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Abstract. This paper questions the correspondance between resilience engineering theory and the theoretical fundaments of traditional CRM training, with its related behavior assessments. Reviewing the theoretical roots of CRM it is concluded that such concepts are rather founded in the information processing paradigm hiding the complexities of adaption to rapidly changing situations. An alternative approach to team training and team performance assessment, called Operational Resilience, is introduced. Operational Resilience is rooted in complexity theory and in theorizing cognition as a distributed phenomenon. The most important principles of Operational Resilinece are the focus on processes of coordination and control rather than behaviors, analysis of emergent interactions in multi-professional settings, focus on local production of meaning instead of normative accounds of situation awareness (or similar constructions), and finally analysing how to bridge the gaps caused by the inherent system complexity instead of counting and categorizing errors.

1 INTRODUCTION

Recent contributions on the topic of Resilience Engineering have developed new concepts and methodologies for training organizational resilience. In general terms, these concepts have been focused on the understanding of people's adaptative capacity to cope with complex working situations (Dekker, 2006; Nemeth, 2008). Methodologies of RE are still been developed in parallell with the adaption of some conventional methodologies (e.g. team training, risk assessment methods, crises management plans),

in order to provide various safety-critical industries with techniques to introduce resilience thinking in practice (Hollnagel, Paries, Woods & Wreathall, 2011).

In the wake of the development of Resilience Engineering the experience of Crew Resource Management (CRM) training, firstly in aviation, and secondly in healthcare, has been identified as a conventional training practice with potential for improving organizational resilience in highly complex technological settings, considering dimensions at thel level of the individual (e.g. leadership skills), team (e.g. communication, coordination), and the organization (e.g. safety culture) (Bergström, Dahlström, Henriqson & Dekker, 2010; Dekker & Lundström, 2007; McManus, Seville, Brunsdon, Vargo, 2007).

In this paper an agenda for the development of conceptual fundaments of sharp end team training, and team performance assessment, will be outlined. The proposition will be made that CRM concepts and methods should be reviewed, and tailored in light of resilience theory before being applied in training. First CRM principles and its epistemological fundaments will be discussed in order to present some fragilities of the traditional view. Then an alternative approach to team training and assessment, based on resilience theory, will be presented. Finally some implications for the analysis and training of sharp end performance will be outlined.

2 TRADITIONAL CRM-PRINCIPLES

The currently established starting point to understand sharp end work is fundamentally based on the information processing paradigm, in which the human is seen as a stimuli-response system (Hollnagel & Woods, 2005). From this paradigm, “folk models” of what goes on in the human mind (e.g. concepts such as “Situation Awareness” or “Complacency”) follow naturally and seem to provide a simple and seductively convincing way of understanding human work in safety critical systems (Dekker & Hollnagel, 2005).

The study of man as a stimuli-response system puts the focus on human behavior, such as making correct and rational decisions based on optimal information processing based on accurate awareness of the situation, assertive communication and effective interaction between leaders and followers. The ultimate implication of the information processing-paradigm in the field of current Human Factors and CRM training is the use of different techniques to assess such behaviors. Some examples are the use of behavioral markers to (such as NOTECHS, KSA markers) and different forms of Line Operation Safety Audit (LOSA), which is focused on counting and categorizing errors.

Although these models and techniques are simple to understand and use this simplicity comes with a price. The price one pays by adapting to these models is that they exclude or hide the complexities of the multiple factors, which can support and enhance local adaption in unforeseen situations.

3 AN ALTERNATIVE APPROACH

An alternative approach to understanding sharp end work in safety critical systems needs

to be based on the perspectives provided by Complexity Theory and cognition as a phenomenon distributed among the actors engaged in a specific context (Hutchins, 1995a). It brings about the possibility of focusing on complexity and coupling of interactions in joint human-machine systems thus shifting from human cognition and behavior analysis to Operational Resilience.

