Adaptive Team Behaviors for Coping with Unexpected and Unknown Situations - An Observational Study

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ABSTRACT

Industries with high risk-potential like nuclear power plants need to manage abnormal potentially critical situations on team level for assuring reliable and safe operating. Safety is looked at as a "dynamic non-event" (Weick & Sutcliffe, 2001) and therefore has to be continually built on by the operating team through adaptive actions in relation to the situational context. The team processes and behaviors used for achieving shared mental models (or common situation awareness) are especially interesting for good problem solving, decision making and adaptation. In our study we collected data from eight four- to seven-person control room teams working in a nuclear power plant in Switzerland during their annual training in the interactive simulator of the plant control room. Simulations of two different scenarios were videotaped. The simulator scenarios generate an unexpected unstandardized situation (situations that were not covered / could not be solved solely by standard operation procedure) the team has to solve in order to stabilize the plant. Additionally, we got individual data by a questionnaire to capture individual characteristics of the team, especially regarding professional experience. The results still have to be considered as explorative in nature, due to the small sample size and time consuming coding of further additional team behaviors.

Keywords: Adaptation, Team Cognition, Safety, Nuclear Power Plant

INTRODUCTION

Industries with high risk-potential like nuclear power plants (NPP) need to manage abnormal potentially critical situations on team level for assuring reliable and safe operating. According to Weick and Sutcliffe (2001), safety is looked at as a "dynamic non-event" and therefore, it has to be continually built on by the operating team through adaptive actions in relation to the situational context. Apart from the strategy to handle unexpected, potentially critical situations by highly standardized procedures, teams have to be capable to switch to flexible team coordination in order to manage situations that are not covered by standardized procedures and to find the right balance between standardization on the one hand and flexibility and openness to changes in unexpected situations on the other (Ritz, 2012; Grote, Kolbe, Zala-Mezö, Bienefeld-Seall and Künzle, 2010). The breaking point between the highly regulated work-process structured by standard operating procedures and the necessity of problem solving in abnormal situations seem especially interesting for assessing adaptive capability in teams. Especially the development of modified situation awareness (or shared mental model) within the team seems to be important for effective adaptive problem-solving and decision-making when unexpected and unknown situations (that means there

are no existing standard procedures for handling these situations) occur. The accurate situation assessment is the basis for further problem-solving activities and should involve intensive phases of information exchange and reflexion within the operating team with possibilities for speaking-up (esp. reactor operators) and updating (esp. foreman / supervisor) (Kolbe, Burtscher, Wacker, Grande, Nohynkova, Manser, Spahn and Grote, 2012). The adaptive process that is necessary for handling changing task requirements, is characterized to a bigger part by "a fundamental activity of groups (that is) … the integration of individual knowledge into collective knowledge." (Okhuysen and Eisenhardt, 2002, p. 370)

The working context in the operating room of a nuclear power plant (NPP) is characterized by the special situation of a complex expert organization (Vidal, Carvalho, Santos and dos Santos, 2009). Such an organization can be looked on as a distributed cognition environment, where nobody has complete information about everything that is happening at a particular moment, so the operators need to share their cognitions to be able to operate the plant in a more resilient way. Especially in this environment the explicit coordination of information sharing seems essential for good team-performance in problem-solving and decision-making. Information collection and exchange in the operating team of a nuclear power plant is mainly dominated by the shift supervisor (team leader). Vidal et al. (2009) described that during problem-solving situations, the strictly centralized control mode is modified and all team members submit hypothesis and participate in a collective decision-making process supplying information. However, all the information is submitted to the shift supervisor who has the ultimate authority to make decisions. Sharing information is the main way, team members use to cooperate in control room environments. The coordination of this information sharing process by the shift supervisor seems to be important for the adaptation of the team.

