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BA Rescue Team Performance - exploring team situation awareness, mental models, and team processes in breathing apparatus rescues

Abstract

The current study aimed at investigating the concepts of team situation awareness, mental models, and team processes in relation to performance in the complex, dynamic environment of breathing apparatus rescues. Data was collected during exercises at Ågesta training center through questionnaires and after action reviews. 28 firemen and 5 instructors participated in the exercises. Also, a stimulated recall interview was conducted with 2 of the firemen that had participated in one of the exercises. The different data collection methods all indicated that well-developed mental models or a high degree of pre-task knowledge affected performance in a positive way. Moreover, a multiple regression analysis showed that both pre-task knowledge and team processes significantly can predict performance. The results of the analysis of team situation awareness in relation to performance were fairly ambiguous. Therefore, further research is needed to establish the relation between these concepts in the domain at matter.

Keywords

BA rescue, team situation awareness, mental models, team processes, performance, dynamic environment

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Prestation i rökdykarteam – studie av situationsmedvetenhet, mentala modeller och processer inom team vid rökdykning

Sammanfattning

Syftet med studien var att undersöka hur situationsmedvetenhet i team, mentala modeller och teamprocesser relaterar till prestation i en komplex och dynamisk miljö som den vid rökdykning. Data samlades in under övningar vid Ågesta övningsanläggning via enkäter och under så kallade ”after action reviews”. 28 brandmän och 5 instruktörer deltog i övningarna. En vecka efter datainsamlingen vid Ågesta genomfördes även en ”stimulated recall”-intervju med 2 brandmän som deltagit i en av övningarna. De olika metoderna för datainsamling gav alla resultat som antyder att välutvecklade mentala modeller eller en hög grad av ”pre-task knowledge” påverkar prestationen i en positiv riktning. En multipel regressionsanalys visade att både ”pre-task knowledge” och teamprocesser signifikant predicerade prestation. Resultaten gällande hur situationsmedvetenhet i team relaterar till prestation var ej entydiga. Vidare forskning kring relationen mellan dessa begrepp i den aktuella domänen är därför av intresse.

Nyckelord

rökdykning, situationsmedvetenhet, mentala modeller, team-processer, prestation, dynamisk miljö

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Definitions of nomenclature

Most of the translations used in the report can be found in the *Command and control glossary*. This is developed by James Butler at the Swedish Rescue Services Agency – SRSA (Räddningsverket), and can be downloaded as a pdf-document from: http://www.srv.se/upload/In%20English/glossary.pdf (available 2004-10-22)

However, some terms did not have an English equivalent, in which cases I defined my own translations. The terms used in this report are presented below.

BA = breathing apparatus = andningsapparat
BA firefighter = rökdykare
BA pair = rökdykarpar
BA team = rökdykargrupp
BA rescue = rökdykning
BA leader = rökdykarledare
BA communication set = rökdykarradio
BA operations channel = rökdykarkanal
BA controller = rökdykarkontrollant
Incident commander = räddningsledare (vid skadeplats)
Pump operator = pumpskötare
Base point = baspunkt
Reinforced base point = förstärkt baspunkt
Attack route = angreppsväg
Forward control point = brytpunkt
Incident site = skadeplats
Reference room = referensrum
Points of reference = referenspunkter
Line of retreat = reträttväg
Fire chief = brandmästare
Branchpipe = strålrör

Worth mentioning is that in the British fire service there is no specific word for "rökdykare". However, all use of the terms mentioned above refers to the function and role that exist in the Swedish organization of rescue service.

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1 BA Rescue Team Performance – exploring team situation awareness, mental models and team processes in breathing apparatus rescues

Today, teams are used for accomplishing job tasks in a variety of domains. One reason is that teams are able to tackle goals beyond the reach of individuals. Therefore, it is of great interest to investigate what factors are crucial to efficient teamwork and why certain teams are more successful than others.

During breathing apparatus (BA) rescues, firemen are putting their own safety in risk with the purpose of saving lives and extinguishing fires. The time pressure is obvious, and the constantly changing environment often requires quick decisions of the members of the BA team, of both formal and informal type. While the incident commander has to plan ahead regarding for example crew resources needed, the BA pair inside the building among other things decides about which search technique that is suitable for the current object.

To be able to make correct decisions and thereby facilitate performance, information has to be shared within the team in an adequate way. Above this, the fact that the team members are working in different physical locations puts further demands on a functioning communication, making the members jointly aware of the current mission objective and developing a shared understanding of the situation. Information about smoke characteristics and heat from the BA pair can in combination with the cues observable from the outside environment facilitate for the BA leader to notice whether an explosion of smoke gases is about to occur, which is a severe risk for the BA firefighters being inside the building.

Thus, the team's shared understanding of the situation and team processes like communication and coordination can seriously affect both performance outcome and safety for all people involved during rescues. Therefore, this study aims at investigating how information and knowledge, both at individual level and shared across the team, can affect team behavior and goal accomplishment in the domain of fire fighting.

1.1 Description of domain

According to Arbetarskyddsstyrelsens Författningssamling (AFS) 1995:1 2 §, BA rescues are defined as: "Entering dense fire smoke, usually indoor, with purpose of saving lives or fighting fire or other similar activities." (author's translation).

Normally, the smallest unit allowed for BA rescues consists of incident commander, BA team (i.e. BA leader and BA pair), and a pump operator (AFS, 1995:1). The incident commander has to make sure that the risks the BA pair may be exposed to are reasonable considering what the rescue can accomplish, while the pump operator is responsible for establishing a safe access to water.

The organization allows for some level of job rotation. A fireman can one day be a BA firefighter and the next day a pump operator. However, the roles of BA leader and incident commander have further requirements regarding occupational experience and education (Fogel et al., 2004).

The equipment of BA firefighters consists of alarm clothing in accordance with AFS 1995:1, compressed-air apparatus, mask with safety pressure, BA communication set, lifeline or aired hose line, and hand lamp (Region Stockholm, n.d.). The equipment can be seen in Figure 1.

Figure 1. Examples of BA firefighters wearing equipment.

During rescue, the BA leader is located at the base point. Information regarding where the base point is located is given to the BA pair through the BASS – Swedish, short for: Baspunkt, Angreppsväg, Syfte, Särskilda risker, in English: base point, attack route, purpose, particular risks. The BA leader gives the BASS to the BA pair at the beginning of the rescue, while checking that the equipment and clothes of the BA firefighters are in order (Fogel et al., 2004). As mentioned above, the BASS also contains information regarding where the BA firefighters enter the building, the purpose of the rescue (to save lives if people are left in the building, or e.g. to stop the fire from spreading to other buildings), and if there are any particular risks associated with the rescue (e.g. if any explosive materials are in the building).

If needed, the base point can be reinforced with another BA pair. It is the responsibility of the incident commander to establish the reinforced base point. The new BA pair should as quickly as possible make their way to the base point from the forward control point, to assist the BA leader with tasks as rescuing the BA pair if needed, be available if the active BA pair encounters any trouble with the equipment, and so forth. By staying at the base point, relieving at the branchpipe is also facilitated (Region Stockholm, n.d.).

When the BA pair enters the building, they create a reference room. This is generally the first room the BA pair step into, since it gives the BA firefighters a secure starting point that they can return to if they get disoriented. For security reasons, both of the BA firefighters shall agree that the certain room is their reference room before they continue their work. The reference room shall also be reported to the BA leader and be searched through (establishing number of doors and getting an image of the building and adjacent rooms) before the search continues (P Rytterlund, fire chief, personal communication, May 26th, 2004).

While performing their search, the BA firefighters should inform each other about so-called points of reference. The reason for this is to facilitate the BA firefighters' perception of the building and to establish a safe line of retreat. It is preferable that these points of reference are

more or less fixed objects (e.g. large furniture, refrigerators), since the hose often moves other objects during search.

According to 10 § (AFS, 1995:1), firefighters engaged in BA rescues shall have gone through theoretical and practical education for the work. The skills shall be maintained by at least four exercises a year, of which two with added heating. In order to count as an exercise with added heating, the temperature should be 50 degrees Celsius or above (Avdelningsmeddelande, 2002-02-14).

BA rescues are risky situations for the people performing the work. Moreover, the risks are of very shifting kinds and often hard to estimate. Among other things the firefighters are exposed to risks such as explosions and collapsing parts of the building and other objects, but also the risk of falling down when sight is reduced or non-existing (AFS, 1995:1). The use of plastics in building materials and furniture has also increased the level of danger in that it increases the intensity of the smoke and the amount of injurious substances in the smoke. Moreover, the employees are often exposed to extreme heat while performing a physically very demanding job, wearing equipment weighing approximately 25 kilos.

Considering the risky environment BA rescues are performed in, it is of greatest importance that the BA firefighters have self-knowledge of their own capacity and are keeping an eye on how the other member of the pair is feeling. When BA firefighters get tired (getting low blood pressure caused by loss of fluids) they can experience difficulties in maintaining awareness of the situation and orientation, which stresses the importance of starting the retreat in time (Ragell, n.d.).

Finally, it is worth mentioning that the organization of the fire department falls under the responsibility of respective municipality, why the regulations in certain municipalities can be stricter than the regulations of the AFS.

2 Theory

This section will begin with a description of characteristics of teams and teamwork and then continues with discussing how knowledge and information is processed within a team, by handling the concepts of mental models and situation awareness (SA). Finally, there will be an overview of some processes that occur within a team (coordination, adaptability, and communication), and of team performance and how it is measured.

2.1 Teamwork

Teamwork can be seen as the behaviors carried out by two or more individuals as a function of coordinating their needs. The needs are determined by interdependent tasks that are executed to achieve a common goal (Brannick, Prince, Prince, & Salas, 1995). Thus, characteristic of a team is the requirement for interaction and task interdependency among team members (Stout, Cannon-Bowers, & Salas, 1996).

Further, a team can be defined as “a distinguishable set of two or more people who interact, dynamically, interdependently, and adaptively toward a common and valued goal/objective/mission, who have each been assigned specific roles or functions to perform, and who have a limited life-span of membership” (Salas, Dickinson, Converse, & Tannenbaum, 1992, p. 4).

In order to understand how a team works, it is most important to define the elements of knowledge that has to be shared by the members of the team, as a guide towards performance as well as the team's ability to create a shared picture of the operation during performance (Blickensderfer, Cannon-Bowers, Salas, & Baker, 2000).

Team knowledge is the foundation of certain skills in the team. Members with team knowledge know what to do and when to do it, how to compensate for other members in the team, what information to provide to their teammates, and are able to accomplish their duties without further prompting by other members.

There are also different ways of organizing teams. In a divisional team structure, each work unit possesses the skills or resources required to complete a product or a task and thus can work relatively autonomously. In contrast, a functional team structure focuses each work unit on one type of skill or resource, which leads to a greater need for coordination between units (MacMillan, Entin, & Serfaty, 2002).

Different models of team functioning has one framework in common: the input-process-outcome (IPO) framework. Inputs are pre-existing conditions to a performance and may include characteristics of the members, team, and organization. Processes are the transformation of inputs into outputs done by the team, and the outcomes are results and other by-products that are achieved through activities of the team and valued by one or more constituencies (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000).

Moreover, many teams are accomplishing their tasks in dynamic environments, under stressful conditions and limited access to information. While performing in dynamic environments, this continually changing and dynamic nature of the situation cannot be overemphasized. The team must ongoing assess and reassess the current situation in relation to the mission goal (Stout et al., 1996).

Earlier research has shown different behaviors of effective and ineffective teams (e.g. Endsley & Jones, 2001; MacMillan et al., 2002). For example, in ineffective teams members did not share relevant information with each other, if one member provided incorrect information it affected the team in a negative way, and ineffective teams had difficulties to prioritize among goals and sub-goals. On the other hand, the effective teams showed ability to check their own actions in relation to the group during performance, they tried hard to coordinate the information within the team, had an ability to prioritize goals and sub-goals and to make contingency plans, and also had an open and questioning norm within the group. One other basic notion is that in effective teams, team members monitor each other and offer help.

2.2 Mental models

According to Mathieu et al. (2000), the three crucial purposes of mental models are to help people describe, explain and predict events in their environment. Mental models can be defined as organized knowledge structures which also serve to recognize relationships between objects in the environment, thereby making it possible to construct expectations of what is likely to occur next.

