Comenius University in Bratislava

Faculty of Mathematics, Physics and Informatics

A Narrative Review of Organizational Improvisation in Emergency Response Teams through a Distributed Cognition Lens

Diploma thesis

2022 **Lauren Kondratiev**

Comenius University in Bratislava

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Diploma thesis

Study Programme: Cognitive Science

Field of study: 2503 Cognitive Science

Department: Department of Applied Informatics

Supervisor: doc. RNDr. Martin Takać

2022 **Lauren Kondratiev**

Comenius University Bratislava
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THESIS ASSIGNMENT

Name and Surname:	Lauren Kondratiev
Study programme:	Cognitive Science (Single degree study, master II. deg., full time form)
Field of Study:	Computer Science
Type of Thesis:	Diploma Thesis
Language of Thesis:	English
Secondary language:	Slovak

Title: A Narrative Review of Organizational Improvisation in Emergency Response Teams through a Distributed Cognition Lens

Annotation: Looking at organizational improvisation through the lens of distributed cognition may prove to be beneficial in order to further our understanding of improvisation itself. By exploring the organizational ecosystem of emergency management teams, this thesis sets out to find which elements of the ecosystem foster or hinder the use of organizational improvisation.

Aim:
1. Narratively review some of the most notable research works in OI as well as those which focus on emergency management teams.
2. Take an in-depth look at concepts such as bricolage, interorganizational trust, organizational memory and virtual role systems.
3. Assess the influential elements of organizational improvisation within emergency management teams through cognitive distribution, essentially describing the OI ecosystem by means of conceptual connections.

Literature:
Wachtendorf, T. (2004). Improvising 9/11: Organizational improvisation following the World Trade Center disaster (Doctoral Dissertation). Available from Penn State database.
Moorman, C. and Miner, A.S. (1998). Organizational improvisation and organizational memory. The Academy of Management Review, 23(4): 698-723.

Supervisor:	doc. RNDr. Martin Takáč, PhD.
Consultant:	Dr. Lukas Zenk
Department:	FMFI.KAI - Department of Applied Informatics
Head of department:	prof. Ing. Igor Farkaš, Dr.
Assigned:	27.02.2020
Approved:	13.10.2020

prof. Ing. Igor Farkaš, Dr.
Guarantor of Study Programme

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Student

.....
Supervisor

Declaration

I hereby declare that I elaborated this master's thesis independently without any unauthorized third-party support. Used literature and ideas taken from other sources are cited as such.

Bratislava, 2022

Acknowledgment

I would like to thank the unforgiving patience of my supervisor doc. RNDr. Martin Takać, for being a constant inspiration for what it means to be a cognitive scientist. I would also like to give a big thank you to my second supervisor Dr. Lukas Zenk, for gifting me the love of organizational improvisation, and sharing his wisdom and ongoing projects within the field. It goes without saying that my fellow program colleagues have been an immense help as well.

Abstract

When emergency response professionals are faced with a critical and time sensitive challenge, a space opens up wherein they have the choice: to improvise or follow protocol. This, sometimes split-second decision can be a matter of life or death. When a team runs with the decision to improvise this means that they are engaging in organizational improvisation (OI). Certain teams seem to engage in this behavior more often than others, however this does not always mean that their end results are successful. Is there a specific predefined formula for successful organizational improvisation? Over the last 20 plus years, research has been sprouting in the field of OI, but has not yet come up with a concrete answer to this question. By means of a narrative review of the body of literature having to do with OI and more specifically focusing on OI within high reliability organizations (HRO) this work's objective is to compile a list of specific features that either foster or hinder OI. This will include an in-depth look at bricolage, organizational culture, organizational memory and virtual role systems. This current work will also look at OI in HROs through a distributed cognition lens, in which the different nodes of the OI system will be examined and analyzed in order to assign them particular levels of importance when it comes to interconnectivity, interaction and influence on one another.

Keywords: organizational improvisation, distributed cognition, organizational culture, high reliability organizations, self-organizing teams, virtual role systems

Abstrakt

Keď pracovníci záchranných zložiek čelia kritickej a na čas citlivej výzve, otvára sa priestor, v ktorom majú na výber: improvizovať alebo postupovať podľa protokolu. Toto rozhodnutie, niekedy v zlomku sekundy, môže byť otázkou života alebo smrti. Keď sa tím rozhodne improvizovať, znamená to, že sa zapája do organizačnej improvizácie (OI). Zdá sa, že niektoré tímy sa do tohto správania zapájajú častejšie ako iné, čo však nie vždy znamená, že ich konečné výsledky sú úspešné. Existuje konkrétny preddefinovaný vzorec úspešnej organizačnej improvizácie? Za posledných viac ako 20 rokov sa v oblasti OI rozrástol výskum, ktorý však zatiaľ nepriniesol konkrétnu odpoveď na túto otázku. Cieľom tejto práce je prostredníctvom naratívneho prehľadu množstva literatúry súvisiacej s OI, a konkrétnejšie so zameraním na OI v organizáciách s vysokou spoľahlivosťou (HRO), zostaviť zoznam špecifických vlastností, ktoré buď podporujú, alebo bránia OI. To bude zahŕňať podrobný pohľad na brikoláž, organizačnú kultúru, organizačnú pamäť a systémy virtuálnych rolí. Táto aktuálna práca sa bude na OI v HRO pozerať aj cez optiku distribuovanej kognície, v rámci ktorej sa budú skúmať a analyzovať jednotlivé uzly systému OI s cieľom priradiť im konkrétne úrovne dôležitosti, pokiaľ ide o vzájomné prepojenie, interakciu a vzájomné ovplyvňovanie.

Kľúčové slová: organizačná improvizácia, distribuovaná kognícia, organizačná kultúra, organizácie s vysokou spoľahlivosťou, samoorganizujúce sa tímy, systémy virtuálnych rolí.

Outline

Chapter 1

1. Introduction

When emergency response professionals are faced with a critical and time sensitive challenge, a space opens up wherein they have the choice: to improvise or follow protocol. This, sometimes split-second decision can be a matter of life or death – for both the professionals themselves, as well as for those in need of help. When a team runs with the decision to improvise this means that they are engaging in organizational improvisation (OI).
This work's aim is to investigate what exact characteristics of emergency response organizations, otherwise known as High Reliability Organizations (HRO) or Emergency Management Organizations (EMO) enable or constrain the individuals/teams/organizations, respectively, to engage in organizational improvisation. The work sets out to do so by means of a narrative review of the most influential works within the field of OI, more specifically those who find their focus on emergency response teams. The narrative review demonstrates that disregarding the concrete subject focus, research in OI typically displays a pattern of concepts and characteristics that are imperative and central to the optimal functionality of OI. These include such precepts as organizational memory, interorganizational trust, virtual role systems, sensemaking, and bricolage. Additionally, the work will attempt to shed a new light on the OI concept/system by analyzing OI within emergency response teams through a distributed cognition lens. This perspective is essentially a particular take on social cognition within the realm of cognitive science, originally coined by Hutchins (2014) and further extended by Slors (2019). The novel interpretation of the distributed cognition lens taken on in order to analyze OI may make the concept of OI more accessible to a wider audience and prove further research crucial, since it will examine the separate nodes that constitute OI within a HRO, and explore their interconnectivity, interaction and influence on one another. What this will be able to portray is not only the conceptual relationships of the central OI ideas, but their ranked importance, which may prove useful in further development of future research directions, and

even, perhaps more importantly, of training programs for various HRO fields that recognize the significance of improvisational skills.

Improvisation is a conflictual topic when it comes to emergency events and the organizations in charge of their management and mitigation. It plays no consequential role if the subject matter takes place in an emergency room or in a forest fire, but there is a widespread reluctance to improvise in such teams (Hadida, 2014; Batista et al., 2016). The reason being is that organizations who engage in emergency management pride themselves on always being prepared, in fact that is the embedded understanding of the purpose of these organizations – to *manage* an emergency. Organizations are even defined to be rooted in routine, by bringing individuals together under the presumption that they are to engage in similar activities and routines in order to achieve the same goal (Cunha, 2006). The truth of the matter is that the need to improvise indicates the opposite in the eyes of the public and the higher tier of organizations – the team was not prepared for what the situation had in store. However, even more accurate would be to say that if an event does not call for improvisation, it is most likely not a true emergency (Wachtendorf & Kendra, 2006).

This brings us to our next point. What is improvisation, and why is it so crucial when it comes to managing crises?

1.1 What is Improvisation?

Improvisation finds its roots in the word “proviso”, meaning to create a condition or provision ahead of time, to prepare for something in advance, or to go through with something that was previously deliberated upon, (Weick, 1998). When the prefix “im” is added on to this word, this creates the exact opposite of the original meaning. Stemming from Latin *improvisus* - improvise literally means to deal with the unforeseen or unexpected. When confronted with the word ‘improvisation,’ often times the first associations that come to one’s mind are somewhere in the realm of improvisational theater or jazz music. Most of us are well acquainted with the often awkwardly acted out scenes of improv theatre or the improvised, yet harmonious

melodies that jazz musicians lay out on the stage. Although these connections are not unfounded, since indeed improvisational research finds its beginnings with the theatre metaphor, they do not encompass the vastness of improvisation as a concept. However, in order to fully comprehend improvisation, one must acknowledge that it initially was noticed, studied and widely used within theatre and music, due to its practicality and close relationship to entertainment of an audience. Jazz music has been used in a wide number of research and works to illustrate the complex nature of improvisation. Berliner extended the jazz metaphor in order to create his own definition of the word: "Improvisation involves reworking precomposed material and designs in relation to unanticipated ideas conceived, shaped, and transformed under the special conditions of performance, thereby adding unique features to every creation," (1994). Although the first theories that arose from this have proven to be remarkably insightful and helpful, it seems that the jazz metaphor was only a good start to harbor interest for the topic. The metaphor is quite limiting in its understanding of improvisation as a concept. In fact, many tend to conceptualize improvisation as a single and isolated skill, simply being creative and in the moment, which is a gross misunderstanding. Improvisation a *set* of skills that may be accumulated and enhanced over time and through purposeful training. Improvisation is not simply an action, but a compilation of its performer's experience, creativity, divergent thinking, openness to fail, and so much more (Weick, 1998). Veritably, individuals who employ improvisation within their daily lives oftentimes equate it to a toolbox, wherein each tool is a skill, and said skills can each be honed and perfected separately. (Tint, 2015). Even better put, more closely relating to the focus of this thesis, "improvisation is […] a set of skills that provide for recovery in the face of disasters and emergencies, (Rerup, 2001). In turn, these skills can be used in nearly all spheres of life, they don't belong to the stage alone. A logical reaction to our increasingly unpredictable and fast-paced world can indeed be seen as nothing other than improvisation. Zenk and colleagues believe that improvisational skills and the competences that come with them could essentially further a society more dynamic in its nature and experiencing continuous change (2022). Noted by Tint in an interview transcribed by myself, "we are all improvisers, of course, because none of us wake up with a script." However, if one excels in improvisation on stage, he or she is bound to excel in improvisation when it comes to real

world situations, such as awkward social settings or better yet, an unexpected turn of events during project planning or business interactions. A conclusive definition of what this set of skills exactly is has yet to be established, nevertheless there is a staggering amount of agreement among the field's researchers as to how improvisation itself should be defined.