In our research project TeamSafe we had the opportunity to observe operating teams in a training simulator when they managed scenarios with unexpected and unknown situations - that means they had to cope with a task situation where they did not have a developed operating procedure to follow. Our aim was two-folded: First, we wanted to explore and better understand the process of regaining control over the situation by the team, that mean adapting as a team for coping with new situational demands - so we wanted to explore the process used by successful teams. Second, we combined these successful activities we had identified into a method for guiding adaptive team process by a "formal intervention" (Okhuysen, 2001; Okhuysen and Eisenhardt, 2002) (see also, Brüngger, Kleindienst, Koch and Ritz, 2014).

The following study was done to a large extent on the basis of research of Waller (1999) as well as Waller, Gupta and Giambatista (2004) with regard to the main assumptions of adaptive behaviours. There also has been an important influence from Kolbe, Strack, Stein and Boos (2011) for the inclusion of coordinative behaviours.

TEAM ADAPTATION IN THE CONTROL ROOM TEAM

Adaptive Team Behaviors

Adaptive behaviours occurring after the recognition of changing situational circumstances by the operating team will serve primarily for orientation within a "new" environment (Waller et al., 2004; Burke, Stagl, Salas, Pierce and Kendall, 2006). That means the main interest within the team has to be to gather relevant information about the actual state of the environment, in the case of the nuclear power plant, the plant and the main systems. Information collection behaviors have been shown to be extremely important to crew performance under high workload conditions (Stanton, 1996) and involve collecting and recognizing information concerning the need for action (Waller, 1999). Behaviours of searching and collecting information are important tasks in situation assessment on the individual level. On the team level, the individually collected information and knowledge about the system status, has to be exchanged, that means processes of horizontal interaction and communication should take place so that the individual knowledge is spreading out in the team and individual information is integrated for becoming common information. The interaction process for information exchange to determine the status quo within the situation is two-folded: on the one hand, there are actions to get information from others (asking/questioning), on the other hand giving information without being asked or in a dialogue. Information collection also plays an integral role in both individual and team performance when looking at the development of situation awareness. Operators of complex systems collect information about system cues in their environments, comprehend that information in terms of the current situation and their past experience, and use that information to project future situation problems and

dynamics (Endsley and Garland, 2000). At the team level of analysis, the collection of information by team members plays a critical role in increasing the team's awareness of the situation (Prince and Salas, 2000).

Besides the above mentioned adaptive communicative behaviours of information collection and exchange, Waller et al. (2004) looked at behaviours of task management as central for the adaptation process on the team level. Task distribution refers to the effective allocation of tasks as a process whereby a team can shift the workload among its team members to achieve balance during high-workload, time-pressured or emergency situations. Waller (1999) also found that high-performing crews are significantly more likely than other crews to engage in task distribution behaviors during nonroutine situations.

Coordinative Team Behaviors

Coordination of team process and collaboration is one of the central activities in teams. Coordination can be defined as "the process by which team resources, activities, and responses are organized to ensure that tasks are integrated, synchronized, and completed within established temporal constraints" (Cannon-Bowers, Tannenbaum, Salas and Volpe, 1995, p. 345). Burtscher, Wacker, Grote and Manser (2010) defined coordination (in medical teams) "… as those activities of team members that aim at organizing the joint task execution …" (p. 283). In professional teams there is often a specialized function or position with regard to coordination of task delegation or distribution and the coordinated moderation of the communication process. Within the operating team this function mainly is hold by the shift supervisor (Schichtchef) who is in charge of decisions.

In unexpected and unknown situations it is thought that coordination activities have to be changed to face the challenges of new and unstructured situational demands. Burtscher et al. (2010) defined adaptation or adaptive coordination as “a team´s ability to change its coordination activities in response to changing situational demands, such as the occurrence of unexpected events and varying task characteristics (e. g. level of task load, degree of standardization, time pressure)" (p. 283). Burke et al. (2006) described as one mode of adaptation the adjusting process, i.e. changes in coordination mechanisms, decision making, and communication patterns in response to unexpected events. For example Zala-Mezö et al. (2009) have shown that teams in healthcare adapt their coordination pattern to changing situational demands. The relationship between adaptation and team-performance has to be investigated more deeply.

