Cogn Tech Work
DOI 10.1007/s10111-011-0186-3

ORIGINAL ARTICLE

A case study of factor influencing role improvisation in crisis response teams

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Received: 6 May 2011 / Accepted: 25 July 2011

Abstract Common characteristics of crisis situations are ambiguous and unplanned for events. The need for improvised roles can therefore be an imperative factor for the success of an operation. The aim of this study is to deepen the understanding of the processes taking place during improvised work "as it happens". A case study of a crisis management team at work is presented and provides an in-depth analysis of the information and communication flow of persons acting in improvised roles, including contextual factors influencing the task at hand. The analysis suggests that three main factors lay behind decreased performance by the team when some of its members were forced to take on roles for which they lacked professional training; lack of language skills, lack of domain knowledge and insufficient organizational structure of the tasks. Based on the observations from this case study, we suggest three ways of improving a team's performance and hence resilience when forced to improvise due to lack of personnel in one or more required competence areas. These are training to take on the responsibility for tasks or roles outside ones professional area of specialization, developing formal routines for changes in roles and tasks and developing and using tools and routines for information sharing.

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Keywords Role improvisation · Crisis management · Resilience engineering · Organizational improvisation · Episode analysis

1 Introduction

The need for adaptability and flexibility in crises management is well known. Its dynamic and unpredictable nature makes it necessary for organizations to adjust to the prevailing situation. Planning and preparation helps enable rapid coordinated actions. It is, however, not possible to foresee all possible events and improvising, to various degrees, is a critical capacity in emergency responses for successful accomplishment of the tasks (Medonça et al. 2001, 2003; Webb 2004; Kendra and Wachtendorf 2006; Kreps and Bosworth 2006). An absence of improvisation and adaptation signifies in practice the inability of the responding teams to cope with dynamic situations and to adjust to the current conditions, i.e., available resources and time, and to anticipate the changing shape of risks (e.g., Hollnagel 2006; Hollnagel and Woods 2006).

The ability to manage disturbances and to adjust to new or unforeseen situations by improvisation is therefore of utmost importance for successful crisis management. To better understand factors influencing successful improvisation research in other areas such as music and theater improvisation have been consolidated, as well as after the fact analysis of improvisation in crisis management (Cunha et al. 1999; Drabek and McEntire 2002, 2003; Mendonça and Wallace 2006, 2007; Somers 2009).

However, research on improvisation as it occurs in real crisis management teams or organizations is rare. Although it has been done in other domains, it is conceivable that

Published online: 09 August 2011

improvisation, while sharing many features across contexts and types of activities, also is affected by the specific activity or practice of each domain and type. It therefore becomes important to also study improvisation in crisis management as it occurs.

In this paper, a case study of the Swedish Response Team (SRT) during a role-playing exercise is presented, followed by an analysis of factors influencing improvised performance of the task. The Swedish Response Team (SRT) is a rapid response taskforce with flexible composition that can be deployed to assist and support Swedish embassies and the Ministry of Foreign Affairs during a crisis abroad. The SRT operates across multiple governmental authorities. The Swedish Civil Contingencies Agency, the Swedish National Police Board, the Ministry of Foreign Affairs and the Swedish National Board of Health and Welfare are the core organizations contributing to this taskforce.

The structure of the paper is as follows. First, we review previous research on resilience, improvisation and team communication. Second, we describe the case study and the methods used for data collection and analysis. Third, we describe and analyze situations where the team members need to improvise. In the final section, we discuss some possible measures aiming at improving the ability to manage disturbances, in this case improvise, in teams of this kind.

1.1 A systemic approach to crisis management teams

To deal with unexpected events in crisis management, resilience is a common approach (for a review on views on resilience in disaster management, see Manyena 2006). The resilience perspective offers a holistic view of a system and stems from the Cognitive Systems Engineering (CSE) approach (e.g., Hollnagel and Woods 2005). In CSE, a system comprises both humans and artifacts, and the interest lies in understanding the functions of the joint system rather than the individual parts. Resilience is the ability to deal with changes that go outside of the designed-for system tolerances, and improvisation is therefore a key characteristic. A resilient system has the abilities to anticipate, monitor, respond and learn (Hollnagel 2009). Resilience thus is not a state, but an adaptive process (Lundberg and Johansson 2006) where improvisation plays a part. To analyze resilience, the analyst can focus on different facets such as the ability to cope with specific disturbances (buffering capacity) or behavior near or beyond the margin of the current coping strategy (tolerance), see e.g. (Woods 2006; Mendonça and Wallace 2006). The analyst can also focus on particular behaviors that contribute to things going right. An example of this is the identification of how "playing" increased resilience in the domain of controlling trains (Smith et al. 2009). Another behavior that has contributed to resilience in previous studies is collaborative cross-checking. This was, however, dependent on supporting factors such as individual expertise and having people around to listen-in on conversations (Patterson et al. 2007).

1.2 Previous research on improvisation

A factor that contributes to a systems' resilience discussed by, for instance, Somers (2009) includes the ability to take on different roles. The success of taking on different roles might, like collaborative cross-checking, also depend on supporting factors. Improvisation may range from modest adjustments to the abandonment of all existing plans and routines (Moorman and Miner 1998). The actual process of improvisation may contain activities such as selecting and executing alternative courses of action, as well as taking on new roles or switching roles (Mendonça and Wallace 2007). Role improvisation is destabilizing compared to having a non-improvised role, but it is nevertheless better than not getting the task done. To conduct a task without training can sometimes be less dramatic, such as digging a trench as part of a team, but can also demand more, as when taking over a logistics function without having logistics expertise at hand.

Improvisation can be seen as a range of different behaviors—at one end as small deviations in intended courses of action and at the other end spontaneous actions based mainly on intuition (Crossan 1998). An important factor, which differentiates improvisation from intuition, creativity, or adaptation, is its temporal convergence (Chelariu et al. 2003). For instance, Moorman and Miner (1998) suggest that "composition and execution converge in time", i.e., the structuring and planning of tasks take place as it is being carried out. Medonça et al. (2001) suggest that improvisation constitutes "reworking knowledge to produce a novel action in time to meet the requirements of a given situation". That definition emphasises the importance of previous training and experience, which all comes together during improvisation. Note, however, that this definition seems primarily to apply to cases of same-role improvisation, where the participants have previous training in the role they take, even though the specific circumstances are new to them.

