Improving emergency response through cognitive task analysis

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IMPROVING EMERGENCY RESPONSE THROUGH COGNITIVE TASK ANALYSIS

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Abstract

Society has a responsibility to aid its citizens in case of emergency. This calls for planning and preparations. However, societal emergency response activities are not always fully effective. This might be due to suboptimal emergency planning and preparations, with some planned response actions not working as intended. For example, it is possible that some actions show to be 'over-planned' with too much content detail, while other actions show a lack of adequate drill or information support. Each emergency has its own specific characteristics, and good emergency response demands conscious thought processes for guiding the interaction between the response and the dynamic course of events. Yet, some response generated demands almost always arise during emergencies (Quarantelli, 1997), and such demands should preferably be handled automatically. Thus there is a need for a mix of conscious and automatic processes during emergency response. Conscious processing has the ability to adapt to the present situation, but is relatively slow and confined to one thing at a time. Automatic processes are relatively fast and can operate in parallel, but can not be adapted to the situation. The question is which task belongs on which level. Rasmussen (1983) described a model over different cognitive performance levels, linking control mode (automatic vs. conscious) to situation (routine vs. novel problems). We believe that Rasmussen's ideas can be used throughout the emergency planning and response processes to sort tasks in accordance with their probable optimal mental control modes. Based on a study of emergency planning and response activities in the Swedish city of Malmö we propose and discuss an algorithm for guiding the selection of appropriate competence types for different tasks.

Introduction

In case of emergency society has a responsibility to support its citizens. This calls for planning and preparedness at different administrational levels. Due to the possible complexity of emergency situations planning is a very difficult task and may not always be as optimal as it could. Since it is not possible to predict future events in detail, one has to save some capacity for conscious processing of what is going on and 'on-line' problem solving.

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While the responses to a specific emergency situation are unique, there are some functions that are almost always needed in emergency response activities. Quarantelli (1997) discusses the concept of response-generated needs, and arrives at the conclusion that there are some generic needs that response organisations can be almost certain to face when activated. Such things are preferably prepared for in advance in such ways that they can be taken care of practically without any (mental) effort. There is a tendency during emergency planning to forget that some tasks can be executed in a reflex-like manner, while others necessarily have to be attended to with great mental effort. As a result, some actions get 'over-planned' while others get less attention than desirable. This might lead to sub-optimal response performance.

The aim of this paper is to describe a possible method for cognitive task analysis, to be used for improving emergency planning and response. The result is a schematic routine for sorting tasks in accordance with their probable optimal mental control modes. The empirical focus is on the example of manning/staffing in the emergency response organisation of the city of Malmö, but the general principle is what is important.

Emergency management in the city of Malmö during the Lebanon crisis of 2006

In the middle of July 2006 an armed conflict between Lebanon and Israel broke out. This resulted in a decision from the Swedish government to evacuate Swedish citizens from Lebanon. At the time many Swedes descendant from Lebanon were visiting their families during their summer holiday. In addition, many people with permanent residence permit in Sweden have moved back to Lebanon during the last years. A first estimate of the number of people that needed evacuation from Lebanon to Sweden was 3,500, but in the end about 8,000 people had been transported to Sweden and about 1,000 of them to the city of Malmö. The day after the evacuation of Swedish citizens began, Malmö started up a part of their emergency response organisation. Most of the people evacuated to Sweden arrived in Stockholm and was then transported by train or bus to other parts of the country. Busses and trains arrived at Malmö station where a reception committee was arranged. The reception committee provided information, and when needed also helped with places to stay and in some cases even with resources to buy food. Malmö also started up a support centre, primarily for worried relatives. In total, the Malmö response organisation worked for about three weeks.

