COLLABORATIVE ELASTICITY AND BREAKDOWNS IN HIGH RELIABILITY ORGANIZATIONS: CONTRIBUTIONS FROM DISTRIBUTED COGNITION AND COLLECTIVE MIND THEORY

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"The discussion of the coordination of action showed the people to be a sort of connecting tissue (…) the flexibility and robustness of the system stems from the ability of this connecting tissue to adapt to changing circumstances. (…) In all cases, the management of the deployment of human resources, the on-line negotiation of the distribution of labor, is essential to the operation of the system. If the distribution of labor was fixed, the system would surely fail whenever one of its components failed. The distribution of labor can only be negotiated if the distribution of knowledge and ability is at least partially redundant." (Hutchins 1990) page 211

"Minimal organizations such as Mann Gulch are susceptible to sudden loss of meaning" (Weick 1993) page 632

Introduction

Collective action characterizes most work in organizations (Orlikowski 2002). It involves two or more people and – increasingly – technical tools to accomplish outputs that exceed individuals' capacities (Simon 1991). Today's dynamic society demands flexibility of collective action (Brown and Eisenhardt 1997; Volberda 1997). Most people are not expected to repeat the same habitual pattern of action for a prolonged period of time. They must adapt, learn, and respond to unique and evolving situational

circumstances (Tyre and von Hippel 1997). I refer to this adaptation as elasticity, meaning that people must jointly change and stabilize the way they operate as individuals and collective[1].

Researchers have reported on instances where collective groups adapted successfully, like in case of the Apollo 13[2]. In many cases, however, groups do not adjust effectively to changing circumstances, as examples show like the Mann Gulch disaster, the Tenerife disaster, and the Challenger disaster (Weick 1993; Vaughan 1996; McCreary, Pollard et al. 1998). As Weick (1993) suggested, these organizations (in a broad sense, see footnote 1) can loose connection, meaning, and jointness of action. They are not (sufficiently) elastic in their collective performance. They fall apart, and disintegrate, sometimes even without people realizing that process as it is occurring (ARAIC 2002; BFU 2002). Hutchins (1990) refers to the flexibility and robustness of group performance.

Collective elasticity

As organizations face dynamic, unpredictable and sometimes turbulent environments, it becomes of paramount importance to understand the components of collective elasticity and to gain insight in the process of breakdown. So far, literature includes examples of specific cases of breakdowns and disasters. But two problems remain.

First, a breakdown (Challenger disaster, Mann Gulch, friendly fire (Snook 2000)) or a success story (Apollo 13) is investigated in detail as a case study. Researchers develop new scripts for avoiding future disasters and prepare response. While these contributions are indispensable for understanding and 'resolving' particular case studies, as researchers we tend to ignore cumulative results. We do not often compare these studies and cross-analyze them rigorously. Such an integrative analysis is important for practitioners and academics. For practitioners it highlights lessons that emerge from several cases rather than showing how to win the most recent 'battle'. For academics it is an opportunity for theory building and moving beyond single-case analysis (which is of course indispensable).

A second problem is that organization literature distinguishes between organizations that operate either according to a fixed set of routines (Adler and Borys 1996), or in an adaptive mode, like improvisational theatre and jazz teams (Barrett 1998; Pasmore 1998; Hatch 1999; Sawyer 2000). In practice, as case studies have shown, organizations do not operate in either of these ideal modes. They must shift between routines and improvisation; they evolve as situations demand (Eisenhardt 1993). Task variation and elasticity become important themes. This raises questions like: why is elasticity required, how do people stay connected, and why does the elastic break sometimes?

Objective and research design

The purpose of this short article is to show dimensions and concepts that have emerged in multiple studies on collective elasticity and breakdowns. The paper focuses on High Reliability Organizations (HRO) where people work with advanced technologies and face potential danger (e.g., nuclear power plants, aircraft and spacecraft crews). I want to answer the question why these organizations must operate elastically at times, and what causes them to breakdown.

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[1] 'Collective' could refer to an organization or organizational unit in the traditional sense (Scott, W. R. (1992). Organizations: Rational, Natural, and Open Systems. Englewood Cliffs, New Jersey, Prentice-Hall.). It also refers to an ad hoc aggregation of individuals contributing to a common activity, like Air Traffic Control, and disaster mitigation groups Smith, W. and J. Dowell (2000). "A case study of co-ordinative decision-making in disaster management." Ergonomics **43**(8): 1153-1166, Leveson, N., M. de Villepin, et al. (2001). A Safety and Human-Centered Approach to Developing New Air Traffic Management Tools. ATM, Albuquerque..

[2] Success is here not defined in terms of mission completion, but the safely returning the crew.