A majority of definitions of the term 'improvisation' generally lean in the following direction: a real-time reaction to an event without the ability to prepare, or a response to an event wherein planning and execution merge at the same time (Hutchins, 1991; Weick, 1993; Berliner, 1994; Moorman & Miner, 1995; Crossan & White, 1999; Kamoche & Cunha, 2001; Kamoche et al., 2003; Balachandra, 2005; Zheng et al., 2010). Furthermore, if the skill set of improvisation is employed on an organizational level this transpires it into organizational improvisation.

1.2. Defining Organizational Improvisation

Before tackling OI, let us first define what an organization is, in and of itself. As stated in the Merriam Webster Dictionary an organization is an association, society, an administrative and functional structure (such as a business or a political party); also, the personnel of such a structure. It is connoted that the members of an organization all have a common goal or objective towards which they collectively stride.

Initially finding its roots in managerial literature and research, OI has expanded into its own branch of research. For one particular reason - it is a set of skills found beneficial not only among managerial hierarchies, but more specifically in every sphere of both professional and prosaic life. Hadida and colleagues proposed the first consolidating overview and framework of OI, wherein she outlined the general tendency of management disciplines of strategy, organizational behavior and theory, as well as focused attention on potential areas of research among varied organizational settings and industries (2015). What Hadida and her team draw attention to is the ideation of managerial decisions becoming increasingly more dynamic and demanding of flexibility and unpremeditated action, rather than routine and practiced

operations. This means that research is becoming increasingly attuned to change rather than stagnant practice or following protocol.

Not only did Hadida compile an extremely helpful and novel review of OI literature, but she also developed an insightful framework for improvisation within organizations. It is a 3x3 matrix, wherein one can differentiate the levels at which improvisation occurs within the organization. These include individual – enacted by one person within an organization, interpersonal – occurring within a relatively small group, and organizational – taking place within the entire organization. Moreover, this matrix portrays the degree to which the performed improvisation is carried out, which could be minor (minor alterations to pre-existing processes) bounded (e.g. creating new products or ideations within) and structural (e.g. carrying out a new task toward a new outcome), (Hadida et. al, 2015). The degrees of improvisation in this particular framework essentially stem from a jazz metaphor, yet display that improvisation is a fluid concept, in that the degrees in which it is carried out should be seen as a continuum rather than a set scale.
In her doctoral thesis on Organizational Improvisation, Darwina Arshad (2011) has created a collection of definitions and key notions on what she believes to be the core of OI. She posed that the cumulative definition for OI is "an action taken in real time situations where it involves a high degree of spontaneity, creativity, and intuitive insight by individuals, group or the whole organization," (Arshad, 2011). Within these confounds Arshad believes that the most optimal way to look at OI is through strategy process theory, rather than through musical metaphors (since the majority of previously gathered material on the subject has been focused on the realm of music and theater). A key criteria for something to be seen as improvisation would be the length of time in between the design or composition of an action and its actual execution or performance. This can be seen as a measurement of improvisation itself. Improvisation cannot, by definition, afford to have a 'regular' chronology or to be within a linear sequence of events, since it is the degree of novelty and intentionality behind said novelty, which makes it what it is. Moreover, in order for improvisation to exist there must be a connection with the level of environmental uncertainty, (Arshad, 2011).

Conjointly, most research in the OI field has been carried out along two main vectors: “arts-based metaphors, in particular jazz, to illustrate and shed light on improvisation in organizations, [and] empirical, naturalistic-based illustrations and anecdotal evidence to define improvisation and its causes and effects within organizations,” (Hadida, 2015). These vectors tend to run in the same direction when it comes to the description of what makes up the proverbial improvisational skillset: “spontaneous action without preparation, emergence, quickness, spontaneity, bricolage, intuition.”

This particular thesis shall focus on concepts that are more specific. “Organizational improvisation is a vital skill as it can contribute to making meaningful decisions, within a limited timescale, without the best information and resources.” Arshad and Hughes posit that in more situations than not, managers may not have enough time on their hands to rely solely on rational and analytical decision-making or planning, which means that many decisions must be undertaken with a good amount of uncertainty and without a full scale of information on a given matter. Hence, “intuitive and rational thinking processes should be used together in improvisational practice. This concurrent process is best used in alternating stages, a stage of intuitive thinking where imagination is encouraged followed by a rational logical stage where ideas generated by the creative stage are analyzed, grouped and selected [these procedures are particularly useful when traditional approaches are failing]”, (Arshad & Hughes, 2009).

However, such practices may only be employed when one has the luxury of time. For in an emergency there is no time to rationally think through each step one requires. Emergencies, in their true nature, are extremely erratic, time-sensitive and unpredictable occurrences. More precisely put “[w]e live in a volatile, uncertain, complex and ambiguous (VUCA) world,” (Tint, 2015). Even though there may be a preplanned protocol of how to go about such predicaments, the likelihood of the plan not covering certain crucial peculiarities pertaining to the event is very high. HROs that deal with the VUCA environment on a regular basis are in need of specialists who are not afraid to take acute risks, who can strategically demonstrate resilience,

who pride themselves in being able to communicate and work together to achieve an objective. Professionals who are fluent in organizational improvisation.

Let us take the fire brigade as an example. In their field study on the Incidence Command System within emergency management, Bigley and Roberts (2001) found that more often than not fire fighters would improvise on the scene of an emergency. In many cases, upon arrival of the scene, fire fighters would break protocol altogether, sometimes even engage in actions that were prohibited by the original handbook. For instance, an individual member of a fire brigade once recalled how his team had used 'opposing hose streams,' even though this operation was against the rules, since it could push the fire of one group into the fire of another. Moreover, "the execution of standard routines, such as those for 'hose laying' or 'ladder throwing', also may be tailored to specific circumstances," (Naikar & Elix, 2021). Many cases that emergency teams meet with are extraordinary, and therefore require exceptional and sometimes unprecedented responses. Teams such as fire brigades may not always be optimally equipped to deal with the situation at hand, but since their priority is to mitigate the current danger or threat to the environment, they oftentimes find novel uses for the tools at hand.

The emergency room one finds at a hospital is no exception. In the field of healthcare, there may be myriad instances wherein "different logics coexist or compete against each other," (Batista et al, 2016). In such cases, the physicians deemed the professionals with the upper hand in the situation must rely on their autonomy and use their responsibility wisely in order to individualize the care they administer in unique patient situations. "Clinicians may be forced by the actual conditions of patients to use different 'pieces' of knowledge embedded in protocols, combine them, or activate expertise and experience via intuition," (Batista et al, 2016). In fact, it has been argued that physicians are required to be skilled in improvisation in the interest of those patients whose anomalous condition is a divergence from the 'norm,' (Haidet, 2007). It is impossible to completely systematize and accommodate for all emergencies, ergo improvisation is an implied component of such situations.

In those organizations, which do not normally manage crises, it is not only possible, but highly encouraged to engage in crisis-foresight, as well as OI. However, in HROs, a majority of the events that arise with which large impact decisions need to be made in small snippets of time, OI at times can seem to be the only safety raft for the organization. Real time foresight is a must during a turbulent and ambiguous event. (Mendonça et al, 2003).

1.3 Introducing distributed cognition theory to OI

Organizational improvisation, although a relatively new field, has a lot to offer us in terms of learning what to focus on when trying to successfully train teams for more optimal collaborative work, why people choose to improvise in given situations, what kind of cognitive processes go into improvisational actions, and much more. Yet, it has not been substantially operationalized to the liking of the scientific community in order to conduct concrete quantitative studies or create computational models. Within this thesis, I put forth the proposition that the scientific community should view OI through the lens of distributed cognition in pursuance of better accounting for the relationships between the most bearing concepts of the field. Coined by Hutchins, distributed cognition aims to recognize and interpret cognitive systems in terms of organization. As with many other branches of cognitive science, distributed cognition or DCOG takes into account cognitive processes such as "memory, decision making, inference, reasoning, learning, and so on. Also following mainstream cognitive science, it characterizes cognitive processes in terms of the propagation and transformation of representations," (Hutchins, 2000). What makes DCOG stand apart from the other branches of cognitive science is that it stretches the perimeter of cognition's unit of analysis, as well as the confines of the presupposed mechanisms, which constitute cognitive processes. In his introductory work on the subject, Hutchins presented "distributed cognition looks for a broader class of cognitive events and does not expect all such events to be encompassed by the skin or skull of an individual," (2000). If the reader believes that this sounds like a remnant of the extended mind perspective in cognitive science, then the reader is not at all mistaken. Being that DCOG does in fact find some of its roots within the extended mind branch. This shall be

explored in more depth in the following section. However, DCOG is primarily a sociocultural system. Better explained by Artman and Waern (1999), "[s]uch a system is a functional system consisting of people as well as cultural artifacts, designed and evolved to accomplish a certain goal. This goal and the means for achieving it may not be physically represented in any single one of the components of the system, thus illustrating the distributed nature of the accomplishments of the system." Hence, when analyzing a sociocultural system through the lens of distributed cognition, it is not the individual's cognitive properties, which are taken into account, rather the intercommunications within people as well as among people and artifacts. What artifacts factor in is not overlooked when it comes to analysis, since they play a crucial role within the dynamic system.

Distributed cognition is a way of systematically looking at the world. The many diverse connections that make up a system do not magically fall under the same umbrella in an orderly fashion and work in a straightforward manner. Different relations of parts belonging to a holistic system can have stronger or weaker points, they are by far not simply one-way tracks, and they are prone to change over time, along with the rules that apply to their functionality. An optimally functioning human body is not just a running, working machine, but a system whose processes produce, down the line, an entire human experience. This human experience cannot find its existence without one's cognition to shape and form it into such. "While social institutions shape our cognition in part through functional integration, the more significant way in which they determine and constitute our cognition is through what I will label task-dependency; roughly, the holistic inter-defining of tasks and roles. Task-dependency is not a causal notion, but a notion that pertains to organization and coordination," (Slors, 2019).