Research concerning organizational improvisation (for a review, see Cunha et al. 1999) includes using jazz and theatrical improvisation as models for understanding how improvisation is orchestrated (Vera and Crossan 2005; Mendonça and Wallace 2007). Several factors influencing the quality of improvisation appear to be consistent throughout the studies. For instance, improvisation is a highly structured activity, implying that a certain amount

of structure is necessary even in unpredictable situations (Cunha et al. 1999; Grøtan et al. 2008; Lundberg and Johansson 2006; Mendonça and Wallace 2006; Vera and Crossan 2005). Previous research has also observed that fruitful improvisation requires training, resources and skills (Crossan and Sorrenti 2002; Drabek and McEntire 2002; Vera and Crossan 2004).

However, as Cunha et al. (1999) points out, there are limitations in the jazz-model, and new methods are necessary for studying phenomena related to improvisation. There are several previous contributions aimed at widening and complementing the limited jazz-model (Kamoche 2003; Mendonça and Wallace 2006). Kamoche (2003) provides valuable insights by contrasting the jazz-model to improvisation in Indian music, music therapy and role improvisation. Situation (e.g., nature of the crisis, organizational structures, laws and rules), cultural (organizational culture, religion, regional) and contextual factors (e.g., weather, resources available, surroundings) are some of the aspects that influence improvisation and need to be considered when creating a general model for improvisation. In Indian music, there is, for instance, no specific leader, but skills are very important, and in music therapy, no prior skills are necessary but strong leadership is central (Kamoche 2003). Also, these kinds of improvisations, with the possible exception of music therapy, are all instances of same-role improvisation. In disaster responses and other cases of Crisis Management (CM), there is, however, in addition another kind of improvisation that often becomes important—namely different role improvisation, i.e., when a member of the team is forced to take a role for which s/he lacks professional training. These different role improvisations often occur when the CM team loses one member, or when for other reasons members with the relevant expertise are not at hand.

1.3 Improvising in crisis management

Mendonça and Wallace (2006) compare and provide insight to the similarities and differences between improvising in an emergency management setting and in a jazz setting by highlighting three dimensions; decision making, context and task. Similarities are for example group size, pre-defined roles, leaders, time constraints, unplanned for contingencies and the availability of physical resources.

Other similarities are the need to identify when and how to depart from a plan as well as the occurrence of individual and collective improvisation. Although there appears to be many similarities between improvisation in varying fields on a high level, the details on a lower lever differ greatly. Physical resources are of great importance in all areas, but it is expected in jazz improvisation to have great familiarity with the instruments, whereas in CM, the array of resources available is too large to make this possible. Further, in CM improvisation, there may be a decision or a high-level instruction made at a management level, but details of the improvisation need to be worked out by the operational staff. The present study demonstrates operational staff taking on tasks they are not specifically trained for. The topic of role improvisation in CM will therefore be discussed in more detail below.

Mistakes made when improvising with an instrument are generally viewed as something positive as it creates a learning situation. Role improvisation, on the other hand, distinguishes itself in several ways. A feature of role improvisation is that it often results from an unintended deviation from a structure of prescribed roles (Kamoche 2003). Compared to other areas of improvisation role improvisation is less deliberate, often there is no audience, and it is used out of necessity rather than to impress. Further, individual power to influence the situation may play an important role and depends to a large extent on the culture of the organization. An improvised role may still have clear instructions and boundaries, or it might be created ad hoc and be open to new creative ways of solving problems in a particular situation. It is also common that relationships and roles are constantly re-defined depending on previous actions and situational factors (Kamoche 2003).

In CM, improvisation often takes place in established organizations with structured roles and tasks. During an emergency, the roles and tasks may need to be improvised in order to respond to the prevailing situation (Drabek and McEntire 2003). Reasons for this may be, for instance, that a task cannot be assigned to a particular organization or that trained personnel may be unavailable (Medonça and Fiedrich 2006). Abandoning our occupational role is something that, according to sociologists, almost never happens during normal work (Webb 2004). However, in crisis situations, procedural and structural innovation is a necessity for enabling its success (Webb et al. 1999). For instance, a task usually performed by a particular role may be performed by someone else, such as the fire command performing crowd control which traditionally is a police activity (Mendonça and Wallace 2006).

Previous research by Webb (2004) has presented a classification scheme of different types of role improvisations in CM. Categories are based on, for example, procedural changes, status changes or physical changes in the environment such as the loss of equipment or relocation. Procedural changes are alterations in the way a role is actually performed and a status change is when someone takes on new activities that he or she may not normally be authorised to carry out. In his comprehensive study, Webb (2004) found that the procedural changes were the most

common type of improvisation in both natural disasters and civil disturbances. The primary reason for this is the immediacy of the situation: an alteration in the way a task (or procedure) is normally executed to meet the demands of the on-going situation.

Although different types of role improvisation in disaster responses have been categorized (Webb 2004), we have not found any studies that look at different role improvisation as it happens, to discover factor that influence the task in a positive and negative way. Having adapted to the loss of professional competence by role improvisation, the system (organization) still has the function, but weaker than before, lacking the expertise or a trained professional. How such a team functions, and which factors contribute to its performance is the focus of this paper.

1.4 Team communication and information sharing

One of the key factors for teams to successfully adapt to the ongoing situation of a crisis is effective ways to coordinate their actions. The ability to coordinate actions requires well-functioning communication. This is perhaps even more true when one or more of the members in a team need to take on roles for which they lack previous training and professional competence. It is well known that different communication structures and information systems will foster different capabilities and have to be adapted to the needs of the organization (e.g., Johansson and Hollnagel 2007; Fussell et al. 1998). It has for instance been shown that managing multiple tasks at once requires parallel processing by different members, which decreases the amount of shared information, whereas sequential processing offers better collective understanding and common ground, but takes more time (Artman 2000). (For an overview of recent research on team cognition, see e.g. Salas and Fiore 2004).

In a review on research on teamwork in multi-person systems (Parisi et al. 2000), the authors also point to areas in need of research. Paris et al suggest that the perhaps most important area of research is the implications of cognitive theory for team performance and state "One needs to understand how teams function as information processing units, that is, how knowledge is acquired, shared and acted on" (Parisi et al. 2000, p 1,068). In this paper, we want to contribute to that endeavor by analyzing a team's information processing under circumstances where expert knowledge is lacking among the team members, and which therefore puts additional pressure on the ability to acquire, share and act on necessary information as one or more of the team's members is required to improvise in performing tasks for which they have no previous training.

2 The case study

In this section, we describe the basic foundations for the case study, which is based on an exercise for the Swedish Response Team (SRT). First, some background information on the SRT and the research leading up to the exercise is given. Second, a description of the simulated exercise scenario is presented together with the motivation for the study. Third, a description of the data collection and episode analysis is described and examples are given.

