FROM RESILIENCE TO ROUTINES AND BACK: INVESTIGATING THE EVOLUTION OF WORK ADAPTATIONS

Jop Havinga [1], Andrew Rae[1] and Sidney Dekker [1]

[1] Griffith University, 170 Kessels Road, Nathan Brisbane, Australia

[1] j.havinga@griffith.edu.au

Abstract

This paper explores how a routine shapes how small crews perform work. We investigated this on blast crews and power line crews, and will illustrate our findings with examples from the blast crews in mining. Literature generally describes routines as repeating action patterns, however, we found that there was a lot of variation between actions. We did find stability in how crews understood a problem and how they divided a task into sub tasks. The shared problem understanding and solution structure, provided sub-goals which crews could opportunistically act towards and enabled the creation of meaningful signals. These elements are returning between multiple iterations over time, but are subject to change as well. For development of resilience, this view of routines offers two possibilities, (1) the creation of routines that allows teams to deal with varying conditions and (2) the creating conditions that allow routines to change quickly over time.

1 INTRODUCTION

1.1 Significance of the Problem

No socio-technical system is fully pre-specified; people always have to fill in gaps. This is a sign of resilience: the ability to adapt fluidly to changing circumstances to meet production and safety expectations. However, when teams do the same task multiple times, they replicate things they have done before. People, teams, and systems in general, do not only respond to their goals and constraints but also have a path dependency. Their actions are at least inspired by, and often even structured around, what has been done in the past. We approach this phenomenon on the team level with the concept of a routine. Our research has explored the space between variation and replication in performing a task, the formation of a routine, and the change of routines.

1.2 Routines

Both safety and cognitive systems engineering literature refer to routines of teams. Klein, Feltovich, Bradshaw, & Woods (2005) say that the routines a team can perform form part of the common ground between members. Weick and Roberts (1993) regard routines as the opposite of heedful interaction. Snook (2000) and Vaughan (1996) both talk about how groups changing their routines over time is inevitable, but that without reflection on the changes, this can lead to accidents. These papers all consider routines important, but do not consider in depth what it means for a group to have a routine.

There is a diverse body of literature in organisational science on organisational routines. In this literature, routines have been linked to many things: routines reflect the skills and capabilities a team has, routines support coordination, routines capture a truce between competing goals, and routines are both inert and ever changing (Becker, 2004). The most common definition used for organisational routines is ‘‘repetitive, recognisable patterns of interdependent actions, carried out by multiple actors". Routines here are viewed as a duality, consisting of a performative and an ostensive element. The performative element is the actions as done in a time and place, and as these actions or performed they imprint an ostensive image. The ostensive in turn provides a script of actions that guides the people when they perform the routine. Both parts are mutually constitutive, in that the parts form each other. Recognised challenges within this literature include that there is no clear explanation how actions in a routine link together (Pentland & Hærem, 2015) and that the line between variation within a routine and a change of a routine is difficult to identify (Feldman, Pentland, Adderio, & Lazaric, 2016).

1.3 Blast Crews & Powerline Crews

To investigate this, we studied both blast crews in mines and power line crews. Both blast crews and power line crews work do safety critical work, with partly interchangeable roles within crews. Both blast crews and power line crews bring their own equipment and practices to different working environments. In our research, we built

and triangulated patterns with data from both types of crews. However, for communicative purposes, we will focus on blast crews in this paper.

Blast crews' work in mines is to 'soften' up the ground. By using explosives they crush the ground, so that diggers in the mine have an easier job. If their blast is too weak, the rocks afterwards are too big. If their blast is too strong, environmental norms can be exceeded and debris can be flung away from the blast area. Besides debris, the job of blast crews is safety critical due to risk of premature and uncontrolled detonation, and managing risks that come with operating and working alongside heavy machinery.

Before a blast can be done, the area to be blasted is surveyed. After it is surveyed, a 'shot' is designed, which means a plan is made to decide what kind of explosive 'product' is used and how the product will be distributed around the area. The holes where the product will be loaded into are drilled per the plan. Next, the holes are filled. To fill a whole the crew first 'baits' the hole by lowering a booster (a small cylindrical explosive) attached to a detonation cord into the hole. Then, the product is loaded into the hole and the hole is all topped off with stemming. The detonation cord sticks out of the top of the hole. The last step is to connect the detonation cords before the shot is set off from a safe distance.