When task demands are changing, coordinative activities have to be adapted and adjusted according to these changes. If there is the necessity of more information exchange during a new situation, coordinative behaviors have to encourage this. This could also mean a change of the coordinative strategy. One important basic mechanism for a broad information collection with the participation of all team-members seems to be a high ("optimal") attentional level or mindfulness within the team. That means for example, that the shift supervisor is open (attentive) for input of all team members as well, as the team members are able to promote their informational input, that means, can get attention of the shift supervisor. Coordinative behaviors that can foster these basic processes of attention level could also be non-verbal behaviors, like pointing (gesture for orienting attention; see also pointing and joint attention, Tomasello, 1999). Bangerter (2004) describes the role of pointing for focusing attention in dialogue.

Another explicit coordinative behavior that could have a positive influence on the attentional level within the team, could be "addressing someone by name" (Kolbe et al., 2011). For example this could appear when shift supervisors are distributing tasks to team members or questions are posed to a team member. The attentional influence of hearing subjectively important information like one's own name for example is known as the "Cocktail Party Effect" (Cherry, 1953).

The role of these coordinative behaviors should be explored more in detail with regard to the adaptation in teams.

Development of Shared Mental Model / Shared Situation Awareness

The above mentioned adaptive and coordinative behaviors have essential functions in the adaptation of teams to changing task environments. But as Waller et al. (2004) emphasize: "Engaging in adaptive behaviors might be helpful to crews managing the emergence of nonroutine situations and high workloads in dynamic environments, but research suggests that engaging in adaptive behaviors alone might not always lead to success for control crews. Without a gestalt of the current state of the multiple systems they manage, the plan to implement if problems should arise, and the actual problem or problems at hand, control crews might engage in adaptive behaviors because they have been trained to do so, but still might be unable to coordinate their behaviors and contain system problems quickly and correctly." (p. 1536) This means, that without integrating the coordinated collected information into a

new, resp. modified knowledge structure (mental model) concerning the new task situation and required measures, adaptation will not be effective.

According to Waller et al. (2004) there are numerous definitions and conceptualizations of shared mental models. For a review they refer to Mohammed and Dumville (2001). Rouse and Morris defined shared mental models as "a mechanism whereby humans generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states" (Rouse and Morris, 1986, p. 360). Shared mental models provide team members with a common knowledge structure that helps them predict what other team members will need and will do during excessive-workload conditions and therefore help teams quickly adapt their activities during nonroutine situations (Cannon-Bowers et al. 1993; Waller et al., 2004).

Communication processes used by groups to convey information during problem-solving episodes such as shared mental model development are critical to overall group performance (Weick and Sutcliffe, 2001). During these communication processes the proximity of group members has direct effects on group communication and performance. Groups with members that are located physically near each other are able to engage in face-to-face communication during problem solving and are more able than other groups to communicate nonverbally, as well as verbally. Nonverbal communication includes facial expression, eye contact and movement, and physical gestures and can greatly enhance the amount of information communicated in a group setting (Feldman, 1992 according to Waller et al. 2004, p. 1537).

Uitdewilligen, Waller and Pitariu (2013) in their recent study investigated whether team mental model updating - changing mental models in line with changes in the task situation - is positively related to team performance in a situation requiring adaptation and they emphasize the importance of extending the view from a static perspective to a dynamic view of updating of mental models with regard to adaptation in teams: "Authors have emphasized the importance of the structured knowledge team members have regarding their task or team in the team adaptation process (Burke et al., 2006). In particular, team mental models - team members mental representations of knowledge, relationships, or systems - are considered pivotal for successful team adaptation (Cannon-Bowers et al., 1993). However, previous work, while explicating the role of mental models in team adaptation often take a static perspective on team cognition, focusing on characteristics such as similarity, accuracy, or quality. Yet research from the field of managerial and organizational cognition suggests that under dynamic task circumstances, it may not be the momentary stable characteristics of mental models that impacts performance, but the ability to update mental models in light of changing task situations." (p. 129).