A well-developed mental model for a certain domain or a certain system provides the individual with the dynamic of guiding attention toward critical cues, expectations concerning

future states of the environment, and a direct link between the classification of the situation and typical actions (Endsley, 1995).

Rouse et al. (1992) assumed that the explaining and predicting qualities of the mental models are central elements for team coordination, communication, and performance. In other words, if the members of the team know what to expect and can explain what they are observing, this will most likely enhance performance. The authors also concluded that mental models are able to give a principled explanation of how the team performs, and a basis for enhancing performance.

The construct of mental models is also included in what Blickensderfer et al. (2000) term *pre-task team knowledge*. This knowledge is the degree to which the members of the team arrive at the scene with compatible knowledge and mental models. It contains knowledge about the overall goal of the mission and the team, roles and responsibilities of the different members, knowledge about equipment, the personal traits and characteristics of other teammates, and what kinds of team behaviors that are acceptable.

In general, knowledge about the procedures, sequences, and timing allows for the team to expect or predict what is going to happen next and thereby what their next action should be. Knowledge about procedures and the interaction patterns within the team can help the individual member to predict when other members are in need of information, help, and when something has gone wrong. Above these expectations the understanding of procedures can help the individual to explain why things happen.

Another classification of knowledge within a team is to use the concept of shared mental models. The function of shared mental models is to make it possible for team members to draw on their own knowledge in selecting actions that are consistent and coordinated with their teammates. In environments where overt strategizing is limited (e.g. because of high workload or time pressure), these shared mental models become even more crucial because they help the team members to predict and anticipate the information and resource requirements of other members of the team (Stout et al., 1996).

Stout et al. (1996) also distinguish between three types of shared mental model knowledge: declarative, procedural, and strategic. The shared declarative knowledge enables the team members to create a compatible understanding both of the overall task or mission and of member roles and activities needed to meet task or mission demands. Shared procedural knowledge helps the team members to understand the general sequence of task activities necessary to perform efficiently. Shared strategic knowledge is the most important type of knowledge for effective performance in dynamic environments, and builds on the other types of shared mental model knowledge. Team members who have pre-existing, shared strategic knowledge are able to perform effectively by compatible interpretations of cues/action sequences, the significance of cue patterns, resources of the team and their capabilities, and suitable task strategies.

Moreover, the shared mental models can be divided into two major content domains: task mental models (concerning equipment, technology, and job models) and team mental models (e.g. concerning interaction among team members). Relating this to the pre-task knowledge mentioned by Blickensderfer et al. (2000), the team mental models would respond to the knowledge of personal traits and acceptable team behavior, and the task mental models to the equipment and roles of the team members.

Also, highly similar mental models are expected to allow team members to be more "in sync", to easily coordinate their actions because of the shared objectives and visions of how the team is to function. There is an indication that both task and team mental models have unique effects on subsequent team processes. These processes are in turn significantly related to team performance (Stout et al., 1996).

2.3 Situation awareness

Earlier research has primarily focused on the situation awareness of the individual. The situation awareness (SA) of an operator is a crucial construct that affects decision-making and performance. SA involves more than just the awareness of multiple pieces of data. It requires a more advanced level of comprehension of the situation and an ability to predict future states in the system and relate these to the goals of the operator (Endsley, 1995).

In complex systems the environment is constantly changing, which means that a great deal of the operator's time is required to create and maintain a good SA. To more specifically define SA, it can be described in the following terms: "Situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." (Endsley, 1995, p.36).

Endsley (1995) thereby suggests that SA works on three levels: 1) *perception* – the states, attributes and dynamics of relevant elements in the environment are perceived, 2) *comprehension* – based on the elements in level 1, in particular when they are put together to make a pattern, this is where the operator is making a holistic picture of the environment and a comprehension of the significance of objects and events, and 3) *projection* – this is achieved by knowledge about the status and dynamics of the elements in the environment and by a comprehension of the situation.

Several human information-processing stages are important in achieving SA; the short-term sensory store, attention, perception, working memory and long-term memory. Because of the rapidly decaying nature of the short-term sensory store, only the cues that are most perceptually salient will be paid attention and thereby reach conscious awareness. The cues will once perceived be interpreted by the long-term memory, given that there is enough capacity available in working memory. If needed, the cues will then be acted upon (Salas, Cannon-Bowers, Fiore, & Stout, 2001).

When looking at situation awareness in teams, each member must have SA for all requirements or become the weakest chain of the link (Endsley, 1995). Team situation awareness (team SA) requires both a high SA for those aspects in the situation that are needed for the job (i.e. individual SA), and that a shared SA is developed among the members of the team, which will provide the team with a common (and correct) picture of aspects in the situation (Endsley & Jones, 2001).

According to Salas et al. (2001), team SA builds upon the combination of the degree of shared understanding within the team (shared mental models) and the degree of each individual's SA (which is based on already existing knowledge bases and cue/pattern assessments).

Stout et al. (1996) propose that implications of work on team SA include: 1) that existing mental models affect and shape the situation awareness of the individual, 2) shared mental

models seem crucial to team performance by allowing team members to form appropriate explanations and expectations of task and team actions, and 3) that team situation awareness enhances team performance.

Team situation awareness can be defined as a dynamically changing state, which is affected by the cue and pattern assessments of the individuals and team process behaviors. The state at any given point in time is influenced by the situational context, environmental factors, and temporal factors. Moreover, the present level of situation awareness of each team member and the level of shared understanding among team members influence the team SA.

Team SA involves the team's judgment (i.e. the perception, comprehension, and projection) of the current situation, which include the environment (also equipment and system), the task and the team itself (Cooke, Stout, & Salas, 2001).

The multiple cognitive structures and processes that are integrated in team SA makes it complex. Situation models at individual level and shared mental models can be seen as precursor products to team SA in that they are cognitive structures the member's of the team bring to the task of interpreting the situation.

Cooke et al. (2001) distinguish in their framework, both at an individual and a team level, between the *understanding* of a certain moment that is captured in the situation model, and the durable *knowledge* that is the foundation of the understanding and are represented in the mental models.

The members of the team are integrating their own individual situation models and shared mental models by *team process behaviors*, which include behaviors such as communication, coordination, planning, and leadership. Communication enables the information in the individual situation models to be shared across the team and to be integrated in the situation model of the team.

During performance, the members of the team has to monitor several variables, e.g. how the plan is proceeding to see if problems have occurred, but also each other in the team to discover physical and/or mental fatigue, too high workload, and so forth. (Klein, 2001).

Blickensderfer et al. (2000) also points out a kind of team SA in terms of their definition of *dynamic team knowledge*, which is knowledge developed during task performance. Dynamic understanding is the degree to which the members of the team develop compatible assessments of cues and patterns in the situation, how these will affect the team and the task, how the work of the team is proceeding, and particular actions that certain members need to take. Moreover, this dynamic understanding is combining the knowledge before performance with cognizance of the characteristics of the current situation.

However, it is not desirable for team members to have entirely overlapping knowledge, instead the critical point is that each team member has sufficient understanding of their team-mates' tasks. While some sort of information must be explicitly shared across the team, other information, if shared, may only be distracting and affect the SA of the individuals negatively (Salas et al., 2001).

Relating to the types of mental model knowledge mentioned before, shared declarative and procedural knowledge are necessary but not sufficient components in creating team SA. What

is crucial is the application of this knowledge in dynamic environments (i.e. strategic knowledge). The strategic knowledge can ensure the use of and a continuous updating of cues in the environment, facilitating the situation assessment process, which enables high levels of team SA.

This strategic knowledge, in form of shared mental models, can give an explanation for how team SA is created and enhanced while performing under conditions where communication is severely restricted. Endsley and Jones (2001) also mentioned the importance of shared mental models because they enable the team to create a shared SA at higher levels without the need for extra spoken communication.

2.4 Team processes

Klein (2001, p.70) defines coordination as "the attempt by *multiple entities to act in concert* in order to achieve a *common goal* by carrying out a *script/plan* they all understand". Acting in concert means that the sequence of tasks is arranged in order to improve efficiency and to arrange timing. He also points out the distinction between coordination and adaptability, where coordination is when the team is carrying out well-trained procedures and adaptability is the team's ability to adjust to unexpected demands. Therefore, adaptability requires more energy than coordination. Results in a study by Stout, Salas, and Carson (1994) indicated that team coordination was significantly related to the team's mission performance beyond individual skill level.

When a team has a low ability to coordinate they have to rely on a sequential performance of the tasks. The ability to coordinate develops as a function of skill. The team then is capable of overlapping several of the different member's activities. However, this more skilled coordination is more vulnerable than the slower, more robust type of coordination that is typical for a low ability to coordinate (Klein, 2001).

The fewer routines a team has got, the more time is needed for planning. Through practice, a team's coordination is enhanced in several ways. By the use of more standardized and automatic scripts, the team's workload will be reduced since it will be easier to predict what is going to happen next. This in turn makes it easier to discover deviations from the plan and the team thereby has more time available to adapt. The shared expectations that emerge in an experienced team bring that the need for communication decreases, which further reduces workload.

The adaptability of a team improves the higher the ability to coordinate. This happens because the team then has safe routines to develop adjustments from. The better a team is at adapting, the stronger the coordination will get, since it takes the team less effort to recover from problems that has occurred.

If a team is to effectively achieve its common goals, the team must have shared information about both the situation and the other team members. To build and maintain this shared awareness the team cognition requires communication. It is also suggested that efficient communication is the basis for both effective team cognition and performance. However, this efficiency can be achieved by multiple means, including the use of an organizational structure that reduces communication workload as well as collaborative pre-planning activities that may reduce the amount of communication needed or make communication more efficient by increasing mutual awareness and shared mental models (MacMillan et al., 2002).

According to a study conducted by Rouse et al. (1992), shared expectations in a team affect communication. Without correct expectations (which is linked to the shared mental models of the team members), the members of the team could not communicate, alternatively they communicated in an erroneous or ambiguous way.

2.5 Team performance

Generally speaking, it is easier to collect broad outcome measures of a team's performance. It is also possible, to some extent, to evaluate an individual's task performance if the tasks within the team are sufficiently delineated (Brannick & Prince, 1997).

As mentioned earlier, different models of team performance tend to categorize team functioning as consisting of inputs (e.g. training, equipment, type of task), throughput (e.g. team processes), and output or team product. These models also agree that teams must be considered on three levels of analysis: individual, team, and organizational. MacMillan et al. (2002) present a theoretical framework linking the organizational structure of a team to the team's performance. This is done by looking at factors like the team's need for coordination, the need for communication, the extent to which the team's mission can be pre-planned, and the team's mutual awareness of each other's tasks.

Another approach to team performance is looking at the team as concurrently engaging in two major activities: *taskwork* and *teamwork*. The taskwork activities include the team member's interactions with tool, machines, and systems. These activities have traditionally been associated with individual task performance, but in the team setting, it is assumed that the members of the team must co-operate and work jointly in order to accomplish the tasks assigned to the team. The other type of activity, teamwork, refers to the interpersonal interactions among individuals in the team that are necessary for exchanging information, developing and maintaining communication patterns, maintaining social order, coordinating actions etc. (Bowers, Braun, & Morgan, 1997).

An issue in measuring team performance concerns process versus outcome. Often, the performances of teams are valued for their outcomes (e.g. whether the football team won the game or not, if the surgical team managed to save the patient). What is important to recognize, is that outcome measures often contain variance attributable to factors other than teamwork. Therefore, a truer picture of team functioning can be obtained by team process measures. These may provide insight in problems encountered by the team and the means to fix them. However, Brannick and Prince (1997) mean that a comprehensive measure of team performance needs to consider elements of both process and outcome. Brannick et al. (1995) also argue that team process variables may be a more sensitive tool in measuring effects of training, selection, or task design than team outcome.

Rouse et al. (1992) investigated the relationship between shared mental models and team performance and argue that earlier research has shown a number of team-related phenomena that often can be linked to incidents. Three of these typical problems were 1) lack of clearly and appropriately defined roles, 2) lack of explicit coordination, and 3) difficulties in communication.