2 METHOD

We conducted fieldwork for a total of seven weeks (usually with 12-hour shifts, excluding shared travel time) across different crews and different locations. The fieldwork consisted of observation, as well as semi-structured interviews about what people would do in different situations shown in pictures. The focus was on:

- How actions followed each other
- Differences and similarities between multiple instances of a task
- Differences and similarities within crews, between crews and between locations
- Changes over time in how people or teams would have addressed similar problems

3 RESULTS

While the routines literature described repeating patterns of actions, we found instead considerable variation in the patterns of actions of crews and crewmembers. Variation was both found in what actions were done and in the order of actions. There did not seem to be an ideal pattern of actions for a task, as individuals were often attuned to variations in the environment. Whilst crews and individuals did have predictable patterns in how they conducted work, these elements were not on the level of action sequences. The returning elements were in the things that produced the actions. These elements included:

3.1 Problem Space Understanding:

The problem space understanding reflects what a person believes that needs to be done under what constraints. This includes the scope of work, what equipment is available, and how conditions affect the job. For example, in some mines crews had to border their working area, while in others this was done by other teams in the mine. Another example is that some crews would assume ground was wet and prepare accordingly, while crews would hardly ever encounter wet conditions and would only prepare if there were indications of wet conditions. This level builds on the experience of people and tends to converge for individuals in similar environments, as they have similar experiences. However, recognising the same problem does not mean the same solution is used to solve it, which refers to the next level.

3.2 The Solution Structure:

This level is closest to how most literature talks about routines. The solution structure is about how work is divided into sub-goals or in-between-states to achieve shared across a team. This includes how the sub-tasks relate to each other and whether they need to be done in a particular order. The solution structure builds on the problem understanding but can vary between crews in similar environments. This exists on for high-level tasks, for example, at what moment a crew has a toolbox talk, as well as on a more detailed level, on what knot to use when tying up wires. Within a crew, there is a standardisation on what is achieved, not how crew members achieve this. A knot with which cords are tied up is standardised across a crew, but the technique used to produce that knot is not. Crew members will correct each other on deviating knots but are mostly oblivious to different tying techniques of fellow crewmembers. Allowing this variation in how to achieve sub-goals allows crew members to adapt to conditions.

Crews can know multiple ways of structuring the problem into sub-goals. For example, when loading a shot, the truck can move along the rows echelons. This fits with the idea that a team can roll out different routines.

On points where crew members interact, the sub-goals of different crew members tend converge within a team.

However, this does not mean the division of the problem into sub-tasks is exactly the same for an entire team. For example, with measuring the water depth of a hole and writing it on a peg next to the hole, novices tended to divide the task into more and smaller steps with a constant order, while experts would adapt order of the steps based on what gear and information were closest at hand. Here experts did not roll out an 'ideal' or 'ostensive' pattern of actions, instead they responded opportunistically towards the sub-goals. Experts can also add more steps to the process than novices do. For example, experts might spend more time in a preparation phase to look for challenges. In general, however, experts were more sensitive to sub-goals further down the track, while novices were mostly guided by immediate sub-goals.

Having shared sub-goals facilitates that the work of individuals together solves the whole task. The stability in these sub-goals facilitates the establishment of meaningful signs within crews, which in the next level of a routine.

3.3 Established Signs:

A shared problem understanding and shared solution structures with standardised sub-goals (in-between-states) enables the formation of meaningful signs within a crew. The problem understanding can help in the way that Peirce (Flach, 2015) describes that a signifier is interpreted in relation to a problem domain. For example, a dewatering truck and inflatable bags can signal an operator that a crew is dealing with wet in holes, but an operator from a crew that works in dry areas, might not recognise this equipment and not relate this to wet conditions.

Standardised sub-goals create quickly recognisable signs, even when the signifier does not directly relate to the problem understanding. For example, one crew would park a car at the point they planned to finish that day. None of the other crews had this practice, so people from other crews would not give this meaning to the location of the parked car when they viewed pictures of this crew at work, but they would recognise the car was ‘weirdly’ parked in the path of the truck.

Standardisation of in-between-states also enables deviance to become a sign. When tying up wires on a blast side, team leaders tend to be specific about which way they want the wires connected and are very particular about how they want leftover cords to be organised. This is not because they consider their way superior, but by having cords laid out according to a standard, unintended slips would easily be spotted during the check-up process. With no standardisation, the team leader would have to follow each wire individually to determine whether the wires would ignite the right way. The standardisation allowed him to trade computational demands for perceptual demands, as in moving from knowledge-based processing to rule or skill based processing in the S-R-K framework (Rasmussen, 1983). Deviance from the norm would function as a sign that things were not done as intended.

