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Title

Learning from safety events in healthcare: A sensemaking and mental model perspective

Abstract

Organizational learning from safety relevant events is critical for improvement of healthcare practice. The identification of causes of safety events in hospitals and the design of improvements engage decision making processes that involve a high degree of interpretive activity by various professional groups (physicians, nurses, risk managers, pharmacists, etc.). From a sensemaking perspective (Weick, 1995, Weick, Sutcliffe, & Obstfeld, 2005), we conceptualize the event investigation and action planning processes as driven by cognitive structures that help individuals understand an event from their own perspective, based on their experience, anticipation of what could happen, professional education and situational perceptions. To better understand these processes, we propose an individual-level framework suggesting that the construction of causal scenarios and the design of improvements are influenced by habitual mental models that contain assumptions and knowledge about safety and accident causation as well as by the analysts' perceived action repertoires in defining corrective actions.

Various influences on the individual cognitive processes in event analysis are discussed, such as professional education, cognitive style, organizational tools, culture, and the use of safety theories. As the framework is intended to stimulate future research, potential research questions and methods are discussed.

1 Introduction

1.1 Learning from safety events in healthcare

Hospitals, in common with organizations in many industries managing safety hazards, seek to identify the causes of safety events and near misses in order to make improvements. They use various organizational learning mechanisms (Lipshitz & Popper, 2000) centered around the investigation of patient safety events, e.g., incident reporting systems, root cause analyses (Nicolini, Waring, & Mengis, 2011), or morbidity-mortality meetings. For the more serious events, hospitals often apply a structured approach (e.g., root cause analysis tools) to find out what factors contributed to the event. These activities are typically conducted by multi-discipline teams to integrate various perspectives and to be able to access relevant information. In this paper, we will present an individual-level framework to describe the cognitive structures and processes involved in event analyses in the healthcare context. As learning from safety events is a key process for improving healthcare, our framework describes what cognitively drives causal inquiry and corrective action planning.

Hospitals are complex organizations embracing various challenges such as using latest technology, doing research, teaching, and caring for patients within one organization, along with facilitating the collaboration of staff with various professional backgrounds (nurses, physicians, managers, pharmacists, etc.) while facing increasing financial pressure. The causal structures of patient safety events reflect this complexity. Basically, there are many potential causes and ways to address them, given the ambiguity of each event and the uncertainty of what actually contributed to it and how it would best be prevented in the future. Therefore, individuals have to make many decisions under uncertainty about what they think caused the event and how the countermeasures will affect the identified causes.

Although event investigations (which are often called root cause analyses) in hospitals (Tamuz, 2011) and other industries (Carroll, 1995) appear to be formal and rigorous, there are many varieties of practice that are applied in an intuitive and variable way. The same event in different hospitals could be attributed to different causes and different corrective actions could be designed; even in the same hospital, similar events may have different interpretations depending on the individual analysts or particular contextual details. It is therefore important to know how individuals make sense of these inherently ambiguous event reports in order to take action. This sensemaking (Weick, 1995, Weick, Sutcliffe, & Obstfeld, 2005) activity needs to be understood more fully for its ability to inform and enrich theories of decision making as well as the opportunity to improve learning and thereby safety and quality.

The tendency to blame individuals in the aftermath of adverse events is an often discussed impediment to developing systemic improvements in healthcare (Catino, 2008). Individually-oriented explanations are associated with actions targeted toward individuals and also to a culture of blame (e.g., Runciman, Merry, & Tito, 2003) and make it difficult to design organizational action that might effectively prevent the event in the future (Perin, 1995). Incident investigators tend to begin their analyses by considering staff near to where the problem emerged rather than situational circumstances, i.e., they apply a sharp end focus (Carroll, 1995; Reason, 1990). The call for a systemic focus in event analysis and improvement design has been brought forward by researchers, practitioners and consultants alike. By following a more system-oriented mental model, people may regard incidents as a symptom for problems located deeper in the organization, taking into account the various interrelations of tools, tasks and work environments (Dekker, 2005). However, the system model may have its own limitations in reducing individual accountability and initiative. Our proposed framework is designed to guide further research on understanding this phenomenon, and the consequences that are attached to using different mental models in event analysis.

Thereby, we adopt a descriptive approach in acknowledging that each mental model has its advantages and potentially appropriate settings for application.

1.2 Aims of the paper

In this paper, we propose a theoretical framework to describe relevant cognitive processes and structures acting in understanding an event, in assessing its consequences and contributing factors and in imagining improvements. In adopting a sensemaking perspective (Weick, 1995, Weick, Sutcliffe, & Obstfeld, 2005) we conceptualize the event investigation and action planning processes as driven by cognitive structures that help the individuals understand an event from their own perspective, based on their experience, anticipations of what happens after the analysis, professional education and situational perceptions during the analysis. We propose that people make sense of adverse events by using internal mental models that store knowledge, assumptions and information related to safety improvement. While it is well-known that attributed causes guide future behavior (e.g., Spector, 1982), we further propose that the *anticipation* of action possibilities also guides sensemaking (c.f., action repertoires, Weick, 1995). The framework is developed to provide a basis for future studies of organizational learning from events in high-risk environments, while integrating prior research.

1.3 Mental models about safety and accident causation

Events and situations are described and explained by representing them mentally, i.e., in using mental models. The term mental model has been used in prior research, e.g., in system dynamics, cognitive psychology, strategy, management science, learning and instruction (see Kolkman et al., 2005, for a more comprehensive list). For organizational learning, Kim (1993) emphasized the role of mental models that “help us to make sense of the world we see and they can also restrict our understanding to what makes sense within the model” (p. 39).

Due to cognitive limitations of humans and to the plethora of conditions that can be interpreted as causes of an event, event investigators need to reduce complexity and simplify the event and its potential causes in order to be able to represent it mentally (Burns, 2000). We propose that they use habitual mental models about accident causation and safety to guide them in their cognitive assessment of an event. The habitual mental models develop over time and are cognitive structures containing a more or less rich, diversified, and interrelated set of assumptions, beliefs, and knowledge about what makes people and an organization work safely, what usually causes accidents, and what process the event investigations should follow. In the analysis situation, the habitual mental model supports the construction of meaning and is at the core of the decision-making processes in analyzing the event and planning change, because it defines the information that is used and the perspective that is taken on defining the problem. Thus, the habitual mental model directs attention and acts as a filter in perceiving and defining what circumstances, actions, conditions and factors are perceived as relevant in the event situation (Kolkman et al., 2005). The habitual mental model of an individual may be very rich and sophisticated or may consist of rather unrelated assumptions and heuristics that are rarely reflected upon, such as the primacy of a root cause or individual blame.