2.1 Background

The SRT consists of assessment teams and base units. An assessment team usually consists of eight persons and should be ready to leave Sweden within 6 h of an issued deployment order. The base unit consists of a group of commanders (six persons), a command staff (18 persons) and three field support teams (11 persons in each team) which is ready to leave Sweden within 12 h of the deployment order (Larsson 2008; Kulling et al. 2008).

The taskforce has a flexible composition and is assembled based on the needs of the crisis, for instance, natural disasters, terrorist attacks, major accidents or political disturbances. The primary task of the SRT is to assist Swedish citizens living or visiting the area. Examples of tasks are; assist victims with information, crisis support and medical care, establish command teams, reconnaissance, assess the need for further support, and evacuations.

In prior research based on interviews and focus groups with members of the SRT, a number of positive and negative aspects of role improvisation were identified (Trnka 2009). The interviews and focus groups focused on two real operations performed by the SRT: response operation after the tsunami in Thailand 2004 and the Middle East operation in 2006 (Trnka 2009). The results show that improvisation is viewed as an important part of the SRTs work during the operations as tasks and roles changed over time during a mission. Role flexibility has many positive qualities, such as increased communication, a better understanding of other people's tasks and less resources necessary (Trnka 2009). Problems identified when taking on new roles were, for example, reduced quality of work and lessened clarity of the organizational structure. Based on these results, the role-playing exercise in this study was created. The study design was aimed at creating a dynamic and non-routine situation in which the participants would show adaptive and improvised behavior.

2.2 Scenario

The scenario used for the exercise is based on a real event; the 2007 California Wildfires. According to the scenario,

around 20,000 Swedish citizens are in the affected area, and a large number of citizens are requesting assistance from the Swedish embassy. The SRT's mission includes an assessment of needs in the area of operation, as well as support and assistance of the Swedish authorities and citizens in the area.

Normally, it would take a few days before a full taskforce is sent to the site. In the scenario, the exercise therefore takes place (i.e., the team arrives) on Day 6 of the crisis. An assessment team was sent out a few days prior (according to the script) and reported back that the full SRT taskforce would be necessary. In the days before departure (i.e., the day of the actual exercise), the participants received news reports and updates, via post, on the fires in California. This was to simulate information normally acquired prior to departing for an international operation (e.g., media coverage, reports from authorities). The scenario (and exercise) begins with the command staff arriving at the command post, which had been established by the assessment team in the outskirts of Los Angeles (part of the scenario script). The main tasks of the simulation participants, i.e., the SRT command staff, were to (a) take over the command post, (b) establish a functional command staff and (c) initiate activities according to the mission objectives.

Participants were operational personnel, acting in their professional functions and posts. Under normal circumstances, the command staff includes 18 members in total, but in the scenario, this number was intentionally reduced to 11 in order to create a situation that was "stressed", i.e., a situation where available resources did not meet actual needs. Competences missing in the command team were medical, fire engineering, safety, ICT/communications and crisis support competences. This created a situation where participants, in various degreed, had to take on other roles in order to accomplish the SRTs tasks in the simulation.

Although data were collected from the entire exercise, the analysis presented in this paper is focused on the main tasks where the command team lacked expertise; dealing with the air quality issue. The aim of this focus was due to the lack of expertise on this topic, which forced the participants to manage tasks which were normally performed by other roles in the command staff. Tasks included were, for example, increased awareness about hazardous smoke, information on what protective face masks may be suitable and information on how to acquire face masks.

2.3 Data collection

A large set of data was collected during the simulation. Five observers were present, and video cameras were placed in each corner of the room (see Fig. 1). All phone calls were recorded, and e-mail communications were logged, as well as the participants own notes, logs and reports. A large amount of photos were taken. The simulation went on for approximately 4 h. After the simulation, a 1-hour after-action review took place, focusing on the participants' experiences from the exercise. A review of all data was done and anything that could be related to, or affect, the task that was in focus for the analysis was considered for inclusion in the detailed episode analysis. As the data collection is very comprehensive, only some key examples of where persons were outside their field of competence (improvising) are presented here. For more results from the exercise, see Rankin (2009), Trnka (2009).

Fig. 1 Command staff during the exercise

Initially, all information concerning poor air quality was compiled using a support system: CITE Explorer.[1] CITE Explorer is a tool for integrating and exploring data from exercises such as observation reports, telephone conversations, pictures, video clips, documents and maps.

2.3.1 *Episode analysis*

To structure and analyze data of multi-party conversations, *episode analysis* was used (Korolija and Linell 1996). Episode analysis is a bottom-up, data-driven qualitative research method used to study communication where multiple participants are involved. Communication is broken down into subunits, called "episodes" (Korolija and Linell 1996). Each unit contains an unbroken chain of actions internally bound together by a topical trajectory and/or a common activity (i.e., the communication and information sharing). This means that the episodes emerge from the data and not from predetermined missions.

The method originates from conversation analysis and has been adapted to fit the objectives of this study. This means that a higher level of abstraction has been implemented, not focusing in detail on how individual utterances

[1] More information on CITE Explorer can be found at http://www.vsl.se

Table 1 Excerpt from episode "air quality"

Time	Source	Event
10.33	Phone call	Team coordinator calls field commander
10.40	Observation	Team coordinator informs analyst 1, logistician 1 & 2 about the field commanders concerns
10.40 → 10.52	Video recording	Conversation between team coordinator and Logist1 concerning expert advice
10.44	Log report	Information from Swedish contingency agency (SCA) entered into log book
10.54	Phone call	Logist1 calls SCA for advice (no answer)
10.54 → 10.57	Video recording	Logist2 reviews previous reports. Logist1 says that not much can be done. Additional information from the EPA is needed
11.02	Phone call	SCA return Logist1 phone call

are structured. Focus is on the information content and the flow of information in the conversation rather than specific utterances, pauses, etc. This abstraction level of episode analysis has previously been applied to studies of joint emergency response operations (e.g., Aminoff et al. 2007; Rankin et al. 2010; Trnka and Johansson 2009).

As previously mentioned, the main episode in this study was concerned with air quality issues. All information regarding the task on air quality was derived, and relevant recorded interactions and phone calls were transcribed. This provided a natural way of compiling data related to a particular context where many tasks are being performed simultaneously. It also provided a way to manage several participants in a particular conversation at the same time.

This mapping of information sharing provided a way of capturing how information spread throughout the organization. An example is shown in Table 1. Each unit of information has a time stamp, information about the source and a short summary of the event.