During Malmö's emergency response activities to the Lebanon crisis the organisation initiated the emergency response activities according to plan, and the manning of the 'front line' (e.g. a psychological and social support centre) worked well. However, some other things did not work quite as well. When the front-line response activities were up and running deficiencies in the advance planning of the relief of personnel were revealed within the central organisation. The central organisation did not plan and prepare for long-term staffing. Because the crisis happened during the period of summer when most people in Sweden are on vacation there was hesitation to bring in more than a minimum of staff. This hesitation was due to cultural norms, and not to legal matters. As a consequence some individuals on duty were overloaded with tasks. The individuals responsible for arranging personnel rostering were occupied with other tasks, continually demanding their attention. After approximately one week, some people were exhausted. Further, they did not know neither whether nor when they were to be relieved. When pointing out fatigue and/or requesting relief, personnel were referred back and forth between managers, due to uncertainty on which mode the organisation was in, and accordingly on who was actually responsible for managing personnel relief in the central organisation. There was no planning and therefore no routines to immediately arrange and ensure a long-term manning. We conclude that the manning of the central organisation did not function properly in a long-term perspective. Put together, there was an obvious threat to the organisation's ability to continue operations. In the event of greater emergencies, perhaps with more acute threats involved, this could result in great negative consequences. These problems call for measures to prevent them from reoccurring.

Before the Lebanon crisis of 2006 occurred, Malmö's response organisation had some preparations related to manning. In their operational plan it was expressed that the need to ensure access to personnel and other resources is the main purpose of a contingency plan. In the plan we found some items interpreted as concerning manning, e.g.:

- During an emergency the support staff decides how many persons are needed for service. According to the plan the support staff shall also "Estimate the need for resources", "Work out a plan for the support staff" and "Plan the emergency response in detail". The plan also mentions "Schedule for relief", without any information on what or how to do. *Our comment: These tasks can be seen as concerning personnel rostering. Because of their vague formulations in the plan these tasks are left to be solved 'on-line'.*

- Each section-leader shall "Be responsible that the members of the section are relieved when needed". *Our comment: No instructions are given on how to interpret 'when needed', and no advance planning in this matter is actively supported in the operational plan.*

- Updated lists with names and telephone numbers for calling people in to duty.

As shown by the list of example items above staffing/manning is mentioned in some places in the operational plan. However, in none of the places any details are given regarding what and how to do. There are no explicit routines for how to manage personnel rostering.

Theory and method

Theory

Human performance varies between routine tasks and unfamiliar tasks, regarding e.g. cognitive functioning and capacity. It is well established that human activity consists of parallel processes occurring with different degrees of conscious control (e.g. Kellogg, 1995). A cognitive approach places consciousness in the short-term memory system (sometimes called working memory) (Baddeley, 1986). Human short-term memory has a limited capacity, literary meaning that one cannot hold more than a few things at a time active in memory (e.g. Miller, 1956; Baddeley, 1986). In each moment, a person can be consciously occupied with only one single thing, sometimes referred to as being in focal awareness (e.g. Marton & Booth, 1997). The same person can at the very same time be engaged in numerous other activities, taking place on other levels within the cognitive domain. In a specific situation the combination of the task at hand and the person determines which activities will take place, and on which cognitive level each activity predominantly will be executed.

Rasmussen (1983) describes a model of human cognitive performance, separating the skill-, rule- and knowledge-based levels. The model (simplified) is illustrated in figure 1. In the model, a certain stimulus is first tested at the S-level. If it is found (maybe falsely) to be familiar enough to be handled without conscious involvement it is responded to on the S-level. Otherwise it is passed on for check at the next higher level, the R-level. There a check is performed whether any prior experiences have established a rule of some kind that seems (maybe falsely) probable to be applicable in the situation. If a rule judged acceptable is found, the stimulus is responded to on the R-level. If no acceptable rule is found, the stimulus is passed on to the highest level (the K-level), where it receives conscious attention and demands precious mental resources.