Evidence produced in root cause analysis may seem objective – it is, however, a social construction of an interpretation of an event and stays within the mental models the analysts apply to it. Rasmussen (1990) showed that the causes that people attribute to an event depend on the implicit frame of reference they are using. For example, implicit stop-rules determine the end of the causal search depending on the availability of a cure or on the familiarity of a cause (see also Hilton & Slugoski, 1986). While an engineer

may focus on technical aspects, a psychologist might end the search for causes with something related to human behavior, e.g., poor collaboration between teams.

For car drivers, Kouabenan (1998) showed that the beliefs about accident causation can lead to a perception of control or of lack of control over risks. For example, car drivers having fatalistic beliefs about accident causation perceive less personal control over whether an accident happens to them and thus behave more risk-prone, have more accidents, and exhibit more self-defensive attributional patterns in their event explanations.

1.4 Perceived action repertoires in event analysis

From an attribution theory perspective, identifying underlying causes is considered to be an important step for taking effective measures in organizational learning from a negative event (DeJoy, 1994). Yet, the organizational context may determine the perceived action possibilities and thus also direct the causes that are identified. Sensemaking is intimately tied to action (Weick, 1995; Weick, Sutcliffe, & Obstfeld, 2005). Accordingly, a study of root cause analysis teams in the British National Health Service (Nicolini et al., 2011) found that investigation teams tend to focus on what they can influence: Event investigators faced difficulties if problems pointed to conditions that were out of their control and thus worked on actionable rather than necessary changes. Therefore, the interpretation of an event is influenced by what people anticipate being able to do about it, i.e., the perceived action repertoire. According to Weick (1995), contextual features influence the extraction of cues which are then used to interpret situations and to develop meaning from them. This means that small contextual features can have large effects on organizational learning, e.g. the organizational level of the analysis (unit or organization-wide), the composition of the team, the type of event, and so forth.

In order to illustrate the influence of action repertoire on the event investigation, consider a drug error, where instead of the right drug, a look-alike drug was administered. In taking into account how the situational circumstances of the analysis impact the action repertoires, we can understand how different analysis results may develop: If pharmacy was involved in the event analysis and they collaborated with the pharmaceutical companies to solve the problem of look-alike drugs, this might direct the analysis towards a more system-oriented solution, e.g., to improve labeling processes of the pharmaceutical company (or the purchasing processes of the hospital). If, in contrast, the analysis team had less formal power and there were no relations to pharmacy or to the managers purchasing the drugs, the action repertoire would be much more narrow and the event more likely be interpreted as a training problem of the administering nurse, because there is an available, actionable cure of additional training.

2 Conceptual framework on individual cognitive processes in event investigations

We have developed a framework focused on the cognitive processes that are at the core of causal analysis and action planning in organizational learning from events (see figure 1). We propose three cognitive structures: (1) a habitual mental model about accident causation and safety, which interacts with (2) a perceived action repertoire in constructing (3) a causal scenario. From this causal scenario, the improvement actions are designed to address selected causes. We furthermore expect these cognitions to be influenced by personal and situational factors.

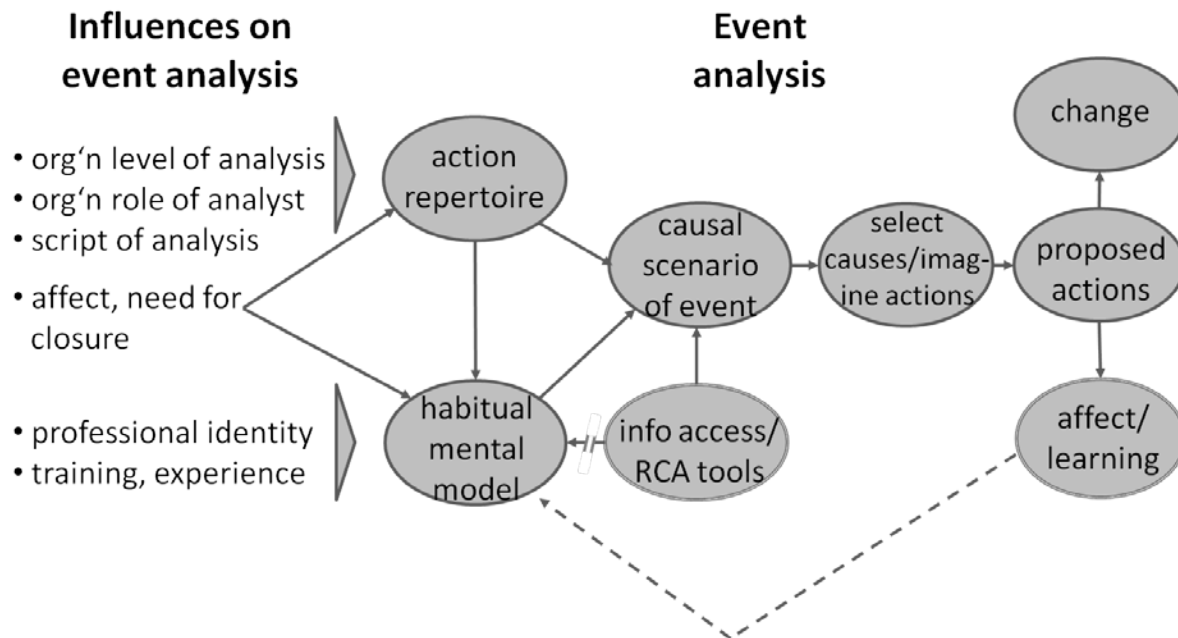


Figure 1. Conceptual framework for the proposed project

Causal scenario. Event investigators act on a mental representation of the event. The causal scenario of an event is the mental representation of causes of the event that the event investigator develops in the analysis. This causal scenario is developed in an iterative process using the available information and knowledge drawn from the person’s habitual mental model and perceived action repertoire. The more sophisticated and rich the habitual mental model, the more complexity she or he might be able to represent in the causal scenario of the event. We expect furthermore that the need for closure and negative affect influence the complexity and kinds of causes represented in the causal scenario (see later section on the role of affect and need for closure). The process of developing a causal scenario of the event is characterized by mental simulations and counterfactual thinking (Hilton, McClure, & Slugoski, 2005; Klein & Crandall, 1995). Although our framework is presented in a linear manner, the causal search is an iterative process that includes anticipation of action steps. Event investigators may have varying access to information about the event and about events in general, depending upon the team composition and the resources available to them.