2.3.2 *Sub-episodes and context dependence*

Within the main episode, "air quality", several parallel events took place. To unravel some of these events, the main episode was broken down into sub-episodes. Identifying sub-episodes was done using a context-dependent approach (Korolija and Linell 1996). A new sub-episode was defined each time an event that altered the course of events took place. This could be, for instance, new information being introduced to the participants, additional information or an emergency situation that needed immediate attention. For example, a new sub-episode was created when concerned field personnel called the command team and asked if they should wear face masks. A second sub-episode was initiated when a command staff member calls the Environment Protection Agency (EPA), as new information was retrieved. However, the information was in response to previous concerns and therefore part of the first episode as well. The same information can therefore be a part of several sub-episodes, and new sub-episodes can spring from previous ones (see Fig. 2). This approach ensures that the episodes (and sub-episodes) emerge directly from the data and not from a predefined task.

Figure 2 provides an overview of the eleven sub-episodes identified from the main episode "air quality" on a spatial-temporal scale. The purpose of the illustration is to provide an understanding for the spatial and temporal distribution of the sub-episodes. Several sub-episodes use overlapping information as tasks and activities are intertwined. The horizontal line indicates the temporal scale.

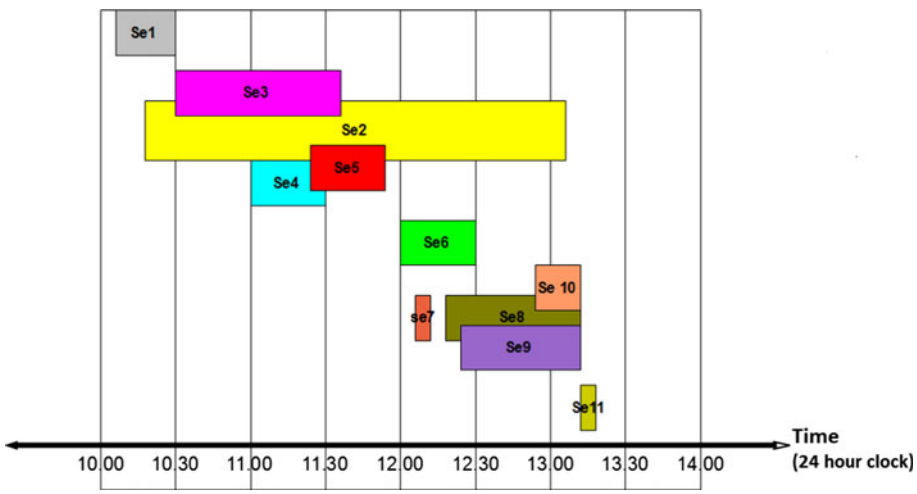

Fig. 2 A spatial-temporal scale of the eleven sub-episodes of the air quality episode

As previously mentioned, the simulation went on for approximately 4 h. Overlapping sub-episodes show the spatial scale; this means that the two episodes are present in the same interaction. For instance, sub-episode 2 (S-E2) involves two staff members searching through newspaper-articles and reports to gather information about the hazardous smoke. A phone call about the smoke is made to one of the two staff members; this is the event that triggers S-E3, but both S-Es are present in the same interaction and therefore overlap in the figure. The coloring is of no significance other than making it easier to distinguish one S-E from another. For a more elaborate description of the method and the content of each individual sub-episode, see Rankin (2009) and Rankin et al. (2010).

Figure 3 illustrates all data units recorded and analyzed for the air quality episode. The episode starts when the SRT staff arrives at 9:45. The staff members are provided with a situation report, and a hand-over is given from the assessment team (simulation management) who had done initial work at the site, but who had to, according to the scenario, leave for a meeting at another location. The hand-over was followed by a brief staff meeting where tasks and responsibilities were handed out and this is how the exercise begins. The data contained phone calls, video from four angles of the room, emails from and to the staff, log made by the staff and other contents of the computers used by the staff.

In the top part of Fig. 3, the excerpts presented in the next section are visualized with regard to the time in which they occurred and from what data source the information is given. Also, the figure provides an overview of the different sources and amount of data collected in the episode. The excerpts are examples of each of the three main contributing factors identified in the analysis. In the next section, they are explained in detail to provide an in-depth understanding for the interplay that can take place between the different factors when staff members are acting outside their expert roles.

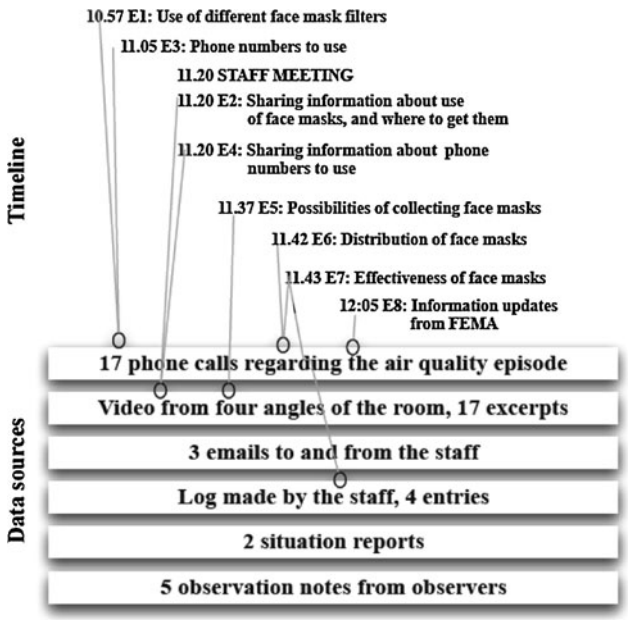

Fig. 3 Excerpts from air quality episode

3 Three main factors influencing the performance

The analysis from the exercise revealed three factors that affected role improvisation. Important information such as what networks had been set up and where face masks can be acquired did not reach the "right" people. Further, information that did reach the staff members were in several cases distorted such as what types of filters provide sufficient protection, where these can be found and what the cost is. The sub-episodes provided a map of how information traveled through the organization. Several factors point toward the mishaps occurring due to the improvised roles.

In this next section, the identified reasons for problems with information sharing will be presented in more detail along with examples from the analysis. A summary is provided at the end (Table 2). Three main reasons for the problems are identified: (1) language skills and communication, (2) insufficient domain knowledge and (3) organizations structure. Interestingly, the misunderstandings do not appear to stem from one root cause but rather several factors contribute to each of the misunderstandings that occurred. The examples are presented according to which of the three identified factors appear to contribute the most. However, several of the examples could fit under several of the main reasons that illustrate that several combining factors lead to the miss-communication. This also means that several factors could unravel the mistakes made and that there are multiple ways of strengthening a team's ability to improvise.