In order to tackle the issue of distributed cognition, one must first become acquainted with its beginnings. As Hutchins, father of DCOG, eloquently wrote: "The roots of distributed cognition are deep, but the field came into being under its current name in the mid-1980s. In 1978, Vygotsky's *Mind in Society* was published in English. Minsky published his *Society of Mind* in 1985. At the same time, Parallel Distributed Processing was making a comeback as a model of cognition (Rumelhart, et al, 1986). The nearly perfect mirror symmetry of the titles of Vygotsky's and Minsky's books suggests that something special might be happening in systems

of distributed processing, whether the processors are neurons, connectionist nodes, areas of a brain, whole persons, groups of persons, or groups of groups of persons," (2000). Although initially the extended mind (EM) was introduced by the likes of Putnam (1975) and Burge (1979), as a means to classify or describe intended mental states in the realm of philosophy of mind and language, it gained a more enticing interpretation with Clark and Chalmers, (Wilson, 2005).

From works in the social sciences to the writings of philosophers and economists, scientific research of the last century has shown us a new direction: one in which the cognitive characteristics of an individual are a complete different set of characteristics than those of a group of individuals. In 1988 these ideations were translated into something less abstract for the community of cognitive science with Minksy and Papert's proposition that multiple lower level agencies could compose a higher-level agency, in which the low-level agencies could comprise distributed computations in connectionist nets, (Hollan, Hutchins, Kirsh, 2000; Hutchins, 2001). Essentially proposing that the individual's cognition is also distributed, since "[…] each brain contains hundreds of different types of machines, interconnected in specific ways which predestine that brain to become a large, diverse society of partially specialized agencies," (Minsky, 1986). If one follows this reasoning for individual cognition, then it can be extended onto cognitive properties of a social group. Therefore, DCOG seems to be the most felicitous perspective to take on organizational improvisation.

Chapter 2

What drives OI?

2.1 Bricolage

In 1998, Moorman and Miner outlined and summarized what they sought out to be the constructs and/or correlates of improvisation. These were creativity - “a degree of novelty or deviation from standard practice,” (which can involve absolutely no improvisation, yet can represent valuable competence for it); intuition, wherein “choices are made without formal analysis;” and bricolage - “making do with the materials at hand.” With this outlining of constructs they wanted for it to be clear that each concept could be as much a part of an improvisational act, as it could be a separate action altogether. In other words, improvisation can have traces of creativity or intuition, yet it can exist without them as well. Further investigation into these constructs has led us to believe that particularly when it comes to improvisation on an organizational level, well-executed bricolage is an organizational trait of great importance. So let us explore why this may be the case.

In early OI research, bricolage and improvisation were nearly synonymous in regards to their definition. Both concepts have been used interchangeably and it has been assumed that one could not exist without the other (Hadida, et. al, 2015). In her comprehensive review of OI literature, when researching definitions of improvisation, Hadida found 6 works, which included bricolage within their definitions. It comes to no surprise, since both bricolage and improvisation have to do with the creation of a novel solution from what one already has on hand, so to speak. In truth, these concepts are indeed quite similar, however it is important to distinguish between them, for each can be an independent action, exclusive of the other. Cunha defined bricolage “as the invention of resources from the available materials to solve unanticipated problems,” (2005). It is not difficult to make the seemingly short jump between

improvisation arising from lack of foresight to bricolage being a solution to an unexpected situation. However, a key difference between the two is still present. On its own, improvisation may come to fruition without the conception of something wholly new, and rather deals with on the spot action and using primarily mental resources, all while having a time constraint. On the other hand, bricolage refers to the actual invention of something novel or the reinvention of something already existing, and more often than not implies the utilization of a physical resource.

Bricolage can essentially be conceived as the acquisition and restructuring of accessible materials, as well as their complete reinvention for a new purpose or solution. In HROs, this is almost always necessary, for such organizations have to navigate dangerous waters while one way or another being constricted in time. It is not possible to be entirely prepared for every situation that is thrown into one's direction, which means not all ideal or most optimal tools will always be readily available to help deal with the situation at hand. Let us take one of the most prominent examples of a situation wherein bricolage saved lives in an emergency.

Within the first three days of its launch, NASA's Apollo 13 mission reared its course from a mission of lunar discovery to one of survival tactics. In short, an explosion occurred during which an oxygen tank on one out of two modules, that was meant to supply half of the entire trip's oxygen, was damaged. There were two cartridges on the Lunar Excursion Module or LEM (the undamaged module) whose main purpose was to gather accumulated carbon dioxide, and once one of them would fill completely, it would be replaced by a successive cartridge. These two cartridges were intended to last the entire mission, since the men were not meant to spend the entire trip on the LEM, however even in that case – the cartridges were meant to support the life of two astronauts, not three. Due to the explosion damaging an oxygen tank on the first module, the third astronaut who was initially going to stay on it was forced to move to the LEM, cutting down the time before the cartridges were completely filled with CO2 significantly. A solution needed to be found, and quick. In the spirit of bricolage, the NASA ground team had gathered materials they knew the astronauts had on board and began to work out solutions. The solution, for the sake of brevity, here stated in a grossly simplified

manner, consisted of repurposed plastic bags, duct tape and a canister that took on the intended purpose of the cartridges. Bricolage saved the Apollo 13 mission (Rerup, 2001).

Initially coined by Levi-Strauss in his 1962 work *The Savage Mind*, bricolage "was originally presented as an analogy for how mythical thought works, selecting the fragments or left-overs of previous cultural formations and re-deploying them in new combinations," (Johnson, 2012). This was an anthropological definition that later extended into different branches of both sciences and humanities. Yet another way of presenting the manner in which OI comes from art into science. Thus, it is to little surprise that such a unique field of study like OI, which is essentially a scientific approach to an artistic construct that has to do with creativity, examines bricolage as well. Rerup (2001) beautifully summarized how Levi-Strauss believed in "creative recycling" and restructuring of previously lived experiences. Thus, one could potentially say that bricolage is creative recycling of available resources, and is a felicitous fit to improvisation. Now the question may arise – what makes bricolage so special for HROs in particular?

Bechky and Okhuysen, by means of comparing gathered data on improvisational actions from both SWAT teams and production crews came to a profound, yet somewhat unsurprising conclusion: such teams deal with bricolage on a daily basis (2011). Each of the previously mentioned researchers had separately been conducting research in their respective fields of interest, and when comparing notes they came to the realization that their gathered data had a lot more in common than initially thought. SWAT teams deal with elements of surprise in their daily tasks, just as much as production crews do. The execution of daily tasks for both SWAT and production teams depends on factors such as the external environment, time pressure, weather, bystanders, and a general ambiguity or uncertainty with the way events may unfold. The main difference between these two distinct types of teams lay in the consequences that improvisational actions or bricolage might yield: for SWAT teams a mistake can either result in a severe injury or cost a life, whereas for production crews the cardinal repercussion is generally of a monetary nature. Notwithstanding the essence of the obstacles each team may face, it was found that each of them tend to engage in organizational bricolage more than basing their actions around a novel improvisational response. They are inclined to approach their problems by restructuring the resources they have readily available on hand. In the case of a SWAT team,

this may be rethinking a storm-in tactic on the spot, due to outdated blueprints, while a production team may have to quickly reorganize an entire day's scheduling and filming tactics due to high winds tampering with the initial plans.

With the aforementioned scenarios, we may begin to understand that bricolage is a vital part of OI. It is important to develop and grow this skill within all types of teams, but even more so within teams who deal with the management of turbulent and ambiguous events. Albeit bricolage is a key element to OI on its own, its strength lies in its combination with other key elements, namely organizational culture and organizational memory.

2.2 Organizational Culture

The aptitude and willingness to improvise may of course be fundamental on an individual level for its occurrence, however these factors can mean next to nothing if the organizational culture does not foster or support such behavior. Organizational culture is "defined as a learned way of perceiving, thinking, and feeling about problems that is transmitted to members in the organization," (Walsh & Ungson, 1991). In other words, if an organization does not carry a certain level of creativity readiness it is highly unlikely that the members will readily jump ship from learned protocols and practices to improvising during an emergency state. "Creativity Readiness is the presence of attitudes and practices that promote conditions conducive to creative idea generation and application within an organization," (Fichet, 2018). In her dissertation on creativity readiness, Fichet summarized and outlined the chief levels and their dimensions originally formulated by Anderson, et. al (2014) which play a decisive role in the crisis management organization's proclivity towards this ordained readiness. The four levels are: the individual, the work team, the organizational and multilevel.

Within the individual level, one finds individual factors, which include intrinsic motivation, that is the internal and genuine drive or interest of the individual in completion of a certain task or achievement of a goal, as well as creative confidence, which is self-explanatory and simply means the individual's level of confidence in creative actions. The situational context within the individual level includes whether or not the situation calls for improvisation, as well as the time pressure or constraint in a given situation. Suspension of judgement and psychological safety go

hand in hand, since one is a precursor for the other. Together these constructs work as a safety net both, on the individual and organizational levels, to promote a surrounding in which "uncertainty and risk-taking are accepted," (Fichet, 2018). Meaning, an individual feels safe to introduce his or her novel ideas and solutions without fear of judgment or rejection. Psychological safety within an organizational team can provide individual members, among many other things, a proactive voice and overall proactive behavior, which is vital to organizational learning (Edmondson & Lei, 2014).

Psychological safety found its beginnings dating back to the literature on organizational change in the 1940s. Professor Kurt Lewin, often recognized as the father of social psychology, developed a model of social change. His work was further expanded and applied to organizations, and can essentially be watered down to the three step "Unfreeze, Change, Freeze" model. The belief that guided the evolvement of this model was that "the key to resolving social conflict was to facilitate planned change through learning, and so enable individuals to restructure their perceptions of the world around them," (Sarayreh et al., 2013). Unfreezing referred to letting go of habitual practices and remaining open for new modes of action. During the change stage of the model it was implied that the group would learn new practices by doing them and realizing that they either improve overall productivity or make reaching objectives easier, thus embedding the new practice into their daily rituals. The new behavior would then be 'stabilized' during the unfreeze stage, wherein it would be reinforced and finally become a new norm. Through application of this model, Lewin had observed that norms and habitual methods of the group needed to be amended in order for individual behavior within the group to endure. "In organizational terms, refreezing often requires change to organizational culture, norms, policies and practices," (Sarayreh et al., 2013). It is paramount to comprehend that this model was the beginning of psychological safety, even though the term itself had not been coined until Amy Edmondson had ventured into studying team learning and performance in 1999. Psychological safety is most relevant to organizational change, for it has the ability of allowing people to conquer "the defensiveness, or learning anxiety, that occurs when they are presented with data that contradict their expectations or hopes," (Edmondson & Lei, 2014).

In fast-paced environments, where exigent events happen often, the need for organizational learning is extremely valuable. Lastly, autonomy in the work is a decisive factor for improvisation proneness, since one is automatically more intrinsically motivated to apply him or herself wholly when he or she has a certain degree of ownership and control over the work. Moreover, higher autonomy has been found to be positively correlated with greater psychological safety (Edmondson & Lei, 2014).