Beside of adaptive behaviors for exchanging information within the team, special interaction activities for ensuring common situation awareness (shared mental model) should be regarded. Okhuysen and Eisenhardt (2002) pointed on the mechanisms of "formal interventions" that focus on the improvement of the group process as a potential way to achieve superior knowledge integration. Formal interventions provide explicit instructions for the group to follow and help guide the discussion among members. "These process interventions are designed to create a more structured group discussion, and enhance the communication of personally held information … These formal interventions are intended to structure the group process so that more knowledge is revealed and effectively combined." (Okhuysen and Eisenhardt, 2002, p. 340, 341)

Conclusion and Research Question

Team adaptation in the control room team is a complex process with a lot of different mechanisms running on the individual and on the team level. Perhaps this complex process in the special configuration of an operating team in a nuclear power plant resembles the process within an orchestra which individual parts are synchronized or harmonized by their score, their expertise and by the conductor.

Only a few team processes resp. behaviors have been theoretically mentioned above, but these are looked at being in the center of team adaptation. Collecting and exchanging information from the environment, coordinating the process in the direction of synchronization of the individual actions and re-building a common cognitive (knowledge) base in form of situational awareness or shared mental model should be the basic activities in coping with unexpected situations.

The empirical study we conducted in a Swiss NPP aimed to explore these basic adaptive processes by means of behavioral observation within a real working context as well as to develop a device for supporting operating teams in coping with unexpected and unknown situations (see also, Brüngger et al., 2014).

EMPIRICAL STUDY IN A NUCLEAR POWER PLANT

The observations for this study were made during the annually scheduled training simulations with eight control room teams (four to six persons per team, 61 persons in total). Simulations were audio- and videotaped. Each team worked on the same two simulation scenarios, which had been developed by instructors of the simulation training unit. The scenarios contended non-routine situations that should be handled under a slight pressure of time. Each team member held a specific role in each scenario (shift supervisor (Schichtchef 1), control room supervisor (Schichtchef 2), primary operator (Primäroperateur), secondary operator (Sekundäroperateur), shift technical advisor (Pikettingenieur) and an additional third reactor operator in some of the groups). Some roles had been switched between the two scenarios. The recordings were coded in the software "Noldus Observer", using a coding scheme in dependence to Waller, Gupta & Giambatista (2004). Adaptive behaviors, coordinative behaviors and group discussion phases were coded for each team and analyzed on individual levels (e.g. shift supervisor) as well as on a collective team level. The group discussion phases were considered as phases, where a shared mental model was developed.

Organizational Context

The study was conducted by the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) in collaboration with a Swiss nuclear power plant over a three-year period.

The aim of this project is to identify successful adaptive team behaviors in critical situations within control room teams and to provide the findings not only as a base for further research but also for the use in actual practice. The recordings for the study were made during the annually scheduled training simulations from 2011 to 2013. In the first phase (2011), successful coping mechanisms in critical and non-standardized situations were identified within the control room teams. On the basis of these findings and theoretically based considerations, a prototype of a structuring tool has been developed. It supports control room teams in the process of problem-solving and decision-making in non-routine and potentially critical situations not covered by standardized procedures (see also, Brüngger et al., 2014). In the second phase (2012), the new tool was introduced during the simulator trainings and adapted afterwards by means of the control room team members' feedback.