2.6 Theory summary

To sum up, the efficiency of teams performing in complex systems to a great deal depend on the ability of the team members to coordinate actions, integrate information and resources, and adapt to changing task demands (Rouse, Cannon-Bowers, & Salas, 1992). The durable knowledge of mental models are both facilitating team processes such as communication and coordination and a crucial basis in creating team SA, which in turn is developed by means of team processes. Thereby, these three constructs are all important in investigating the performance outcome of teams.

3 Purpose and goal

The study can be seen as divided in two parts. One part investigates questions regarding how team SA and shared mental models are related to performance outcome, referring to earlier research described in the theory section. The second part has a more explorative approach, investigating what factors contribute to successful performance in the current domain.

The goal is to find what factors and/or types of knowledge that affect performance and give suggestions how this in different ways can be achieved and maintained.

3.1 Questions

- Is any level of team SA of particular importance in achieving successful performance?
- Are the amount of pre-task knowledge and/or the level of shared mental models of importance in performing well?

3.2 Explorative approach

- What factors are contributing to successful performance?
- Could a rescue be divided into stages, which in different ways affect performance?

4 Method

The following section describes in detail how the data was collected in the current study.

Data was collected by recording communication during exercises, recording and taking notes during interviews and by questionnaires. The purpose of recording the communication during exercises was to investigate how information was provided and shared across the team.

4.1 Participants

28 firemen participated in the study. The age ranged from 27 to 58 years (M = 40.7, SD = 8.95) and all of the firemen were male. The participants were not randomly selected – in general, the firemen participating in the exercises during one day belonged to the same shift and fire department (a few exceptions existed in some of the exercises where firemen from another shift at the same fire department participated). However, there was no deliberate selection of specific fire departments that were to be observed before conducting the study. The occupational experience among the firemen ranged from 2 to 34 years (M = 15.1, SD = 9.48). The questionnaire answers of one BA leader strongly diverged from the rest of the

participants, why he was considered an outliner and hence excluded from the analysis, see below in section 4.5.5.

The participants received information of the study through a document that was sent to the fire departments. In this document a presentation of the study was given, along when and how it was going to be performed. Further information was given when the firemen arrived at Ågesta training center, where the participants were showed the equipment and informed about confidentiality.

4.2 Instructors

Five different firemen participated as instructors in the exercises. The purpose of the instructors was to monitor the progress and performance of the firefighters. One instructor also "played" different roles taking part in the exercise scenario. The age of these firemen ranged from 28 to 46 years (M = 36.8, SD = 8.17) and the occupational experience was 6 to 21 years (M = 11.2, SD = 6.61). Their experience as instructors was approximately three months.

4.3 Apparatus

The throat microphones (see Figure 2) used for recording the entire communication of the BA firefighters were especially built for the current study by Aketoma AB in Stockholm and were used in combination with Jens of Sweden MP-300 (256 MB) MP3-players. The radio communication was recorded digitally onto a laptop.

Figure 2. Throat microphone.

The after-action review and the stimulated recall interview were recorded with an external microphone and an iRiver iHP-120 MP3-player.

During the exercises a FinePix S602 digital camera and a Sony Digital HandyCam video camera (Sony DCR-TRV 330E) were used for documentation.

4.4 Material

Four different types of questionnaires were developed with basis in the FOI PPS (Pilot Performance Scale) (Castor, Nählinder, & Lindström, 2003; Castor et al., 2003). Questions and formulations were adjusted to the present domain and the different versions were designed for the BA firefighters, for the BA leader, for the instructors observing the BA firefighters, and for the instructor of the BA leader, respectively. Several questions were similar across the questionnaires, although there also were questions specific to the task of the BA fire fighter and BA leader. For example, only the BA firefighters received questions to measure adaptability, since it was assumed that it is primarily these members of the team that have to adjust to one another when working tightly together. The questionnaires aimed at establishing the team situation awareness (perception, comprehension and projection levels), the quality and level of pre-task knowledge, team processes (communication, coordination, and adaptability) and performance in general by means of subjective ratings of the firemen and the instructors.

In this study, the construct of team SA was defined as the degree to which the firemen had perceived and viewed the situation in the same way. This brought that the team SA questions aimed at capturing the degree of discrepancies in how the team perceived the situation.

The ratings ranged from 1 to 7. Regarding the team SA items, where the answers within the team were compared, a low discrepancy value would indicate a high degree of team SA. The remaining concepts that were to be measured in the questionnaires were measured in absolute values, where a team scoring a 6 as mean index on coordination was interpreted as coordinating well.

The use of subjective ratings has been criticized because the operators themselves cannot be aware of their own lack of SA. However, it can be argued that if not the true SA is being measured, it is at least an indication of the operator's confidence of his or hers own SA. Concerning the observer ratings, it has been argued that observers have limited access and knowledge about the operator's concept of the situation. On the other hand, an observer typically has more information than an operator about what is happening in a given simulation, that is, a more complete knowledge of reality (Jones, 2000). In this study, it was not able to disrupt the ongoing exercise to get immediate measures of the team SA, which made it natural to use the method of subjective ratings instead.

The questionnaires can be found in appendix A, B, C, and D.

4.5 Procedure

Before the data collection was conducted, the sound quality of the throat microphones was tested. This was done at the fire department in Linköping. Two firemen wearing full BA equipment tested the microphones during physical activity.

Moreover, the formulations of the questionnaire questions were checked by three firemen at the fire department in Linköping and a fire chief at Ågesta to ensure that the questions were functional.

4.5.1 Description of exercise

The data was collected at Ågesta training center. According to the regulations of AFS 1995:1 regarding exercises, a fireman has to perform four exercises a year (of which two with added heating). In general, firemen employed in the community of Stockholm visit Ågesta twice a year for different types of exercises. The type of exercise observed in the current study was performed in a climate construction, which provides exercises with added heating, achieved by steam generators. The temperature inside the building during the exercise reached 75 degrees Celsius, and there was an atmospheric humidity of 75%.

The exercise took place on two floors of the building (the first BA pair started on the upper floor) and the size of the building was 75 m^2/floor. The walls in the building are changeable and furniture is moved so that the appearance of the building will change between the occasions the firemen visit Ågesta for exercises. The two floors were connected through a ladder. An approximate map of the building is available in appendix E.

The purpose of the exercise was to practice search technique and communication. Therefore, there was no fire or smoke used in the exercise. Inside the building, the walls were painted black and the flashlights of the BA fire fighters were covered with red tape to reduce sight. The hoses contained no water (since there was no fire), instead they were filled with air and foam for a natural appearance. Also, four "people" (see Figure 3) were placed at different locations in the building.

Figure 3. Example of dolls used as "people" in the exercise.

Within each exercise, five firemen (two BA pairs and one BA leader) and four instructors participated. Two of the instructors were observing the BA firefighters (one for each pair) inside the building and the other two instructors were observing the exercise from outside the building. One of the instructors observing from outside was primarily engaged in observing the BA leader and also played the roles of incident commander and BA controller.
At the beginning of the exercise, the BA team was informed of fire in a concrete building containing "mixed activity" (i.e. both business activity and apartments). They were also told that another unit already had arrived at the incident site, and was working in another part of the building.

During the exercise, the instructor who played the role of the incident commander provided the BA leader with ongoing information. This contained information about another BA pair available at forward control point (when the BA leader decides to, this pair will reinforce base

point), passing on information from civilians (in this exercise, a caretaker), giving information about more than one floor and about people in the building.

At some point in the exercise, a second BA pair would join the operation. Depending on the tactics and decisions of the BA leader, the two BA pairs could meet either inside or outside the building. After the first BA pair had completed their BA rescue, they gave additional information to the BA leader at the base point outside the building, for example to help guide the second BA pair and reporting which areas or rooms were searched through.

Communication between BA firefighters, BA leader, BA controller, and incident commander took place on the BA operations channel, while the instructors used a separate channel for talking to each other and commenting on the exercise.

4.5.2 Observation

A total number of six exercises were observed (two exercises a day for three days). The complete communication of the BA firefighters were recorded by throat microphones, which were attached to the firemen before they put on their equipment. The four BA firefighters then were asked to jointly count down from three to one, to create a reference point from where it would be possible to synchronize the sound files.

During the exercise, one experiment leader stayed in a cabin with the instructor observing the BA leader while taking notes and listening to the radio communication on both channels. The other experiment leader stayed outside taking pictures and handing out the questionnaires. A researcher from FOI did the video recording of the BA leader.

4.5.3 Questionnaires

Immediately after completed BA rescue, the BA firefighters, the BA leader and the instructors received a questionnaire. The participants were prompted not to cooperate or discuss the questions with each other. To answer the questionnaires, the firemen were placed in a small building beside the climate construction.

4.5.4 After action review

After the exercises the firemen and instructors gathered for a meeting, similar to what in the military domain is known as *after action reviews* (AAR's), where experienced officers provide feedback and analysis on how the team has performed (Mathieu et al., 2000).

The two BA pairs each made a drawing of how they had perceived the building (rooms, doors, furniture etc.). The instructors then guided the BA team through the course of events, asking questions where appropriate (e.g. about decisions made), and giving feedback of both good and less good actions/behavior. During the meetings notes were taken and the conversation was recorded.

4.5.5 Instructor meeting

One week after the data collection was conducted, an additional meeting took place at Ågesta. The purpose of this meeting was to give some initial feedback regarding the firemen's opinion of the exercise (e.g. the difficulty of the exercise and how much they thought they had learned

from it), and also to validate the findings. This was done by means of descriptive statistics from the questionnaires.

During this meeting computer-drawn maps of the building were validated by the instructors.

Moreover, the instructors confirmed that the answers of the outliner described in section 4.1, most likely depended on that this participant had not taken the exercise or the questionnaire seriously, which further supported the decision to exclude this participant.

4.5.6 Stimulated recall and interview

Among the six exercises that were observed, one was selected for a stimulated recall interview. The method implies that the subject is recorded (by video or tape) while performing work, and shortly afterwards is confronted to the material with the possibility to comment upon it (Haglund, 2003). This method was chosen because of its advantages to take the interviewee back to the course of events and thereby make it easier for the subject to remember details about how he or she was thinking and reasoning at that moment (Alexandersson, 1994).

The purpose of this interview was to gain more insight in how the BA team had been thinking and reasoning during the exercise. It aimed at capturing the degree of which information was shared across the team members and how this affected actions taken and team SA, respectively.

Nine days after the exercise, the interview took place at the station where the selected firemen work. Unfortunately, only two of the five firemen originally participating in the exercise were able to attend the interview (due to working other shifts and occasionally serving at other stations). Of the two firemen participating in the interview, one had been in the first BA pair and the other in the second.

An edited file mixing the throat microphone recordings with the radio communication of the BA leader was played to the firemen to help them remember the course of events. Occasionally, the playback was stopped, and the firemen were asked questions or asked to explain the situation (e.g. “Where is your partner now?”, “What is your partner doing now?”, “What made you choose that course of action?”).

During this interview, the firemen also were asked to draw a map of how they perceived the building and use this to explain where they and their partners in the BA pair were located at different points in time.

Due to technical problems, most of the communication in the file of the second BA pair was unsynchronized, and therefore was omitted from the interview.

After performing the stimulated recall, the interview continued as semi-structured.

5 Results and discussion

This section starts with a description of the scoring procedure of the different data collection methods. Then follows analysis and results of each of the research questions in this study, presented and organized by the method or methods used for the question at hand.

5.1 Scoring

Both quantitative and qualitative methods were used to collect data, and below is a description of how the different methods were scored and analyzed.

5.1.1 Questionnaires

Participants were grouped into two types of units: pairs and teams (the team unit consisting of BA pair and BA leader), resulting in 12 pair units and 10 team units.

Pairs and teams were analyzed separately. In cases where data for analyses were missing (e.g. unanswered questions), these cases were excluded from the current analysis.

Indices of team SA were scored both on the three levels (perception, comprehension, and projection, below referred to as Level 1, Level 2, and Level 3) and in one general index. The scoring consisted of computing the discrepancy of the participants' answers on the items and then dividing the total discrepancy with the number of comparisons in the unit to obtain a "mean discrepancy". The pair analysis considered all three levels of Team SA, but the team analysis only considered Level 2 and 3, since the answering frequency of the BA leaders was too low on the items for Level 1 to be part of the computations. The discrepancies ranged between 0 and 2 for pairs on Level 1, 0 and 3.67 for pairs and 0.22 and 2.89 for teams on Level 2, and 0.5 and 2.75 for pairs and 1 and 2.17 for teams on Level 3.