On the work team level within the environmental context, what plays a large role for improvisational proclivity is the leadership behavior and support. With the previously discussed notions, it becomes self-evident that in order for the team to engage more freely and willingly in creative processes the leadership must be open to it, give value to such behavior, as well as generally support creativity in itself. Psychological safety, of course, comes into play on this level as well. If not all members perceive the presence of psychological safety in a similar manner then it simply cannot be a group-level construct and will not provide the desired effect (Edmondson, 1999). Group diversity regarding heuristics as well as multifarious perspectives has also been noted to either foster or hinder a team's improvisational tendency. If the team's objective is clear to all members then team diversity can even aid in the group's propensity to display behavior that is more creative. Processes that become intrinsic and regularly practiced such as brainstorming have also been found to guide teams towards more profound and creative work effort. This provides feelings of value for all ideas, being heard, as well as a lateral thinking approach. In fact, findings suggest "training in brainstorming may support task-relevant creativity and that the embedding of heuristics in a creativity support system does not hinder task-relevant creativity," (Mendonca, et. al, 2001). Mendonca and colleagues even went on to posit that in order to advance decision aids within and for HROs we must first and foremost further our comprehension of cognitive processes in improvisation.

At the organizational level one sees branding come into play. Meaning, creativity needs to be advocated as an intrinsic part of the overall values of the organization. Even though this may seem counterproductive when speaking of a police or fire department, for example, it is

important to note that no matter the nature of any organization it is still perceived by the public eye and thus has a certain image it portrays and needs to uphold. Hence, the manner in which an organization communicates how accepting it is of creative approaches to the outer world can either damage or strengthen the team's readiness to improvise. This notion goes hand in hand with the way in which the organization communicates its value of creativity to its individual members as well. In support of this insight, among the key shared characteristics of resilient organizations found in Boin & van Eetan's study was the concept of "a culture of reliability that distributes and instills the values of care and caution, respect for procedures, attentiveness and individual responsibility for the promotion of safety throughout the organization," (2014). I will take the liberty of extending Anderson and colleague's factors within their organizational level to include this culture of reliability.

The final level is the multilevel in which the previously listed factors combine in one way or another. This includes the overall attitude towards creativity, which can be displayed through discussions after particular failures, during the planning stage, and so on. Technology used by the organization also plays a large role in creativity, and combines multiple levels due to its ability to manage knowledge storage, communication within and throughout the organization, as well as the sharing of ideas and much more. When considering the technology to be used in a crisis management organization it is crucial to "always consider the human as an integral part of the decision making process," (Mendonca, et. al, 2001). If individuals of the team have to work around technological limitations during an emergency with time constraint, among many other situational and environmental factors, this can cause an unnecessary loss of precious cognitive power and energy, and administer more room for failure.

In sum, organizational culture is multifaceted, yet undeniably an integral and vital part of organizational improvisation. Without optimal support of creative effort both on the individual and organizational levels, that fosters psychological safety and the adoption of regular practices that support and train these abilities, the improvisational proclivity of organizations will undoubtedly suffer. Therefore, it is in the interest of all organizations, and most importantly HROs to hone such a culture that will breed teams who feel safe and confident enough to

improvise. An intrinsic component of organizational culture, which works in tandem to further the culture as well as improvisational proneness is organizational memory.

2.3 Organizational Memory

Organizational memory is a pillar and antecedent of OI, for in it lie the resources the organization can utilize both mentally and physically. This is the overall stored knowledge of skills, rules, procedures, failures, decisions and more that are inherent to a given organization. In other words the organization's collective knowledge. It is what allows an organization to carry on with its activities, even when an individual who initially acquired some particular intelligence is no longer with the organization itself. Similar to the classic psychological definition and according to Moorman and Miner (1998), among many others (e.g. Cunha, 2001; Kamoche & Cunha, 2001), there are two types of memory within any organization – procedural (skill) and declarative (fact) memory. Essentially being implicit and tacit knowledge, respectively. Depending on what a particular organization concerns itself with, the memory content will naturally differ.

According to Walsh and Ungson (1991), organizational memory is composed of "information about decisions made and problems solved […] over time." When an event occurs that calls for a decision to be made, members of the organization first recognize and acknowledge it, then draw up an according response. The stimuli that make up these two steps of (1) decision and (2) response are acquired and encoded into organizational memory. Human memory is known to be faulty and at times precise details of a memory may seem distant or even ambiguous, and an important note to mention is that the same can be said for organizational memory. Hence, it is a common occurrence for certain schemata to develop on both the individual and organizational levels pertaining to decisions and responses.

These schemata or guiding images are also highly influenced by the organizational culture, previously discussed in this work. For the sake of this thesis, I will define these shared guiding images as shared temporal cognitions. "Shared temporal cognitions are emergent states, which are constructs that characterize properties of the team that are typically dynamic in nature and vary as a function of team context, inputs, processes, and outcomes […] It is known that shared

temporal cognitions are positively related to team adaptation and to team performance," (Abrantes, et al., 2018). They act as a form of cognitive heuristics, taking off cognitive load or allowing individuals to come to a decision in a more succinct manner. In most cases such organizational schemata result in a smooth work flow when all or most members of a team indeed share the temporal cognitions. When taking firefighters as an example, let us imagine just how many environmental and informational cues they must attend to when they arrive to a scene. Source and direction of smoke, ground layout, hydrant position, information provided by bystanders – all these and many more instances make up the cues that fire ground commanders need to pay close attention to before taking any further action. Moreover, upon arrival at the scene, most of these cues are not clear cut, and it takes time and effort to filter and gather all relevant information in order to take further action. Let us also not forget, in these situations time is of the essence. Okoli and colleagues (2014) found that when encountering these cues, pattern recognition and/or intuitive decision-making processes come into play, however due to the cues deriving from multiple sources at once, the cognitive load in working memory increases. Although professionals have a trained cognitive architecture, which allows them to use their knowledge in order to navigate situational awareness and gain a perceptual advantage "even as events unfold," this is largely due to a present schema Okoli et al., 2014). Okoli and his team also noted that when it comes to fire, identifying the class of the burning fire grants the firefighters the ability to dedicate their thoughts with information privy to that specific fire class. "Information relating to other classes of fire is therefore screened out and pushed to the subconscious 'window' in order to keep working memory load reasonably low," (Okoli et al., 2014). However, cognitive shortcuts, just as any type of shortcut, have no guarantee that they will yield the desired result, due to certain details of a problem being left unnoticed or unattended to. In fact, a core issue with a shared schema in organizations is that it may result in managers or leaders of a team applying new information (which requires a new type of solution) to an existing schema (Cunha, et al., 2006). Such situations can result in gruesome failures and reinforcement of rigid habit following, which is the opposite of dynamic thought processes that ambiguous and high-risk environments require. This can be mollified by means of optimal information processing within an organization.

Information processing in general, but more specifically within an organization seems to be a vital and crucial factor of organizational improvisation. It "consists of locating/acquiring and capturing/retrieving information which relates on organization and stored/dissemination of information." (Arshad & Hughes, 2009). A four stage process of information gain (on an organizational level) is made up of (1) acquisition and retrieval phase, wherein in the organization or group actually acquires information be it from internal (within-group) or external (environment, market, etc.) sources. This raw data is then (2) spread throughout the group and (3) ascribed a certain type of interpretation and meaning. *Shared interpretation* is a crucial stepping-stone for improvisation as well as an important component of team mental models (TMM). This information must then be (4) stored in a way that each group individual can access it – this is called *organizational memory*. Only by following all these 4 steps may organizational learning occur (and further lead to successful improvisation on a communal level). Of course, even if all these steps are followed in a rigid manner they are not to be treated as a doctrine or set of rules to follow in order to attain a particular result – there is no one panacea for optimal human interaction or reaction. However, paying close attention to these processes and tailoring them to individual/organizational goals may assist in creating stronger team mental models, as well as promote situational awareness.

The transfer of knowledge is also a key factor in organizational memory, as well as the overall inclination to improvise. For knowledge alone, may be codified, but it does not apply itself directly to situations or the immediate environment. Those on the receiving end of the knowledge transfer must concern themselves with the knowledge application. For example, an instructional manual may provide one with the knowledge of how to build a ship, however the individual must adjust that knowledge depending on whether the ship is intended for distant travels in challenging ocean waters or for lake cruising.

So where does this information come from? Naturally, the answer to that question depends on the given organization. For example in the case of fire fighters, information sources include: information retrieved from experience (acquired through longer time periods of hands on practice), information retrieved from training and deliberate practice (obtained by means of training programs), situation awareness (field observation of that, which they are trained to pay

attention to), victims/passers-by (information that comes straight from the victims or observers of the event), team consultation (crew member interactions), (Okoli & Watt, 2016).

Procedural memory consists of the skills, procedures and routines that any given organization regularly executes. Just as one learns to ride a bike and with time performs the required actions without thinking about the sequential steps involved in the action itself, procedural organizational memory, with time, becomes accessible on a subconscious or automatic level. Without having access to such memory, improvisation would not be able to take place, for one needs a stepping ground upon which to build something new. When it comes to emergency management organizations, procedural memory is of extreme importance, due to the fact that specific protocols are in place for a majority of events that occur. Yet, not all details may be accounted for during planning, and it is exactly in moments unaccounted for when an organization can optimally benefit from improvisation. Some argue, "following too rigid to procedures and routines may inhibit creativity and spontaneity and therefore could obstruct the improvisational process," (Arshad, 2011). Crossan et al. (1996) along with Weick (1999) go so far as to say that even if creative potential is high and the level of expert knowledge is rich, most individuals are inclined to rely on routines and actions that are familiar (Cunha OI). Authors Moorman and Miner (1998) argue that although such memory is crucial for an organization to work, the more it is called upon in a rigid manner – the less improvisation one may see. Yet there are areas within an organization, wherein once a good set of procedural memory is employed – it may further improvisational outcomes (such as having technological routines, which can aid in improvising product development). Moorman and Miner essentially propose that "the greater the procedural memory level, the greater the likelihood that improvisation will produce action low in novelty." In Weick's opinion, it is therefore crucial that members of organizations become willing to unlearn their learned responses, in order to make room for improvisation to step in during times of need. This can be accomplished with the help of the organizational culture.