Deviation was also used as a sign intentionally. If blast crews would run into a problem with a hole, they would often mark the hole with whatever was closest at hand. This could things as placing a stone across the hole, marking it with spray paint, or tying a bag to the peg next to the hole. Different signifiers could have the same meaning, and the same signifier could have different meanings, in different phases of work. Even tough the signifier varied, by relating it to what work had been done in an area to the solution-structure as well as the problem understanding, they could typically interpret these signals. If they could not, they would ask fellow crewmembers why a hole was marked. Some crewmembers specifically mentioned that this adaptiveness in markers was required. Specific markings for specific problems, like coloured ribbons, had been tried, but this approach was found not to work. People would not run into problems when it was not expected and not have the right markers at hand. Without the right markers, a hole would have to be left unmarked, at least till the right marker was organised, which could take up to 20 minutes if it was at the depot. The paradox here is that standardisation facilitated crews to be adaptive with their markers.

3.4 Change of Routines:

So far we have talked about what replicates in routines - what crewmembers take along between multiple iterations of a task. While these elements show permanence, they are not completely static. Small changes are common and often go unnoticed, especially if a change does not affect other parts of the work. However, one change would often feed into other changes in the routine. For example, cardboard holders were introduced to blast crews to prevent material from rolling away. Expectedly, crews added putting out these holders next to holes into their routine, and it when putting out gear, and new acceptable in-between-states had the gear inside these holders. Unexpectedly, some crews would turn these holders upside down if they encountered problems with a hole, a practice that developed from these cardboard holders now often being the closest thing at hand.

While routines did not specify actions within a crew, we did see routines change by instructing actions. For example, from management there had been the instruction to tie loose cords into a bundle, to prevent people from tripping over it. Across crews this same instruction led to different knots, creating differences in acceptable

in-between-states between crews. Also, some crew would knot the cords after check up, which turned the knots into a sign that the holes had been checked. While the action of tying up loose cord was instructed to multiple crews, it led to different sub-goals and different signals across crews.

4 CONCLUSION AND TAKEAWAY

The actions of a team can quickly change if the environment changes. However, there was consistency in the problem understanding, a division of the problem space into sub-goals, and signs. On the level of actions towards these sub-goals, however, crewmembers to responded to local conditions and acted based on what was available. These elements are carried over through between enactments and show permanence between enactments, but can change over time.

To support team resilience, this offers two paths. One is to create routines that can handle more situations; the other is to facilitate the change of routines. To build routines that can handle a wide range of conditions, for this the problem understanding and solution structuring should be as shared as possible within a crew and develop a redundancy of established sign. For this, teams are best kept stable, while they encounter varying conditions. To facilitate the change of routines, goal feedback should be visible, interaction between people with different problem understandings and solution structures should be encouraged, and the signifiers need to get a different meaning overtime. Exchange of practitioners between crews is beneficial for all of these elements.

Acknowledgements

This research is part of a larger research project funded by ORICA. The views presented are those of the authors and should not be taken to represent the position or policy of the funding bodies.

REFERENCES

Becker, M. C. (2004). Organizational routines: A review of the literature. *Industrial and Corporate Change*, *13*(4), 643–677.

Feldman, M. S., Pentland, B. T., Adderio, L. D., & Lazaric, N. (2016). Beyond Routines as Things: Introduction to the Special Issue on Routine Dynamics. *Organization Science Publication*, *27*(3), 505–513.

Flach, J. M. (2015). Supporting productive thinking: The semiotic context for Cognitive Systems Engineering (CSE). *Applied Ergonomics*, 1–13.

Klein, G., Feltovich, P. J., Bradshaw, J. M., & Woods, D. D. (2005). Common Ground and coordination in joint activity. In W. B. Rouse & K. R. Boff (Eds.), *Organizational simulation* (pp. 1–42). Hoboken, NJ, USA: John Wiley & Sons, Inc.

Pentland, B. T., & Hærem, T. (2015). Organizational Routines as Patterns of Action: Implications for Organizational Behavior. *Annual Review of Organizational Psychology and Organizational Behavior*, *2*(1), 465–487.

Rasmussen, J. (1983). Skills, rules, and knowledge; signals, signs, and symbols, and other distinctions in human performance models. *… , Man and Cybernetics, IEEE Transactions on*, (3), 257–266.

Snook, S. A. (2000). *Friendly Fire: The Accidental Shootdown of U.S. Black Hawks over Northern Iraq*. Princeton, NJ: Princeton University Press.

Vaughan, D. (1996). *The challenger launch decision: risky technology, culture, and deviance at NASA*. Chicago, US: The university of Chicago Press.

Weick, K. E., & Roberts, K. H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly*, *38*(3), 357–381.