The composition of control room teams

Control room teams usually consist of a leading shift supervisor (Schichtchef 1), a control room supervisor (Schichtchef 2), a primary operator (Primäroperateur), a secondary operator (Sekundäroperateur) and a shift technical advisor (Pikettingenieur) who is contacted in emergency situations. An additional third reactor operator optionally complements the team (monitoring of the digital readouts and reserve pool employee (Libero) or carrying out actions outside of the control room (Anlagenoperateur)). The shift supervisor bears responsibility for the decisions reached by the team. In the recorded simulation scenarios, each of the four to six team members held one of the mentioned roles. The roles of the shift supervisor and the control room supervisor as well as of the primary and the secondary operators had been switched between the two scenarios. Defining a team as a certain composition of roles, after switching roles in scenario 2 the teams are considered as different, even though the persons remain the same.

The preliminary results are thus based on the sixteen simulations recorded in 2012. The recordings of the simulations in 2013 are still being coded and will be added to the analysis as soon as possible.

Situational requirements for the control room teams: Simulation scenarios

Whereas routine work follows structured guidelines and processes lead by the shift supervisor, in non-routine situations all team members are equally involved in a collective problem-solving process (Vidal et al., 2009). Following Vidal et al. (2009), the work in the control room of a nuclear power plant is characterized by the fact that none of the team members ever possesses complete information about a present situation. Everybody has to share his cognitions (e. g. perceptions, estimations,…) with the other team members in order to be able to stabilize the plant. Especially in non-standardized situations, it is fundamental that the members share information of their areas of responsibility, which leads to a collective understanding of the actual situation as a basis for successful problem-

solving. The shift supervisor is meant to coordinate this process of information exchange.

The simulation scenarios had been developed by instructors of the simulation training unit and generated a non-routine, unexpected and potentially safety-critical situation which could be handled within 30-60 minutes. The generated problems could lead to a more severe situation if not contained within a certain amount of time. Due to the fact that the simulated scenarios consisted of non-routine events, the known procedures did not lead to a solution of the problem given. It therefore became necessary for the team to identify anomalies and elaborate adequate counteractions in a collaborative problem-solving process. Pressure of time and dimension of workload can both be considered as moderate.

The design of the scenarios' complexity was led by the objective that differences in team performance should be shown. The team performance was assessed by the instructors of the simulator training centre by rating the quality of the technical solution.

Aims and Hypothesis

As already mentioned above, the aim of this research project is the description and explanation of adaptive team behaviors within the control room team that have an impact on safety oriented coping in unexpected and non-standardized situations. In order to handle such situations, teams have to be capable to switch to flexible team coordination and to build collective understanding of the actual situation through an interactive information-exchange process within the team. In dependence on theories and empirical findings in literature (Waller et al., 2004; Kolbe et al., 2011) this study focuses on cognitive structures and behaviors supporting a successful collective problem solving process in non-standardized situations.

Based on the indications of previous research (Waller et al., 2004; Kolbe et al., 2011), it was postulated that successful teams would engage more in adaptive behaviors, coordinative behaviors and group discussion phases (development of shared mental models) and that there would be a positive correlation between these behaviors and team performance.

Data Coding and Team Performance Categorization

The recordings were coded in the software "Noldus Observer", using a coding scheme according to Waller, Gupta & Giambatista (2004). Adaptive behaviors (information collection, information provision, task distribution) were coded for each team member as well as group discussion phases for each team. Group discussions are defined as phases of collective reflection of gathered information, of cause identification in order to build a collective situational understanding as well as of decision making among the team members. Moreover, two additional coordinative behaviors guiding attention were coded, since they had been identified as potentially relevant during the first, rather explorative phase of the project (2012): Pointing and addressing by name.

The coding scheme has been elaborated by the research team in dependence on Waller et al. (2004) in an evolving process of testing, reflecting and adapting. To set the final version of the coding scheme some videos were double coded by two different researchers to allow for assessment of interrater agreement. The final agreement can be described as acceptable to good.

The team performance was assessed by the instructors of the simulator training centre by rating the quality of the technical solution.