Specifically, I use two theoretical areas: distributed cognition and collective mind theory. First, distributed cognition theory has been associated with work by Hutchins on ship navigation and cockpit management (Hutchins 1990; Hutchins 1996; Hutchins and Klausen 1996). In this study I emphasize the organizational side of distributed cognition theory, rather than the cognitive side. A second perspective is collective mind theory which was developed by Weick and colleagues as they studied High Reliability Organizations like aircraft carrier crews, fire crews, and cockpit crews (Weick 1993; Weick 1993; Weick and Roberts 1993; Weick, Sutcliffe et al. 1999). These two theoretical domains are used to investigate the elasticity of organizations and causes of breakdowns.

The paper is structured as follows. I start with presenting factors that stretch an organization. This is followed by a discussion of six dimensions that emerged from literature and define collaborative elasticity:

1. Individual cognition
2. Relating and relationships
3. Repertoire of routines
4. Knowledge for collaboration
5. Organizational roles
6. Communications

The paper concludes with a discussion section.

Elasticity drivers

Elasticity is required when groups face uncertainty. They may encounter natural disasters and technology breakdowns (Cooper Jr 1972; Smith and Dowell 2000). This uncertainty triggers change in a group. People must adapt to circumstances in order to survive, or handle and reduce risks. Elasticity is also caused by individual and group functioning. Individuals may behave unpredictably as they encounter stress, danger, and novel tasks (Weick 1993). This affects a group and its members and environment. 'Elasticity' may be tested too far within situational constraints, leading to a breakdown.

In the next sections I present six dimensions that help frame elasticity. These are derived from distributed cognition and collective mind theory research.

(1) Individual cognition

Distributed cognition and collective mind theory emphasize the importance of individual processing and performance. Group performance is built upon individual contributions. Individual functioning is therefore closely intertwined with group performance. Group elasticity requires individuals who are knowledgeable, who can improvise, and who can deal with stress. People must remain predictable, in particular leaders. They must possess interpersonal social skills, and actually like to connect depending on situational demands. They must respect others' territory and be humble to accept feedback from others (Weick 1993). People must be able to act wisely and with realism. Procedures should offer them guidance but not limit improvisational, collaborative action (Weick 1993). Task knowledge is more important than procedural correctness (Hirschhorn 1993). At the same time, common concepts and practices must be followed to avoid confusion and misunderstanding (Weick 1993). People must be capable of operating under conditions of noise, extreme temperatures.

A risk associated with individual performance and collaborative elasticity is that people become locked up in a small task and a local concern while forgetting the systemic dimension of their job (Weick and Roberts 1993). This undermines collective elasticity. Similarly, people may become irritated and unheedful towards counterparts. Individualism and reduced sociality puts the burden on counterparts to sustain collective meaning and action.

(2) Relating and relationships

A second area associated with elasticity and breakdowns concerns relationships and how people interrelate. Relationships are built on communications. They imply knowledge sharing. This increase predictability of people. Relationships enable anticipation and make communications more effective (Gabarro 1990). 'Half a word is enough' for people who know each other. Inversely, people without relationships must build mutual understanding during task execution. This may be difficult in case of communications constraints like time pressure and distance (Weick 1993).

Relationships make groups more elastic, but can also have a detrimental effect if people develop interlocked thought patterns that disconnect them from the outside world (group think) (Janis 1972). Elasticity thrives on healthy relationships that are defined by mutual respect and open mindsets.

(3) Repertoire of routines

Groups with a limited set of routines are unprepared for dynamic task requirements. Their focus has been on practicing lockstep activity patterns, rather than building repertoires of routines (Pentland and Rueter 1994). Hutchins (1990) refers to this mode of organizing as procedures. Groups that work with fixed routines (closed structures) are capable of accomplishing known tasks with great efficiency. But their order is temporary and constrained. It implies that people perceive their task environment with a single dominant logic (Bettis and Prahalad 1995). This inhibits structuring as a group, and producing order in unexpected situations (Weick and Roberts 1993).

(4) Knowledge for collaboration

Hutchins and Weick stress the role of knowledge for collaboration in three ways: (1) common knowledge, (2) knowledge redundancy and (3) transactive memory. First, common knowledge includes concepts, categorizations, standards, and norms that people share. Commonality makes communications more efficient (Carlson and Zmud 1999). People can use less exchange to invoke a similar meaning (Grant 1996).

Second, knowledge redundancy implies that people know something about their counterpart's job (Hutchins 1990). They practiced that job on earlier occasions, or shared (similar) training and collaborative experiences. The resulting knowledge overlap helps them predict their counterpart's response patterns and it lowers communication needs (Grant 1996). Knowledge substitutes for communications.

Third, transactive memory means that people know who does what in their (ad hoc) group (Wegner 1987; Hollingshead 1998; Moreland 1999). This third type of knowledge brings stability to a collective group. It channels and thereby economizes communications, without the necessity to communicate on who does what. When people abandon this 'virtual role system', the group becomes less coherent and runs the risk of disintegrating (Weick 1993).

The three types of knowledge reduce communication needs and enable anticipation. People know who does what. They also know what someone facing a particular situation will need (Hutchins 1990). As a result, communications become more focused, economical and meaningful.

