	x	x		x		x					6
1	x	x	x	x			x	x					6
1	x	x		x	x	x					x		6
1	x	x	x	x	x	x					x		7
Sum	47	47	45	23	17	8	4	4	4	3	2	3	206

[a] Team 36 with five members had two members with missing values on team role

Team effectiveness. In this field study, team effectiveness was externally rated by response trainers with experience in emergency management at the scene. These trainers provided on-scene information about the development of the incident to the team members from the perspective of a key player, such as the first ambulance driver or the fire department commander at the scene. In total, we included 51 raters in our analyses who provided 115 team effectiveness ratings (1 – 5 raters per team, 4% women, 49% higher educated, aged 31 – 61 years (M = 47, SD = 8.9), tenure of 3 – 45 years (M = 14.05, SD = 10.15), and working at different organizations: 53.1% fire department, 10.2% police, 21.9% medical disaster management, 9.4% government, 3.1% safety region, and 2.3% other, e.g. consultancy). Different sets of raters per exercise scored team effectiveness. The raters had at least three years of experience in a function related to emergency management so that we could expect them to have a professional opinion about emergency management. Besides that, each rater had a function in emergency management on scene (e.g. on scene commander) or was educated for such a function but presently had a related function (e.g. policy development, training). The raters without such a function or education profile had a higher education level.

We used the formerly validated emergency management team effectiveness rating scale (Van der Haar, et al., 2013; see Appendix A) that consists of three factors: quality of actions (e.g. 'The actions at the scene are adequate'; M = 5.70, SD = .74, α = .92), goal achievement (e.g. 'The crisis is controlled'; M = 5.36, SD = .84, α = .93), and error rate (e.g. "There are no unnecessary victims"; M = 5.06, SD = .79, α = .64). The response scale ranged from 1 ("strongly disagree") to 7 ("strongly agree"). We aggregated the individual judges' ratings to determine team scores. This decision was supported by the *Rwg* scores, the ICC (1) and (2) scores, and the significance of the *F*-scores (Table 3). These scores indicated high inter-rater agreement (James, Demaree, & Wolf, 1984, 1993) and acceptable inter-rater reliability (Bliese, 2000; Lebreton & Senter, 2008).

Table 3. Mean within group agreement (rWG) and intra class correlation coefficients (ICCs).

		rWG	*ICC(1)*[1]	*ICC(2)*	*F-statistic*	*p*
External ratings: response trainers	*Team effectiveness*					
	Quality of actions	.97	.55	.43	1.755	.017
	Goal achievement	.87	.54	.41	1.707	.022
	Error rate	.75	.53	.38	1.624	.034
External ratings: researchers	*Team learning processes*					
	Co-construction	.97	.13	.16	1.19	.381
	Constructive conflict	.93	.81	.84	6.32	.001

[1] The ICC(1) values are calculated using Bliese & Halverson's (1998) equation for unequal group sizes.

5.5 Control measures

Team leadership, number of meetings, number of team members. Data was collected on the field during regular exercises organized by field practitioners. The teams had two (n = 21) or three (n = 26) meetings during the exercise. Teams had different numbers of members (three members n = 20; four members n = 2; five members n = 13; six members n = 11; and seven members n = 1) with an average of four members per team. In meeting 1, each team appointed an informal leader; in meeting 2, 23 teams replaced their informal leaders with formal leaders who were trained to chair an OSCT from a multidisciplinary perspective. We included these factors as control variables.

Stress, responsibility, and risk. Each team participated in one of nine different scenarios. To compare these scenarios, we measured the level of perceived stress, responsibility, and risk using a context-specific 10-item Likert scale that we developed together with field practitioners (see Appendix A). Participants responded to such statements as "I experienced as much stress as I would have if the incident was real" and "The responsibility I had in this exercise was realistic" ranging from 1 ("strongly disagree") to 7 ("strongly agree"). The *F*-scores (stress: $F = 1.403$, $p = .067$; responsibility: $F = 1.444$, $p = .053$; risk: $F = 1.099$, $p = .330$) revealed that teams participating in different exercises did not differ significantly in their scores on each of the three variables. Therefore, we concluded that scenarios were comparable.