Habitual mental model. We assume that the habitual mental models are activated in order to make sense of the event, and direct attention to causes that are “thinkable” within the model, and away from other possible causes. For example, the tendency to blame individuals for an event is based on a particular mental model that focuses attention on individual knowledge and skill. Although this mental model has been very effective in reducing individual errors, it misses many opportunities for improvement based on attention to the larger system (organization of work, teamwork, equipment design, supportive resources, etc.).

Carroll (1995) identified ‘root cause seduction’ as a tendency to think in linear cause-effect terms and to avoid ambiguous interpretations, which results in narrow focus on a single cause. The practice of finding a “root cause” is part of a habitual mental model that people apply to make sense of events, and that is embedded in many applied procedures of root cause analyses (e.g., Vincent, Taylor-Adams and Stanhope, 1998). However, in complex systems such as hospitals, there is no single cause for an event, but events are always caused by multiple influences interrelating with each other. From this perspective, it is hardly

possible to weigh the causes and separate them into “root cause” and “contributory factors” (Leveson, 2012). However, root cause is a culturally widespread habitual mental model that encourages selection of implementable interventions.

Accordingly, mental models about accident causation may contain beliefs such as ‘safety is following rules’, or ‘safety is acting mindfully’. To which extent a certain belief is actualized defines what the analysts look for in the analysis of an event. According to the belief that safety is ensured when everybody closely follows rules and procedures, instances of non-compliance with rules would be seen as the causes for an event – and, possibly, developing a procedure to ensure that rules are followed would be proposed as an improvement of safety. There are manifold examples in healthcare, where such a control logic (Carroll, 1998) is applied to try to make hazardous practices more safe, i.e., when double-check procedures are introduced for reducing errors in administering drugs. Other mental models may include systemic influences such as financial pressure, for example.

Perceived action repertoires. We propose that the perceived action repertoire influences the causal search by focusing on what is considered feasible. It is expected to be defined by contextual features such as: the organizational level of the incident investigator and the anticipated audience for the analysis, whose degree of authority make action possibilities seem more or less possible. Unit level analyses by investigators with little authority are likely to produce incremental, local solutions, in comparison to higher-level analyses with organizational leaders involved in the analysis or as sponsors, who bring a broader scope of possible actions (Bunderson & Reagans, 2011). Presumably, clinicians working at the sharp end perceive a different action repertoire than risk or quality managers, and nurses have different roles, authority, and viewpoints than physicians, for example. The ‘solution-driven search’ that was diagnosed to be a part of the culture of engineers in problem analysis (Carroll, 1995), may be applicable also to medical professions, especially physicians. It means that the search for causes is basically skipped in favor of finding a quick solution, because they may feel that it is against their culture to talk about problems without knowing a solution. This effect can increase the impact that the perceived action repertoire has on the causal search.

Selection of causes. In moving from a causal scenario to the recommendation for improvements, analysts have to make choices about which of the identified causes they seek to address (see also Hilton & Erb, 1996). The selection of causes from a set of influential conditions is driven by their relevance to a good or actionable causal explanation (Hilton & Erb, 1996). The process of imagining a corrective action to address the causal background of an event is driven by the same logic that produced the causal explanation: the event investigator has to choose the action(s) that he or she thinks will address the problem. A cause may be chosen because people know of a cure (see Carroll 1995, Rasmussen, 1990), hence the action repertoire can guide the selection of causes. For example, diagnosing “lack of training” as a cause for an event is basically a rewording of the solution, i.e., training is the proposed corrective action. Thus, the problem that is identified to have caused the event is fit to an already available solution (see also garbage can model, Cohen, March & Olsen, 1972). Furthermore, causes may also be used as explanations and rationalizations for a corrective action that is preferred because it is easy to implement or conforms to the habitual mental models in use or offers more status to a favored group that controls the new actions.

Professional identity. Attribution patterns reflect mental models that are acquired from socialization within certain professional groups. Event analyses bring together different professional groups (physicians, nurses, risk managers, pharmacists, etc.) with different responsibilities, expertise, and multiple habitual mental models of what is important for the safety of the organization. While physicians and nurses are working at the ‘sharp end’, risk managers tend to work more disconnected from direct

patient care, which gives them a different perspective on risks and how they should be managed. Pharmacists are involved with all hospital units but have a very different perspective on the clinical process from their remote, centralized location (Tamuz, 2011; Edmondson, 1996). Gherardi, Nicolini, and Odella (1998) showed that different communities of practice (i.e., different professional groups) develop differing views about safety and accident causation within one organization. Nurses have a general role identity as a safeguard for the patient's wellbeing that is very centered on caring (Piliavin, Grube, and Callero, 2002). For example, nurses were found to be more comfortable than physicians in discussing errors and in reporting them (e.g., Wild & Bradley, 2005). In contrast, physicians live in a different "thought world" (Dougherty, 1992) that was traditionally centered around expertise and individual competence. Schein (1996) described how members of different professional groups will often not notice that there are underlying assumptions that govern the different forms of overt behavior, which impedes effective organizational learning. The framework therefore proposes an influence of professional group membership in attributing causes and defining corrective actions.

Training and experience. Hilton and Slugoski (1986) argue that what people consider as normal is highly dependent on their knowledge and prior experience. In the analysis of the Concorde disaster (Hilton, McClure & Sutton, 2009), debris on the runway may be regarded by many people as the root cause of the accident, because it led to the bursting tire, which itself produced debris that finally ruptured the fuel tank. For an expert, debris on the runway is normal, because it happens frequently and can hardly be avoided. Therefore, an expert might look elsewhere to explain why the accident occurred and knowledge background is an important predictor of which conditions or events people may perceive and select as potential causes. Rasmussen (1990) showed that implicit stop-rules determine the end of the causal search depending on the familiarity of a cause (see also Hilton & Slugoski, 1986).

