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TECHNOLOGICAL SUPPORT TO IMPROVISATION DURING CRISIS: AN IMAGE THEORY BASED APPROACH

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Abstract

Improvisation is a core dimension of crisis response. It helps organizations to deal with complexity and to figure innovative responses to crisis in a short delay. Still, our knowledge on how improvisation develops cognitively is scarce. As a result, managers miss tools that would support improvisation cognitively. This paper aims at responding to this need, by reviewing literature on crisis and improvisation to develop an artifact and deduce requirements for technology. We rely on the Image Theory developed by Beach (1998) to conceptualize improvisation as a double step cognitive process that includes the screening process. Based on the use of ontologies and semantic distance, we then translate our understanding into a set of IT requirements, which will eventually help us designing the IT artifact.

Keywords : *Improvisation, Crisis, Ontologies, Design Science, Semantic Distance, Image Theory*

1 INTRODUCTION

Improvisation in management has been growingly attracting researchers and refers to decision as action unfolds (Moorman, Miner, 1998). Improvisation has been frequently associated with crisis situations (Hutchins, 1991; Ciborra, 1996; Rerup, 2001), even if the concepts of improvisation and crisis response remain loosely coupled conceptually. Improvisation enables organizations to figure innovative response in a context of strong time pressure, complexity and uncertainty (Crossan, Cunha, Vera, Cunha, 2005) and also because planning is not always relevant in that every crisis is unique (Waugh, Streib, 2006).

In fact crisis has been defined as a threatening situation for organizations (Hermann, 1963) and can be triggered by a large panel of unanticipated events, coming from financial crises to natural disasters (Pearson, Claire, 1998). In spite of an extended literature on crisis response, our knowledge on Information and Communication Technology remains under-developed and technology has been criticized. Even if technology has been evidenced as a crucial means for updating and transmitting information (Comfort, 2007), it is not always reliable (Dawes, Creswell, Cahan, 2004), needs improvement to address emergent coordination (Gonzalez, 2008) and to support quick reflection on alternate actions from plans (Mendonça, 2007).

Undoubtedly, managers lack more appropriate tools than the ones they use nowadays. Recently, an ongoing stream of research has been responding to that need by framing new artifacts to support improvisation in crisis response (Mendonça, Beroggi, Wallace, 2003; Mendonça, Wallace, 2007). This stream of research has been focusing on cognitive processes that compose improvisation during crisis response. This research deserves more development in that we still need to clarify boundaries between improvisation and other type of decision-making (Mendonça, Wallace, 2007) and therefore seek additional theoretical foundations to define cognitive processes that take place during improvisation.

This study aims at responding to this need. By doing so, it addresses the two following research questions:

- "How to understand the cognitive processes that structure improvisation in crisis response?"
- "What are the IT requirements and IT artifacts that will cognitively support improvisation in crisis response?"

This study aims at gaining new insights on cognitive processes and suggests a new approach based on the Image Theory developed by Beach (1998). Image Theory asserts that decision-making relies on a screening process (i.e. compatibility test) among multiple candidates (e.g. solution to the crisis). By viewing this screening process as a part of improvisation, we propose a new IT artifact that focuses on the confrontation between internal images and representations from the external world as source of improvisation. In this study, we use ontologies and semantic distance to reify this confrontation. Indeed, the generation of new ideas is supported by new, expected or unexpected components of possible solutions to the crisis, as well as their relationships.

We expect two main contributions from this research. First, we gain new insights on the cognitive dimension of improvisation in critical situations. We suggest the image theory as a new source of inspiration for further reflection on improvisation. Also, we account for requirements regarding future development from our artifact. In future research we aim at translating our artifact into a tool. Therefore we aim at better support to improvisation for crisis responders.

2 IMPROVISATION AND CRISIS RESPONSE

In this section, we argue that improvisation relies on a two step process that includes the creative formulation of alternatives to plans and their quick selection. As we present therein, we suggest image theory is a relevant theoretical basis to understand the cognitive dimension of improvisation. In addition, we suggest that the use of ontologies and semantic distance enhances creativity and help actors to distance themselves from the crisis and find new solutions. In the remainder of this article we present each concept we use in this study: crisis response, improvisation, image theory, ontologies and semantic distance. We then deduce requirements for the future design of the artifact.