Figure 1. A sketch of Rasmussen's S-R-K-model.
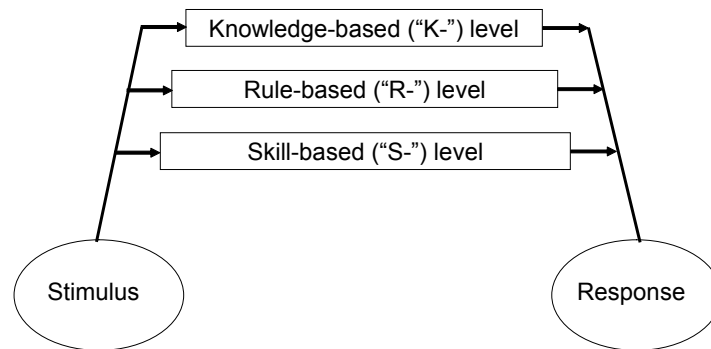
Performance at the *skill-level* typically takes place without conscious attention or control. In everyday life we usually perform several different tasks simultaneously at this level. Generally, much of human performance can be thought of as a sequence and coordination of building-blocks in the form of skilled acts. Such sequences of skilled acts can be guided by stored rules, describing procedures aggregating separate acts. Such rules belong to the next higher, *rule-based* level of performance. They can be empirically based on the individual's experience, stem from some other person, or be thought out deliberately. The actual performance is characterized by feed-forward control, i.e. the execution of one or several rules with little or no feedback guidance. Rule-guided action demands relatively little conscious mental resources. Conscious monitoring as part of a feedback control activity may be considered a concurrent activity at the highest, *knowledge-based* cognitive level. Note that there is interaction between the different levels, where different aspects of a complex response to a complex situation are taken care of at different levels (Rasmussen, 1983).

In unfamiliar situations, of which a person has no prior experience, there is a need for conscious, symbol-based analysis of the situation and its options for action (Rasmussen, 1983). This demands lots of cognitive resources, and must be done in a time-consuming, serial manner. On this so-called K-level goals are explicitly stated, and action is guided by feedback from mental or physical trials. Obviously, K-level activities are extremely dependent on the available mental model of the situation.

The level on which a certain task is performed may vary. Familiarity with a (type of) task and/or prior experience of similar situations makes it more probable that the task will be performed on a lower cognitive level in the S-R-K-hierarchy. In combination with the significantly more limited capacities at higher levels such a shift downward is highly desirable, since it frees valuable K-level capacity for what may need it more. The tendency of familiar tasks to gradually be performed on lower levels in the hierarchy and to accordingly need less conscious control is what sometimes is referred to as automation (through experience). The downside with automatic processes is that they in themselves cannot adapt to the situation.

Bearing in mind these characteristics of human performance and different levels within the cognitive domain, what can be done in advance in order to increase the likelihood of successful performance? On the K-level, the ability to swiftly construct mental models can be strengthened. Here, e.g. access to previously tested constructs and symbols to use in conscious elaboration can be of great help. This can be addressed by training and education. Competence on the S- and R-levels can be built up through routines and exercises that build up experience.

To optimize emergency response, preparations should aim to free as much as possible of the responders' precious and limited K-level capacity to what needs it the most. Typically, this

may be critical thinking and problem solving, used to adjust emergency response to the actual situation.

Method

The aim of this paper is to describe a possible method for cognitive task analysis, to be used for improving emergency planning and response. The method was developed using data from a study of Malmö's handling of the Lebanon crisis of 2006. Found weaknesses in Malmö's response activities were analysed and conceptualized in S-R-K-terms (Rasmussen, 1983). From that conceptualization we formulated an algorithm (a structured process) for checking anticipated emergency response actions against the S-, R- and K-levels, aiming to sort tasks in accordance with their probable optimal mental control modes.

The study of the Malmö handling started with an examination of journal notes from the response organisation's information system and notes and minutes from managerial meetings during the events. Documents such as written preparedness plans and organisational charts were also studied. From analysis of the initial material an interview guide was constructed, and a series of interviews were conducted with people who had participated in the response organisation. In an iterative process additional informants and documents were identified. In recurring meetings with a high-rank representative from Malmö's organisation our tentative understanding of the intended plan as well as of implemented actions during the Lebanon crisis were checked. As an overarching strategy, we aimed at triangulation of facts through the use of several sources of information with partly overlapping scope. This strategy brought a "convergence of evidence" (Yin, 2003, p 100), strengthening our confidence in the reliability of our findings.

Results

Considering which cognitive level would be suitable for different (sub-) tasks might help in forming and elaborating emergency planning and preparations. Such sorting might build upon Rasmussen's S-R-K-model (Rasmussen, 1983). An algorithm for emergency planning encompassing an S-R-K-based optimization might look like this[4]:

1. Identify the probable aim (-s) of a future emergency response.

2. Think out successions of actions that would lead to the fulfillment of the aim (-s) identified. This might be accomplished using e.g. backtracking or task analysis.