6. Analyses

Concerning Hypothesis 2, we predicted the conditional indirect effect of co-construction on team effectiveness (2a quality of actions, 2b goal achievement, 2c error rate) through TSM as a mediator variable, and conditional on the moderating role constructive conflict has on the path from co-construction to the TSM. This has been termed a conditional indirect effect (Preacher, Rucker, & Hayes, 2007) and is alternatively known as moderated mediation. Accordingly, we considered the possibility of a statistically significant indirect effect being contingent on the value of the proposed moderator. To test Hypothesis 2a, b, and c we utilized PROCESS, an SPSS macro designed by Preacher and his colleagues (2007) which facilitates the implementation of bootstrapping methods and provides a method for probing the significance of conditional indirect effects at different values of the moderator variable. Table 4 presents the descriptive statistics, intercorrelations, and internal consistencies of the scales.

Table 4. Means, standard deviation, and correlations for the (aggregated) study variables.

	M	*SD*	1	2	3	4	5	6	7	8	9
1. Team leader presence	1.49	.51	--								
2. Number of members	4.38	1.31	.86**	--							
3. Number of meetings	1.55	.50	02	-.16	--						
4. (Co-) construction	5.00	.74	-.23	-.16	-.12	(.90)					
5. Constructive conflict	4.89	.90	-.17	-.14	-.22	.59**	(.79)				
6. Team situation model	.78	.11	-.17	-.24	.11	.11	.24	--			
7. Quality of actions	5.70	.74	-.33*	-.23	.16	-.02	-.04	.43*	(.93)		
8. Goal achievement	5.36	.84	-.32*	-.16	-.02	.06	-.01	.26	.82**	(.93)	
9. Error rate	5.06	.06	-.30*	-.18	-.06	.11	-.06	.06	.64**	.82**	(.64)

Cronbach's Alpha's of the individual measures are in parentheses along the main diagonal; * $p < .05$, ** $p < .01$

7. Results

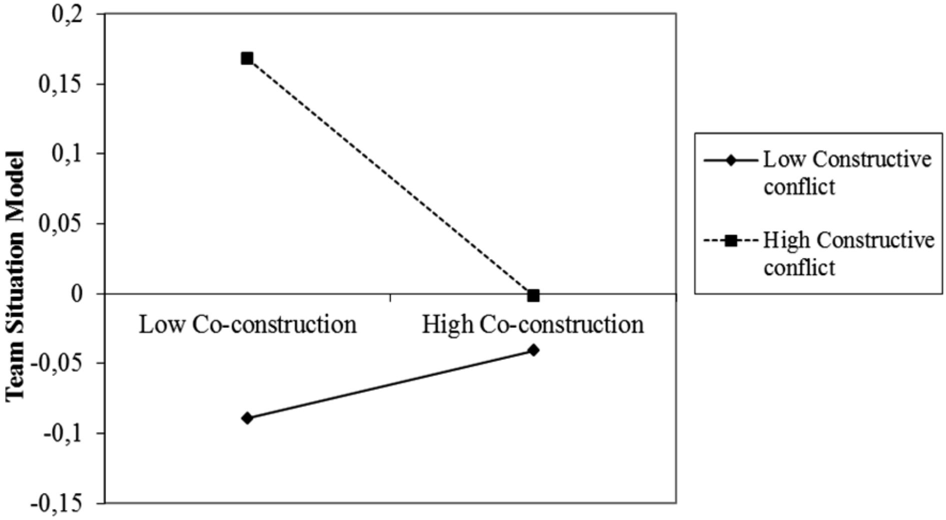
Test of moderation. In hypothesis 1, we predicted that the positive relationship between co-construction and the TSM would be strengthened by the occurrence of constructive conflict. Results of a hierarchical regression analysis (Table 5) indicated that the cross-product term between co-construction and constructive conflict on TSM was significant (β = -.51, p = .05). We applied conventional procedures for plotting simple slopes (Aiken & West, 1991) at one standard deviation above and below the mean of the constructive conflict measure (see Figure 2). Consistent with our expectations, the slope of the relationship between co-construction and the TSM was relatively strong (and negative) for teams with high levels of constructive conflict (simple slope = –0.12, t = -1.74, p = .09), whereas the slope was weak for teams showcasing low levels of constructive conflict (simple slope = 0.41, t = 1.297, p = .20). These results partially support hypothesis 1 in the sense that co-construction only has a predictive value for the TSM in case of high constructive conflict.