Table 2 Summary of reasons for misunderstandings

Main reasons for misunderstandings	Examples
Language skills and communication	Did not pick up on contradicting information
	Misunderstanding due to grammatical mistakes
Expert (domain) knowledge	Hazardous smoke
	Protective filters used in face masks
Structure (organization)	Unclear responsibility
	No formal hand-over
	Insufficient spreading of information

We have here chosen to illustrate the factors identified by using examples that fit under each of the three categories, which we hope will make is easier for the reader to follow the information processing in the team and to understand the interaction between the team members. For more examples from the analysis, see Rankin (2009).

3.1 Language skills and communication

Although the overall English language skills of the Swedish team were good, and they all had experience with international operations where communication in English is a necessity, several key factors were misunderstood when receiving information from the American authorities. The first misunderstandings occurred about 1 h into the simulation when initial contact with local American authorities was made. The following excerpt is from a phone call between a logistician (Log) from the Swedish Response Team (SRT) and representative from the Environmental Protection Agency (EPA). The logistician is trying to get information concerning necessary protection against the hazardous smoke. The SRT have received reports of people walking around with face masks:

(Excerpt 1, phone call start time 10.47)
(EPA) Ah yes, they use the paper filters which you can use on construction sites and so on, but they are largely ineffective
(Log) Ok
(EPA) Effective protection concerns filters such as P1 or P2 level and protection of the entire face.
(Log) Ok
(EPA) And the recommendation for the police force in the San Diego county is to use the P2-filters on their masks.
(Log) Ok, but your recommendation for the general population is to stay indoors and in case they go outdoors they should be covering their faces with some kind of
(EPA) Yes
(Log) Handkerchief or…
(EPA) You should always check it, I mean those construction filters are useless but if you stay outside for more hours then you should raise your protection level.
(Log) Ok, and it is sufficient to use an ordinary handkerchief or a paper towel or whatever is…
(EPA) Eh, no, you should use masks
(Log) Ok, and they are available at the pharmacy?
(EPA) Eh, that is a good question. Well these, this is special equipment which I think the San Diego county buys from Scott.[2] *Eh, the best thing is your… where do you have your stuff?*

Although the logistician says "ok" to the responses provided by the EPA, it is made clear in later communications (excerpt 2, 6) that it, in fact, is not clear. On the contrary, the logistician does not understand that construction masks are insufficient, and he also incorrectly assumes that these can be acquired at pharmacies and evacuation centers, something that EPA representative did not say. During the joint briefing, the logistician tells the rest of the command staff the following:

(Excerpt 2, Joint briefing start time 11.20, translated[3])
(Log) … If you for some reason need to go outdoors a face-mask or face-protection should be used because of gases from the smoke. If you don't have one you should contact a pharmacy or an evacuation center, they will provide one…

Another misunderstanding that appears to stem from language difficulties is the following. The EPA representative informs the logistician about a phone number for receiving weather updates.

(Excerpt 3, Phone call start time 10.47)
(EPA) In San Diego we use the 211…
(Log) 211
(EPA) Information line, and then via the Qualcomm[4] station via the, there is information center. All the evacuation centers have received the information, and all the command post has received the information too.
(Log) yep, yep
(EPA) KCLA and other local stations have information and our staff is giving news to the TV station and we spread the information. I don't know about the L.A. channels but it is on the San Diego TV all the time. So if you are…
(Log) But you recommend that people listen to the radio and in case they need more information they can go to one of these evacuation centers of similar tourist information?
(EPA) Normally there is a nurse at the evacuation center so if they have any problems they can discuss that. They shouldn't be calling 911
(Log) No, no. No, no. Ok
(EPA) But they can call 211, 211 has information and we have experienced staff operating on 211 and so, 211
(Log) Ah, ok
(EPA) Well, you may consider talk to someone from 211, maybe San Diego ask them, maybe they can help you. They are quite busy there but, you'll see.

[2] Scott is a website where equipment for fire fighters is sold.

[3] All translations are from Swedish to English and are performed by the first author.

[4] Qualcomm is an area in California, according to the scenario one of the evacuation centers was located here.

(Log) Yes, no problem, we will contact them and I hope I can call you back and get some updates maybe later, today or tomorrow, maybe later if something happens?
(EPA) Yes, you can do that.

Corrective information is given by the EPA and the logistician says "ok" to assure the EPA representative that the information has been received and understood. However, it is made clear in several subsequent interactions (e.g., excerpt 4) that the logistician believes that the 211 number should be used only in case of emergency. Further, it is not registered that the staff can call the evacuation centers for more updates and information. Or at least no information about this is passed on. Excerpt 4 is taken from the joint briefing when the logistician is informing the rest of the command staff what information was given by the EPA:

(Excerpt 4, Joint briefing start time 11.20, translated)
(Log)… And of you feel that you have any problems you should immediately contact your local doctor or a hospital. There is a special emergency number for air quality problems and it is 211. This number can be used if something happens… but it is an emergency number, if you get acute problems they will help you…

About 15 min after the joint briefing, the logistician discussed face masks together with a second logistician also working on the air quality issues (Log2), and the staff member in charge of the economy. The following is heard:

(Excerpt 5, Interaction 11.37, translated)
(Log2) It is possible to collect masks irrespective of nationality at evacuations centers and pharmacies here.

Excerpt 5 shows that more incorrect information has been added by the participants themselves, not only do they believe that the face masks are available at evacuations and pharmacies but also that they can be collected "irrespective of nationality", something that was never discussed with the EPA. This information appears to stem from a question raised during the joint briefing. Although no one had an answer to the questions, it was later assumed that all nationalities would be provided with face masks (also incorrect information). Interpretations like this show how information can get distorted when being passed on, in this case creating an even more inaccurate picture of reality. When such a false model of reality once is created within a group, it may be hard to create a new one. This may be one reason why contradicting information does not uncover the misunderstanding in following interactions, as will be presented later (excerpt 6).

3.2 Domain knowledge

Another factor identified as contributing to the misunderstandings is the lack of domain knowledge concerning toxicology, hazardous materials and protective equipment. Had an expert been present when questions about filters were raised the misunderstandings occurring in excerpts 1, 2 and 3 would most likely not have occurred as general knowledge about hazardous smoke and sufficient filter types would have been available. An expert would be alarmed when learning that the smoke was so hazardous that "P1" and "P2" filters were necessary. Furthermore, an expert would most likely have had a larger network for gathering information concerning these issues, or at least better knowledge of who and what to ask, leading to more information flowing into the organization.