Declarative memory within an organization, consisting of tacit knowledge, is what essentially alters the qualitative content of decisions and responses (Cunha, 1999). Due to the fact that tacit knowledge is highly influenced by personal beliefs and experiences, it is not as easily accessible as procedural memory, and can therefore be more laborious to transfer and share within a team. This type of memory adheres to more general knowledge about one's domain of interest and can be extremely useful when it comes to improvisation. Moreover, the same piece of declarative memory can be used and applied in various ways to myriad tasks. "When improvisers have rich stores of declarative memory they are able to recognize various patterns in external events and to select actions that link their actions to these events so that a coherent whole is achieved, both within the action itself and within the context," (Moorman & Miner, 1998). To highlight this notion, one may look at the infamous Mann Gulch fire disaster, described and analyzed by Weick in 1993. In this incident, a lightning storm caused a raging hazardous forest fire to break out, and due to its rapid spreading from high winds a fire crew was sent out in attempts to keep the fire contained and salvage what they could. From a crew with sixteen members only three survived. While advancing along the fire's route the crew became entrapped by fire and had no visible escape. One of the team members had set a small fire in order to escape, which caused an area to burn over, making the fire circumnavigate it, essentially leading the man to his freedom. This practice was in no way a regular procedure, and, in fact, was generally ignored by the other team members. However, in this case, declarative memory had played its role in the brave crew member's improvised act: he "was an experienced woodsman, with lots of hands-on experience," who had a sufficient enough amount of tacit knowledge regarding fire to know that this procedure could save his life, as well as the life of others (Weick, 1993).

2.4 Virtual Role System

One of the cruces of OI is the virtual role system or VRS. Its existence alone embodies the concept that a team must improvise in order to continue in a steady workflow and keep organizational face. It also flies close to the concept of self-organization in teams, which we shall explore more fundamentally in the upcoming section. For a clearer understanding of what

a VRS entails we must first acknowledge that it may only be in place when an organization can be considered as resilient. As with almost any term in the natural sciences, there are numerous definitions of a resilient organization, yet an underlying commonality may be found among them: when an unexpected danger or threat emerges, the organization can restore its original structure and form in a timely manner, and may even come out of the situation stronger. Weick (1993) even went so far as to define organizational improvisation as "when one organizational order collapses, a substitute is invented immediately." So here, we may see just how closely regarded resilience is to OI. Members of an organization are expected to "continuously and reliably fine-tun[e] their actions to the local context, to achieve a proper balance between competing safety and productivity imperatives," (Naikar & Elix, 2021).

Depending on when the organization tends to 'jump back,' this resilience can either take on the form of precursor ("the ability to accommodate change without catastrophic failure, or a capacity to absorb shocks gracefully" (Boin & van Eetan)) or recovery ("the ability to respond to singular or unique events, bouncing back to a state of normalcy). A notable difference between these two types of resiliencies is that one may be physically observed (the organization that can revitalize after a crisis) and in the precursor sense, if one is not within the organization then one may have troubles realizing that there ever was a crisis to begin with. Regardless of which resiliency we are taking into consideration, it becomes increasingly clear that improvisation is a crucial component of either one of these forms. If the reader finds him or herself questioning just how this is evident, then the reader must ask him or herself how an organization could bounce back from a disastrous situation without improvisation in general. They simply go hand in hand.

Research on resiliency has provided ample evidence that resilience and adaptation are nearly tantamount concepts, quite similar to the concepts of bricolage and improvisation. On one side of the coin, one may be able to adapt to a situation without exuding resiliency. On the other side – resiliency cannot exist without a sufficient display of adaptability. Thus, research regarding resiliency tends to cover adaptability as well, though not always.

Let us consider Arshad's work in order to better understand why this may be the case. In her doctoral thesis, she mentions how if an organization comes to face an unexpected and volatile event, due to time constraints it may be difficult to categorize the observed adaptation as improvisational. She then posits that exactly such an event portrays how "the adaptation element can be categorized as the element that drives improvisation, but not as a descriptive element of improvisation," (Arshad, Understanding organizational improvisation…)" In this case, I believe Arshad was referring to resiliency, however did not realize that this was the exact concept on the tip of her tongue. In fact, in over 380 pages worth of work explicitly discussing OI and its core concepts, Arshad did not once mention the word resiliency. Although she takes a deep dive into managerial characteristics, organizational culture and structure, as well as internal and external outcomes of OI, I believe she did not come to include the concept of resiliency in her work simply because of its similarity to the concept of adaptation. In earlier foundational works of the OI community contributed by scientists such as Kamoche, Mintzberg, Cunha, and others - resiliency was not a word that sparked much interest, for it was an organization's potential to adapt to a novel situation that was being studied more vigorously, rather than its resiliency. In fact, Grotan et al, rendered adaptation to be a key component of resiliency, being that adaptation carries within itself "knowledge in terms of anticipation (what to expect), attention (what to look for), and response (what to do)," (2008). This is yet another example of how synonymous these two terms seem to be within the assortment of research on the topic. In sum, a resilient organization is one capable of facing an unexpected event and being able to optimally cope with (or adapt to) it in a timely manner. Which brings us to our next point – the virtual role system.

Originally coined by Weick in his study of the Mann Gulch fire, a VRS can essentially be seen as an extension or a deeply embedded characteristic of a resilient organization. If a VRS is strongly present within a team, it implies that each individual member of said team is capable of mentally taking on almost all or (ideally) all individual roles within the group. This hypothetical (until used) role taking means that any given individual belonging to the team could potentially replace a missing member if the need arises. Compared to a holograph, "each person can reconstitute the group and assume whatever role is vacated, pick up the activities, and run a

credible version of the role," (Weick, 1993). This definition is analogous to that of resilience; only it accentuates the existence of the individuals within a given organization, rather than solely considering the organization as a whole. In other words, a VRS is the resiliency of each person within an organization or team in relation to the team in its entirety. In his *Analysis of the resilience of team performance during a nuclear emergency response exercise*, Gomes wrote, "[h]aving a large number of individuals might degrade teamwork, especially if some agents do not have an active participation in the team's decisions and actions," (2014). This simply reiterates the need for continuously tending to the VRS within a team, in order for it to function at full capacity. The holds true especially for HROs. Having a stable VRS in place can mean a more optimal distribution of cognitive resources for the team overall. Both social and cognitive resources are undeniably crucial when an organization is faced with an unexpected emergency or situation. "Shared role systems have been found to enable action in response to dynamically evolving situations facing medical trauma teams, ship navigators, and firefighters," (Bechky & Okhuysen, 2011).

2.5 Distributed cognition and its beginnings

How exactly is distributed cognition different from other theories of cognition in cognitive science? This theory emphasizes the environment as a whole, drawing more attention to the what and the how of actions, analyzing cognitive processes established within the functional relationships of participating elements (Hollan, et al., 2000). It opens the horizon for cognitive scientists to look beyond the cognizance delimited by the skull or body and to factor in that the surrounding environment and our interactions with it are just as much a part of our cognition as our internal thought processes and subconscious or autonomic actions. In other words "a process is not cognitive simply because it happens in a brain, nor is a process noncognitive simply because it happens in the interactions among many brains," (Hollan, et al., 2000).

Chapter 3

OI in emergency management teams through the lens of distributed cognition

3.1 What is Distributed Cognition and why is it relevant?

As discussed in the prior section, distributed cognition found its humble beginnings with the extended mind thesis; however, its current state is far more sophisticated. The reason I use the word sophisticated is that this lens has been tailored to be more applicable to the quantifiable aspects of a sociocultural cognitive system. In the extended mind thesis, for instance, there tends to be a limited focus on the individual and the individual's interaction and relations with artifacts. However, this more or less narrow study of cognition had been expanded by Hutchins and those who followed in his footsteps. Distributed cognition assigns more concrete definitions to the separate parts of a system, which can easily be viewed as an entire whole. Hence, when OI looks more at qualitative characteristics of the sociocultural system, the DCog lens can appoint attributes to those qualities, which may in the long run allow us to study OI in more depth, thus more qualitatively.

It comes to no surprise that Hutchins had his "A-Ha" moment of distributed cognition when studying ship navigation teams. Such teams are tediously trained for their specific allotted areas and tasks. Yet, for each overall assignment to run smoothly there must be an alternative task distribution in place in case something goes wrong. In general, ship navigation is a continuously ongoing task, which is performed at any time the naval vessel is not anchored or attached to a pier. Although typically the task of navigation is assigned to one individual of the team, at times the ship may need to enter an environment where mobility is limited. In these moments, navigational computations may surmount the abilities of the individual assigned the task of computing the navigational system. This is where various members of the team can step in and work collectively (often limited by time constraints), in order for the task to be completed in an optimal manner (Hutchins, 1990). Ergo, the task becomes essentially one cognitive task that is distributed among various individuals. It was posited by Hutchins within a distributed system elements must be interdependent in order for the task to be fulfilled. Weick and Roberts, in

their 1993 work *Collective Mind in Organizations: Heedful Interrelating on Flight Decks* wrote about a quite similar topic, but summarized the collective mind (which I took the liberty of extending to the concept of DCog) "as a pattern of heedful interrelations of actions in a social system." Within this system, the actors comprehend that their input is received by a system (contributions), wherein the system itself is comprised of connected actions which stem from the actors themselves as well as others (representation), "and interrelate their actions within the system (subordination)," (Weick & Roberts, 1993). Weick and Roberts (1993) went on to posit that the stronger the interrelations between representation and subordination, the less probable it becomes for organizational error. These instances only enhance the compatibility of OI and DCog.

OI tends to looks at the team as an entire whole, acknowledging that different team members may exude different qualities that can help the team and its collective improvisational proclivity. In other words, OI recognizes that a team is comprised of interdependent members. For example, some group members, more particularly those closer to the top of a vertical hierarchy, may be more supportive and provide a psychologically safe environment for others to flourish in and thus be more predisposed to improvise, as we have seen in more detail in the previous sections.

It is stated within the *International Encyclopedia of the Social and Behavioral Sciences* that there are three main components that distributed cognition concerns itself with. "Cognitive processes may be distributed across the members of a social group, cognitive processes may be distributed in the sense that the operation of the cognitive system involves coordination between internal and external (material or environmental) structure, and processes may be distributed though time in such a way that the products of earlier events can transform the nature of later events," (2001). This may sound familiar to the reader. Let us equate these key concepts to those of organizational improvisation. In order for something to be categorized as OI, a group must be involved and a collective system of communication needs to be intact – organizational culture. Said group may interact with the environment and artifacts found in this environment in order to achieve its common goal – organizational culture and bricolage. Lastly,

organizational memory or collectively accumulated experience may influence how improvisational accounts come to fruition. Of course, in both instances, these key factors are refined for the sake of brevity, and those who concern themselves with the study of each respective field understand that there are many other factors that come into play. However, even in their general summaries of what constitutes the field of OI and the DCog framework, they are very similar to one another. Let us delve deeper into why this may be the case.