2.1 Improvisation in crisis response

Organizational crisis is a critical experience that threatens organizations major goals and values (Hermann, 1963). In spite of important time and emotional pressure organizational crisis requires quick and innovative response. Organizational crisis implies not only material but also social cost (Perry, Quarantelli, 2005).

Responding to crisis, organizations usually have to coordinate between distant locations (Quarantelli, 2006) and stakeholders may interfere with action (Perry, 1991), which makes crisis response complex. Complexity also stems from the rarity of occurrence of the crisis and refers to the fact that any action has an intricate set of interdependent outcomes (Milburn, Schuler, Watman, 1983). Complexity compels organizations to be resilient and constantly adapt action by improvising.

Improvisation has been frequently associated with crisis situations (Hutchins, 1991; Ciborra, 1996; Rerup, 2001), even if the conceptual ties between improvisation and crisis response remain loosely coupled. Improvisation refers to a strictly limited delay between acting and planning (Moorman, Miner, 1998), which results in a seemingly extemporaneous action. Also improvisation includes novelty of action, also called *bricolage* (Kamoche, Cunha, Cunha, 1999). Improvisation occurs in crisis response because of strong time pressure, complexity and uncertainty (Vera, Cunha, Crossan, Cunha, 2005) and also because planning is not always relevant in that every crisis is unique (Waugh, Streib, 2006). Improvisation was described as a convenient way to respond to the lack of relevance of plans in crisis situations. More specifically, we consider improvisation complements Business Continuity Planning (BCP).

2.2 The cognitive side of improvisation

Improvisation stems from a subtle mix of knowledge exploration and knowledge exploitation (Clegg, Cunha, Cunha, 2002; Joffre, 2007). Cognitive structures such as routine, scripts, patterns of action, are useful for improvisation (Feldman, 2000). Individuals rely on them to maintain order and a coherent collective action. Creativity also participates in improvisation and boils down to the emergence of alternatives to planned procedures.

Johnsons Laird (2002), cited by Mendonça and Wallace in 2007, refers to music improvisation to understand how ideas emerge and are selected. Such an approach is relevant for us in the sense that both improvised performance and crisis improvisation imply time pressure, emotional stress and thriving. Improvisation is therefore structured in a two steps process. As Mendonça and Wallace explain (2007), the first step to improvisation consists of bringing up and developing new ideas. The second step refers to choose which of the emerging solutions is the most adequate.

As we explain here in, idea development is a built-in process of improvisation. Ideas development enables to find alternates to established usage for the sake of victims of the crisis (Crossan, 1998). To explain new idea development, authors have largely referred to the terms of creativity (Sawyer, 1999; Weick, 1993), bricolage (Kamoche, Cunha, Cunha, 1999) and tinkering (Ciborra, 1996) to define how actors elaborate new ideas. The notion of bricolage corresponds to an innovative use of resources while tinkering refers to actors who have creative ideas in unexpected settings. They both embody the same process of idea creation/development.

Improvisation subsumes not only idea development but also their experiencing and/or selection. Interactions with co-improvisers and their knowledge foster idea development and selection (Weick, 1998; Zollo, Winter, 2002). Thanks to that selection, actors do not do whatever they like and maintain the coherence of the collective action, (Hutchins, 1991). To do that, actors select ideas according to their degree of consistency to the context: available time, other actor's actions and initiatives, human and material cost associated with the solution.

2.3 Design Requirements

We inspire from Mendonça's work (2007) to present here some requirements we extract from our literature review on crisis and improvisation and represent them in table 1. First, emotional and time pressure requires a user-friendly and intuitive interface so as to facilitate information treatment and alleviate additional stress that may be due to technology use. Second, improvisation is a two-step cognitive process that requires support to creativity and selection. Creativity can be supported by the enrichment of existing knowledge by other sources of knowledge. We view selection can be completed thanks to graphical representation and manipulation of ideas as objects. Finally, as crisis is not predictable, technology should be used both in crisis and routine situation, even from mobile devices. In the following section, we argue that idea selection corresponds to the screening process described by Image Theory.