During the joint briefing, further questions are raised by other staff members, and a decision is made to call the EPA for more information concerning the face masks. The phone call does, however, not uncover the previous misunderstanding that construction masks are sufficient:

(Excerpt 6, Phone call start time 11.42)
(EPA) You can be out one or two hours, that's ok. People buy these constructions face masks which are paper based or cotton based, they are…
(Log) Yeah, they can buy them at the pharmacy?
(EPA) They can, but those are completely useless
(Log) Ok
(EPA) They don't provide any protection at all
(Log) Ok, eh
(EPA) It's the same effect as if you have a handkerchief around your face or a scarf
(Log) Ok, so where do they get this construction site mask?
(EPA) Well, in any workshop
(Log) Workshop?
(EPA) Any workshop they are selling construction material and so on
(Log) Ok, so like hardware stores or something
(EPA) But they are useless, but if they are going to stay outside they should do that. But you for example, if your staff is going to stay outside for long periods of time they should use half or full proof masks with P2-filters and they cost around 150 dollars a piece
(Log) P2-filters?
(EPA) Ah, yeah, mask with P2-filters
(Log) Ok, and they are available where?
(EPA) Ah, they are sort of eh, it depends, we have agreement with FEMA, there could be some stores at the county fire department, you could get them there.

The representative from EPA repeats several times that the construction masks are useless but it appears as though the logistician is only is seeking to get answers to the predefined questions, which unfortunately are based on the wrong information, and not listening to what is actually being said. The staff member does, however, pass on the

information that P2 filters may be needed, but without full comprehension of what this means. In the after-action review, the logistician mentions that using technical terms outside ones field of competence, such as P2-filter, can cause problems.

A lack of expert knowledge can, as in this case, expose language and communication difficulties. For example had the logistician known what P2 filters are it would have been obvious that P2-filter are not handed out at evacuations centers as they are very expensive and hard to come by. Therefore, it is neither the lack of language skills nor the lack of domain knowledge that leads to the wrong information but rather a combination of the two.

3.3 Organizational structure

The organizational structure plays an important role when it comes to spreading information, questioning information and making decisions. Information regarding the air quality came from several sources during the exercise, one of these was a field team (played by simulation staff). The information came via phone to the team leader in the SRT staff. Information and concerns from the field team were passed on to the logisticians currently working on the task, and the information available (although incorrect) was at first passed on. However, as the information was updated, no one made sure this was passed on the field team. The team leader also makes some efforts to e-mail the Swedish authorities to get more information on different types of smoke. A reply was sent, but the information had not, at the end of the simulation, reached any other participants working on the task or the team in the field. This was about 1, 5 h before the simulation ended. In one of the last phone calls in the simulation, the simulated field team expresses concerns about handling the air quality.

During the joint briefing, part of the incorrect information is questioned, and further information is gathered. Joint briefings, where team members share information, are therefore an important support system for discovering mistakes and conflicting information. The logistician contacts the EPA a second time, after the joint briefing, and parts of the previous misconceptions are clarified.

(Excerpt 7, Phone call start time 11.42)
(Log)… Yeah, fine, how are you? Just one more question regarding this face-mask that was available at the evacuation center or pharmacy etc, how would they react at the evacuation center if there were Swedish citizens coming and asking for these masks? Will they be able to get them free of charge or buy them, or how does it work exactly?
(EPA) You misunderstood me, we don't distribute any masks at evacuation centers or pharmacies
(Log) Ah, ok
(EPA) People buy their own masks. Our instructions are stay indoors, you can…

The information about evacuation centers not distributing face masks is uncovered and reported in the command staffs shared log book. Shortly after this interaction tasks more related to a logistician normal line of work start to stream into the organization and both the logisticians devote their time to this. The updated information is not communicated to the rest of the staff (besides being noted in the common log book), and at several points in the analysis, it is apparent that several participants had the incorrect information throughout the rest of simulation.

The joint briefing also led to other team members' expert knowledge to be of benefit for the team. For instance, the media respondent brought up the topic of possible psychological effects that may be caused by alarming information (such as hazardous smoke) to tourists and citizens. It was emphasized that the information that was conveyed should not cause more concern than necessary.

A shift in responsibilities is normally done with a formal hand-over between the shifting members. However, the task of staying updated on issues concerning the air quality gradually shifts between different staff members without any formal hand-overs being acknowledged. An example of how this affects information being misunderstood is when the media informant takes over the responsibility of staying updated on information concerned with the air quality. This shift in responsibilities is briefly mentioned by a couple of team members, but no formal hand-over ever takes place. The media informant calls the Federal Emergency Management Agency (FEMA), to make sure they are providing the Swedish command team with updated information.

(Excerpt 8, Phone call start time 12.10)
(Media informant) Yes, we will try to get better connections with you if possible, you know. I guess you know that we are here?
(FEMA) Yeah, I know, I have it in the log system that you are on site. I have you under the name Swedish response team B
(Media informant) Yeah, right. Do you have a, do you have an e-mail address?
(FEMA) Oh, yes we have…
(Media informant) Ok, because we don't see any incoming information and so if you have anything of interest for us please call us or give us an e-mail
(FEMA) Oh yeah, do you want my e-mail address?
(Media informant) Ah, yes I would like to have your own, yes
(FEMA) E-X (…)

The media informant appears to believe that a network already has been set up. As he calls FEMA's reception, he assumes the receptionist has been informed about their ongoing work with assisting Swedish citizens, which in fact is not the case. This false assumption leads to several misunderstandings. From a sharp end-perspective, the cause for this misunderstanding are language difficulties as the media informant does not mean "do you have an e-mail address?" but rather "do you have *our* e-mail address?" When the media informant gets a positive response, he assumes that a continuing flow of information will come via e-mail from FEMA. However, when taking the whole situation into account, it is also a failure from an organizational perspective as information had not been passed on. A network is never set up, leaving the SRT without information updates from FEMA. The topic is not further discussed.

The factors described here are summarized in Table 2.

4 Discussion

The findings suggest that in most cases, it is not one factor that causes the misunderstanding or fail points. It is a combination of several factors in different combinations. Responsibilities and information loss within the team are a recurring problem, and the information systems were not made use of in efficient ways. This includes for instance new, and corrected, information not being distributed to the necessary parties. The analysis shows that several persons are involved with questions concerning the air quality.