3.2 Organizational improvisation as a sociocultural system

In his 1968 work *Society as a Complex Adaptive System*, Walter Buckley defined the sociocultural system or society as "a complex adaptive system." Furthermore elaborated as "open 'internally' as well as externally in that the interchanges among their components may result in significant changes in the nature of the components themselves with important consequences for the system as a whole," (Buckley, 1968). Buckley posited that no matter if the adaptive system was on the biological level, psychological or sociocultural levels it "must manifest (1) some degree of "*plasticity*" and "*irritability*" vis-à-vis its environment such that it carries on a constant interchange with environmental events, acting on and reacting to it; (2) some source or mechanisms for *variety*, to act as a potential pool of adaptive variability to meet the problem of mapping new or more detailed variety and constraints in a changeable environment; (3) a set of *selective* criteria or mechanisms against which the "variety pool" may be sifted into those variations in the organization or system that more closely map the environment and those that do now; and (4) an arrangement for *preserving and/or propagating* these 'successful' mappings," (1968). This definition paved the way for scientific research to change its direction when it came to studying the society as a whole. It furthered the idea that our sociocultural system is built upon symbiotic, non-linear relationships and connections. This suggests that one individual agent cannot comprise an entire system, just as in organizational improvisation – a group needs to be present before OI can be considered. Moreover, the connectivity and interrelations involved within the system are what make up the system in its entirety. Meaning, the definition, categorization and general comprehension of the interrelations within the system are crucial to studying and understanding whole systems.

Although quite self-explanatory, it should still be noted that the more complex and dynamical the system – the more connections and interrelations one may find within it. Now that the sociocultural system has been defined, let us narrow down our focus and take a look at OI as a sociocultural system in and of itself.

We can begin by taking the four defining points of a sociocultural system, as mapped out by Buckley, and applying them to OI.

1) Some degree of "*plasticity*" and "*irritability*" vis-à-vis its environment such that it carries on a constant interchange with environmental events, acting on and reacting to it

At this level, we can assume that since organizational improvisation can only exist within an organizational grouping or team, it is constantly dealing and interacting with the dynamic environment, which carries and action-reaction response. Team members act upon their environment collectively, and must react to the environment's reverberation almost continuously.

2) Some source or mechanisms for *variety*, to act as a potential pool of adaptive variability to meet the problem of mapping new or more detailed variety and constraints in a changeable environment

Here, we may see a resemblance to the organizational culture as a whole. If we recall from chapter 2, section 2.2, the way the organization goes about perceiving, thinking, and feeling about problems that is transmitted to members in the organization, is, in itself, organizational culture. Thus, this may account for the source of mechanisms for variety, in that depending on the rigidity or flexibility of organizational policies and manners – the organization is either strict or lenient in how it accepts novel approaches to tried and tested problems.

3) A set of *selective* criteria or mechanisms against which the "variety pool" may be sifted into those variations in the organization or system that more closely map the environment and those that do now

In this case, the organizational memory that lives within and among the team members, as well as the organization as a whole seems to be the most relevant area to be applied. In the

organizational memory one plays witness to the accumulated knowledge of the organization, ergo instances of success or moments that were encoded to be fruitful in their asserted situations, as well as instances of failure or actions that were flagged as not producing desirable results.

4) An arrangement for *preserving and/or propagating* these 'successful' mappings

This definitional component may unequivocally be charted as the virtual role system. For, it is within the VRS that accepted roles and practices within the team are reinforced, and continuously redefined as they are applied to each individual member of the team, acting as the whole.

Members belonging to an organizational team require a certain level of interconnectivity in the pursuance of better OI and a more successful adaptive system in general. Customarily, teams who fortuitously employ OI tend to have a deeper bond within and among the individual members. Thus, we look to the individual members who make up the team. Their participation and overall contribution to the sociocultural system is insurmountable. "Structures of collective meaning that emerge in and coordinate the activities of the group can be considered a basic condition for successful coordination," (Gilardi, et al., 2013). Even more exactly put by Artman & Waern "when complex dynamic situations are at stake, several people have to co-ordinate their conceptions as well as their actions; i.e., cognition is performed in a team environment," (1999). Meaning, the more complex a situation is the more necessary it is for group cognition to come into play in order achieve a solution in the most optimal form possible. It is also important to give credit to what culture itself brings us, especially in the context of organizational improvisation in the DCog perspective. "Culture provides us with intellectual tools that enable us to accomplish things that we could not do without them. This is tremendously enabling. But it is not without cost. For culture may also blind us to other ways of thinking, leading us to believe that certain things are impossible when in fact they are possible when viewed differently," (Hollan et al., 2000).

With the previously established connections between OI and a sociocultural system, we may now add distributed cognition into the equation. It was Hutchins himself who duly noted "when

applied to systems that are larger than an individual actor, distributed cognition is an approach to cognition that is deliberately framed in a way that keeps culture in mind. When units of analysis that are larger than an individual are examined as cognitive systems, acknowledging the involvement of culture with cognition is unavoidable," (2006).

3.3 Self-organization in organizational improvisation and teams alike

Within this thesis, we have already established that we live in a volatile, uncertain, complex and ambiguous world, and even more so is this the case for workers of HROs. The members of HROs deal with extremely complex problems that usually require a robust solution in small increments of time. Since the structures that such organizations are accustomed to operating with cannot always be fully present or intact, we have seen previously that the virtual role system comes into play. The VRS, even though not always as good as the original structure, still provides security and is undeniably better than achieving no result at all due to a team standstill, (Naikar & Elix, 2021). For a team to seamlessly adapt itself to a new structure, yet still be capable of facing the same nature of problems, there needs to be some kind of cognitive process, which can mitigate the rough edges of the transition back into the team's nearly original structure. It is with this in mind, that we may attribute the concept of self-organization to teams.

"This concept can explain how adaptations in actors' behaviors and structures can be achieved spontaneously, continuously, and relatively seamlessly, particularly in well-established systems, and why this process of self-organization is necessary for dealing with instability, uncertainty, and unpredictability in the task environment," (Naikar & Elix, 2021). In fact, here we may reference back to the task-dependency that was defined by Slors (2019) as "the holistic inter-defining of tasks and roles [...] not a causal notion, but a notion that pertains to organization and coordination." Even in situations wherein in the original team structure remains intact, learned protocols and the system's general structure may inhibit the team from achieving a desirable goal, for in some instances a desirable goal may require a novel approach based on situational awareness or other environmental cues. These may hinder the eagerness to engage in improvisational or novel behaviors. "The interplay between the structures of multiple actors

and the behaviors of individual actors is integral to the process of a system adapting to its environment," (Naikar & Elix, 2021).

For the sake of this thesis, I shall equate the words sociocultural and sociotechnical, since as soon as we accept OI as a sociocultural system, but also within the distributed cognition framework, most of the time we are looking not at cultural artifacts alone, but rather technological ones as well. Henceforth, if a sociocultural system is a system of adaptability, wherein agents and artifacts alike are taken into consideration, and we have assimilated OI as a sociocultural system, wherein cognition is distributed, the next logical step would be to regard OI as a sociotechnical system. The reason being - a particular type of OI, which occurs in HROs, involves technological innovation. A sociotechnical system (STS) is comparable to a sociocultural system, but differs since it is focused on an organizational level, where the interaction of human agents and their interrelations with technological artifacts are put to the forefront. The STS finds its beginnings among familiar names, one of which is Kurt Lewin, who was revered in Ch. 2, section 2.2 for his 3 step change theory. This same theory, conflated with ideas from Eric Trist (its original founder), participation research, and other concepts guided the STS approach into existence (Fox, 1995). What particularly makes the STS framework stand apart from the sociocultural is that it concerns itself more with the interdependency of the technical and social systems of an organization, so much so that organizational design takes a front row seat in this framework. This is an important juncture for us, since when analyzing OI in HROs with the DCog perspective, we must pay close attention to how exactly the interrelations of agents and their artifacts develop, where they stem from, how they *self-organize*. In this sense, bringing technology into the equation may prove helpful and insightful for more quantitative researchers, being that OI may become less abstract and more systematic.

With that in mind, Naikar and Elix (2021) also inspected 60 journal papers on resilience, which brought them to the conclusion that "research on resilience is concerned fundamentally with adaptation and, therefore, could provide a basis for designing for self-organization." So here we may see how deeply interwoven all the aforementioned concepts are. When it comes to designing for self-organization Naikar and Elix (2021) take cognitive work analysis as a

framework for STSs, which mainly deals with designing teams and training systems with the inclusion of worker adaptability, primarily for unpredictable and unique events. The cognitive work analysis is 3-dimensional in its nature. In the view of Naikar and Elix, the work domain analysis "offers an event-independent representation of a system's work demands, or constraints," (2021). Naikar and Elix (2021) also posit that the other two dimensions, activity analysis and strategies analysis, investigate work demands of repeating classes of situation, instead of specific events or circumstances.

For VUCA environment designs, this is extremely helpful, being that it is often impossible to account for all unforeseeable situations. Thus, these three previously mentioned analytical dimensions are completely independent of specified system agents, and "model the constraints inherent to the work context, capturing the action possibilities afforded by the environment," (Naikar & Elix, 2021). Application of this type of reasoning is novel for designing work teams or training systems, being that the more traditional models used for this activity have not been so accommodating to unforeseen events, and as we have witnessed thus far, HROs, which account for a large number of world organizations, tend to deal with exactly those type of novel instances. When modeled, constraints on the organization are defined rather than specific possibilities, which allows the constraints to act as limits on the distributive nature of work demands within the environment across agents; these limits then "differentiate distributions that are possible or acceptable from those that are never suitable," (Naikar & Elix, 2021). However, these constraints still provide space for myriad work organization possibilities. Naikar and Elix (2021), accommodating the previously mentioned three dimensions, created a diagram of work possibilities based primarily on a fourth dimension of the cognitive work analysis, namely social organization and cooperation analysis. If the other three dimensions did not concern themselves with specified actors, but with the possibilities of actions, the diagram developed by Naikar and Elix (2021) demonstrates the affinities between the possible actions and the actors. In essence, this provides us with information on "the action possibilities of the work context at the levels of the behaviors of individual actors and the structures of multiple actors in a manner that is compatible with the phenomenon of self-organization in sociotechnical systems," (Naikar & Elix, 2021).

The diagram developed by researchers Naikar and Elix (2021) takes into account that the agents of sociotechnical systems often engage in improvisational activities, being that so many circumstances cannot be considered for, a priori. Moreover, “in sociotechnical systems, there is usually no single, best way of organizing work,” (Naikar & Elix, 2021). Which is yet another reason the flexibility offered by this framework is so crucial. The reason the diagram itself is not portrayed in this thesis is that it serves as a hypothetical motivation for future research and modeling of team and training system designs alike. For the majority of HROs, be it firefighters, naval aircraft carriers, or other high intensity areas – it has been found that basic ground training does not account for a multitude of circumstances one may be met with on the field, (Rochlin et al., 1987). This is precisely why the type of flexibility that the self-organizing STS framework provides through analysis is crucial for future research development. The diagram of work organization possibilities developed by Naikar and Elix (2021) also accounts for actors who engage in novel actions or improvisations without violating work protocols or constraints; for the constraints or limits that were previously mentioned do not place specifics on actors’ behaviors but on the boundaries of optimal work performance. Hence, allowing the level of behavioral possibilities of individual actors within the team to be accounted for as action possibilities at the work context level.