Indices of pre-task knowledge, performance, and team processes were scored by taking absolute values of the answers in the unit and computing a mean index, ranging between 1 and 7 (a mean index of 6 would signify well-functioning coordination or a high degree of pre-task knowledge within the unit).

For all types of indices, the reason for computing mean values was to enable comparison between the indices, since they contained varying number of items.

Table 1 shows the descriptive statistics of the indices.

It is also important to stress, that in the following analyses and discussion, the concept of pre-task knowledge is used in a wider way than described by Blickensderfer et al. (2000). The following use of the term pre-task knowledge refers to the total degree of knowledge within the team, while the concept of shared mental models more strictly refers to the compatible knowledge of the team members.

Table 1 *Descriptive statistics of pair and team indices used in the analyses*

		Pair			Team	
Index Type	n	M	SD	N	M	SD
Performance	11	4.95	1.22	7	4.67	1.15
Team SA						
General	12	1.17	0.36	10	1.44	0.35
Level 1	12	0.79	0.68			
Level 2	12	0.93	1.02	10	1.33	0.80
Level 3	12	1.79	0.83	10	1.68	0.35
Pre-task knowledge	11	5.09	1.15	7	5.07	1.23
Coordination	11	5.12	1.13	9	4.92	0.79
Communication	11	5.35	0.79	9	5.00	0.46
Adaptability	11	5.30	1.09			

In order to receive an indication of how well the firefighter's estimates of performance were in agreement with the more objective rating of the instructors, the correlation between the instructor's and firefighter's estimates were computed on the item: "How well did the BA pair accomplish its tasks?". Since the instructors made one estimate per pair, each instructor value was used twice to refer to the two firefighters in the pair, respectively. The results showed a moderate positive correlation between instructors and BA firefighters (Pearson $r = .67$, $p < .05$).

5.1.2 After action review

The purpose of this analysis was to achieve a deeper understanding of what is considered to contribute to higher and lower performance, respectively. It also aimed at capturing the way the firefighters themselves talk about information and knowledge in the team, and team processes. Thus, the recorded material was analyzed using a qualitative approach.

In qualitative analysis, data reduction can be made by coding, clustering, and identifying themes (Lyons, 2000). Therefore, the first stage in the analysis of the after action reviews consisted of writing down the occurrences of positive and negative comments of the instructors for each exercise. The reason for this was to capture desirable (but also inappropriate) behaviors and actions, which implicitly was presumed to gain insight in factors affecting performance.

The next step of the analysis aimed at clustering the amount of comments into different kinds of categories, which contained both positive and negative examples of the behavior/action associated with the category. Finally, the behaviors and actions in the categories were connected to the different theory constructs of interest in this report.

The categories established were: 1) search technique/tactics, 2) orientation/references, 3) communication/information, 4) relieving/reinforced base point, and 5) awareness of status of other team members.

Some of the categories only contained information about for example team SA, why the results will not present all of the categories below each research question.

5.1.3 Stimulated recall and interview

The recorded material and notes taken during this interview were analyzed in relation to the constructs of interest in the current study. The analysis therefore builds on an extraction of the participants' statements.

5.2 Is any level of team SA of particular importance in achieving successful performance?

All of the above mentioned methods were used in investigating the team SA construct and below follows the results of each method, respectively. However, it is only the questionnaires that in depth investigate the difference between the levels of team SA, while the qualitative measures treat the concept of team SA as a whole.

5.2.1 Questionnaires

The team SA question was analyzed by conducting a 2 x 3 Performance (Higher/Lower) x Team SA (Level 1/Level 2/Level3) ANOVA with performance and the levels of team SA as independent variables, and the discrepancy value of team SA as the dependent variable. The Performance variable was determined by dividing units into two equal sized groups depending on their estimates on the performance index. This was done since there was no natural occurring separation in the data. Units with equal values were distributed to the different groups by randomization. The three levels of team SA was treated as a within-subjects factor.

The pair ANOVA (n = 12) showed a main effect of Team SA ($F_{(2,20)} = 4.35$, $p < .05$) with Level 1 M = 0.79 (SD = 0.68), Level 2 M = 0.93 (SD = 1.02) and Level 3 M = 1.79 (SD = 0.83). Descriptive statistics are presented in Table 2. Further, pairwise comparisons of the Team SA levels showed a significant difference in means between Level 1 and Level 3, $p < .05$. There was no main effect of Higher/Lower Performance. There was no main effect of Performance.

Table 2 *Descriptive statistics of the Higher and Lower Performance groups in the pair unit Team SA ANOVA*

Team SA	Performance	n	M	SD
Level 1	Lower	6	1.13	0.79
	Higher	6	0.46	0.51
Level 2	Lower	6	1.31	1.29
	Higher	6	0.56	0.55
Level 3	Lower	6	1.46	0.91
	Higher	6	2.13	0.65

There was no interaction effect, however, a weak tendency of interaction between Team SA and Performance could be noticed ($F_{(2,20)} = 2.34$, $p = .12$), where pairs in the Higher Performance group (high subjective estimation values) tended to have lower discrepancies than pairs in the Lower group on Level 1 and 2, but in turn a higher discrepancy value on Level 3 (see Figure 4).

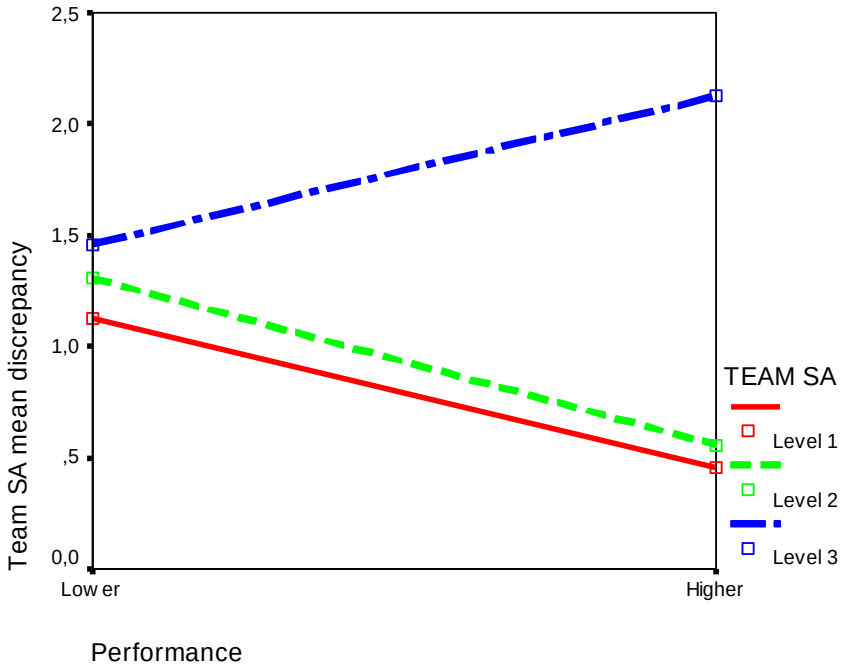

Figure 4. Interaction between Team SA and Performance for pair units, n = 12.

This suggests that the Higher group agreed more with each other concerning perception and comprehension of the situation than did the Lower group, but that the Lower group in turn had a higher level of agreement (but not necessarily correctness) about prediction of the situation.

An equal analysis regarding teams (n = 10) revealed neither significant main effects, nor any interaction effect for Team SA x Performance. Thus, the team data failed to show any differences in Team SA discrepancies for the two Performance groups.

In order to discover more distinct tendencies in the pair units of the gathered data, the two extreme values in each performance group were selected for an additional ANOVA, same design as mentioned above. The descriptive statistics of this analysis is presented in Table 3. Again, the results showed a main effect for Team SA ($F_{(2,4)} = 153.39$, $p < .05$) with Level 1 M = 0.69 (SD = 0.47), Level 2 M = 0.96 (SD = 0.52) and Level 3 M = 1.75 (SD = 0.54). Pairwise comparisons of the Team SA levels showed significant differences between Level 1 and Level 3, as well as between Level 2 and Level 3, $p < .05$. There was no main effect of Performance.

Table 3 *Higher and Lower Performance values in the extreme values pair Team SA ANOVA*

Team SA	Performance	n	M	SD
Level 1	Lower	2	0.50	0.71
	Higher	2	0.88	0.18
Level 2	Lower	2	1.34	0.47
	Higher	2	0.59	0.12
Level 3	Lower	2	2.13	0.53
	Higher	2	1.38	0.18

Moreover, there was an interaction effect between Team SA and Performance (Higher/Lower), $F_{(2,4)} = 53.12$, $p < .05$. However, in this analysis, the Higher Performance group had lower discrepancies on Levels 2 and 3, but in turn a higher discrepancy value on Level 1 than the Lower group (see Figure 5).

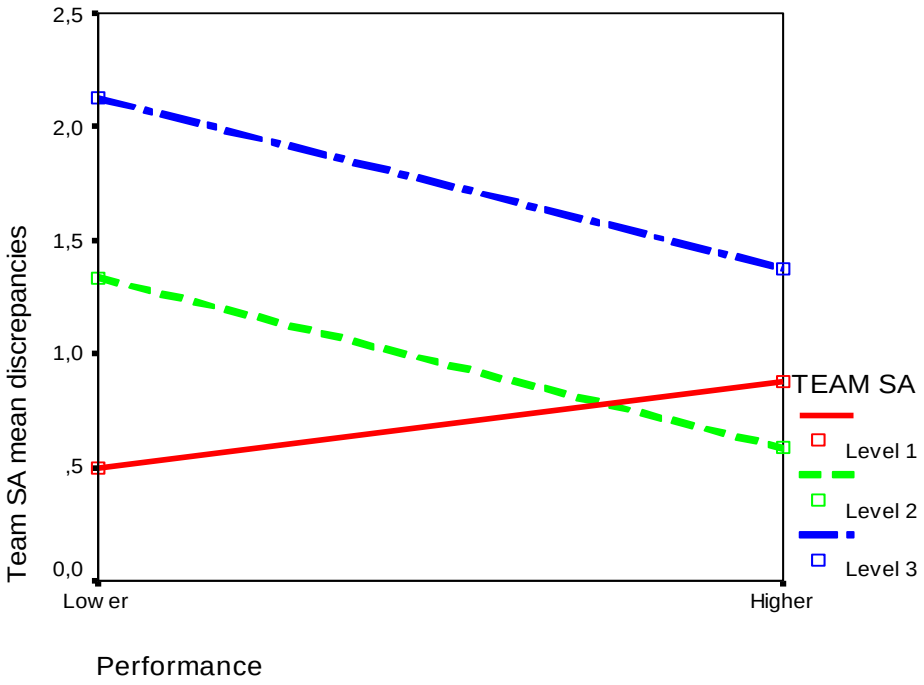

Figure 5. Interaction between Team SA and Performance for pair units, n = 4.

This result differs from the previous pair ANOVA in that the Higher group now had a higher agreement on both comprehension and projection level of Team SA, and that the Lower group instead were more in correspondence on the perception level. This in turn suggests that the BA firefighters will not have to agree on the perception level (e.g. how many rooms they searched), but that performance instead depends on how well the pair is concordant regarding the comprehension and projection of the situation.

A summary of the three Team SA ANOVA analyses are presented in Table 4.

Table 4 *Result summary of the three Team SA ANOVAs*

Unit of analysis		Df	F	p
Pair	Team SA	2	4.35	.03
	Performance	1	1.54	.24
	T * P	2	2.34	.12
Team	Team SA	1	1.04	.34
	Performance	1	0.10	.76
	T * P	1	0.01	.94
Extreme values	Team SA	2	153.39	.01
	Performance	1	0.80	.47
	T * P	2	53.12	.01

All three ANOVAs had in common a lack of main effect of Performance. This indicates that the distribution of Performance outcome in the gathered data was narrow, and therefore a significant difference in the means of the Higher and Lower group was absent. However, both of the pair analyses showed main effects of Team SA. Both analyses indicated a difference between Level 1 and Level 3, moreover, the analysis of extreme values showed a difference between Level 2 and Level 3. Common for these differences in Team SA, is that the mean discrepancy increases, the higher the level. The pair analyses also showed effect of interaction and a tendency to interaction. These results, however, were not corresponding.