The figure below illustrates the information flow and situation awareness of the command team during the improvised work. The illustration is aimed at providing a holistic perspective of the episode where staff members had to coordinate in an ad hoc manner and take on tasks normally performed by other roles. The specific shortcomings of individuals are, from a resilience perspective, not as interesting, as these will differ even in similar situations depending on factors such as individual traits, stress level or having a bad day. It is the detailed analysis of the interplay between different parts of the system and the emerging outcome of the system as a whole which is in focus.

Figure 4 demonstrates how a positive and negative aspect of the team work affects the overall outcome of the response when team members have to take on roles outside their field of competence. The illustration starts at the top left with an individual taking an improvised role (1) to fill in for an expert missing from the team (0). This individual lacks knowledge about key terms and facts (2). Improvised work (3) is then conducted, which can either result in (4) correct information given, or incorrect information being given. The figure illustrates several factors that influence work toward things going right, but also several factors influencing the situation going wrong. *First*, one kind of improvisation is to compensate for the lack of own expert knowledge, which can be done through communication with an expert. However, misunderstandings influenced by lack of knowledge regarding key terms can affect this activity negatively. *Second*, joint briefings can either amplify the effect of successful work, through sharing the correct information, or amplify the effect of misunderstandings, through sharing incorrect information. *Third*, the joint briefings provide an opportunity for the group at large to discover erroneous/implausible information. However, this could be weakened by a lack of competence to discover errors in the group, or by a reluctance to publicly (or privately, after the meeting) question information given by other people (it is not clear from the data whether competence in the group was completely missing or reluctance was present). It could also be weakened if the staff does not realize that the information really needs to be critically examined, since it emerges from work in an improvised role (there was no indication that information from the improvised role was treated differently compared to information from other roles). Alternatively, time pressure (workload) might force the joint briefings to be too short for critical discussions (there was no evidence for this being the case during this exercise). *Fourth*, placing the information in the log book could, just like the joint briefing, amplify both erroneous and correct information, and give the team members individually the opportunity to critically examine it. Furthermore, new (correct) information can be added between meetings (this fortunately happened during the exercise). This strategy can, however, be weakened if the other staff members do not read the log (this unfortunately also happened). The analysis suggests that the staff were much more concentrated on writing their pieces on information in the log book than reading what other people had entered. *Fifth*, a formal hand-over of the role to a new person could have ensured that this individual starts out with the new and correct information, rather than previous incorrect information in mind (as well as other, assumed, information). This strategy, however, is dependent on a more formal hand-over (this was not done during the exercise).

4.1 Communication and coordination for increased resilience

We suggest that the most efficient measures for strengthening the systems resilience, in this case the improvised performance, should be at an organizational level. This is not to deny the positive effects of improved technical domain knowledge and language skills of the team

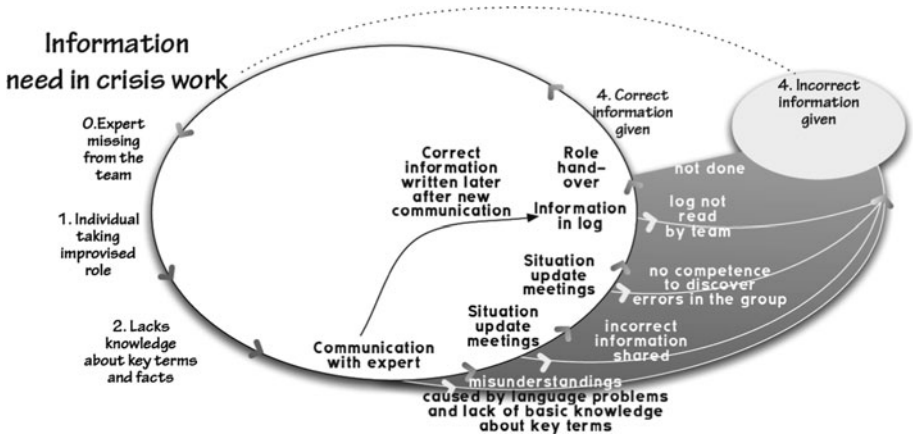

Fig. 4 Model of the information flow in the command team

members. However, it is impossible to train members to a level of competence in, for example, language skills, which guarantees that they will be sufficient in all situations. As the results from this study show, reasons for the problems stem from several sources and can therefore be alleviated in several ways. Just as previous models of improvisation in other areas have demonstrated improvisation is a structured activity requiring, for instance, a referent, a strong core structure or highly skilled individuals. If skills are lessened, other parts must take over. The cognitive system of the crisis management team must be more reliable than what can be expected of its individual members. Since individual team members are fallible, organizational structure and work routines must be created with interrelated goals in mind such as to minimize the risk of the misunderstandings going unnoticed and to minimize the risk that changes in the team members' task responsibilities leave tasks unattended. Further, we believe that members of a crisis management team need training in taking roles outside their sphere of professional competence. Based on the results from the analysis, we therefore suggest the following points as potential areas for improving the team's performance when team members are forced to take on a role and responsibility outside his or her professional area of competence.

1. Training to take on different roles
2. Formal Responsibilities for roles and tasks
3. Team coordination: communication and information sharing

4.2 Training for taking on different roles

As previous research has shown, a situation where persons have to act outside their own field of competence is a common occurrence (Medonça et al. 2001; Medonça and Fiedrich 2006; Trnka 2009; Vera and Crossan 2005). Also, as Kamoche (2003) points out, roles (when not properly defined) are constantly redefined based on the ongoing situation.

We suggest that training on taking on new roles, outside one's field of competence, will provide personnel with confidence and awareness of the problems that may occur. In addition to improving performance when there is a need to take on tasks outside ones professional competence, which is the focus here, it will *probably also* allow team members to form new social relations by increased understanding for others work which is of great importance to ad hoc coordination (see, e.g., Johansson and Hollnagel 2007). Since members of these teams are highly qualified in their areas of expertise and since the team members have different areas of expertise and workload is often high, it is natural to work independently. However, when taking on a role outside their area of competence, this is not an appropriate position to take. They are not experts; help or support may be necessary for the success of the completing the task. In the exercise, this is clearly illustrated in the logistician's comment in the after-action review, where he admits being on thin ice when talking about P2 filters and the like. This suggests to us that team members should be made aware of the difference between working within their field of competence and on other tasks. Training to take on new roles and having another member of the team working outside his/her area of competence can increase awareness and give the team members support in how they can increase their support network when acting outside their area of expertise. Note that this training thus needs to focus on the whole team, to support individuals working in improvised roles. For instance, collaborative cross-checking as suggested by Patterson et al. (2007) might have supportive in this situation, although this would have required more resources for this particular task. The manager might also need to specifically

monitor quality of work in improvised roles, as well as if the team as a whole appears to support improvised roles.