From Comlexity Theory the corollary that a system cannot be fully described nor fully controlled (Cilliers, 2005) is important for understanding safety-critical work. Complexity is what emerges when a system, put together by physically separated elements and artifacts (e.g. different wards at a hospital or different aircrafts on approach to an airport), shifts from loose to tight coupling, from high autonomy to high interdependence in a short span of time (as when different hospital wards normally functioning relatively autonomously becomes highly interdependent in response to an escalating situation) (Dekker, 2005).

From the approach of analysing cognition as distributed the focus shifts from the human as an information-processor to the work in which the human engage together with other team players as people (spread over hierarchical boundaries) and technological systems (Woods, 2003). By not focusing on the specific indivudual's behavior focus is shifted to the perspective of studying cognition as distributed in the entire system engaged in a particular work situation (Hutchins, 1995b).

Thus, from the perspective of Oprational Resilience the interest lies not in observing human behavior, nor in deconstructing human work from motivationally-based models or concepts such as situation awareness, complacency, or human error. Instead the interest of analysis lies in the complexities facing the sharp-end operators in their day-to-day work in complex, dynamic systems.

3 IMPLEMENTING OPERATIONAL RESILIENCE

In our respective organization we, the authors of this paper, are incorporating the notion of Operational Resilience into training programs as well as methods to assess team performance. Bergström is involved in developing a training program for multiprofessional team training of health care staff. Henriqson and Bergström are together developing methods for team assessment based on Operational Resilience rather than behavioral markers, and Dahlström has, toghether with Bergström worked for several years with alternative approaches for training team coordination in escalating situations. Now Dahlström is closer than ever to ”reality” being head of the human factors training at Emirates Airlines.

Now that the context of our work is outlined the last part of the paper will be focused on describing the main principles of the Operational Resilience-approach to team training and team performance assessment.

3.1 The role of the observer

In complex systems an observer cannot measure behaviors or errors, because each behavior and error is a construction made by the observer herself (in contrast to being

constructed as a social fact in a Durkheimian sense) (Hollnagel & Amalberti, 2001). The role of the observer will rather be to interpret (in contrast to explain) coordination and control of the entire cognitive system engaged in the ongoing safety critical work.

This argument has been made by Dekker, Nyce, van Winsen & Henriqson (2010) asking the community of human factors to apply a more modest view to their epistemological assumptions when analyzing human activity. When developing protocols for team performance assessment this argument is considered by always incorporating the perspectives of the participants, together with the interpretation of the observer, into the evaluation.

3.2 Control

Cognitive systems theory has adopted a cybernetics approach to define control by its circularities of feedback and feedforward. This approach combines, the cybernetic notion of regulation (Ashby, 1959), the Perceptual Cycle of Neisser (1976) and Hutchins' ideas of distributed cognition (1995a, 1995b), to provide a functionalist approach of control. In this sense, control 'happens' during the interaction of "human-task-artifact" and is goal-oriented and influenced by the context in which the situated activity happens.

When developing methods for team performance assessment Hollnagel's model of contextual control modes (Hollnagel & Woods, 2005) has been operationalized to map how the perceived level of control shifts during a scenario by including both the participants' own reflections and the observer's interpretations (Palmqvist, Bergström, Henriqson, 2011). Noteworthy is that no level of control is seen as more appropriate than another, but instead is highly contingent upon the situation and context. This is a promising way to go beyond the behavioral markers or error classifications of the information processing paradigm.

3.3 Coordination

Complexity is managed in context dependent processes of coordination rather than in local processes of stimuli and response. When developing methods to analyze and improve sharp-end work in complex systems the concept of coordination is more valuable than the concepts of individual cognitive phenomena. The paradigm of joint cognitive systems has advocated the view that coordination must be analyzed as a distributed phenomenon emerging from the interactions between people and artefacts.

In a recent study Henriqson, Saurin and Bergström (2011) described how coordination may be interpreted as a situated and distributed cognitive phenomenon in the cockpit of commercial aircraft. The study provided an integration of the perspectives of joint cognitive systems theory with four coordination requirements described in the literature: common ground, interpretability, directability and synchrony (Klien et al, 2005). Automation, along with the pilots, were conceived of as a third activity agent. As a result of this integration, four coordination modes in the cockpit, occurring at different flight stages, were proposed according to the degree of interdependence of actions, the task flow, and the purpouse of the coordination iniciatives at the joint system level.