Crisis Response Key Dimensions	**Tool Requirements**
Emotional Pressure	User-friendly interface
Time Pressure	Intuitive interface
Complexity & Improvisation	Support idea development & selection by graphical representation of ideas
Need for innovative response	Refreshment of existing cognitive structures. Need for new associations between images and ideas.
Coordination between distant locations	Use of mobile devices
Surprise	Possible use of the tool in routine situations

Table 1: IT requirements (1)

3 IMAGE THEORY

3.1 Definition and main mechanisms

In this section, we introduce image theory, through its definition and main mechanisms. Image theory is an influential decision-making theory that has been used in the IS field (Niederman, Sumner, Maertz, 2007; Joseph, Kok-Yee, Koh, Soon, 2007). Image Theory views a decision maker as a "manager of knowledge and information who attempts to keep a reasonable degree of consistency among his or her images of what is right, what she/he is attempting to achieve, and what he or she is doing to promote those achievements" (Connolly, Beach, 1998, p.251).

We illustrate Image Theory with a real case example of a crisis situation.

In this example from Crossan, 1998, the scene takes place in a swimming pool, where a young woman had the foot caught in the drain and therefore was unable to breath. Because lifeguards were focusing on only one solution (i.e. loosening her foot), she finally drowned. What should have been done to avoid the swimmer's drowning?

3.2 Image

An *image* is defined as a "schematic knowledge structure to organize [the decision-maker's] thinking about decisions" (Beach, 1998, p.12). Three types of image were identified by Beach and are related to: (1) values (i.e. principles), (2) trajectories (goals) and (3) strategic (plans regarding tactics or forecast).

In the case of the swimming pool example, the image of the solution could be an oxygen bottle with a mask, quickly available and that could be easily brought to the swimmer. Therefore, this image has several constituents (e.g. oxygen bottle, availability, ease of reach).

3.3 Type of decision

Beach introduces two types of decision with regard to one's image: the "adoption decision" and the "progress decision." Because crisis improvisation implies finding and evaluating alternative solutions to a current situation, we only consider the first type of decision (i.e. adoption decision) which focuses on "adoption or rejection of candidate [principles], goals or plans" (Beach, 1998, p.14).

3.4 Image violation (IV)

Beach and Connolly define violations as "negations, contradictions, contraventions, preventions, retardations, or any similar form of interference with the realization of one of the standards defined by the images' constituents" (Beach, Connolly, 2005, p.165).

For example, if no oxygen bottle could be found in the next 5 minutes, this is considered as an image violation (IV), i.e. the images' constituent: "bottle of oxygen available in the next 5 minutes".

3.5 Screening process and compatibility test

In Image Theory, the screening process (also called the "compatibility test") eliminates the unacceptable candidates based on screening "the relevant constituents of the three images" (Beach, 1998, p.14). Actually, this test seeks to identify *incompatibility* (I), whereby compatibility "decreases as a function of the weighted sum of the number of its violations of the images where the weights reflect the importance of the violation" (Beach, 1998, p.15). Each identified violation is either all-or-nothing. Image Theory calculates whether the "weighted sum of the violations exceeds some absolute *rejection threshold*" – in which case the alternative or "candidate is rejected, otherwise, it is adopted" (Beach, 1998, p.15)

If an image violation occurs regarding one constituent of the candidate (i.e. an element of the potential solution to the crisis), according to the screening process, this constituent can be deleted from all potential solutions found by the software. Therefore, future candidates will not contain this constituent.

For example, if there is no oxygen bottle quickly available in the swimming pool, any solution initially suggested by the software requiring an oxygen bottle will be deleted from future appearance.

3.6 Profitability test

The process of screening the set of images (in our case, potential solutions to solve the crisis, automatically generated by the software) may result in considering several "candidates" (options or choices). In such a case, the next test to perform is the profitability test, to sort out the most profitable candidate, (Beach, 1998). However, as a situation of crisis is also an emergency situation, if one candidate is considered as a good-enough solution, the users may just stop there and apply it. Therefore, in a crisis situation, the existence of multiple candidates is less likely to be found compared to a non-crisis situation. In the coming paragraphs, we propose to translate the characteristics of the image theory into requirements for the design of the software.