A questionnaire has been handed out to all the participants, aiming at a descriptive characterization of the teams, such as age average, level of education, period of employment or degree of familiarity among the team members.

Statistical evaluation

The results have to be considered as preliminary so far, by reason of the small number of cases (sixteen simulations). The simulations of the third phase (2013) are currently being coded and will be integrated into further data analysis.

In order to analyze the correlations between the adaptive behaviors within the teams and the team performance, Spearman’s rho has been calculated. Additionally, differences between groups rated with either specially high or low performance have been explored. Furthermore, correlations between the showed adaptive behaviors on the individual level of the responsible shift supervisor and his group’s performance have been focused. Preliminary results are presented in the following chapter.

Results

In this status of the research process, no significant correlations between adaptive behaviors and team performance were found, neither between coordinative behaviors and team performance. There was also no significant correlation detected between development of mental model (team discussion) and team performance. The results could be influenced by two limitations: Firstly, the actual sample size has to be considered as small (N=16) and secondly, the team performance measure was generally rated high ("ceiling effect"). After the scenarios of the third training simulation in 2013 will have been coded, these data will be integrated into the analysis as well as into further evaluation.

There are some individual results of interest for further exploration. With respect to development of mental model (team discussion) two results can be pointed out: The moment of the beginning of the first team discussion correlates positively with team performance (r = 0.32, Sig. 0.84, N = 16). That means successful teams begin later with the first team discussion than less successful teams.

We could speculate that the beginning of discussion in the team could be relevant for the further evolution of the problem-solving process. The timing of the team discussion sequences should be taken into account as well as the relation of team discussion and adaptive and coordinative behaviors as patterns of interaction (see also Waller, 1999; Stachowski, Kaplan and Waller, 2009). For example it could be relevant if there is a relation between the amount of information collection and the beginning of the first team discussion. Given the fact that the actual sample size is very small and the result is not significant, it should be seen as a tendency setting a basis for further exploration.

Another result of interest is the correlation between the time spent on team discussion and the degree of familiarity within the team (r = 0.409, Sig. 0.058, N = 16). This result indicates that teams with high familiarity between team members spend more time on team discussion than teams with a lower degree of familiarity. We could speculate that mechanisms like psychological safety or trust within the team could be of relevance for the participation of team members in the discussion (the more they are involved, the longer the phases of discussion would last). Psychological safety and trust could also have an influence on the willingness of the shift supervisor to let team members participate in the decision making process. Further data analysis with more focus on detailed interaction processes during team discussion phases are being planned.

Whereas adaptive team behaviours and team discussions only occur during non-standardized phases, when official guidelines cannot any longer be followed to handle the situation, coordinative behavior as "addressing by name" can appear in both standardized (sP) and non-standardized (osP) situations.

The analysis of only one of the two scenarios (N=8) showed two different significant correlations between the number of the behavior "addressing by name" and team performance: "Addressing by name" in non-standardized situations (osP): r=0.676, Sig. 0.0333 (N=8) and "addressing by name" in standardized situations (sP): r=-0.688, Sig. 0.030 (N=8). These results show that successful teams display the coordinative behavior "addressing by name" during unstandardized phases more often than less successful teams (in scenario 2). This correlation is reverse for standardized routine work: In a standardized situation successful teams show the behavior "addressing by name" less often than less successful teams. It could be speculated, that different kinds of cognitive modes are required in standardized and unstandardized working phases. The functionality of the behavior "addressing by name" with regard to attentional influence could therefore change with the actual situation and the cognitive modes required.

Furthermore, a nearly significant positive correlation between the coordinative behavior "addressing by name" displayed by the shift supervisor and team performance was found: r=0.479, Sig. 0.061, N=16. The comparison between groups with a high and groups with a low team performance rating revealed that shift supervisors of the best performing groups showed the behavior "addressing by name" three times more often than shift supervisors of the lowest performing groups.