Additionally to the knowledge about the context in which the event happened, knowledge and training in root cause analysis procedures or formal safety theories may play an important role in the cognitive processes. In gaining more experience in event investigations, especially in interaction with diverse kinds of events and colleagues with a variety of mental models, people may develop more stable and rich habitual mental models about safety and accident causation.

Root cause analysis (RCA) tools. Root cause analysis tools and training are intended to complement and enhance intuitive judgment so that people can extract more useful lessons and implement changes to improve safety. There exist various approaches and procedures in practice (Nicolini et al., 2011). For example, the tool proposed by Vincent, Taylor-Adams and Stanhope (1998; see also Taylor-Adams, Vincent & Stanhope, 1999) is based on Reason's (1990) accident causation model and directs attention to organization and management decisions, work environments such as shift patterns, team factors, individual factors such as task motivation and attitude, and patient characteristics. According to Vincent (2003), the analysis of clinical events needs to include a definition of the care-management problems, which are the healthcare equivalent to Reason's (1990) unsafe acts. After the care management problems have been identified, they are linked up with potential contributory factors. According to the kind of RCA procedure, the investigating team relies on written records and interviews with the staff involved, to discover information on what exactly happened. We expect the procedures and embedded categories of causes in the RCA tool to inform the construction of causal scenarios and corrective actions and, over time, the development of habitual mental model about safety as well as the perceived action repertoire.

Role of affect and need for closure. Although learning from past events in root cause analysis settings means that the actors learn from events they were not necessarily involved in, the analysis may lead to distress and negative affect. For example, the occurrence of a certain patient safety event may question the

control one has over similar work processes, especially for doctors whose professional identities rest of their being “iron men” (Kellogg, 2009) and perfect. For physicians, Fischer et al. (2006) highlighted the strong emotional response to the idea of committing error that is expected to affect the interpretation of events. We expect that in situations of negative affect people tend to narrow their attention (Fredrickson & Branigan, 2005) and construct simpler scenarios that help in coping and include causes that imply that the negative conditions raised by the occurrence of an adverse event can be addressed quickly and effectively. Making sense of an event means creating feelings of structure and order (Weick, 1995) and reducing cognitive dissonance (Festinger, 1957) or negative affect to which the event potentially gives rise. The extent to which an individual needs to find a mental representation that suggests order and reduces complexity varies between persons and situations. The need for closure (Kruglanski & Webster, 1996) refers to the tendency of an individual to find clear answers and avoid ambiguity. People with a high need for closure direct their cognitive processes toward firm and clear representations of an event. For finding solutions that are instantly feasible, it may be easier to blame the individual involved in an event and propose punishment or training, thus avoiding complex systemic causes that are poorly understood and not easily actionable (e.g. changing the design of a workplace, or initiating cooperation between hospital units). Thus, we expect that people who have a higher need for closure also terminate the causal search more quickly whereas people with a low need for cognitive closure tolerate more ambiguity and tend to construct more complex scenarios, including causes that may not be instantly actionable.

For the analysis of reported events, we expect that counterfactual thinking (e.g., Markman, & Tetlock, 2000; Sirois, Monforton, & Simpson, 2010), i.e., comparing an event to an imagined more desirable version of it, may lead to negative affect, especially in situations where patients have been hurt. In contrast, downward counterfactuals imagining a worse outcome of an event, may lead to positive feelings. Future research could investigate whether this mechanism applies to event investigations, as it may explain how the type, i.e., severity of an event influences its analysis (Ellis, & Davidi, 2005).

Scripts about event analysis and improvement activity. Knowledge about and familiarity with event analysis and improvement procedures will support the development of an internal script (Schank, & Abelson, 1977) of how event investigations usually unfold. Organizational learning procedures can be seen as collaborative learning scripts that define the learning objectives, the type of activities performed, the sequencing of activities, the distribution of roles, and the type of representation of script information (Kollar, Fischer, & Hesse, 2006). In an individual’s mind, the scripts may incorporate knowledge and experience about the kind of accountability that is usually applied to judge the event analysis. For example, in applying outcome accountability, the success of the event analysis will be measured in metrics of actually improved patient safety, whereas in applying process accountability the event analysis is evaluated on criteria relating to how it was done, i.e., whether a rigorous analysis was applied and whether it was documented in a written report (Markman & Tetlock, 2000). Knowledge about the organizational consequences of an event investigation influences the analysis process. For example, root cause analysts shifted to a mode of legitimization of their analysis and sanitized their reports from contradictions that had been discussed in the analysis (Nicolini et al., 2011). Knowledge about who will read the report and how it will be acted upon may also lead to the tendency to refuse naming certain groups or organizational members that are held responsible for the occurrence of an event (‘account acceptability’, Carroll, 1995). For example, event investigators tend to avoid blaming their leaders, or own unit, profession or group, which relates to Edmondson’s (2004) work on psychological safety in speaking up about errors when the team or the leader may feel threatened.

Turning event analyses into change. The ultimate goal of event investigation and improvement design is to change organizational activity in order to improve safety. Each potential improvement contains an assumption about how it will affect safety. In moving along from the causal scenario to improvement proposition and from the proposed action toward changing organizational practices, there may emerge gaps in the line of reasoning and acting.

For example, Carroll, Rudolph, and Hatakenaka (2002) found in other high-risk industries that the proposed actions often did not match the results of incident investigations. So even if the incident reviews addressed the underlying assumptions about work practices relevant to the problem, the proposed actions often remained superficial with respect to the actual problem. Furthermore, the transition from a written report with recommendations to the implementation of action can involve gaps, in part because people with different mental models are responsible for different phases of this learning and change process (Carroll & Fahlbruch, 2011).