Table 5. Hierarchical regression analyses of the relationship between team learning processes and the team situation model (TSM)

	Step 1			Step 2			Step 3		
	***B*[1]**	***SE***	***β***	***B***	***SE***	***β***	***B***	***SE***	***β***
Constant	.85	.11		.81	.11		.89	.11	
Team leader presence	.02	.08	.10	.02	.09	.09	.02	.08	.08
Number of members	-.03	.03	-.31	-.02	.03	-.27	-.03	.03	-.41
Number of meetings	.01	.04	.06	.03	.05	.12	.03	.04	.13
Co-construction				-.01	.04	-.06	-.04	.04	-.28
Constructive conflict				.03	.03	.28	.08	.04	.68*
Co-construction x constructive conflict							-.08	.04	-.51*
R^2		.064			.121			.254*	
R^2 *change*		.064			.057			.133*	
F		.611			.607			1.559	
P		.614			.638			.271	

Notes: 1) * *p* < .05, ** *p* < .01; 2) We used centralized scores to avoid problematic multi collinearity effects between the independent variable and the moderator, and the interaction terms (Aiken & West [1991], cited in Holmbeck, 1997); 3) n = 47.

Figure 2. Effect of constructive conflict on the relationship between co-construction and the Team Situation Model (TSM)



Tests of moderated mediation. The results of the hierarchical regression analysis (Table 6; n = 47) show that the TSM has a predictive value for the quality of actions (β= .40, p = .05). A one-percent increase of the TSM can result in a 2.70 points higher score for the quality of actions on a 1-to-7 scale. Overall, the model explains 37% of the variances in quality of actions (R^2=.37, p = .05). We did not find any significant results for goal achievement or error rate. Then, we used PROCESS (Hayes, 2013) to examine the conditional indirect effect of co-construction on the quality of actions, through the mediator TSM, at three values of constructive conflict (n = 31): the mean (0.00), one standard deviation above the mean (.66), and one standard deviation below the mean (-.66). Normal-theory tests indicated (Table 7) that none of the three conditional direct or indirect effects were significantly different from zero. Bootstrap CIs corroborated these results. Thus, hypothesis 2a was not supported, indicating that the indirect and positive effect of co-construction on quality of actions through TSM was not observed when levels of constructive conflict were low, moderate, or high and the sample included 31 teams. Hypothesis 2a is rejected. We did not find significant results for goal achievement nor error rate, so we rejected hypothesis 2b and 2c as well.

Table 6. Hierarchical regression hypothesis 2a; team effectiveness measured by quality of actions.

	Step 1			Step 2			Step 3			Step 4		
	B1	***SE***	**β**	***B***	***SE***	**β**	***B***	***SE***	**β**	***B***	***SE***	**β**
Constant	5.66	.67		5.73	.72		6.11	.75		3.71	1.36	
Team leader presence	-.99	.53	-.68	-1.03	.554	-.70	-1.04	.54	-71	-1.09	.51	-.74*
Number of members	.22	.21	.39	.22	.22	.40	.17	.21	.30	.26	.21	.46
Number of meetings	.35	.28	.24	.34	.29	.23	.36	.29	.24	.28	.27	.19
Co-construction				-.09	.23	-.09	-.25	.25	-.24	-.13	.24	-.13
Constructive conflict				-.00	.19	-.00	.23	.24	.28	.01	.25	.01
Co-construction x constructive conflict							-.39	.27	-.36	-.17	.27	-.16
TSM										2.70	1.30	.40*
R^2		.175			.183			.248			.367*	
R^2 change		.175			.008			.065			.119*	
F		1.905			1.118			1.319			1.906	
P		.153			.376			.287			.115	

Notes: 1. * $p < .05$, ** $p < .01$.

2. We used centralized scores to avoid problematic multi collinearity effects between the independent variable and the moderator, and the interaction terms (Aiken & West [1991], cited in Holmbeck, 1997).