3.7 Design Requirements

We summarize in table 2 the different requirements emerging from Image Theory as they will be used for the design of the software.

Image theory	**Design requirements**
1. Image	The software suggests potential candidates that may support the process of generating a solution (e.g. allowing the possibility of breaking the pattern of the first solution, Crossan, 1998). The software uses the classification of images: values (i.e. principles), trajectories (goals) and strategic (plans regarding tactics or forecast).
2. Image violation (IV)	We consider two type of rejection : (1) the threshold is reached with only one IV (2) the threshold is reached with several IV, in such a case, one IV alone is not sufficient. Consequently, potential initial candidates will not appear if they embed previously identified an IV or a set of IV which have lead to a rejection as previously identified.
2bis. Compatibility test / Screening process	For each potential candidate, the user will report any image violation (e.g. absence of oxygen bottle) or group of IV leading to a rejection.
3. Multiple candidates	The software allows the possibility to save multiple candidates to further retain the best candidate using a profitability test.
4. Profitability test	This test is less relevant in a situation of crisis. Future research may use different strategies to evaluate the multiple candidates, e.g. considering the risk, the probability of success, the time required.

Table 2: IT requirements (2)

In sum, Image theory, through the screening process allows the users to access to select the appropriate solution amongst multiple candidates. However, how do we suggest those multiple candidates to the user? This will be the subject of the next paragraph, where we consider using

ontology and semantic distance to generate potential alternative solutions based on the description of the problem.

4 ONTOLOGY AND SEMANTIC DISTANCE

Our artifact includes notions of ontology and semantic distance that stimulate new associations between concepts and allows representing and manipulating them. That way, idea development and selection that structure improvisation are supported.

The first element we bring in the artifact is ontology. An ontology is useful to describe the traits of one's world, (Weber, 1997). It has been defined as an index of formalized notions that are interrelated to each other's semantically. Ontology gradually appears as a crucial resource for crisis response in that it supports data classification, knowledge expansion and information flows representation (Guarino, 1998; Gruber in Guarino, 1998). In design science, search for some automative extension of ontologies in crisis response between rescue forces and civilian population is growing (Segev, 2008). In our research, once the crisis is described, the ontologies are queried and relevant keywords (hypernyms and hyponyms) can be used.

More specifically, the artifact we propose includes hinges the users' ontology to an external ontology. The former refers to a specific ontological basis developed within the organization previously to the crisis response. The latter refers to an external ontology *ThoughtTreasure* (http://www.signiform.com), "One of the 3 major common sense large-scale generic knowledge bases of commonsense", (Liu, Lieberman, Selker, 2003). As a commonsense database, *ThoughtTreasure* is flexible in use (Mueller, 1997) and general. On the contrary, we expect the user's ontology to be more partial and centered on the users' domain of knowledge. In that sense the external ontology and the users' ontology are complementary. Associating an internal and specific ontology to an external and general ontology opens a new window on new semantics so as to bring up new ideas for improvisation. Another example is the World Wide Web as a multiple users set of ontologies (Gligorov, Alekovski, Ten Kate, Van Harmelen, 2007).

We use in our research the semantic distance to evaluate how connected two notions are. The use of ontologies and semantic distance intensifies the diversity of likely relationships between ideas, therefore nourishes improvisation (Woodman, Sawyer, Griffin, 1993). In our research, the artifact searches additional keywords based on the crisis description; the selection of those keywords is directly related to the semantic distance. Semantic distance is frequently used on Internet. For instance, as Cilibrasi and Vitanyi (2007) suggest, Normalized Google Distance (NGD) measures the semantic distance from the frequency of access to web pages that are related to one notion.

Figure 1 presents how semantic queries bridge the users' ontology to external ontologies. Queries can be adjusted depending on the semantic distance.