5.2.2 After action review

Search technique/tactics

Generally, the instructors encouraged a behavior called “close search”. This means that the BA firefighter performs a search with his arm of the nearest area in the adjacent room, being located in the doorway. The close search can help the firefighters to characterize the rooms in the building, which in turn helps them to create an overall picture of the environment and makes it easier to remember where they have been and what rooms are still to be searched. Hence, this behavior should enhance the firefighter’s ability to create a higher degree of individual and team SA. Moreover, if people are left in the building, it is not unusual to find them in doorways, which makes the close search an action that might get people out of the building more quickly. The close search behavior was especially encouraged when one of the BA firefighters had to wait while the other one for example was pulling the hose, since this made the performance more efficient.

Orientation/references

BA firefighters were encouraged for creating and telling each other about points of reference, both in the pair and reporting on the radio to the BA leader. This behavior most likely enhances the team SA, since points of reference are relevant information for both BA firefighters. The behavior was especially praised when performed by the second BA pair, instead of just making their way to the first pair by following the hose. If the second pair only relies on the hose when getting into the building, they could get into serious trouble if they cannot follow it on their way out (e.g. if the way in has collapsed or are unable to pass through in other ways), since they will not have known marks to orientate around.

The BA pair also was recommended to report on the radio when they changed room, since this helps the personnel outside the building (e.g. BA leader, additional BA pairs, incident commander) to create a picture of how much the BA pair has searched through and how much is left. This information sharing is also a way of enhancing team SA.

Communication/information

As mentioned in the theory section, communication is one of the processes involved in creating team SA by making it possible to integrate the individual situational model into the team situation model. Relating this to the AAR's, positive comments were given when the BA firefighters shared individually perceived information with each other, for example what they had found and what they were doing. Because sight is reduced, it is common that the two BA firefighters not are able to share exactly the same perceptual environment, which in turn makes communication vital in succeeding with other processes such as coordination and adaptability. Requesting information within the pair was also rewarded. Since the fireman pulling the hose in the pair literally "has his hands full" and usually has to work more slowly, it easily happens that he just follows the one holding the branchpipe and thereby misses to create an individual perception of the environment. Hence, asking questions and being curious were encouraged since it indicated an active wish to be part of the mission and having control of the situation. Just following the fireman with the branchpipe would instead lead to a deficient individual SA, which would be a great threat to the second fireman's safety if he for example would have to find his own way out of the building.

Preferably, the communication should take place through the communication set since this gives the BA leader a more detailed picture of the situation. If the BA leader can overhear the BA pair talking, it is also easier for him to implicitly get a hint of how physically demanding the rescue is which facilitates for him to decide whether another BA pair is required and/or if it is time to urge the active BA pair to start their retreat. The BA leader can also use the information from the BA pair and relate it to the cues in the environment available outside the building, to make up a "bigger picture".

In turn, some critique was given during the AAR's. This generally concerned situations where the BA pair was using the communication set to a lesser extent than desired, not reporting points of reference or what was happening along their search. As one of the instructors expressed it: "everything is obvious for you when you're inside, but remember that it's not that way for the one standing outside" (author's translation). By not using the communication set and instead shout to each other through the mask, the BA leader misses a lot of "free information", which particularly is of importance if the BA pair gets in distress and has to be rescued. If communication has been deficient, for example if the BA pair is not reporting points of reference or location, then the lack of team SA that it has led to would greatly jeopardize the safety of the firemen and the ability to rescue them quickly.

Relieving/reinforced base point

Early in the exercise, the BA leader was informed that another BA pair was available at forward control point. The BA leader then had free hands in deciding how he would coordinate the resources, that is when he would call for the BA pair to reinforce the base point and when he would let the second pair enter the building.

The instructors encouraged a quick reinforcement of the base point, since this would let the second pair "join the game" (author's translation). This is interpreted as the firefighters' own way of talking about team SA, and "joining the game" could thereby facilitate the developing of both individual SA and the shared understanding of the situation which according to Stout et al. (1996) influence the level of team SA.

Awareness of status of other team members
Because of the high-risk situation during BA rescues, it is of greatest priority that the BA firefighters are aware of their own capacity as well as how the partner in the pair is doing. This is of course of importance in rescuing people, but also for the firefighters' own safety in that they start their retreat at the right time. During the exercises it seemed like the difference between having lots of strength left and feeling exhausted changed very quickly, which brings that the firemen has to be ahead in their planning. One of the BA leaders was praised for stopping the first BA pair in his exercise to continue searching the bottom floor, and instead sent in the second pair to finish. Even if the first BA pair gave the impression of having strength left at that point, changing floors is physically but also psychologically straining, knowing there is a "longer way home".

5.2.3 Stimulated recall and interview

During the stimulated recall interview, it was noticed that the BA firefighters used various types of information in creating compatible situation models and team SA. The firefighters in the BA pair can improve their degree of shared SA by reporting points of reference and if they have contact with the walls. Informing of contact with the walls in turn helps the members of the BA pair to create a mental image of the room, as well as serving as an indicator of how much of the room that is covered in the search.

By reporting points of reference and characterizing the rooms in the communication set, the BA leader (and other crew members listening to the BA operations channel) can follow the progress of the BA pair and for example get an indication of how far they have come in searching the building. This could, as mentioned above, be of importance in planning ahead and making decisions about letting another BA pair enter the building, but also for the safety of the members of the BA pair. Thus, creating a team SA is vital in enabling the team to make plans and appropriate decisions.

5.2.4 Summary

The quantitative analysis primarily shows that there are differences in mean discrepancy between the different levels, regardless performance outcome. Hence, it is not possible to draw any conclusions regarding if any level is of particular importance in performing well. Although, since the mean discrepancy is lowest at Level 1 and highest at Level 3, this suggests that focus should be upon enhancing team SA at higher levels. This can be related to the qualitative analysis, since sharing points of reference, using team processes as communication for getting the status of other team members, and coordinating in the search, all are factors that facilitate the projection of the evolving situation and the ability to plan ahead in the task.

5.3 Are the amount of pre-task knowledge and/or the level of shared mental models of importance in performing well?

As with the question of team SA, both statistics and qualitative data were used in analyzing the constructs of pre-task knowledge and shared mental models in relation to performance.

5.3.1 Questionnaires

A linear regression with Performance index as criterion and Pre-task knowledge as predictor was performed. Descriptive statistics of the analyses are found in Table 1.

The analysis of pair units shows that r = 0.83, $R^2 = 0.69$, $F_{(1,9)} = 20.15$, $p < .05$. The results for a corresponding analysis of team units with Pre-task knowledge index and Performance index shows that r = 0.89, $R^2 = 0.79$, $F_{(1,5)} = 18.41$ $p < .05$. Thus, the Pre-task knowledge explains 69% and 79% of the variance of performance for pairs and teams, respectively. A high degree of pre-task knowledge thereby predicts a high rating of the performance outcome.

To further investigate the relationship between pre-task knowledge and performance two one-way ANOVAs were computed for pairs and teams, respectively. Table 5 presents the statistics of these analyses. The independent variable consisted of dividing up the units in two groups, High and Low absolute values on pre-task knowledge index, with similar procedure as described with the performance index above. The dependent variable consisted of the Performance index. In the analyses there was a main effect for both pairs ($F_{(1,9)} = 7.48$, $p < .05$) and teams ($F_{(1,5)} = 6.79$, $p < .05$).

Table 5 *Statistics of the pre-task knowledge one-way ANOVAs*

		High			Low		F	p
Unit of analysis	N	M	SD	n	M	SD		
Pair	6	5.67	0.33	5	4.10	1.37	7.48	.02
Team	4	5.38	0.48	3	3.74	1.16	6.79	.05

The results thereby show a difference in performance between both pair and team units who differ in the amount of pre-task knowledge.

Since the index of pre-task knowledge consists of one team-related item (”How well do you know your BA partner?”) and one task-related item (”How well-informed were you before beginning the BA rescue?”), separate analyses of both items were performed on the pair units. The values of each item (question) were scored in two ways: one discrepancy index and one absolute value index. The discrepancy index aimed at measuring the degree of shared mental models in the pair, that is how compatible they were in their opinions. In turn, the absolute value aimed at measuring the amount of pre-task knowledge, in terms of the total experienced degree of information and knowledge before the exercise began. The design was a 2 x 2 Absolute value (High/Low) x Discrepancy (More/Less) ANOVA, with the Performance index as dependent variable. The team units were not analyzed since the number of units available for analysis was too low for this type of analysis. The distribution of units within cells, the means and the standard deviations of the team-related analysis are found in Table 6.

Table 6 *Statistics of the team-related item 2 x 2 ANOVA*

Absolute value	Discrepancy value	n	M	SD
"knows partner well" (High)	More	4	5.75	0.29
	Less	2	5.50	0.47
"knows partner less" (Low)	More	3	4.55	1.35
	Less	2	3.42	1.53
Total	More	7	5.24	1.03
	Less	4	4.46	1.52

The corresponding data for the task-related item, "How well-informed were you before beginning the BA rescue?", is presented in Table 7.

Table 7 *Statistics of the task-related item 2 x 2 ANOVA*

Absolute value	Discrepancy value	n	M	SD
"feeling well-informed" (High)	More	1	5.50	-
	Less	4	5.83	0.24
"feeling less informed" (Low)	More	3	4.33	1.73
	Less	3	4.22	1.11
Total	More	4	4.62	1.53
	Less	7	5.14	1.09

The results of the ANOVA for the team-related item shows a main effect of Absolute value ($F_{(1,7)} = 7.39$, $p < .05$) with High M = 5.67 (SD = 0.33) and Low M = 4.10 (SD = 1.37). There was neither main effect of Discrepancy value nor any interaction effect. The results suggests that high values on how well they know each other are more important for performing well and not to which extent the two BA firefighters agree on how well they know each other.

The ANOVA for the task-related question reveals no significant effects, but there is a tendency to a main effect of the Absolute value ($F_{(1,7)} = 3.27$, $p = .11$), indicating that how much information the BA firefighters experienced that they had received before the rescue are of importance for performance.

This suggests that the absolute values (i.e. the total amount) of information before the beginning of the rescue and the knowledge about one another in the pair are of importance in performing well, and not the degree of correspondence in how the firefighters of the pair perceive the situation.

5.3.2 After action review

Search technique/tactics

It is important that the BA pair agrees upon a search technique to make the performance efficient. One BA pair explicitly decided what search technique to use and how to divide the tasks among themselves before getting into the building, since they wanted "as much clarity as possible before the rescue" (author's translation). This is an example of how shared mental models enhance the ability of team members to coordinate their actions.

Communication/information

There were remarks during the AAR's concerning that the second BA pair often did not receive a BASS, which brings a risk that team SA will not be at its optimal level. Although

the second pair probably has implicitly received this information, a clear statement of the current goal and purpose with the rescue would probably just enhance the shared mental models and pre-task knowledge of the team members.

5.3.3 Stimulated recall and interview

According to the firemen participating in the interview, the amount of information that is available before starting the rescue affects the performance in a positive way. A clear organizational structure at the incident site, clearly delineated tasks and goals, and in cases regarding rescues in larger buildings an opportunity for the BA team to review maps are mentioned as factors that facilitate the following work. This indicates that the more information and knowledge about the rescue the BA team has available (i.e. pre-task knowledge), the more effective performance and greater chance for a successful rescue.

Team-related shared mental models also seem to facilitate the BA team's work. Even if any BA firefighters are expected to be able to perform a BA rescue, the interviewees mention that BA rescuing is in practice easier to perform with a colleague from the same fire department. First, each department develops its own "culture", and thereby also to some degree its own nomenclature, which makes it easier to communicate and understand each other within the department: "we speak the same language" (author's translation). Second, knowledge of one another's personal traits (both temper and preferred working procedures) and physical capacity may facilitate both coordination and adaptation to each other, making the task performance more efficient "we know each other; know how the other person works, and know the other person's capacity"(author's translation).