2.1 Learning from events as formed by culture and culture-forming

Learning from events can be regarded as an interplay of action and interpretation over time (Weick, 1979), and as a way for an organization to produce meaning in interpreting incidents and accidents (Daft & Weick, 1984). Over time, the kinds of causes identified and the types of improvements implemented shape and reinforce the safety culture (Guldenmund, 2000; Harris, 1994), just as the predominant culture defines how events are discussed and interpreted (Hofmann & Stetzer, 1998). On a collective level, the habitual mental models that individuals use in event investigation form the theories-in-use (Argyris & Schön, 1996) of accident causation and safety. Carroll (1995) suggested that staff learns what is expected, acceptable, and important by experiencing how events are analyzed and actions taken. Mental models may be reinforced by their use, with new information interpreted to support pre-existing assumptions, making it difficult to disprove a mental model.

According to Schöbel and Manzey (2011), learning from adverse events in high-hazard organizations often leads to increasing numbers of rules, procedures and structures that are developed with the aim to prevent similar events from happening. This approach matches the ‘control stage’ of organizational learning in Carroll and Rudolphs’ (2006) four stage framework of organizational learning. The four stages apply to different modes of learning from events: From a ‘local stage’ (1), in which specialized knowledge and local improvisation are important and corrective actions tend to follow a shame and blame logic, organizations can develop to a ‘control stage’ (2), in which standardized rules or procedures are used to deal with ambiguity and reduce complexity. In moving to an ‘open stage’ (3), learning from experimentation across functional and hierarchical boundaries becomes possible. In the final ‘deep stage’ (4) processes of collaborative reflection (see also Engeström, 2001) and systems thinking are applied.

During the processes of organizational learning from events, tacit and explicit knowledge (Nonaka, 1994) is developed about what are acceptable outcomes of analyses, acceptable viewpoints on the events and what are the rationales to apply in approaching a patient safety event. In this context, individuals unconsciously learn messages that are inherent to the situations, which are not necessarily part of officially espoused theories (Argyris & Schön, 1996), i.e., deuterio-learning occurs (Bateson, 1972, Engeström, 2001, Lipshitz, 2000, Visser, 2007). Learning of a hidden curriculum or a theory-in-use (Argyris & Schön, 1996) may lead to the perception of two contradictory messages in a situation (double blind) and thus be detrimental to organizational learning. For example, when an organization strives to establish a non-punitive environment as an espoused theory, but the discussions in analyzing an event are centered around the question how a certain individual failure should be punished; or, when there are

reward systems that punish failure while a non-punitive approach to failure is advocated, the participant in the organizational learning process experiences conflicting messages.

2.2 Examples of the effects of different perspectives in analyzing an event

In order to exemplify how mental models influence causal thinking, we will discuss possible perspectives on an example safety event in using preliminary data from two members of different professional groups. In the second part of this section we will also take into account how formal safety theories may direct attention and shape causal attribution.

Causal scenarios from different professional perspectives

Preliminary results show that members of different professional groups develop distinct causal scenarios, for which we give two examples. In an interview to analyze the creation of causal scenarios and the design of corrective actions in event investigation, we ask the respondent to do an ad-hoc investigation of an event report. To mimic a real event investigation, the respondents can act like investigators in seeking information that we provide as the investigation unfolds.

Consider the following example safety event:

A patient in a post anesthesia recovery room fell from the bed even though a nurse realized the danger and tried to fix a safety rail on the bed 5 minutes before it happened. The nurse could not attach the bed safety rail available in the room, because it did not fit the type of bed. She then turned to another patient who needed her attention.

A clinical nurse manager and nurse by education brought forward many causes relating to the nurse's role and work in the hospital system. For example, she discussed the patient's state (level of consciousness and agitation, the motivation to leave the bed, age, type of surgery done, whether he was educated about the risk of falling), environment factors (such as the amount of work that day, the staffing and the availability of additional staff, the time of the day, whether there was a policy for risk identification for falls, the layout of the room and how it impacted her possibility to watch all the patients she was responsible for) and nurse factors (number of hours worked until the event, whether the nurse had all the necessary resources to do her job, e.g., the ability to call for help, whether she was trained and knew the fall policies in place). The respondent furthermore ruled out an error in the nurse's clinical reasoning, as the patient was not classified as high-risk for falls. The respondent furthermore identified an equipment issue, as the necessary safety rails were not available to the nurse, however, she did not discuss the reasons for the equipment failure very deeply.

To compare, a researcher in system safety who was trained with an engineering background framed the event from the perspective of why there was no available fitting rail. She discussed various causes relating to the rail-bed mismatch, such as the variety of different beds, the plan of the room and the storage of rails in it, and how the culture allowed that the rails were not provided in a sufficient number. She also discussed patient factors, such as his condition and drug use, staffing, and the workload of the nurse, but in a less deep way than the nurse manager did. Like the nurse manager, she discussed why the nurse did not call for help, but framed it as a culture issue, in asking whether the culture supported the nurses in asking for help.

Using our framework, we can argue that these different causal scenarios are developed because the respondents have different mental models about accident causation and experienced different action repertoires in their jobs and throughout their education that formed their habitual mental models through which they imagine what contributed to this event.

Applying safety theories in event investigation

Scientific theories propose ways to think about safety and accident causation for understanding why organizational accidents happen and how to prevent or mitigate their destructive effects. Examples include High Reliability Theory (Weick & Sutcliffe, 2007), Normal Accident Theory (Perrow, 1984), Systems Theoretic Accident Model and Process (STAMP, Leveson, Dulac, Marais, & Carroll, 2009; Leveson, 2012), and the Swiss Cheese Model (Reason, 1990). These formal theories can also act as a habitual mental models when people receive training and use tools and procedures derived from a theory.

High Reliability Theory (HRT, Weick & Sutcliffe, 2007, Weick, Sutcliffe, & Obstfeld, 2005) with its focus on mindfulness, is increasingly applied in healthcare (Tamuz and Harrison, 2006). HRT has found principles which highly reliable organizations use to maintain mindfulness and to contain damage in case of an accident. The theory suggests that in applying those principles, an organization can be managed to be highly reliable. The fact that there was no attachable, appropriate safety rail nearby could be interpreted as a lack of ‘sensitivity to operations’ (one principle in high reliability theory) by the facility managers responsible for the equipment of anesthesia rooms.