(5) Organizational roles

Group functioning depends on organizational role definitions that channel individual contributions. Weick (1993) defines this structure as a "framework of roles, rules, procedures, configured activities, and authority relations that reflect and facilitate meanings". Lack of structure shifts the burden of coordination to interaction processes. For instance in a novel team, people must sort out how they operate and how roles are divided and defined (Schein 1992). This enhanced communication need limits elasticity when time is potentially scarce.

At the same time, fixed role definitions and communication connections jeopardize adaptation too. If people can operate only according to a predefined recipe, they may encounter sudden loss of coherence and relevance in situations demanding elasticity. Several examples show the limits of indirect organizational structures. 'Indirect' means that A communicates with B through C. for instance people communicate in a line (fire department), or a coordinator aligns multiple actors, like a traffic controller. If a situation complicates, this indirect structure may easily be overburdened (Weick 1993; Weick and Roberts 1993). Teams trained in this approach lack the flexibility to change their communication structure and enhance the elasticity of their performance.

At the same time, to make things even more complicated, Weick (1993) pointed at the risk of people who do *not* adhere to predefined structures. In the Tenerife case, the captain of a KLM flight overruled the role system and caused a major disaster. He exceeded role boundaries in a formal sense. This deviation caused the group of stakeholders in that situation to become less elastic and connected. The captain's behavior surprised others and demanded increased information processing to resolve misunderstanding and tensions. Unfortunately, time was one of the constraints. The next section elaborates on this communication constraint and other factors that impede exchange.

(6) Communications

Finally, communications problems contribute to limited elasticity of groups. Organization scientists have for long pointed at the importance of communications for dealing with uncertainty (Thompson 1967). Uncertainty increases information processing needs. People must communicate on how a situation differs from their expectations and regular routines, and how they want to solve it (Watzlawick, Beavin Bavelas et al. 1967). They communicate to structure common meaning, or 'mutually shared fields' (Weick and Roberts 1993). Lack of communication means that people do not know how others think about a situation and about possible action patterns. As a group, they stop learning and acting as a dynamic collective.

People who do not communicate revert to an individualized mode. Weick (1993) proposes heedful interrelating as a concept to capture the notion that people connect proactively and socially to coordinate their mindsets. If people don't do that or stop doing that, the real-time coordination suffers. From then onwards, a group is prone to disorder. The next quote on the Mann Gulch disaster shows this point.

"As heed began to be withdrawn from the system, activities and people become isolated, the system began to pull apart, the problems became more incomprehensible, and it became harder for individuals to interrelate with a system of activities that was rapidly losing its form. (...) One interpretation of this incident is that individuals were smarter than the system, but the problem was more complex than any one individual could understand. Heedful interrelating of activities constructs a substrate that is more complex and, therefore, better able to comprehend complex events than is true for smart but isolated individuals" (Weick 1993)

An important question is what causes communication problems. Research on distributed cognition and collective mind points at a number of constraints. First, distance makes it difficult for human senses to connect (Snook 2000). When people use technology in dispersed groups, they experience limitations of technology such as bad audio in a cockpit, limited media richness, limited interactivity, and a limited number of people who can participate (Daft and Lengel 1986; Weick 1993; Vaughan 1996).

Second, noise, smoke, fog, and darkness impede interpersonal contact. These factors affect human senses and therefore interpersonal communications, or just observing a situation. People become less aware of a situation and depend on technology and other people for assistance (Endsley and Jones 2001). Because of fog, the KLM crew in the Tenerife case could not see the descending PANAM Boeing (Weick 1993). The same applies to the controllers "Clouds and fog made visibility very poor, as low as 300 meters, so the controllers in the tower and the crews of both aircraft were completely dependent on their radios for information on runway positions" (Weick 1993). The Mann Gulch crew members could not hear each other as they faced a raging fire (Weick 1993).

Third, time pressure reduces the opportunity for observations and interpersonal contact. Time pressure may be caused by the speed at which technology is moving, or the surprise of a terrorist attack and natural disaster (e.g., tornado, earth quake, flooding). It necessitates reduction of uncertainty upfront. The moment a situation escalates, insufficient opportunities remain for structuring shared meaning. Time pressure thus reduces group elasticity. It requires extremely efficient communications that relies on the five areas discussed before this one. These areas reduce superfluous communications and make exchanges that remain possible in a limited time frame meaningful, efficient and effective.

Synthesis: Collaborative elasticity and breakdown of HRO

This paper reviews literature on distributed cognition and collective mind theory to understand the drivers of collective elasticity and causes of breakdowns. I found six areas that seem important: individual cognition, relating and relationships, repertoire of routines, knowledge for collaboration, organizational roles and communications. The contribution of this paper is the identification of this taxonomy. Further research and theory development is required to show how these areas interrelate. This research would include two levels. First, analysis of specific cases that derives insights and theory refinement from empirical evidence. And second, cross case analysis that elicits generic theory statements. Both approaches could work mutually reinforcing. This increases our understanding of collaborative elasticity, and helps us understand and remedy causes of breakdowns.

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