3. n = 47

Table 7. Regression results for the conditional indirect effect on quality of actions (PROCESS)

Predictor	***B***	***SE***	***t***	***p***
	Team Situation Model (TSM)			
Constant	.89	.12	7.53	.00
Co-construction (Cocon)	-.01	.04	-.26	.80
Constructive conflict (Confl)	.07	.04	1.75	.09
Cocon x Confl	.02	.63	.32	.75
	Team effectiveness: quality of actions			
Constant	4.03	1.32	3.06	.01
Co-construction (Cocon)	.21	.24	.87	.39
Constructive conflict (Confl)	-.02	.25	-.10	.93
Cocon x Confl	-.44	.38	-1.16	.26
TSM	2.50	1.24	2.02	.06
Constructive conflict	Boot direct effect	Boot *SE*	Boot *t*	Boot *p*
Conditional direct effect at constructive conflict = *M* +/- 1 *SD*				
-1 *SD* (-.6638)	.50	.32	1.56	.13
M (= 0.00)	.21	.24	.87	.39
+1 *SD* (+.6638)	-.08	.37	-.23	.82
Constructive conflict	Boot indirect effect	Boot *SE*	BootLLCI	BootULCI
Conditional indirect effect at range of values of constructive conflict = *M* +/- 1 *SD*				
-1 *SD* (-.6638)	-.06	.14	-.39	.17
M (= 0.00)	-.03	.10	-.29	.13
+1 *SD* (+.6638)	.01	.16	-.23	.42

Note. *n* = 31 teams (16 cases deleted due to missing data). Unstandardized regression coefficients are reported. Team leader presence, number of team members and number of meetings were controlled for. Bootstrap sample size = 20,000. Co-construction and constructive conflict were mean centered prior to analysis. CI = confidence interval; LL = lower limit; UL = upper limit.

8. Conclusion and discussion

The aim of this study was to shed light on how the team learning processes in terms of co-constructing knowledge and engaging in constructive conflict influence the extent to which teams have a shared understanding of what is going on and needs to be done at a certain moment during task performance (TSM) and, in turn, how this influences team effectiveness. The study is conducted with on-scene-command-teams (OSCTs), multidisciplinary command-and-control emergency management teams operating at the scene of an incident while dealing with work and time pressure. With this study we add to the relatively small amount of research on team learning outside of the laboratory (Kozlowski & Ilgen, 2006) and to team cognition research on the team situation model.

Houghton, Simon, Acquino, and Goldberg (2000) expressed the concern that similarity may discourage a critical attitude towards the input information with a negative impact on team performance. On the contrary, we found that it is not that similarity suppresses a critical attitude; a critical attitude supports similarity. The team learning process of constructive conflict (discussing differences in interpretation by arguments and argumentations, Van den Bossche, et al., 2006) is a prerequisite, even, proved by the relation we found between the team learning process of co-construction (sharing facts and ideas and building meaning, Van den Bossche, et al., 2006) and the TSM on the condition of high constructive conflict (H1). More specifically, a high level as well as a low level of co-construction predicts the TSM on the condition that there is a high level of constructive conflict.

In the context of emergency management, this result could indicate that it is not so much the question whether all relevant information is shared in a process of co-construction during the meeting. Rather, in teams working under such pressure as the OSCT, it is to be expected that the members do not wait to share relevant information, for instance about new threats, until a meeting, but also share this information in between meetings. Furthermore, team members do not have to share everything they know during a meeting, but only the things relevant to the multidisciplinary coordination. It seems more important, then, that team members are not afraid to question input information, to comment on ideas, and to act upon those comments. Such a process of constructive conflict creates new meanings and ideas and can lead to the sharing of additional information. It is possible that teams that merely engage in co-construction and not constructive conflict do not negotiate their knowledge and ideas as well and therefore are less capable of developing a shared understanding. This extends the earlier findings of Van den Bossche and colleagues (2006, 2011) that constructive conflict is required to reach mutual agreement. Since they studied the more long-term knowledge construct of shared mental models of student teams participating in a business game, the value of constructive conflict seems to be generalizable to other team types and to the short-term knowledge construct TSM as well.

We examined the TSM during task execution, in contradiction to studies of the team mental model (TMM), and we thus created insight into the shared knowledge that emerged during cooperation instead of before the cooperation. The results of the study confirmed the earlier finding (Cooke, et al., 2001) that a TSM is beneficial for team effectiveness. More precisely, it is beneficial for the eventual quality of the actions at the scene of an incident if the OSCT members have a shared idea of what the different disciplines will be occupied with at the scene. Considering the TSM is the shared understanding of the situation in terms of emergency management processes that need to be started or continued at the scene at a specific moment in time, we suppose it is logical that this construct relates more to the quality of actions than to goal achievement and error rate. Goal achievement refers to controlling the crisis, source diminishment, and stabilization, and error rate to unnecessary victims and damage (Appendix A).