In a practical example, Naikar and Elix (2021) illustrate how in the emergency room, before a surgery occurs, although criteria such as the professions of team members and their levels of training and experience tend to weigh heavily on task distribution, tasks that may be carried out by any member are not prematurely assigned, but rather come about depending on what specific situations require. This means that even if task distribution is planned, it may take on a completely different structure during the actual occurrence. Therefore, models based on this diagram or general framework may easily account for levels of flexibility within the system, which can complement the work environment’s complexity (Naikar & Elix, 2021). It is within such modeling that we may also more flexibly explore “the processes actors engage in and the resources they use to render their actions and experiences meaningful,” (Hollan et al., 2000). For such information can shed light on how to design conceptually meaningful tools and working environments in general. Being that design should indeed consider how agents can

accomplish more smooth coordination with dynamic behavior by way of using active work materials (Hollan et al., 2000).

3.4 The organization as a computing system

Defined by Strohmaier (2021) as needing to have a function as well as the necessary rules to fulfill that function, an organization is not simply a computational system, but a self-organizing computational system that follows protocol in a strive to optimally adapt in order to fulfill its function in the most dynamic and beneficial way. “They [organizations] reach goal states by engaging in computational processes for which they have been designed.” Yet, simply having a goal to fulfill is not enough to be considered a computational system. The next step for classifying as such is to have a particular set of rules. In a self-learning system or machine-learning system, these rules are continually updated throughout the process of goal fulfillment if it means that the goal will be reached in a faster manner or using less steps, i.e. a more optimal approach. In fact, a machine-learning system is constantly crosschecking data, from its readily available dataset of past input or pre-acquired data to the newly acquired data of the present calculation. “A rule is a map from inputs (and possibly internal states) to outputs,” (Piccinini, 2015). Even if one interprets an organization as having fully developed agents, who at times can disregard implicit rules (qualifying the organization to be a computational system), it does not change the fact that the organization still has those rules in place and that they are a part of the goal fulfillment process. This only means that “an organization is a special computing system,” (Strohmaier, 2021). The third requirement, according to Piccinini, for a system to be considered one of computation, is that the rules regard manipulating medium-independent vehicles (Piccinini, 2015). Strohmaier posits that when it comes to organizations this criteria is also satisfied, being that organizations “are built upon the manipulation of either natural language strings or similar representations,” (2021).

When taking into consideration that a sociotechnical system is essentially a complex adaptive system, which is also self-organizing, then a line can easily be drawn to the organization as a complex computing adaptive system. Fluently mapped out by Strohmaier (2021), the next

paragraph will describe an organization, more specifically a sports center at a university, as a computational model (albeit quite rudimentary):

> *Moving to a higher level of abstraction, the process can be described as the centre taking a number of states in response to various inputs. There is a start state (q_0), from which the centre is moved by requesting a form to the state (q_1) of expecting the completed form or the passage of a week. If a week passes without the completed form being received, the centre returns to state q_0. Otherwise, it advances either to state (q_2) of expecting the sheet certifying that the introduction to the pool has been attended or the state (q_3) of expecting the sheet for the court. Finally, if those sheets are returned, it reaches the state (q_4) of having registered the team. […]*
>
> *The sports centre implements a finite state machine for registering a team. There is an input alphabet Σ, namely the various forms and pieces of paper; a set of states S in which the centre can find itself, including the start state q_0; a transition function δ from state to state based on input, i.e. $\delta: \Sigma x\, S \longrightarrow S$; and there are two final states in my description, the initial state (q_0) and the acceptance state (q_4), after all the documents have been received in order.*

Having established how an organization may be likened to a computational system, we may now look at how exactly an organization may be considered one. Piccinini developed the restrictive analysis, wherein physical computation is defined as "the manipulation […] of a medium-independent vehicle according to a rule," (2015). Piccinini's restrictive analysis defines three restrictions. "Organization must have (1) teleological functions for (2) rule-governed manipulation of (3) medium independent vehicles," (Strohmaier, 2021).

Each organization, especially HROs, are designed to satisfy a specific function. Meaning, they are created in order to achieve specified goals. How then, do we equate an organization to a computing system? Computing systems must not be bounded by their sole computational function, i.e. they may have additional functions as well. Thus, if one of an organization's main objectives is to extinguish fires, and upon arriving at the scene of a fire, the organization must *compute* how the fire shall be put out, then it may therefore be equated to a computational

system. For, even though there are a multitude of additional functions that a fire brigade may fulfill or satisfy, their fundamental aim still remains of a computational nature. Ergo, an HRO does have a teleological function, and thus satisfies the first of the three restrictions established by Piccinini.

The next restriction, which must be satisfied for a system to be categorized as computational is that organizations must act in accordance with rules. If we solely take HROs into consideration, then there is typically no issue with this rule. The reason being that since HROs usually deal with extreme situations, which may result in the loss of a life or something more catastrophically worse, these types of organizations have specific rule books and protocols they are trained to follow. As we have learned thus far, strictly adhering to protocol may not always be the case within HRO teams, nevertheless those rules exist and govern the general tone of organizational behavior. In fact, Strohmaier (2021) points out that since members of an organization are ascertained as full-fledged agents, their personal interpretation (or misinterpretation) of rules does not influence the fact that the organization itself must carry out input-output rules. Therefore, this does not at all interfere with rendering an organization as a computational system, being that the main goals of the organization remains the same.

The conclusive requirement of Piccinini's analysis is that the previously discussed rules target controlling or manipulating medium-independent vehicles. In this case, medium-independent is presumed as meaning "the rules being insensitive to the physical implementation of the vehicle," (Strohmaier, 2021). In the case of HROs, a medium-independent vehicle may be something as seemingly insignificant as an utterance of one team member to another. The reason being that natural language strings are considered to be medium-independent vehicles. Medium-independent vehicles, more plainly put, are media that do not require a "specific physical media with specific physical properties of their own," (Piccinini, 2020). An even better analogy, also provided by Piccinini (2020) would be how a normal computer is essentially a binary device that issues an output signal of opposite type to its input, yet the way the signals are transduced (be it electrically, mechanically or in any other manner) makes no difference; just as it is of no concern what lower-level mechanism physically manipulates those signals.

Thus, “the organizational rules will be specific to the language string rather than the physical manifestations,” in the case of organizations (Strohmaier, 2021).

Now that we have established that organizations can quite successfully be seen through a computational approach, we may see exactly how these combined frameworks are already being used in order to achieve something novel and great. Hollan, Hutchins and Kirsh have founded a research lab called the Distributed Cognition and HCI lab. The lab’s main focus is to, on a deeper level, with the help of DCog, and such frameworks as have been mentioned previously in this work, understand how exactly humans and technologies interact. The lab founders utilize a “loop from observation to theory to design and back to new ethnographic observations,” since it is the most optimal way to accommodate new uses of old materials or vice versa, and easily observe how these new or old uses can be conveyed in another setting, (Hollan et al., 2000). In a world, like the one we see today, findings from this type of research can be observed virtually anywhere. Yet another useful finding that has come from the DCog HCI lab is that we may often find useful informational resources in our simple surroundings. For example, when we interact with objects in the real world, such as a door handle or a book, the signs of use located on these objects, such as the worn off paint of the door knob or the worn out look of a specific book page, may give us a hint as to where our interaction will yield us the most success. “The side effects of use often provide resources for the construction of expert performance,” (Hollan et al., 2000). Since digital objects have the capability of encoding and storing their use history, we may use this to our advantage as humans in order to design more ergonomically smart work environments or promote better team coordination.

Chapter 4

Discussion

4.1 Computing systems for research

The final chapter shall begin with an enticing excerpt taken from Strohmaier's *Organisations as Computing Systems*: "Organisations are an important innovation in human society. As computing systems, they are a special kinds of group that has allowed us to accomplish complex tasks. The proposed theory validates using computational explanations in organizational studies. Furthermore, like paradigmatic natural kinds, organisations have this distinguishing feature necessarily," (2021).

Using the computational framework for organizational improvisation in a sociotechnical system opens up multiple new research horizons. Building computational models, wherein we can account for the many complexities that may arise, especially when dealing with high reliability organizations, allows us to perhaps mitigate mishaps that could otherwise be life threatening. Any instance where technology can aid humanity avoid life threatening situations by means of a priori accounting for them is an instance worth saving. For example, by means of using the cognitive work analysis diagram, proposed by Naikar and Elix (2021), even with the defined constraints, which must be adhered to by the actors in a range of situations, within the system "actors still have many degrees of freedom for action." This entails that designs based on such limitations may still permit workers the mental and physical elasticity to adapt to their work protocols and practices throughout a large array of circumstances without violating boundaries, which effectively enforce effective performance. If such programs are developed and indeed allow for more effective work practices to arise within HROs, or permit us to create more adequate training programs, wherein we may pull more focus towards qualities or practices which foster a safe and productive environment, then work practices within HROs will become much more efficient.

4.2 Field limitations

The most profound limitation in this thesis is by far the fact that organizational improvisation has not yet fully been operationalized, thus a majority of the studies carried out on the subject matter have been of qualitative rather than quantitative value. Yet, there still exists a wide selection of literature, which includes quantitative studies, based on more fundamental matter; such as measurements of group efficiency and organizational performance. This limitation is simply and invitation to conduct more quantitative studies in the future.

Another issue that may arise among the readers is Hutchins distributed cognition framework. As posited by Barranco and colleagues (2017), "to study the cognitive system, the unit of analysis must be broad enough to include the whole set of coordinated agents and artifacts. However, in Hutchins' SDC perspective, the unit of analysis is not fixed in advance: it depends on the scale of the system under study and its boundaries and centers become empirical questions." I believe this may be valid to an extent, however if more research on the topic will be conducted, and the DCog perspective will be taken into account when computationally modeling certain organizations or organizational practices this limitation will subside. For the unit of analysis will be able to be more robust in computational models, albeit it will be a tedious activity to account for all units of analysis, it will not be impossible.

It should also be noted that most works conducted in the field of OI are based on observing or studying particular phenomena, such as resilience or adaptability, collective collaboration efficiency, dynamic work environment circumstances, and so on. Yet, more often than not, more than two or more concepts are usually not undertaken in one single work. Therefore, all generalizations are based on a collective gathering and comparison among and within sources. This only leaves more room for more robust and precise research to be conducted in the future.