In the municipality of Stockholm, fire foremen and fire chiefs can have the role of BA firefighters at exercises, even if they do not perform this task at real rescues. This probably improves and retains their understanding of the role of BA firefighters, which may in turn improve the shared mental models in the team.

5.3.4 Summary

Hence, the different methods all showed that pre-task knowledge is of importance in performing well. The fact that personal knowledge about one another facilitates performance could be seen in the statistical analyses as well as the mentioning of different cultures in the interview. The tendency that the amount of information available before the rescue affected performance was further supported both during the AAR's and the interview.

5.4 What factors are contributing to successful performance?

5.4.1 Questionnaires

A multiple regression analysis was performed, with the indices of Pre-task knowledge, a general index for Team processes and a general index for Team SA as predictors, and the performance index as the criterion. Table 8 shows descriptive statistics of the multiple regression.

Table 8 *Descriptive statistics for pair and team indices in the multiple regression*

	Pair			Team		
	n	M	SD	n	M	SD
Performance	11	4.95	1.22	7	4.67	1.15
Team SA	11	1.14	0.36	7	1.34	0.35
Pre-task knowledge	11	5.09	1.15	7	5.07	1.23
Team processes	11	5.28	0.93	7	4.94	0.63

The regression model for pairs revealed that $R = 0.91$, $R^2 = 0.83$, $F_{(3,7)} = 11.22$, $p < .05$. As Table 9 shows, testing of the predictor variables gave significant values for Pre-task knowledge and Team processes, but not for Team SA. The corresponding analysis for teams also shows that $R = 0.95$, $R^2 = 0.90$, $F_{(3.3)} = 9.04$, $p = .05$. However, the predictor variables showed no significant values for Pre-task knowledge, Team Processes or Team SA. Hence, in the case of team units, no single predictor was able to significantly contribute to the effect, although the Pre-task knowledge index shows a tendency to predict performance.

Table 9 *β-, t-, and p-values for indices in the multiple regression*

Analysis unit	β	t	p
Pair			
Team SA	0.18	1.01	.35
Pre-task knowledge	0.57	2.76	.03
Team processes	0.51	2.34	.05
Team			
Team SA	-0.06	-0.18	.87
Pre-task knowledge	0.64	2.59	.08
Team processes	0.37	0.97	.40

Since the Team processes index consists of three different indices (Coordination, Communication, and Adaptability), a correlation matrix for the pair units containing the three processes and the general process index was created to investigate if any of the processes were of greater significance in predicting performance. The matrix showed that all three processes were highly correlated with the general process index (Coordination $r = .98$, Communication $r = .83$, and Adaptability $r = .90$, $p < .05$, respectively) which suggests that all three processes are contributing in explaining performance by means of the general Team processes index.

5.4.2 After action review

Search technique/tactics

The instructors gave positive comments regarding how well the BA firefighters had broadened the search. A well-performed broadening will of course make the search more efficient since the BA pair will search through a larger area in less time, but it should not be made to the degree that the BA firefighters loose track of one another. Thus, the degree of appropriate broadening depends on the situation and requires the BA firefighters to

coordinate, thereby implying that the coordination process in the pair is related to performance.

Communication/information
As mentioned before, communication taking place through the communication set was preferred by the instructors. The fact that this facilitates for the team members outside the building (i.e. the BA leader and incident commander) to plan ahead also implies that it will improve performance by means of aiding appropriate decision making in right time.

During the AAR's, the preferred amount of communication was discussed. Although most of the remarks about the communication concerned using the communication set less than desirable, there was an exception. Sometimes, when both BA pairs had entered the building, the BA firefighters experienced that there was not enough "radio space" for both of the pairs. This led to a discussion about trying to be more restrict in the use of the communication set while two pairs were active at once, only reporting to the BA leader when changing rooms, about points of reference, et cetera. One BA leader also mentioned that the negative effect of the BA pair reporting "everything" through the communication set, was that it could be hard to perceive all the information, since he at times had to communicate on another radio channel with the incident commander and the BA controller. As mentioned by Salas et al. (2001), sharing all information between members in the team is often not optimal since this instead might just induce an increase of workload, and thereby could affect performance in a negative way. Perhaps, it is not necessary for the BA leader to know that one of the BA firefighters has a sofa on his right side, but rather that the BA pair at the moment is located in the living room.

Relieving/reinforced base point
Standing at the base point, the second BA pair could meet up with the first inside the building to help carrying the "persons" out, which would enable the first pair to continue searching in less time. Hence, this could lead to a better coordination process in the team. Positive remarks were also given regarding one BA firefighter in the second pair helping out with transporting the hose in and out of the building.

The second pair could also facilitate the work of the BA leader, by managing the communication with other team members outside the building, making it possible for the BA leader to concentrate on the communication with the BA firefighters inside the building. Thus, by reinforcing the base point, the resources available is better used than if the BA pair stays at forward control point.

Another reason for reinforcing base point as soon as possible, was that the BA leader then could decide to have the two pairs active at once, to make the search faster and more efficient. Generally, the BA leaders did not decide to send in the second pair until they got information about people left on the bottom floor. Therefore, in most of the exercises observed, the relieving took place at a later point in time than desired by the instructors. If the relieving is performed before the first pair has reached a higher level of mental and physical fatigue, the information passed between the pairs probably will be more detailed and clear, since it gets harder to have awareness and reason when they are physically tired. This will in turn help the second pair to perform more efficiently, for example not to search rooms where the first pair has already been.

Awareness of status of other team members
The BA firefighters were encouraged by the instructors for telling and/or asking each other how they were feeling, since it is just as important being aware of how much strength the partner has left, as it is being aware of ones own status as the activities of BA rescues (and especially life-saving) requires the full capacity of both members of the pair in order to perform successfully.

Worth mentioning, is that the exercises observed also serves as a great opportunity for the firefighters to test themselves and become aware of how they react when they get exhausted. Many of the firemen participating in the exercise stated that they pushed themselves a bit harder than they would during a real-life rescue, which serves a purpose making it possible to reflect upon what happens to them both physically and cognitively, when exposed to heating and loss of fluids.

5.4.3 Stimulated recall and interview

An organizational aspect that affects the BA rescue work is that of a non-existing common nomenclature. In addition, terms are often exchanged for new ones that are adjusted to the latest research findings, leading to variation in the use of terms at the same fire department. The interviewees therefore pointed out the importance of exercises and education to make the new terms the automatic choice of expressing oneself. The diversity of expressions most likely increases the risk of misunderstandings within the team, thereby also risking the quality of performance.

5.4.4 Summary

Altogether, the quantitative analysis of this question showed that the three concepts of pre-task knowledge, team SA, and team processes are able of predicting performance outcome. Moreover, the pair analysis showed significant values for the predictors of pre-task knowledge and team processes. As mentioned in the previous research question, pre-task knowledge was also mentioned as crucial during the AAR's and the interview. Team processes are further acknowledged as important in performance outcome, for example when the BA firefighters coordinate their search, and in the interview, where lack of common nomenclature could risk the quality of performance. Although the team SA predictor did not show significance in the multiple regression, it was stressed during the AAR's that awareness of each others status was crucial. Thus, this indicates a need for the firemen within the team to continuously update their situation model of their team mates, which is interpreted as a need of team SA.

5.5 Could a rescue be divided into stages, which in different ways affect performance?

Since this question was solely explorative, it was only addressed during the semi-structured interview.

5.5.1 Stimulated recall and interview

The firemen were asked to divide a typical rescue into stages, and explain how these could relate to performance outcomes. The stages mentioned in the interview follows below:

- **Locating and reaching the right address.** Since the work in BA rescues is characterized by time pressure, it is of importance for successful performance that the firemen reach the incident site at an early stage of the fire. Examples of what can complicate this process are that vehicles can be blocking the way, or the quite common fact that people reporting the fire are stating their own address instead of the address of the fire.
- **Arranging the hose/s.** Occasionally, there is a break on the hose at rescues. This is not a factor that can be controlled, like the arranging of hoses which can be made in an efficient way, thereby affecting performance positively.
- **Choosing a strategy.** At the incident site, it is the incident commander that is responsible for coming up with a strategy. The incident commander makes an assessment of the situation and orders the rest of the team to perform the task, for example "life-saving, floor 2". It is also important for the incident commander to think in "if-cases", to plan ahead regarding how much crew that is needed or what happens if the fire spreads.

Moreover, the firemen stated that the team can be compared to a "self-playing piano", although all of the team members help to monitor and check each other during performance.

6 General discussion

This section starts with a summary of the results achieved by the different data collection methods. Although the methods to some degree were used to address different questions, the analyses also revealed some converging facts among the results. Then follows a discussion of the methods used, including remarks about the procedure.

6.1 Result discussion

Primarily, several types of statistical analyses showed that a high degree of pre-task knowledge affected performance in a positive way. This fact could also be seen in the interview analysis, where the firemen pointed out that experience of working together and the amount of information available at the beginning of the rescue to a great extent facilitates the ability of performing well. Moreover, the amount of pre-task knowledge may be negatively affected by not explicitly giving a second BA pair a BASS. This was commented upon by the instructors at the AAR's, and can relate to the fact pointed out in the interview that clearly delineated tasks and goals aid performance.

In more detail, the statistical analyses indicated that a high degree in terms of a high total amount of pre-task knowledge in estimating how well one knows the BA partner, is more important in successful performance than the two BA firefighters agreeing on how well they know each other. It could have been argued that two BA firefighters who agree and are aware that they have little personal knowledge about each other could perform well by deliberately compensating for the lack of knowledge (e.g. by a higher degree of overt strategizing and explicit communication), but this could not be supported by the analyses in the current study. Moreover, even if the task-related item (feeling well-informed) did not reveal significant results, there was a tendency that here too it is the total amount of information that facilitate performance. Therefore, it would be pertinent to optimize the development of pre-task knowledge; both in task- and team-related ways.

Further, the quantitative analysis of team SA did not show any homogenous results. Although a main effect of Team SA could be seen in both pair unit ANOVA's, the interaction effects were fairly ambiguous. Moreover, the analysis of team units showed no significant effects. Hence, further research is needed in answering the question if any level of team SA is of special importance in explaining performance. There is also a possibility that other ways of operationally defining and measuring team SA would be better suited. This will be further discussed below. However, the differences between the levels of team SA that were shown in the statistical analysis, indicate that regardless of performance outcome, the discrepancy is higher at higher levels (particularly the projection level). In the qualitative analysis, several means by which this could be achieved are mentioned. For example, reinforcing the base point at an early stage would provide the second BA pair with information vital in planning (projecting) their own work, and use of the communication set and sharing information with each other also facilitates for the team to have a common vision of the future status of the situation.

Even if the statistical analysis could not show how (or if) team SA affects performance during BA rescues, the qualitative methods revealed some interesting facts. First, during the AAR's, the instructors often used the expression "joining the game". This is interpreted as the sharing of information and awareness of the current state of the rescue within the team, in other words the team's SA.

During both the AAR's and the stimulated recall interview, it was expressed that not sharing information through the BA communication set could affect both the performance and the safety of the team members in a negative way. This is in accordance with Cooke et al. (2001) who argue that communication is the process in which the information in the individual situation models are integrated in the team's situation model, and also with what McMillan et al. (2002) suggest about efficient communication as the basis for both efficient team cognition and performance. Even if firemen were encouraged to share information through the communication set, efficient communication is also related to the relevance in the utterances. This was pointed out by both instructors and firemen as important when several BA pairs were active.

The regression analysis conducted in establishing factors predicting performance is consistent with the results discussed above in that both pre-task knowledge and team processes could be seen to significantly predict performance, whereas team SA could not. The importance of pre-task knowledge and well-functioning team processes can in turn be related to the typical problems in team incidents identified by Rouse et al. (1992); lack of clearly and appropriately defined roles, lack of explicit coordination, and difficulties in communication.

As Stout et al. (1996) pointed out, both task and team mental models have unique effects on subsequent team processes. Moreover, these processes are significantly related to team performance. This is supported by the multiple regression analysis, where both pre-task knowledge and team processes significantly explained performance. A suggestion is that the team processes can be seen as a mediator between the mental models or pre-task knowledge and the performance outcome.