Reason’s Swiss Cheese Model (Reason, 1990) proposes that accidents occur when barriers fail that should prevent accidents, due to latent errors (which are system causes), or active failures, which are individual acts (but may also be related to system causes). This perspective aims at identifying latent conditions that may negatively impact the functioning of barriers and thus the prevention of accidents. This barrier model is very common in healthcare (Perneger, 2005), although it is being criticized for its idea that barriers fail for essentially random reasons (Leveson, 2012). The fact that there was no appropriate safety rail in the room might be regarded as a latent condition, i.e., a Swiss cheese “hole” in the room equipment. However, the event could also be interpreted as a sign of poor prioritizing by the nurse, because she did not stick to the task of putting a safety rail on the bed and should have called for help.

Normal Accident Theory (NAT, Perrow, 1984) directs attention to the coupling between organizational and technical components that can accelerate the spread of minor problems into major accidents before operators can react. Perrow argues that the probability of disastrous accidents increases with the complexity of the technical and organizational structures and draws attention toward how high-hazard organizations are regulated and controlled by external bodies and management and how society and policy makers decide which risk they are willing to take. Applied to the example event, a NAT-perspective could draw attention to decision-making in purchasing beds at the hospital, i.e., in asking how it came that there were (at least) two different kinds of beds. On an even higher system level, one might ask, why there is no standard to harmonize beds and safety rails.

Leveson’s STAMP (2012) theory proposes a system theoretic approach in which safety is considered a control problem, thus focusing design and investigation processes on identifying the control structures that organize the work and maintain or fail to maintain safety. In analyzing the fall from this perspective, one would ask how the control structure was designed, so that it was possible that there was no fitting bed rail in the room, including all the different decision-makers involved in equipping rooms on various organizational levels.

These are only examples of potential causes that may be brought up; in a real case they would be much richer and detailed. Furthermore, the same causes such as the nurse not calling for help can be developed from different perspectives, e.g., in framing it as a latent error (Swiss Cheese Model), or as a control problem, i.e., when staff does not feel comfortable to call for help (STAMP). However, in using the example, we can also illustrate the previously mentioned gap between identifying a cause and deriving a corrective action to address it: Identifying for example a lack of sensitivity to operations of the facility

managers as a cause does not mean that the corrective action is easy to determine. If this was the attributed cause, what should be done: Punish the facility managers for their failure, train them, make their salary contingent on number of falls and other performance metrics? Or, establish walkarounds for the facility managers to provide them with a better mental representation of the tasks performed in the rooms and better knowledge about the clinical processes? Or, redesign the beds, the rooms, the nurse staffing plan? To conclude, using a particular perspective in analyzing an event influences how causes are attributed and what corrective actions appear to be a good solution for the emerged problem(s). Regardless of whether the theories are always interpreted and applied as proposed by the researchers that developed them, they often serve as guiding schemes of how to manage safety. Even though these formal theories and analysis procedures exist, their application is not straightforward in practice, because each event needs to be interpreted to make sense of it.

2.3 Applying the framework to understand the development of safety theories

Applying our framework to the described theories, their differences may also be explained by the different theoretical, methodological (Leveson, Dulac, Marais, & Carroll, 2009), and socialization backgrounds that the researchers have. HRT researchers often use an ethnographic approach to study the organizational processes of high-hazard organizations that run without disasters and thus identify patterns of behavior and management strategies that appeared to support safety (Bourrier, 2011). In developing NAT, Perrow (1984) relied mainly on document analysis for retrospectively analyzing how accidents came to happen, thus shedding light on how dysfunctions in regulatory oversight, e.g., in the nuclear industry, and the complexity of a system contributed to the emergence of accidents. STAMP theory arises from a systems engineering background that conceptualizes safety as an emergent system property and acknowledges that safety is designed (or not) by the people who design and run organizations (Leveson, Dulac, Marais, & Carroll, 2009). Furthermore, the action repertoire that the researchers had in developing their theories may also have contributed to the way they reason about what produces safety in an organization. For example, systems engineers are usually involved in developing large systems, thus enacting the perspective that safety is not only emergent, but can be designed into the system. Reason's barrier model, with its focus on latent failures in the organization, directs attention to organizational structures and individual actions.

2.4 Safety culture as an attributional category

The notion of safety culture is being used increasingly in causal analysis (Guldenmund, 2000; Silbey, 2009) of events. Referring to safety culture as a cause makes action planning a challenge, e.g., it may be used as an excuse to avoid allocating responsibility. Investigating how the notion of safety culture is used as a cause in event analysis may give insight into what role culture plays in the habitual mental model. Is culture seen as something designable? What are the means by which culture is to be changed in corrective action design? Silbey (2009) argues that in using the notion of safety culture, an understanding of individual responsibility is fostered, because events are finally traced back to individual human actions and the norms and underlying assumptions that govern it. This perspective contrasts with the idea that safety culture enacts a systemic perspective on accident analysis. Analyzing how safety culture is used as a causal category in event analysis (Lawton, McEachan, Giles, Sirriyeh, Watt, & Wright, 2012) and which kinds of corrective actions are linked to it, will give rise to a deeper understanding of how practitioners view their own system and its changeability and into their habitual mental models about how accidents are caused.

3 Conclusions

In this paper, we propose to view individuals' cognitive processes in interpreting and analyzing a safety event as influenced by the interplay of three cognitive structures: habitual mental models about accident causation and safety, the perceived action repertoires, and causal scenarios, i.e., mental representations of the event. These three cognitive structures furthermore interrelate in explaining an event and in defining appropriate corrective actions.

Our framework supports future research to study the variation in mental models associated with healthcare professionals (nurses, physicians, healthcare managers, pharmacists, etc.), as well as the role of contextual features of the investigation process, of affect, and of cognitive style. Various research questions can be derived from the framework to be addressed in empirical studies. For investigating how habitual mental models about safety and accident causation influence the creation of causal scenarios and the design of corrective actions and whether there are differences between professional groups, interviews using a cognitive mapping approach could be conducted. Cognitive mapping (Ackermann & Eden, 2005; Laukkanen, 1994) of causal scenarios that are elicited by an event report may help to get deeper knowledge about the cognitive processes involved in event analysis. Furthermore, in studying the role that perceived action repertoires play in the event investigation and action planning processes, we can identify how contextual features of these processes (for example, the authority levels of the investigators, his or her work role, and the organizational level on which the analysis focuses) influence their outcomes.