4.3 Conclusion

We live in a dynamic world that is met with challenging and volatile situations, demanding the full dedication and devotion of high reliability organizations. Managing crises has become an irrefutably crucial activity for governmental as well as non-profit organizations; we must look

for novel solutions. Ideally, we must be prepared. However, experience and research has shown us that it is insurmountable to be prepared for every disastrous or dangerous situation that may arise. Therefore, we may look to studying organizational improvisation for answers. When combined with the distributed cognition framework, in a sociotechnical context, OI becomes a human aid. It can teach us what to look out for, what to focus on, what qualities we should hone, and which ones we should abandon altogether. Computational models built on OI may bring forth a new era of team training possibilities, as well as work organization options. This new era will save lives. It can save lives by offloading the very precious and limited cognitive resources those who attend to emergencies have. OI may permit us to become a new type of human. A human who uses technological advancements in the name of preserving our future. Myriad possibilities exist for future research conduction. This work is an invitation to look beyond the traditional, and open new frontiers.

References

Abrantes, A., C., M., Passos, A., M., Cunha, M. P., & Santos, C., M. (2018). Bringing team improvisation to team adaptation: The combined role of shared temporal cognitions and team learning behaviors fostering team performance. *Journal of Business Research, 84,* 59-71.

Anderson, N., Potocnik, K., & Zhou, J. (2014). Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework. *Journal of Management, 40*(5), 1297-1333.

Arshad, D., & Hughes, P. (2009). Examining organizational improvisation: The role of strategic reasoning and managerial factors. *International Journal of Social, Behavioral, Educational, Economic and Management Engineering, 3*(6), 948-954.

Arshad, D. (2011). Understanding organizational improvisation: Foundations and performance implications (Unpublished doctoral dissertation). Loughborough University, Loughborough.

Artman, H., & Waern, Y. (1999). Distributed cognition in an emergency co-ordination center. *Cognition, Technology & Work, 1*, 237-246.

Balachnadra, L., Crossan, M., Devin, L., Leary, K., & Patton, B. (2005). Improvisation and teaching negotiation: Developing three essential skills. *Negotiation Journal,* 435-441.

Batista, M., G., Clegg, S., Cunha, M., P., Giustiniano, L., & Rego, A. (2016). Improvising prescription: Evidence from the emergency room. *British Journal of Management, 27*, 406-425. https://doi.org/10.1111/1467-8551.12143

Bechky, B., A., & Okhuysen, G., A. (2011). Expecting the unexpected: How swat officers and film crews handle surprises. *Academy of Management Journal. 54*(2), 239-261.

Berliner, P., F. (1994). *Thinking in Jazz: The infinite art of improvisation.* University of Chicago.

Bigley, G., A., & Roberts, K., H. (2001). The incident command system: High-reliability organizing for complex and volatile task environments. *Academy of Management Journal, 44*(6), 1281-1299.

Boin, A., & van Eetan, M., J., G. (2013). The resilient organization. *Public Management Review, 15*(3), 429-445, https://doi.org/10.1080/14719037.2013.769856

Buckley, W. (1968). Society as a complex adaptive system. W. Buckley (Ed.), *Modern systems research for the behavioral scientist: a sourcebook* (pp. 490-513). Aldine Publishing Company.

Burge, T. (1979). Individualism and the mental. *Midwest Studies in Philosophy, 4*, 73-122.

Clark, A., & Chalmers, D. (1998). The extended mind. *Analysis, 58*(1), 7-19.

Crossan, M., & White, R., E. (1999). An organization learning framework: From intuition to institution. *The Academy of Management Review 24*(3), https://doi.org/10.2307/259140

Cunha, M., P., Clegg, S., & Kamoche, K. (2006). Surprises in management and organization: Concept, sources and a typology. *British Journal of Management, 17*, 317-329. https://doi.org/10.1111/j.1467-8551.2005.00470.x

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly, 44*(2), 350-383, https://doi.org/10.2307/2666999

Edmondson, A., C., & Lei, Z. (2014). Psychological safety: The history, renaissance, and future of an interpersonal construct. *The Annual Review of Organizational Psychology and Organizational Behavior, 1*, 23-43.

Fichet, E. S. (2018). Creativity readiness in crisis communications: How crisis communicators' ability to be creative is impacted at the individual, work team, and organizational levels (Unpublished doctoral dissertation). University of Washington, Washington, DC.

Fox, W. M. (1995). Sociotechnical system principles and guidelines: Past and present. *The Journal of Applied Behavioral Science*, *31*(1), 91–105. https://doi.org/10.1177/0021886395311009

Gilardi, S., Guglielmetti, C., & Pravettoni, G. (2013). Interprofessional team dynamics and information flow management in emergency departments. *Journal of Advanced Nursing, 70*(6), 1299-1309, doi: 0.1111/jan.12284

Grotan, T., O., Storseth, F., Eitrheim, M., H., R, & Skjerve, A., B. (2008). Resilience, adaptation and improvisation – increasing resilience by organising for successful improvisation. *3rd Symposium on Resilience Engineering,* Antibes, Juan-Les-Pins, France.

Hadida, A., L., Tarvainen, W., & Rose, J. (2015). Organizational improvisation: A consolidating review and framework. *International Journal of Management Reviews, 17*(4), 437-459. https://doi.org/10.1111/ijmr.12047

Haidet, P. (2007). Jazz and the 'art' of medicine: Improvisation in the medical encounter. *The Annals of Family Medicine, 5*(2), 164-169, https://doi.org/10.1370/afm.624

Hollan, J., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: toward a new foundation for human-computer interaction research. *ACM Transactions on Computer-Human Interaction, 7(*2), 174-196.

Hutchins, E. (1990). The technology of team navigation. In Jolene Galagher, Robert E. Kraut, Carmen Egido (Eds.), *Intellectual teamwork: Social and technological foundations of cooperative work* (pp.191-200). Psychology Press.

Hutchins, E. (1991). The social organization of distributed cognition. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 283-307). American Psychological Association. https://doi.org/10.1037/10096-012

Hutchins, E. (2000). *Distributed Cognition.* IESBS Distributed Cognition. https://arl.human.cornell.edu/linked%20docs/Hutchins_Distributed_Cognition.pdf

Hutchins, E. (2006). The distributed cognition perspective on human interaction. In N. J. Enfield, Stephen C. Levinson (Eds.), *Roots of human sociality: Culture, cognition and interaction* (pp. 375-398). Routledge.

Hutchins, E. (2014). The cultural ecosystem of human cognition. *Philosophical Psychology, 27*(1)*,* 34-49*.* https://doi.org/10.1080/09515089.2013.830548

International Encyclopedia of the Social and Behavioral Sciences. (2001). 2068-2069.

Johnson, C. (2012). Bricoleur and bricolage: From metaphor to universal concept. *Paragraph, 35*(3), 355-372, https://doi.org/10.336/para.2012.0064

Kamoche, K., & Cunha, M., P. (2001). Minimal structures: From jazz improvisation to product innovation. *Sage Journals Organization Studies 22*(5), https://doi.org/10.1177/0170840601225001

Kamoche, K., Cunha, M., P., & Cunha, J., V. (2003). Towards a theory of organizational improvisation: looking beyond the jazz metaphor. *Journal of Management Studies 40*(8), 2024-2051.

Mendonça, D., Beroggi, G. & Wallace, W., A. (2003). Evaluating support for improvisation in simulated emergency scenarious. *IEEEE 36th Annual Hawaii International Conference on System Sciences.*

Merriam Webster Dictionary. (N.a). Organization. Retrieved from: https://www.merriam-webster.com/dictionary/organization

Moorman, C., & Miner, A. (1998). Organizational improvisation and organizational memory. *The Academy of Management Review, 23*(4), 698-723.

Naikar, N. & Elix, B. (2021). Designing for self-organisation in sociotechnical systems: resilience engineering, cognitive work analysis, and the diagram of work organization possibilities. *Cognition, Technology & Work, 23*, 23-27. https://doi.org/10.1007/s10111-019-00595-y

Okoli, J., & Watt, J. (2016). Information processing and intuitive decision-making on the fireground: Towards a model of expert intuition. *Cognition, Technology, and Work, 18*(1), 89-103, https://doi.org/10.1007/s10111-015-0348-9

Piccinini, G. (2020). Mechanisms, multiple realizability, and medium independence. In G. Piccinini (Ed.), *Neurocognitive mechanisms: Explaining biological cognition* (pp. 38-43). Oxford University Press.

Putnam, H. (1975). The meaning of 'meaning'. In K. Gunderson, Ed.) *Language, Mind, and Knowledge.* University of Minnesota Press.

Rerup, C. (2001). "Houston, we have a problem": Anticipation and improvisation as sources of organizational resilience. *Comportamento Organizacional E Gestao, 7*(1), 27-44.

Rumelhart, D., E, Hinton, G., H. & Williams, R., J. (1986). Learning representations by back propagating errors. *Nature, 323,* 533-536.

Sarayreh, B., H., Khudair, H., & Barakat, E. (2013). Comparative study: The Kurt Lewin of change management. *International Journal of Computer and Information Technology, 2*(4).

Slors, M. (2019). Symbiotic cognition as an alternative for socially extended cognition. *Philosophical Psychology*, *32*(8), 1179–1203. https://doi.org/10.1080/09515089.2019.1679591

Strohmaier, D. (2021). Organisations as computing systems. *Journal of Social Ontology, 6*(2), 211-236. https://doi.org/10.1515/jso-2020-0052

Tint, B. (2015). Applied improvisation training for disaster readiness and response. *Journal of - Humanitarian Logistics and Supply Chain Management, 5*(1), 73-94. http://dx.doi.org/10.1108/JHLSCM-12-2013-0043

Wachtendorf, T., Kendra, J., M. (2006). *Improvisation, creativity, and the art of emergency management.* Unpublished manuscript. Disaster Research Center. Retrieved from https://udspace.udel.edu/handle/19716/3054

Walsh, J., P & Ungson, G., R. (1991). Organizational Memory. *Academy of Management Review, 16*(1), 57-91.

Weick, K., E. (1993). The collapse of sensemaking in organizations: The Mann Gulch disaster. *Administrative Science Quarterly, 38*(4), 628-652, https://doi.org/10.2307/2393339

Weick, K., E., & Roberts, K., H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38*(3), 357-381. https://doi.org/10.2307/2393372

Weick., K., E. (1998). Introductory essay – Improvisation as a mindset for organizational analysis. *Organization Science 9*(5), 543-555. https://doi.org/10.1287/orsc.9.5.543

Wilson, R., A. (2005). Collective memory, group minds, and the extended mind thesis. *Cognitive Process, 6*, 227-236, https://doi.org/10.1007/s10339-005-0012-z

Zenk, L., Hynek, N., Schreder, G., & Bottaro, G. (2022). Toward a system model of improvisation. *Thinking Skills and Creativity, 43*, https://doi.org/10.1016/j.tsc.2021.100993

Zheng, Y., Venters, W., & Cornford, T. (2010). Collective agility, paradox and organizational improvisation: the development of a particle physics grid. *Informational Systems Journal, 21*(4), 303-333, https://doi.org/10.1111/j.1365-2575.2010.00360.x