This result supports the theory (Comfort, 2007; Lim & Klein, 2006; Stout, et al., 1996) that field teams dealing with time constraints and high task demands operating in non-routine situations need shared knowledge of actions undertaken during task completion for anticipating further actions and making quick decisions. It may enable teams to adapt to novel elements in the situation and take into account the actions or needs of colleagues at the scene (Uitdewilligen, et al., 2010). The results encourage future research to examine the influence of the TSM in other field teams dealing with high task complexity, time pressure, and a changing situation.

This study revealed that team learning processes support the development of the TSM and the TSM enhances the quality of actions at the emergency scene in terms of justification, safety, and adequacy. However, we did not find that the TSM mediates the relation between the team learning processes and team effectiveness. This is in contradiction with the studies of Edmondson (1999) and Van der Vegt and Bunderson (2005) that show that team learning processes enhance team performance. Additionally, Van den Bossche and colleagues (2006, 2011) found that mutually shared knowledge partially mediates the relationship between team learning processes and team performance. It could be that there are other important team processes in this dynamic context, such as decision making, that mediate the relation between team learning processes and team effectiveness. A methodological explanation could be that we need a bigger sample to investigate the moderated mediation effect.

8.1 Limitations and issues for future research

The results of our study show different directions for future research. First, in this study we focused on the similarity of the team situation model (TSM), not on its accuracy, i.e. that the shared understanding is based on the right facts (Mathieu, et al., 2000). In the literature, there is discussion about whether the accuracy of the TMM has a positive impact on team performance and whether there is a combined effect of TMM similarity and accuracy on team performance (Mathieu, et al., 2000; Mathieu, et al., 2005; Mathieu, et al., 2008; Mohammed, et al., 2010; Resick, et al., 2010). The importance of TMM accuracy is evidenced by some researchers (e.g. Cooke, et al., 2001; Edwards, et al., 2006; Lim & Klein, 2006; Mathieu, et al., 2005), but could not be confirmed in other studies (Mohammed, et al., 2010; Webber, et al., 2000). Moreover, it is unclear how the accuracy of the TSM plays a role. We therefore suggest including a measure of this accuracy in future research, to reveal how it is related to the TSM similarity and team effectiveness.

Second, given the significant role of the TSM for the quality of actions and given that the TSM is an emerging construct, we suggest future studies adopt a temporal research design to study how TSM similarity and accuracy evolve over time (Wildman, Thayer, Pavlas, Salas, Steward, & Howes, 2012). In such a design, it is possible to explore the role team learning processes play over time and investigate if and how the development of team learning processes relates to the development of the TSM and, in turn, to team effectiveness (e.g. Edmondson, Dillon, & Roloff, 2006; Knapp, 2010; Wilson, et al., 2007).

Third, in this study team learning processes were rated by external observers using rating scales. In order to get a more in-depth understanding of the content of the interactions between team members, we suggest developing a coding scheme to analyze the frequency and content of team learning processes over time. Fourth, we suggest to train teams of raters to judge team effectiveness in future studies so that the inter rater reliability (ICC(2)) increases. Finally, it is advisable to cross-validate the moderated mediation model with a larger sample of emergency management teams in different-but-comparable situations again to verify whether the mediating role of the TSM can be identified.

8.2 Practical implications

The results of this study indicate that highly dynamic multidisciplinary teams working under time pressure can benefit from collaboratively constructing knowledge about which processes are initiated by whom in between team coordination meetings. If teams regularly share and summarize what every member will be doing at a certain moment in time, for instance by including it in the meeting agenda, this will benefit the quality of actions. Furthermore, given the complexity and risks of their task, team members should be critical towards the contributions of others and open to criticism themselves during their meetings and constructively deal with conflicting perspectives. Team training programs should focus on making team members aware of the importance of co-construction and constructive conflict as well as offering opportunities to practice these team learning processes. Furthermore, training team members in the knowledge of who is responsible for what processes will help the team develop a TSM. In order to learn from experience, the evaluation of team effectiveness should address how teams co-construct knowledge about the situation at hand and how they manage to integrate different perspectives on the same situation in order to develop a shared understanding of what has to be done at a specific moment in time (TSM).