In studying the written reports of root cause analyses, we can compare their use of causal categories and kinds of corrective actions between hospitals that have different organizational learning processes, and thereby gain insight in how different action repertoires shape the analysis outcomes. Additionally, in using this archival approach it can be investigated how the reports link to the actual corrective actions, in tracing reports forward to their corrective actions, and identifying in which ways the mental models applied in the analysis influence the change processes associated with learning from the event.

For studying how cognitive style (need for closure) and negative affect influence the use of mental models in the analyses of an event, an experimental setting could be used. Negative affect could be primed and its influences on the construction of a causal scenario assessed. The need for closure can be assessed with a survey scale (Webster & Kruglanski, 1994) and its influence on causal scenario construction tested both in experimental and survey settings.

Hopefully, research to test the framework will identify opportunities for improving event analysis tools and procedures to better support interdisciplinary collaboration involving different habitual mental models. In making explicit the mental models behind their analysis and recommendations, the results of our proposed research can empower investigation teams to think more broadly about actions and improvement possibilities.

References

- Ackermann, F., & Eden, C. (2005). Using causal mapping with group support systems to elicit an understanding of failure in complex projects: Some implications for organizational research. *Group Decision and Negotiation*, 14(5),355-376.
- Argyris, C. & Schön, D. A. (1996). *Organizational learning II: Theory, methods and practice*. Reading, MA: Addison Wesley.
- Bourrier, M. (2011). The legacy of the high reliability organization project. *Journal of Contingencies and Crisis Management*, 19(1), 9-13.
- Burns, K. (2000). Mental models and normal errors. *Proceedings of the 5th Conference on Naturalistic Decision Making*, Tammsvik, Sweden.
- Bunderson, J. S., & Reagan, R., E. (2011). Power, status, and learning in organizations. *Organization Science*, 22(5), 1182-1194.
- Carroll, J. S. (1995). Incident Reviews in High-Hazard Industries: Sense making and learning under ambiguity and accountability. *Organization Environment*, 9, 175-197.
- Carroll, J. S., Rudolph, J. W. & Hatakenaka, S. (2002). *Organizational learning from experience in high-hazard industries: Problem investigations as off-line reflective practice*. MIT Sloan Working Paper No. 4359-02. Retrieved from SSRN: <http://ssrn.com/abstract=305718> or doi:10.2139/ssrn.305718
- Carroll, J. S. & Rudolph, J. W. (2006). Design of high reliability organizations in health care. *Quality and Safety in Health Care*, 15 (Suppl. 1):i4-i9.
- Carroll, J. S., & Fahlbruch, B. (2011). The gift of failure: New approaches to analyzing and learning from events and near-misses.” Honoring the contributions of Bernhard Wilpert. *Safety Science*, 49, 1-4.
- Catino, M. (2008). A review of literature: individual blame vs. organizational function logics in accident analysis. *Journal of Contingencies and Crisis Management*, 16, 53-62.
- Cohen, M. D., March, J. G. & Olsen, J. P. (1972). A garbage can model of organizational choice. *Administrative Science Quarterly*, 17(1), 1-25
- Daft, R. L., & Weick, K. E. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review*, 9(2), 284-295.
- Dekker, S. W. A. (2005). Ten questions about human error: A new view of human factors and system safety. Mahwah, NJ: Erlbaum.
- DeJoy, D. M. (1994). Managing safety in the workplace: an attribution theory analysis and model. *Journal of Safety Research*, 25(1) 3-17.
- Dougherty, D. 1992. Interpretive barriers to successful product innovation in large firms. *Organization Science*, 3(2), 179-202.
- Edmondson, A. C. (1996). Learning from mistakes is easier said than done: Group and organizational influences on the detection and correction of human error. *Journal of Applied Behavioral Science*, 32, 5-32.
- Edmondson, A. C. (2004). Learning from failure in health care: frequent opportunities, pervasive barriers. *Quality and Safety in Health Care*, 13(suppl_2), ii3-9.
- Ellis, S., & Davidi, I. (2005). After-event reviews: drawing lessons from successful and failed experience. *Journal of Applied Psychology*, 90(5), 857-871.

- Engeström, Y. (2001). Expansive Learning at Work: toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*, 133-156.
- Fredrickson, B. L., Branigan, C. A. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition and Emotion, 19*, 313–332.
- Festinger, L. (1957). *A theory of cognitive dissonance*. New York: Harper & Row.
- Fischer, M. A., Mazor, K. M., Baril, J., Alper, E., DeMarco, D., & Pugnaire, M. (2006). Learning from mistakes. Factors that influence how students and residents learn from medical errors. *Journal of General Internal Medicine, 21*(5), 419-423.
- Gherardi, S., Nicolini, D., Odella, F. (1998). What do you mean by safety? Conflicting perspectives on accident causation and safety management in a construction firm. *Journal of Contingencies and Crisis Management, 6*(4) 202-213.
- Guldenmund, F. W., 2000. The nature of safety culture: a review of theory and research. *Safety Science, 34*, 215-257.
- Harris, S. G. (1994). Organizational culture and individual sensemaking: a schema-based perspective. *Organization Science, 5*(3), 309-321.
- Hilton, D. J., & Erb, H. P. (1996). Mental models and causal explanation: Judgements of probable cause and explanatory relevance. *Thinking and Reasoning, 2*(4), 273-308.
- Hilton, D. J., McClure, J. L., & Slugoski, B. R. (2005). The course of events: Counterfactuals, causal sequences and explanation. In D. Mandel, D. J. Hilton, & P. Catellani (Eds.), *The Psychology of Counterfactual Thinking*. London: Routledge.
- Hilton, D. J., McClure, J. L., & Sutton, R. M. (2009). Selecting explanations from causal chains: Do statistical principles explain preferences for voluntary causes? *European Journal of Social Psychology, 39*, 1-18.
- Hilton, D., & Slugoski, B. R. (1986). Knowledge-based causal attribution: the abnormal conditions focus model. *Psychological Review, 93*(1), 75-88.
- Hofmann, D. A., Stetzer, A. (1998). The role of safety climate and communication in accident interpretation: implications for learning from negative events. *Academy of Management Journal, 41*(6), 644-657.
- Kellogg, K. C. (2009). Operating room: relational spaces and microinstitutional change in surgery. *American Journal of Sociology, 115*(3), 657-711.
- Kim, D. H. (1993). The link between individual and organizational learning. *Sloan Management Review, 35*(1), 37-50.
- Klein G, Crandall B (1995). The role of mental simulation in naturalistic decision making. In P. Hancock, J. Flach, J. Caird, K. Vicente (Eds.), *Local Applications of the Ecological Approach to Human-Machine Systems*. Hillsdale, NJ: Lawrence Erlbaum.
- Kollar, I., Fischer, F., & Hesse, F. W. (2006). Collaboration scripts - a conceptual analysis. *Educational Psychology Review, 18*, 159-185.
- Kolkman, M.J., Kok, M., van der Veen, A. (2005). Mental model mapping as a new tool to analyse the use of information in decision-making in integrated water management. *Physics and Chemistry of the Earth, 30*, 317-332.
- Kouabenan, D. R. (1998). Beliefs and the perception of risks and accidents. *Risk Analysis, 18*(3), 243-252.