CONCLUSIONS

Due to the limitations we mentioned before (small sample size, ceiling effect of the performance measure, time consuming analysis) the reported results should be seen as tendencies and as signs we have to check in more detail when the data base and our understanding of the complex process is growing. The conclusions therefore are generally drawn with regard to further needs of analysis.

Two main complexes seem to be of interest for further and more detailed analysis: First, the contribution of team discussion phases (as formal interventions) and second, the role of the shift supervisor for coordination and synchronization of team activity / collaboration.

The results show no clear proof of the significance of team discussion phases for team performance. In further analysis it should be looked in more detail on the interaction processes going on during team discussion. They could differ regarding the participation of team members, the coordination of shift supervisor and also with regard to the topics discussed (e. g. updating/exchanging information, updating by the shift supervisor, reflecting new information, ...).

So far it was looked on team discussion without considering the time-course (sequence) and development of team discussion phases or the sequences of time-discussion phases combined with different adaptive or coordinative behaviors. By doing this, perhaps there could be identified typical development patterns of discussion phases or interaction patterns and processes typical or especially successful for adaptation. In the first step this analysis of sequence should be qualitative and descriptive because of the small sample size and the time consuming procedure of sequence analysis.

Second, the role of the shift supervisor for the coordination of the adaptation process should be analyzed in more detail, especially the use of coordinative behaviors by the shift supervisor in relation with situational demands. It could be looked for different styles of coordination by the shift supervisor and their success by managing the interaction process. The influence of the coordinative actions of the shift supervisor could be especially looked on in phases of team discussion.

In general, focusing the interest on the integration of individual knowledge to common knowledge by team interaction within phases of team discussion seemed theoretically and practically especially important for a better understanding of successful adaptation in the operating team. According to Pavitt (1993, see Okhuysen and Eisenhardt, 2002, p. 371) researchers rarely examine how interventions (like team discussion) actually work to help groups modify their process to more effectively integrate knowledge, but there should be more attention to actual changes in the interaction among individuals. The complexity of the dynamic adaptation process makes it difficult to look only for one behavior or factor as a cause for good performance. Therefore, the identification of (interaction-) patterns should be one aim of further analyses besides the inclusion of the data of the third project phase (2013) in our statistical analyses.

REFERENCES

Bangerter, A. (2004). Using Pointing and Describing to Achieve Joint Focus of Attention in Dialogue. *Psychological Science*, 15(6), 415-419.

Brüngger, J., Kleindienst, C., Koch, J., Ritz, F. (2014). PUMA - Development and Application of a Tool for Supporting Nuclear Power Plant Operating Teams in Unexpected and Unknown Situations. *Proceedings of the 5th International Conference on Applied Human Factors and Ergonomics (AHFE), Kraków (Poland), July 19th-23rd 2014*.

Burke, C.S., Stagl, K.C., Salas, E., Pierce, L., Kendall, D. (2006). Understanding Team Adaptation: A Conceptual Analysis and Model. *Journal of Applied Psychology,* 91, 1189 – 1207.

Burtscher, M.J., Wacker, J., Grote, G., Manser, T. (2010). Managing Nonroutine Events in Anesthesia: The Role of Adaptive Coordination, *Human Factors* 52, 282-294.

Cannon-Bowers, J. A., Tannenbaum, S.I., Salas, E. and Volpe, C.E. (1995). Defining competencies and establishing team training requirements. In: *Team Effectiveness and Decision Making in Organizations*, eds. R. Guzzo, E. Salas. Wiley, 333-380.

Cherry, E. C. (1953). Some experiments on the recognition of speech, with one and with two ears. *Journal of the Acoustical Society of America*, 25, 975–979.

Endsley, M. and Garland (eds.) (2000). *Situation Awareness Analysis and Measurement*. Mahwah, NJ: Lawrence Erlbaum Associate

Grote, G., Kolbe, M., Zala-Mezö, E., Bienefeld-Seall, N., Künzle, B. (2010). Adaptive coordination and heedfulness make better cockpit crews. *Ergonomics* 53: 211 – 228.