The stages of the rescue mentioned in the interview may by different types of exercises and educations enhance the pre-task knowledge and thereby improve performance. For example, practicing arranging of hoses might increase both the shared declarative and procedural

knowledge within the team, and presenting different scenarios or simulations might facilitate for the incident commander to make appropriate choices regarding rescue strategies.

6.2 Method discussion

Generally, the methods used in the study served their purposes. However, some remarks can be made both concerning the preparatory work and the process of analysis.

First, the questionnaires consisted of subjective estimates, which can be seen as a factor risking the validity of the data. Since the performance estimates of the instructors and the firemen were significantly correlated, it to some degree supports the validity of the outcome measures. However, there were no objective measures of performance outcome.

Moreover, the operational definition of team SA by means of measuring the discrepancy of the estimates within the team may be questioned. Still, this seemed as a reasonable way of interpreting the construct, but since the analysis showed varying results there may be better suited means in measuring team SA.

On the whole, in using questionnaires, there is a risk that subjects interpret questions in different ways, and perhaps this risk is even more prominent when the questions concern more abstract constructs and require meta-cognitive considerations.

The number of units is also fairly small considering the quantitative analysis. Unfortunately, the time available did not allow for further data collection.

Second, regarding the qualitative methods, there is always a degree of subjectivity in interpreting the data collected. For example, the categories extracted from the AAR's might be affected by the fact that the purpose of the observed exercise was to practice search techniques and communication.

Moreover, the small number of participants and the fact that they were employed in the same community restricts the ability to generalize the results to other communities in an extensive way.

Finally, the fact that the data was collected during exercises instead of real rescues naturally affected the results. This was also mentioned during the interview, where subjects expressed that even though it helped having a scenario "played" in the exercise to make it more real, knowing that it is an exercise will not trigger the same adrenaline rush. The awareness of having instructors observing was also mentioned as a factor that to some degree made the firemen trying to communicate correctly etc. Still, the descriptive statistics of the questionnaires showed that the exercise was appreciated by the firemen and considered both challenging and instructive, which signifies that the firemen were taking the tasks of the exercise seriously.

7 Conclusions

Since the amount of pre-task knowledge seemed to affect performance positively, the aim should be to develop and improve this type of knowledge in the team. Exercises thereby serve an important purpose in enhancing the team's pre-task knowledge, both in a task-related (e.g. practicing search and communication techniques) and a team-related way (knowing how one

self and other members behave and react during performance and fatigue). It also may improve the amount of shared strategic knowledge, which according to Stout et al. (1996) is the most important type of knowledge when performing in dynamic environments.

Although pre-task knowledge can be improved by several means, performance will also be affected by factors not able to achieve by training. The amount of information available before starting a BA rescue is one example of a performance-related factor that cannot be secured by exercises.

By trying to introduce a more standardized way of communicating, the degree of shared mental models across fire departments would increase and thereby facilitate performance during rescues in which firemen from different departments have to cooperate.

Further research is needed to establish the relation between the different levels of team SA and performance in the BA rescues domain. It would also be of interest to investigate how team SA affects other cognitive processes as decision making, problem solving or planning in this domain characterized by time-pressure.

Regarding pre-task knowledge and shared mental models, research would be useful in investigating what kind of training method/methods that are more efficient in helping a BA team to achieve a high degree of this knowledge.

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Appendix

Appendix A – Questionnaire BA firefighter

Datum:
Klockslag:
Mp3spelare:

RÖKDYKARE

Vi är två studenter vid Linköpings universitet som genomför en studie om rökdykning i samarbete med Totalförsvarets Forskningsinstitut (FOI). Enkäten framför Dig är en del av denna studie och vi ber därför om Din hjälp med att svara på några frågor. Dina svar kommer att behandlas konfidentiellt och vi garanterar din anonymitet.

Det är 31 frågor som ska besvaras av dig. Har du några frågor så finns vi i närheten för att förtydliga. Säg bara till.

Svaren ska lämnas individuellt och ej diskuteras med kollegorna under besvarandet.

Tack för Din medverkan!
Annelie & Ida

Namn:

Ålder:

År i yrket:

Arbetsplats (brandstation):

Kryssa i vilken roll du hade under övningen: Rökdykare 1 ☐ Rökdykare 2 ☐

1. **Har du tidigare arbetat tillsammans med din kollega under övningen?**
   Ja □ Nej □

   Om ja:
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

   Inte väl 1 2 3 4 5 6 7 Mycket väl

2. **Hur svår tycker du att övningen var?**

   Mycket lätt 1 2 3 4 5 6 7 Mycket svår

3. **Hur utmanande var övningen?**

   Inte alls 1 2 3 4 5 6 7 Mycket

4. **Kände du dig stressad under övningen?**

   Inte alls 1 2 3 4 5 6 7 Hela tiden

5. **Hur löste du dina uppgifter?**

   Inte alls 1 2 3 4 5 6 7 Perfekt

6. **Hur nöjd är du med din insats som helhet?**

   Inte alls nöjd 1 2 3 4 5 6 7 Mycket nöjd

7. **Hur fungerade samarbetet inom <u>rökdykargruppen</u> (rökdykare och rökdykarledare)?**

   Inte särskilt bra 1 2 3 4 5 6 7 Bästa möjliga

8. **Hur väl samordnade var era handlingar i <u>rökdykarparet</u> under övningen?**

   Inte alls 1 2 3 4 5 6 7 Mycket samordnade

9. **Hade du lätt för att anpassa dig efter din kollega (i paret)?**

   Inte alls 1 2 3 4 5 6 7 Mycket lätt

10. I vilken utsträckning löste det rökdykarpar som du tillhörde de uppgifter som ni blivit tilldelade?

Inte alls 1 2 3 4 5 6 7 I allra högsta grad

11. Hur välinformerade var ni innan ni påbörjade rökdykningen?

Inte alls 1 2 3 4 5 6 7 Mycket välinformerade

12. I vilken utsträckning upplevde du att du var tvungen att förändra/anpassa ditt agerande till din kollegas?

Mycket liten 1 2 3 4 5 6 7 Mycket stor

13. Kände du dig någon gång frustrerad på grund av andra personers agerande?

Inte alls 1 2 3 4 5 6 7 Mycket ofta

14. I vilken utsträckning upplevde du att du kunde skapa dig en övergripande bild av situationen?

Mycket liten 1 2 3 4 5 6 7 Mycket stor

15. Upplevde du att ni låg ”ett steg före” i händelseförloppet under övningen?

Inte alls 1 2 3 4 5 6 7 Hela tiden

16. Blev du överraskad av något i händelseförloppet under övningen?

Aldrig 1 2 3 4 5 6 7 Ofta

Om ja, av vad?_____

17. I vilken utsträckning karaktäriserades övningen av oförutsedda händelser?

Mycket liten 1 2 3 4 5 6 7 Mycket stor

18. I vilken utsträckning upplevde du att du kunde förutsäga händelseutvecklingen?

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

19. Hur lång tid tog det för er inom paret att ”reda upp” situationer där något blivit fel/förvirrat?

Alldeles för länge 1 2 3 4 5 6 7 Mycket kort tid

20. Hur lyckades ni med att orientera er i lokalen?

Inte alls bra 1 2 3 4 5 6 7 Mycket bra

21. Hur många rum sökte ni igenom? _____

22. Hur väl kunde ni skapa er referenspunkter i lokalen?

Inte alls väl 1 2 3 4 5 6 7 Mycket väl

23. I hur stor utsträckning hade du ”koll på läget” under övningen?

Inte alls 1 2 3 4 5 6 7 Till fullo

24. I vilken utsträckning upplevde du att du kunde förmedla information till dina kollegor inom rökdykargruppen på ett tillfredställande sätt?

Inte alls 1 2 3 4 5 6 7 Till fullo

25. I vilken utsträckning uppstod missförstånd inom rökdykargruppen under övningen?

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

26. I vilken utsträckning behövde du be din kollega att förtydliga ett yttrande?

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

27. Upplevde du rökdykarledarens kommunikation som störande i ditt arbete?

Inte alls 1 2 3 4 5 6 7 Mycket störande

28. I vilken utsträckning kunde du utnyttja information som kom från det första rökdykarparet?

Inte alls 1 2 3 4 5 6 7 Till fullo

☐ Jag tillhörde det första rökdykarparet

29. Hade du lätt för att förstå din kollega (i paret)?

Inte alls 1 2 3 4 5 6 7 Mycket lätt

30. Hur lärorik var övningen?

Inte alls lärorik 1 2 3 4 5 6 7 Mycket lärorik

31. Om du fick göra om övningen, skulle du vilja göra något annorlunda?

Om ja, vad?_____

_____

_____

_____

Tack för din medverkan!
Annelie & Ida

Appendix B – Questionnaire BA leader

Datum:
Klockslag:

RÖKDYKARLEDARE

Vi är två studenter vid Linköpings universitet som genomför en studie om rökdykning i samarbete med Totalförsvarets Forskningsinstitut (FOI). Enkäten framför Dig är en del av denna studie och vi ber därför om Din hjälp med att svara på några frågor. Dina svar kommer att behandlas konfidentiellt och vi garanterar din anonymitet.

Det är 28 frågor som ska besvaras av dig. Har du några frågor så finns vi i närheten för att förtydliga. Säg bara till.

Svaren ska lämnas individuellt och ej diskuteras med kollegorna under besvarandet.

Tack för Din medverkan!

Annelie & Ida

Namn: _____

Ålder: _____

År i yrket: _____

Arbetsplats (brandstation): _____

1. **Har du tidigare arbetat tillsammans med de som var rökdykare under övningen?**
   Ja ☐ Nej ☐

   För varje kollega du tidigare arbetat med, fyll i:

   - **Namn_____**
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

     Inte väl 1 2 3 4 5 6 7 Mycket väl

   - **Namn_____**
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

     Inte väl 1 2 3 4 5 6 7 Mycket väl

   - **Namn_____**
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

     Inte väl 1 2 3 4 5 6 7 Mycket väl

   - **Namn_____**
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

     Inte väl 1 2 3 4 5 6 7 Mycket väl

2. **Hur svår tycker du att övningen var?**

   Mycket lätt 1 2 3 4 5 6 7 Mycket svår

3. Hur utmanande var övningen?

Inte alls 1 2 3 4 5 6 7 Mycket

4. Kände du dig stressad under övningen?

Inte alls 1 2 3 4 5 6 7 Hela tiden

5. Hur löste du dina uppgifter?

Inte alls 1 2 3 4 5 6 7 Perfekt

6. Hur nöjd är du med din insats som helhet?

Inte alls nöjd 1 2 3 4 5 6 7 Mycket nöjd

7. Hur fungerade samarbetet inom rökdykargruppen (rökdykare och rökdykarledare)?

Med första rökdykarparet:

Inte särskilt bra 1 2 3 4 5 6 7 Mycket bra

Med andra rökdykarparet:

Inte särskilt bra 1 2 3 4 5 6 7 Mycket bra

8. Kände du dig någon gång frustrerad på grund av andra personers agerande?

Inte alls 1 2 3 4 5 6 7 Mycket ofta

9. Upplevde du att du låg ”ett steg före” i händelseförloppet under övningen?

Inte alls 1 2 3 4 5 6 7 Hela tiden

10. Hur välinformerad var du innan ni påbörjade rökdykningen?

Inte alls 1 2 3 4 5 6 7 Mycket välinformerade

11. Blev du överraskad av något i händelseförloppet under övningen?

Aldrig 1 2 3 4 5 6 7 Ofta

Om ja, av vad?_____

12. I vilken utsträckning karaktäriserades övningen av oförutsedda händelser?

Mycket liten 1 2 3 4 5 6 7 Mycket stor

13. I vilken utsträckning upplevde du att ni kunde koordinera era arbetsuppgifter inom rökdykargruppen?

Inte alls 1 2 3 4 5 6 7 Till fullo

14. I vilken utsträckning upplevde du att du kunde förutsäga händelseutvecklingen?

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

15. Till vilken grad upplevde du att du lyckades skapa dig en uppfattning om hur lokalen såg ut på insidan?

Inte alls 1 2 3 4 5 6 7 Till fullo

16. Upplevde du att du visste var i byggnaden rökdykarna befann sig?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

17. Hur många rum uppfattade du att rökdykarna genomsökte?

*Första rökdykarparet:*_____

*Andra rökdykarparet:*_____

18. I hur stor utsträckning hade du ”koll på läget” under övningen?

Inte alls 1 2 3 4 5 6 7 Till fullo

19. I vilken utsträckning upplevde du att du kunde förmedla information till dina kollegor inom rökdykargruppen på ett tillfredställande sätt?