- Kruglanski, A. W., & Webster, D. M. (1996). Motivated closing of the mind: "Seizing" and "Freezing". *Psychological Review*, 103(2), 263-283.
- Laukkanen, M. (1994). Comparative cause mapping of organizational cognition. *Organization Science*, 5(3), 322-343.
- Lawton, R., McEachan, R. R. C., Giles, S. J., Sirriyeh, R., Watt, I. S., & Wright, J. (2012). Development of an evidence-based framework of factors contributing to patient safety incidents in hospital settings: a systematic review. *BMJ Quality & Safety*, 21(5), 369-380.
- Leveson, N., Dulac, N., Marais, K., & Carroll, J. (2009). Moving beyond normal accidents and high reliability organizations: a systems approach to safety in complex systems. *Organization studies*, 30, 227-249.
- Leveson, N. (2012). *Engineering a safer world. Systems thinking applied to safety*. Cambridge, MA: MIT Press.
- Lipshitz, R., & Popper, M. (2000). Organizational learning in a hospital. *Journal of Applied Behavioral Science*, 36, 345-361.
- Lipshitz, R. (2000). Chic, mystique, and misconception: Argyris and Schon and the rhetoric of organizational learning. *Journal of Applied Behavioral Science*, 36, 456-473.
- Markman, K. D., & Tetlock, P. E. (2000). Accountability and close-call counterfactuals: the loser who nearly won and the winner who nearly lost. *Personality and social psychology bulletin*, 29(10), 1213-1224.
- Nicolini, D, Waring, J., & Mengis, J. (2011). The challenges of undertaking root cause analysis in health care: a qualitative study. *Journal of Health Services Research & Policy*, 16 suppl.1, 34-41.
- Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), 14-37.
- Piliavin, J. A., Grube, J. A., & Callero, P. L. (2002). Role as resource for action in public service. *Journal of Social Issues*, 58(3), 469-485.
- Perin, C. (1995). Organizations as contexts: implications for safety science and practice. *Industrial and Environmental Crisis Quarterly*, 9, 152-174.
- Perneger, T. V. (2005). The Swiss cheese model of safety incidents: are there holes in the metaphor? *BMC Health Services Research*, 5, 71-78.
- Perrow, C. (1984). *Normal accidents: Living with high-risk technologies*. New York: Basic Books.
- Rasmussen, J. (1990). The role of error in organizing behaviour. *Ergonomics*, 33, 1185-1199.
- Reason, J. (1990). *Human Error*. New York: Cambridge University Press.
- Runciman, W. B., Merry, A. F., & Tito, F. (2003). Error, blame, and the law in healthcare - an antipodean perspective. *Annals of Internal Medicine*, 138, 974-980.
- Schank, R.C., & Abelson, R.P. (1977). *Scripts, plans, goals and understanding*. Erlbaum, Hillsdale, NJ.
- Schein, E. (1996). The three cultures of management: The key to organizational learning. *Sloan Management Review*, 38, 1, 9-20.
- Schöbel, M., & Manzey, D. (2011). Subjective theories of organizing and learning from events. *Safety Science*, 49, 47-54.
- Silbey, S. S. (2009). Taming Prometheus: talk about safety and culture. *Annual Review of Sociology*, 35, 341-369.

- Sirois, F. M., Monforton, J., & Simpson, M. (2010). "If only I had done better": perfectionism and the functionality of counterfactual thinking. *Personality and social psychology bulletin*, 36(12), 1675-1692.
- Spector, P. E. (1982). Behavior in organizations as a function of employee's locus of control. *Psychological Bulletin*, 91(3), 482-497.
- Tamuz, M., & Harrison, M. I. (2006). Improving patient safety in hospitals: contributions of high-reliability theory and normal accident theory. *Health Services Research*, 41, 1654-1676.
- Tamuz, M., Franchois, K. E., Thomas, E. J. (2011). What's past is prologue: Organizational learning from a serious patient injury. *Safety Science*, 49, 75-82.
- Taylor-Adams, S., Vincent, C., & Stanhope, N. (1999). Applying human factors methods to the investigation and analysis of clinical adverse events. *Safety Science*, 31, 143-159.
- Vincent, C., Taylor-Adams, S., & Stanhope, N. (1998). Framework for analysing risk and safety in clinical medicine. *British Medical Journal*, 316, 1154-1157.
- Vincent, C. (2003). Understanding and Responding to Adverse Events. *The New England journal of medicine*, 348, 1051-1056.
- Visser, M. (2007). Deutero-learning in organizations: A review and a reformulation. *Academy of Management Review*, 32, 659-667.
- Webster, D. M., & Kruglanski, A. W. (1994). Individual differences in need for cognitive closure. *Journal of Personality and Social Psychology*, 67, 1049-1062.
- Weick, K. E. (1995). Sensemaking in organizations. Thousand Oaks, CA: Sage.
- Weick, K. E., Sutcliffe, K. M., & Obstfeld, D. (2005). Organizing and the process of sensemaking. *Organization Science*, 16(4), 409-421.
- Weick, K. E., & Sutcliffe, K. M. (2007). *Managing the unexpected: Resilient performance in an age of uncertainty*. San Francisco, CA: Jossey Bass.
- Wild, D., Bradley, E., H. (2005). The gap between nurses and residents in a community hospital's error-reporting system. *Joint Commission Journal on Quality and Patient Safety*, 31(1), 13-20.