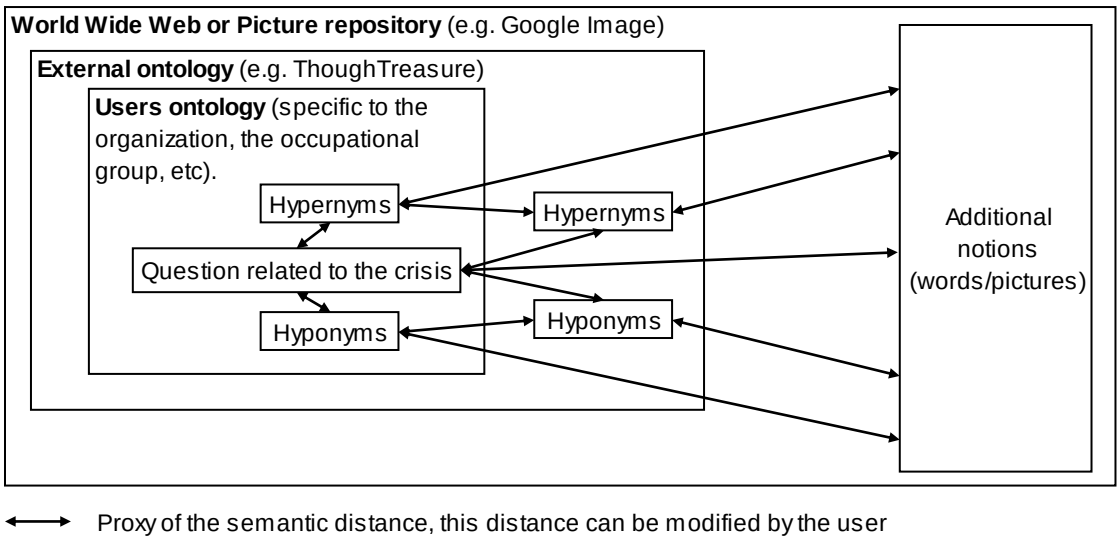

Figure 84: user's ontologies, external ontologies and semantic distance

4.1 Requirement from ontologies and semantic distance

Table 3 presents design requirements we extract from our understanding of ontology role in improvisation. Ontologies are used by queries on words and association between concepts, depending on the semantics distance.

By allowing the manipulation of the distance between the crisis description and the keyword/pictures (we consider pictures in future research), we stimulate idea generation. Although, we recognize this distance as a proxy for a "true" semantic distance, however, we focus on relevance rather than rigor for this specific function.

Ontologies and semantic distance	Design requirements
1. Ontologies	Show the hypernyms and hyponyms for each part of the description of the crisis.
2. Use of semantic distance	The application uses the semantic distance to generate additional keywords. The application uses the distance between a word and its picture (future research). The application allows the user to refine the semantic distance between (1) the elements of the potential candidates and (2) the description of the crisis.

Table 3: IT requirements (2)

5 DESCRIPTION OF THE IT ARTIFACT

Although the application has only been developed as a prototype and need further testing and validation, we describe here how it works.

To clarify the IT artifact (figure 2), let's describe how we could use such a software in the crisis situation of the swimming pool. The first step (1) is to briefly describe the crisis situation (for example, we type in a textbox: "in a swimming pool, a swimmer has the foot caught in the drain, is drowning and can't breathe"). Based on this short description, the software (2) searches ontologies to find hypernyms and hyponyms related to the main components or group of components of the description (e.g. a swimming pool is a building). In addition, by using semantic distance, (3) pictures related to each constituent (i.e.

elements of the story, hypernyms and hyponyms) are searched over the internet and organized on the screen (e.g. breath can be related to a picture of a breathing apparatus and therefore to the picture of an oxygen bottle), in order to stimulate creativity. Then, elements are (4) automatically linked one to another and can manually be moved all over the screen, increasing the association of concepts and generating new ideas. The user can either (5) select the relevant constituents and/or (6) reject and delete the irrelevant constituents, using the screening process of image theory based on image violation (e.g. if no oxygen bottle is available, no other solution implying an oxygen bottle should be suggested). Finally, one or several images (combination of different constituents) emerge and lead to one or several solutions which can be (7) saved by the user (e.g. bringing oxygen to the swimmer) or (8) directly implemented to the crisis situation. At any moment, the parameters can be changed (e.g. semantic distance, number of ontologies, number of constituent, etc) and the user can start again the process to (1). Finally, as any action is recorded, the user can go back and forth to see the different ideas he/she may have had.