Inte alls 1 2 3 4 5 6 7 Till fullo

20. Hur ofta var du tvungen att efterfråga information från rökdykarna?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

21. I vilken utsträckning uppstod missförstånd mellan dig och rökdykarna under övningen?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

22. I vilken utsträckning behövde du be dina kollegor att förtydliga ett yttrande?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

23. I vilken utsträckning kunde du utnyttja information som kom från det första rökdykarparet för att ”briefa” det andra paret?

Inte alls 1 2 3 4 5 6 7 Till fullo

24. Upplevde du att du fick tillräcklig information om händelseförloppet av rökdykarna?

Från första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Definitivt

Från andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Definitivt

25. Skatta mängden radiokommunikation från <u>första</u> rökdykarparet under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

26. Skatta mängden radiokommunikation från <u>andra</u> rökdykarparet under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

27. Hur lärorik var övningen?

Inte alls lärorik 1 2 3 4 5 6 7 Mycket lärorik

28. Om du fick göra om övningen, skulle du vilja göra något annorlunda?

Ja ☐ **Nej** ☐

Om ja, vad?_____

_____

_____

_____

Tack för din medverkan!

Annelie & Ida

Appendix C – Questionnaire instructor, BA firefighter

Datum:

Klockslag:

INSTRUKTÖR rökdykare

Vi är två studenter vid Linköpings universitet som genomför en studie om rökdykning i samarbete med Totalförsvarets Forskningsinstitut (FOI). Formuläret framför Dig är en del av denna studie och vi ber därför om Din hjälp med att bedöma hur teamet utför de olika momenten under övningen. Dina svar kommer att behandlas konfidentiellt och vi garanterar din anonymitet.

Det är 26 frågor som ska besvaras av dig. Har du några frågor så finns vi i närheten för att förtydliga. Säg bara till.

Svaren ska lämnas individuellt och ej diskuteras med kollegorna under besvarandet.

Tack för Din medverkan!
Annelie & Ida

Namn: _____

Ålder: _____

År i yrket: _____

Arbetsplats (brandstation): _____

1. **Hur svår tycker du att övningen var för rökdykargruppen?**

   Mycket lätt 1 2 3 4 5 6 7 Mycket svår

2. **Hur utmanande var övningen för rökdykargruppen?**

   Inte alls 1 2 3 4 5 6 7 Mycket

3. **Hur löste gruppen sina uppgifter?**

   Inte alls 1 2 3 4 5 6 7 Perfekt

4. **Hur fungerade samarbetet inom <u>rökdykargruppen</u> (rökdykare och rökdykarledare)?**

   Inte särskilt bra 1 2 3 4 5 6 7 Perfekt

5. **Hur väl samordnade var handlingarna i <u>rökdykarparet</u> under övningen?**

   Inte alls 1 2 3 4 5 6 7 Mycket samordnade

6. **Upplevde du att rökdykarna hade lätt för att anpassa sig till varandra (i paret)?**

   Inte alls 1 2 3 4 5 6 7 Mycket lätt

7. **I vilken utsträckning löste rökdykarparet de uppgifter som de blivit tilldelade?**

   Inte alls 1 2 3 4 5 6 7 I allra högsta grad

8. **I vilken utsträckning karaktäriserades övningen av oförutsedda händelser?**

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

9. **I vilken utsträckning upplevde du att rökdykarparet kunde förutsäga händelseutvecklingen?**

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

10. **Hur lång tid tog det för paret att ”reda upp” situationer där något blivit fel/förvirrat?**

    Alldeles för länge 1 2 3 4 5 6 7 Mycket kort tid

11. Hur lyckades rökdykarna med att orientera sig i lokalen?

Inte alls bra 1 2 3 4 5 6 7 Mycket bra

12. Hur många rum sökte de igenom? _____

13. Hur väl kunde rökdykarna skapa sig referenspunkter i lokalen?

Inte alls väl 1 2 3 4 5 6 7 Mycket väl

14. Kom rökdykarna snabbt överens om en sökteknik?

Inte alls 1 2 3 4 5 6 7 Mycket snabbt

Var denna sökteknik lämplig i sammanhanget?

Inte alls 1 2 3 4 5 6 7 Mycket lämplig

15. I hur stor utsträckning hade rökdykarna ”koll på läget” under övningen?

Inte alls 1 2 3 4 5 6 7 Till fullo

16. Hur väl lyckades rökdykarna skapa och bibehålla en säker reträttväg?

Inte alls 1 2 3 4 5 6 7 Mycket väl

17. I vilken utsträckning upplevde du att rökdykarna kunde förmedla information mellan varandra på ett tillfredställande sätt?

Inte alls 1 2 3 4 5 6 7 Till fullo

18. I vilken utsträckning upplevde du att rökdykarna kunde förmedla information till rökdykarledaren på ett tillfredställande sätt?

Inte alls 1 2 3 4 5 6 7 Till fullo

19. I vilken utsträckning uppstod missförstånd inom rökdykargruppen under övningen?

Inte alls 1 2 3 4 5 6 7 Mycket ofta

20. Upplevde du att rökdykarledarens kommunikation störde rökdykarnas arbete?

Inte alls 1 2 3 4 5 6 7 Mycket störande

21. Upplevde du att rökdykarledarens kommunikation stöttade rökdykarnas arbete?

Inte alls 1 2 3 4 5 6 7 Till stor del

22. Skatta mängden radiokommunikation från rökdykarna under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

23. I vilken utsträckning hade rökdykarna ”koll på” hur mycket krafter den andre i paret hade kvar?

Inte alls 1 2 3 4 5 6 7 Till fullo

24. I vilken utsträckning hade de båda rökdykarna använt lika mycket av sin kapacitet efter avslutat pass?

Inte alls 1 2 3 4 5 6 7 Till fullo

25. Om de fick göra om övningen, borde de göra något annorlunda? Ja □ Nej □

Om ja, vad?_____

_____

_____

_____

_____

_____

26. Finns det något den här gruppen borde träna mer på?

_____

_____

Tack för din medverkan!
Annelie & Ida

Appendix D – Questionnaire instructor, BA leader

Datum:

Klockslag:

INSTRUKTÖR rökdykarledare

Vi är två studenter vid Linköpings universitet som genomför en studie om rökdykning i samarbete med Totalförsvarets Forskningsinstitut (FOI). Formuläret framför Dig är en del av denna studie och vi ber därför om Din hjälp med att bedöma hur teamet utför de olika momenten under övningen. Dina svar kommer att behandlas konfidentiellt och vi garanterar din anonymitet.

Det är 23 frågor som ska besvaras av dig. Har du några frågor så finns vi i närheten för att förtydliga. Säg bara till.

Svaren ska lämnas individuellt och ej diskuteras med kollegorna under besvarandet.

Tack för Din medverkan!

Annelie & Ida

Namn:

Ålder:

År i yrket:

Arbetsplats (brandstation):

1. **Hur svår tycker du att övningen var för rökdykarledaren?**

   Mycket lätt 1 2 3 4 5 6 7 Mycket svårt

2. **Hur utmanande var övningen för rökdykarledaren?**

   Inte alls 1 2 3 4 5 6 7 Mycket

3. **Hur löste rökdykarledaren sina uppgifter?**

   Inte alls 1 2 3 4 5 6 7 Perfekt

4. **Hur fungerade samarbetet inom rökdykargruppen (rökdykare och rökdykarledare)?**

   Med första rökdykarparet:

   Inte särskilt bra 1 2 3 4 5 6 7 Perfekt

   Med andra rökdykarparet:

   Inte särskilt bra 1 2 3 4 5 6 7 Perfekt

5. **Upplevde du att rökdykarledaren låg ”ett steg före” i händelseförloppet under övningen?**

   Inte alls 1 2 3 4 5 6 7 Hela tiden

6. **I vilken utsträckning karaktäriserades övningen av oförutsedda händelser?**

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

7. **I vilken utsträckning upplevde du att rökdykargruppen kunde koordinera sina arbetsuppgifter?**

   Rökdykarledare + första rökdykarparet:

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

   Rökdykarledaren + andra rökdykarparet:

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

8. I vilken utsträckning upplevde du att rökdykarledaren kunde förutsäga händelseutvecklingen?

Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

9. Till vilken grad uppskattar du att rökdykarledaren lyckades skapa sig en uppfattning om hur lokalen såg ut på insidan?

Inte alls 1 2 3 4 5 6 7 Till fullo

10. Upplevde du att rökdykarledaren visste var i byggnaden rökdykarna befann sig?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

11. I hur stor utsträckning hade rökdykarledaren ”koll på läget” under övningen?

Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

12. I vilken utsträckning upplevde du att rökdykarledaren kunde förmedla information till sina kollegor inom rökdykargruppen på ett tillfredställande sätt?

Till första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Till fullo

Till andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Till fullo

13. Hur ofta var rökdykarledaren tvungen att efterfråga information från rökdykarna?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

14. I vilken utsträckning uppstod missförstånd mellan rökdykarledaren och rökdykarna under övningen?

Med första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Mycket ofta

15. I vilken utsträckning behövde rökdykarledaren be sina kollegor att förtydliga ett yttrande?

Med första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Mycket ofta

16. I vilken utsträckning kunde rökdykarledaren utnyttja information som kom från det första rökdykarparet för att ”briefa” det andra paret?

Inte alls 1 2 3 4 5 6 7 Till fullo

17. Upplevde du att rökdykarledaren fick tillräcklig information om händelseförloppet av rökdykarna?

Från första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Definitivt

Från andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Definitivt

18. Skatta mängden radiokommunikation från <u>första</u> rökdykarparet under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

19. Skatta mängden radiokommunikation från <u>andra</u> rökdykarparet under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

20. Skatta hur väl rökdykarledaren observerade detaljer i brandförloppet (t ex förändringar i rök, ljud etc.).

Inte alls 1 2 3 4 5 6 7 Mycket väl

21. Hur väl kunde rökdykarledaren under övningens gång göra bedömningar angående hur mycket av sin kapacitet rökdykarna hade förbrukat (hur trötta de blivit)?

Inte alls 1 2 3 4 5 6 7 Mycket väl

22. Om de fick göra om övningen, borde rökdykarledaren göra något annorlunda?

Ja □ Nej □

Om ja, vad?_____

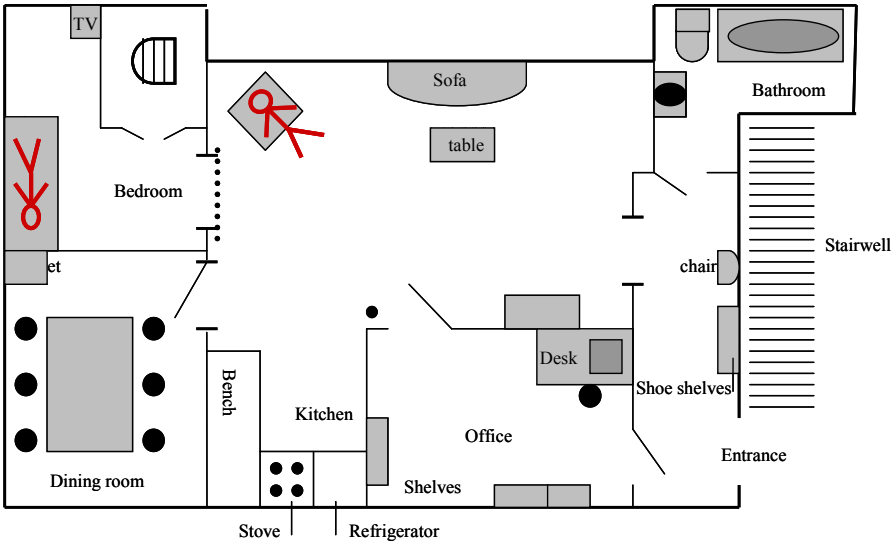
23. Finns det något den här gruppen borde träna mer på?

Tack för din medverkan!

Annelie & Ida

Appendix E – Approximate map of the exercise building

Upper floor



Lower floor