As investigation guidelines for future studies it is proposed that: (a) studies of coordination should be context, as well as, domains specific and hence proceed to broader generalizations; (b) the mechanicist perspective of coordination via the analysis of cause-effect relations needs to be abandoned, because it only increases the rigidity of the process reducing the capability of flexibility and adaptation; (c) work procedures needs to be flexible, providing means of adapting the theoretical system and the operator to the work situation.

3.4 The emergent interactions in the system

Emergence is a property that appears in the interactive process of co-activity between the social and technical parts of the system (Cilliers, 2005). To move beyond containing emergence, it is necessary to establish practices for dealing with variability and uncertainty. In this sense, to analyse the capacity of the human to perform work or analyse technology design, it is necessary to focus on the phenomena emerging from the interactions of joint cognitive work.

The interaction context offers guidance for the action at the same time as it is constructed by the action carried out. In this case, there is no precedence in the interaction, except for the event. For example, Henriqson, Saurin and Bergström (2011) identified that local representations which condition the broader coordination context in a cockpit, are results from interactions between internal (interpreting structure that is peculiar to the individual) and external representations (elements in the action context, such as symbols, numbers, data and shapes), in themselves always partial and incomplete.

When developing programs for team training the importance of the multiprofessional approach is stressed. In a multiprofessional setting the participants can together identify the situations in which the relationships and interactions between them, rather than their respective reliability as safe components, establish safety (or risk) as an emergent property of the system.

3.5 Production of meaning

Training for optimal Situation Awareness is less important than understanding different assessments. Complex systems do not allow for complete, or “correct” descriptions. Instead of using hindsight to accuse operators for not having had an optimal Situation Awareness focus needs to shift to ensuring that different and competing productions of meaning (based on different experiences and viewpoints) are available when working in safety critical environments.

Ultimately this is a shift towards the notion of diversity, so important for complexity theory (Cilliers, 1998). Complex systems are resilient when they are diverse. Diversity implies that different practicioners deploy different repertoires for responding to what, from their respeictive perspective, is seen as evidence as well as to each others’ constructions of such evidence (Dekker, 2011).

Again, when developing concepts for multiprofessional team training in complex settings it is important to gather the actors that at certain points might become tightly

coupled and highly interdependent. Together they need to be given the opportunity to, aided by facilitators, enlight their different perspectives so as to create prerequisites for successful coordination at the organization's most complex moments.

3.6 Focus on bridging gaps instead of categorizing and counting errors.

This implication is based on writings of Cook, Render & Woods (2000) suggesting that to improve safety the gaps that arise in any complex operation, and the expert strategies used by operators to bridge those gaps in practice, need to be understood.

To make the notion of complexity theory graspable and useful for practicioners in any high-risk field complexity needs to get a pedagogical value for their own reflections of their work. The notion of gaps and bridges is a valuable contributor for such pedagogical operationalization of complexity theory. In a multiprofessional setting a valuable exercise could be to sit down together from different subsystems and professions and discuss the gaps that arise during the situations when the actors of the system shift from loose to tight coupling, and the strategies that can be used to bridge the upcoming gaps.

4 CONCLUDING REMARKS

This paper has provided an overview of how the fundamental understanding of safety and CRM training needs to be reshaped and proposed how the current content of such training needs to be developed to be aligned with the theory of Operational Resilience.

Since modern safety-critical industries exhibit an abundance of evidence suggesting the need for analysis using approaches based on complexity theory our models for understanding human work in these systems cannot be based on a paradigm in which human work is reduced to behavior as response internal information processing, such as in traditional CRM concepts. Based on the properties exhibited the perspective of Operational Resilience seems more relevant for these systems, because it brings about the view of the inherent socio-technical complexity, rather than the view of such systems as Cartesian-Newtonian machines susceptible to the rules of information processing paradigm.

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