3. For each identified action, strive to place things as low as possible in the S-R-K-hierarchy and try to avoid overloading the limited K-level of individuals during actual response activities. Ask the following questions:

    *   How could this be done as simply as possible?

    *   Could it be done on the S-level? If so, then what is needed?

    *   If not, could it be done on the R-level? If so, then what is needed?

    *   Is the task probable to (partly) need the K-level? If so, what can be done to create circumstances that facilitate this?

    *   Can routines, information or training help to simplify fulfillment of the action?

Demonstrating the algorithm

Malmö's handling of the Lebanon crisis of 2006 revealed a lack of planning and preparation for long-term staffing within the central organisation. Due to this, some individuals were near exhaustion and long-term operability was threatened. Applying the proposed algorithm to a

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[4] Steps 1 and 2 in the algorithm are found in practically all emergency preparedness processes.

short, simplified example restricted to the manning problems reported from Malmö might look like this:

1. Aims of response activity: Provide psycho-social support and emergency housing.

2. Necessary actions: To conduct the emergency response activities intended there was a need for personnel. Since people cannot work intensely for more than a short period of time without a significant drop in productivity (and perhaps also in health), sooner or later there is a need for personnel relief. Therefore it is necessary to plan and prepare for prolonged manning. Examples of sub-tasks related to the manning need:

   a) The identification of response tasks needed in the present situation.

   b) The identification of manning needs in relation to the situation. How many persons are needed for each task? When? How long shifts are realistic? Etc.

   c) The identification of persons in the organisation suitable for identified tasks related to the situation.

   d) Communication with staff selected to call in.

3. S-R-K-sorting: The first of the sub-tasks above (*a*) requires K-level attention. The latter three sub-tasks (*b-d*) can all be facilitated by preparations of routines, check-lists etc., that has the possibility to transform them from mentally challenging to more or less effortless automatic activities on the S- and R-levels. If successful, that would free K-level capacity for guiding the interaction with the dynamic course of events.

The brief example above shows that it is possible that the problems concerning manning could have been avoided if the proposed algorithm had been used as a tool when developing Malmö's operational plan.

Discussion

We have shown how making use of knowledge about human cognitive abilities and limitations might help to construct better emergency planning and response. The idea of making S-R-K-analyses as part of emergency planning can be seen as making use of knowledge from the fields of human factors and cognitive psychology in emergency management. The short and simplified example above does not include details, and serves only to give an illustration. In real practice much more detail is needed.

The ideas presented in this paper might seem trivial. Trying to think about what might happen, which actions are probable to be needed, which tasks they imply, and then how these can be prepared for are not new ideas. Yet, the discussion above about the Malmö example has shown that the emergency preparation process might benefit from the aid of theories and models that help structuring the analytical process of foreseeing. We believe that considering which of the S-, R-, and K-levels that would be optimal for different sub-tasks can help in several ways. For example, the concept of different cognitive levels can in itself shed light on otherwise overlooked sub-tasks, e.g. ones that are taken for granted because they usually happen automatically. It is also possible to not fully consider the need for K-level resources associated with certain classes of tasks. Such misses can significantly lower the ability of a response organisation.

S-R-K-analysis of operational planning does not solve all problems, but it might help in avoiding some problems from occurring. It can by no means stand alone. 'The big picture' is needed first – it is necessary to have some grasp of possible scenarios before one can start working out response needs, appropriate tasks, and then probable optimal cognitive levels to put them on. At best, it might contribute as a complement to e.g. different kinds of risk and vulnerability analyses.

Other approaches to tackling the example problems concerning manning discussed in this paper could aim at norms and knowledge within the organisation. A general understanding of

the generic response need for persistent long-term manning seems to be a fair goal in that direction. Another example could be a clarification of the responsibilities concerning manning within the organisation. These approaches could be used along with S-R-K-analysis of operational planning. To just put more resources at the problem, e.g. through putting more individuals at the task of manning, would probably be effective but not as efficient as (combining it with) preventive S-R-K-analysis of anticipated manning tasks.

We believe that S-R-K-analysis can be applied to more than manning tasks. Probably it can be used generally in preparedness planning. It would be very interesting to test the proposed S-R-K-analysis algorithm in further contexts, develop more detailed method recommendations and gather more information on its possible merits as a preventive tool.

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