4.2.1 Formal responsibility for roles and tasks

Team coordination in constantly changing conditions requires not only good social relations but also important is the organizational structure (Johansson and Hollnagel 2007). When there are parallel tasks being performed, the team will, to a large extent, rely on pre-defined structures and roles to get things done (Fussell et al. 1998). If for some reason this systems structure is disrupted, as in this exercise, this will have an effect on the management of information flow and tasks responsibility.

Examples of this are shown in the analysis. The fact that the tasks assigned in the air quality episode was outside the staffs field of competence was not acknowledged during the simulation. Further, the implications of handling the assigned task were never discussed by the participants. We argue that this confusion of responsibilities and roles might be the reasons for so much information getting lost along the way. Several staff members were involved in discussions concerning the air quality, but nobody appeared to have all the information that had been made available to the staff. Had the task been a part of a particular staff member's expertise it would have been natural to that particular member, as well as other staff members that this person should receive, evaluate and stay updated on all information concerning the task. Instead, when tasks more related to the participant's normal line of work appear, in this case logistics, these were prioritized and responsibilities informally (i.e., was never said out loud) shifted.

Formal task responsibilities and hand-overs are somewhat connected in the sense that better defined tasks and responsibilities may also have led to more formal ways of passing on information. Not having a formal hand-over will probably *in all cases* increase the risk of information getting distorted or lost. However, in this case, as information is traveling from one non-expert (in this particular field) to another non-expert, a formal hand-over is probably many times more important. Not being an expert greatly increases the risk of misinterpreting information, something that was evident in this simulation. We also believe that if tasks are assigned and handed over more formally, it will be less likely that unfinished tasks will slowly fade away because the team member assigned to it will concentrate on his normal tasks when they require attention, as happened in this case. Also training for this need to involve the whole team, both for all team members to train hand-over of roles, but also for the manager to, for instance, specifically monitor whether hand-over of improvised roles takes place.

4.2.2 Team coordination: communication and information sharing

In previous research on team assessment and information distribution, it has been recognized that although parallel processing of information in a command team leads to quicker decisions, it also lessens the collective awareness (Artman 2000). Although it would not be feasible to handle matters sequentially during a crisis, it is of utmost importance that available and updated information is spread to the relevant persons. As mentioned above, usually all information concerning a certain task would go to a specific role. However, if tasks normally performed by a particular role are distributed to other team members, it is more likely that information is lost and other information sharing channels become all the more important.

An example of this from the exercise is that one of the key factors contributing to misunderstandings being revealed were the joint briefings held by the command staff. During the briefings, all present members participated and each member or team updated the rest of the staff on the current situation of tasks they are involved in. These briefings proved to have an important function for the command staff as they provided a floor for reflection and discussion of current issues. As questions were raised regarding evacuation centers and sufficient filters, it was made clear that more information was needed, or at least that information needed to be verified, and the EPA was contacted again.

Other important sources for information sharing are common artifacts and information systems used by the team. During the exercise, a joint log was set up where updated information was logged. The log did fulfill the purpose of gathering all information but was not used as a resource by the team members to look for updated information. It appeared as if they relied on information concerning their tasks would reach them in other ways, as perhaps it normally would. Making better use of technology for sharing information could be an important option for strengthening the teams overall support system and information sharing during disturbances. In addition to improved technology, team members might need to train specifically on keeping track of changes to the log while conducting their own work. The chief of staff, in turn, could monitor whether such practices are taking place.

5 Conclusions

In the introduction, we argued that improvisation, while sharing many features on an abstract level, potentially requires different abilities, both on the individual and the team level, in different activity types. We also suggested

that there is an important difference between same-role improvisation, where the members are trained for the kinds of activities they are performing, even if the particular circumstances are new to them, and different role improvisation, where one or more of the team's members need to take on tasks or work in areas for which they are not trained for. While most, though not all, of previous research on improvisation has concerned same-role improvisation, in CM different role improvisation is prevalent. Therefore, we need to supplement previous work with studies on this particular type of improvisation, such as the case study presented here, since there might be factors behind successful or less successful performance that only can be seen in these kinds of improvisation. This work complements previous research in areas such as team adaptation, coordination and training. For example, our finding shows that the team managed to adapt (as discussed in Hollnagel 2006), but they did not adapt enough. It also complements studies on co-location, suggested by Fussell et al. (1998), by illustrating that co-location in itself is not enough. Complementing Johansson and Hollnagel (2007), we give examples the focus of "prior" training could be to improve communication and resilience during role improvisation in crisis management.

The present study revealed three factors, which we believe can only be found in this type of improvisation at this detailed level, i.e., domain knowledge, language and communication skills. While all these to a large extent are examples of individuals lacking one or another competence, we believe that remedies cannot only, not even primarily, be made on the level of individual training aiming at improving the team members' domain knowledge and linguistic and communicative ability. The reason is that no matter how well team members are trained there will always be cases where new and unforeseen competences are required or where one or more members of the team are absent. To increase a team's resilience, we therefore suggest that measures need to be taken on a group or organizational level to prepare for these situations and become more resilient to the inevitable fact that disturbances will happen. However, for any competences that can be predicted to become missing at some point, technology could also play a role in increasing resilience, for instance in the form of expert systems (provided that the expertise can also be modeled and made available in meaningful ways). It is important to realize that it is never sufficient to improve the team's performance by training its individual members. This in distinction to, e.g., jazz improvisation, where new constellations of musicians who never have played together before can be created on the fly and create high-level performances, something which illustrates the need to study ecologically valid kinds of improvisation. By doing so, we can build further on previous work on classifying and analyzing different kinds of improvisation (e.g., Webb 2004; Webb and Chevreau 2006).

The results from this case study are limited in its scope and obviously need to be corrobated in further studies, but we hope to have demonstrated the fruitfulness of the approach taken, i.e., doing detailed in-depth analysis of crisis management teams as they are forced to improvise by taking on roles and responsibilities for which they lack sufficient training.

Acknowledgments The authors would like to thank Jiri Trnka, FOI, Sweden, for preparing and realising the role-playing exercise and David Mendonça for his valuable comments and suggestion on an early version of this paper. We would also like to thank the participants from the SRT. Funding from the Swedish Civil Contingencies Agency is gratefully acknowledged. We also thank the reviewers of a previous version of the paper for their constructive comments.

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