6 DISCUSSION AND FUTURE RESEARCH

In this research, we combined four theoretical areas that are represented in Figure 2: Crisis Characteristics, Image Theory, Ontologies and Semantic Distance. This work aims at improving the understanding of the cognitive side of improvisation. In addition, we suggest IT requirements for technological support to improvisation in crisis response (tables 1, 2, 3), therefore answering the first research question and suggesting improvement to these cognitive processes. The screening process of image theory enhances creativity in crisis situations, where a profitability test, (Beach, 1998) could not necessarily be possible. In addition, using ontologies and semantic distance helps responders to confront personal cognitive frames with other representations of the external world, therefore improving one's creativity by thinking innovatively, as well as finding alternative and new solutions to the crisis.

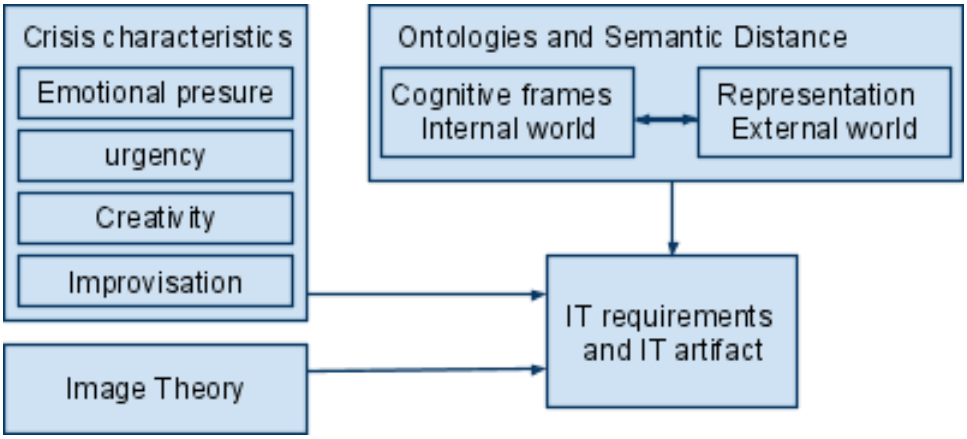

Figure 85: The IT artifact

So far, a prototype has been developed and tested with groups of students. This first round of test helped us improving the prototype, but this does not validate yet the relevance of this research. Also, we intend to test whether screening images is faster than screening words. Doing so implies storing pictures on a depository such as Google Image to enhance the concepts with a picture. The further steps of this study follows a software development approach based on different short iterative cycles (i.e. agile development), including testing with users (students and professionals) and development. Regarding testing the relevance of the artifact, we address the user's satisfaction with the tool and the opportunities for integrating the tool in managerial life.

The artifact is to be evaluated through its prototype, as recommended by Hevner, March, Park and Ram (2004). For that, we intend to lead an experimental design, where the treatment is the use of the tool.

In this design, we will simulate a crisis situation, which will be the same exact simulation for each group. As we need to create a situation of stress, the use of multimedia tools, such as a video could be helpful to generate emotions. The design is composed of a basic two-group posttest-only, randomized experimental design. The experimentation will occur several times with different groups (to avoid a problem link to memory recall) during the different development phases of the prototype until its final implementation, satisfying the requirements and constraints of the problem.

Here are the general metrics we intend to include in the evaluation:

- Functionality, Completeness,
- Design of the prototype (style), (Hevner et al., 2004)
- Usability and particularly ease of use, (Davis, 1989)

Then we will also measure specific crisis metrics:

- Time pressure and stress impacts on speed, ease of use and reliability.
- The consistency of new solutions (by experts).

Finally, an open question will be asked to participants about the system flaws and perfectibility.

We propose here some directions to support managerial integration of the tool. First, we advocate the development of a prototype for mobile devices to multiply opportunities of use thereby facilitating appropriation of the tool and its spontaneous use when crisis triggers. Also, implementing the tool on a collaborative platform would help collective training to use the tool as well as the enrichment of the users' ontology.

In the short term, we believe the artifact will support improvisation, thereby complementing BCP contribution to crisis response. In the long term, we view the tool may help to enrich the users' ontology by a rigorous selection of the ideas that were the most helpful for crisis response.

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