Kolbe, M., Strack, M., Stein, A., Boos, M. (2011). Effective Coordination in Human Group Decision Making: MICRO-CO: A Micro-analytical Taxonomy for Analysing Explicit Coordination Mechanisms in Decision-Making Groups. In: *Coordination in Human and Primate Groups,* ed. M. Boos. Berlin: Springer.

Kolbe, M., Burtscher, M. J., Wacker, J., Grande, B., Nohynkova, R., Manser, T., Spahn, D. R., Grote, G. (2012). Speaking up is related to better team performance in simulated anesthesia inductions: an observational study. *Anesthesia and analgesia*, 115(5), 1099-1108.

Künzle, B., Zala-Mezö, E., Kolbe, M., Wacker, J. and Grote, G. 2010. Substitutes for leadership in anaesthesia teams and their impact on leadership effectiveness. *European Journal of Work and Organizational Psychology,* 19, 505-531.

Mohammed, S. and Dumville, B.C. (2001). Team mental models in a team knowledge framework: Expanding theory and measurement across disciplinary boundaries. *J. Organ. Behavior*, 22, 89-106.

Okhuysen, G. A. (2001). Structuring change: Familiarity and formal interventions in problem-solving groups. *Acad. Management Journal*, 44, 794-808.

Okhuysen, G. A., Eisenhardt, K. M. (2002). Integrating Knowledge in Groups: How Formal Interventions Enable Flexibility. *Organization Science*, 13(4), 370-386.

Prince, C., Salas, E. (2000). Team situation awareness, errors, and crew resource management: Research integration for training guidance. M. R. Endsley, D. J. Garland (Eds.), Situation Awareness Analysis and Measurement. Lawrence Erlbaum & Associates, Hillsdale, NJ, 325-347.

Ritz, F. (2012). Organizational trust and trust in automated systems as predictors for safety related team performance - Results from a cross- cultural study. *Proceedings of the 4th International Conference on Applied Human Factors and Ergonomics (AHFE)*, San Francisco (USA), July 21th-25th 2012, pp. 7249-7258.

Rouse, W. B. and Morris, N. M. (1986). On looking into the black box: Prospects and limits in the search for mental models. *Psychological Bulletin*, 100, 349-363.

Stachowski, A. A., Kaplan, S. A., Waller, M. J. (2009). The benefits of flexible team interaction during crises. *Journal of Applied Psychology*, 94, 1536-1543.

Stanton, N. (1996). *Human Factors in Nuclear Safety.* Taylor & Francis, London, U.K.

Tomasello, M. (1999). *The Cultural Origins of Human Cognition*. Harvard University Press, Cambridge (Mass.)/London.

Uitdewilligen, S., Waller, M. J., Pitariu, H. (2013). Mental Model Updating and Team Adaptation. *Small Group Research*, 44(2), 127-158.

Vidal, M.C.R., Carvalho, P.V.R., Santos, M.S. and dos Santos, I.J.L. 2009. Collective work and resilience of complex systems. *Journal of Loss Prevention in the Process Industries*, 22, 516-527.

Waller, M. J. (1999). The timing of adaptive group responses to nonroutine events. *Academy of Management Journal*, 42, 127-137.

Waller, M. J., Gupta, N., Giambatista, R. C. (2004). Effects of Adaptive Behaviors and Shared Mental Models on Control Crew Performance. *Management Science*, 50(11), 1534-1544.

Weick, K., Sutcliffe, R. (2001). *Managing the unexpected. Assuring high performance in an age of complexity.* San Franciso, CA: Jossey-Bass.

Zala-Mezö, E., Wacker, J., Künzle, B., Bruesch, M., Grote, G. (2009). The influence of standardisation and task load on team coordination patterns during anaesthesia inductions. *Quality & safety in health care*, 18, 127-130.