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A Cognitive Approach*

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# Organizational Intelligence in the Limelight. A Cognitive Approach

Carlotta Meo Colombo

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## Abstract

The aim of the paper is to study how it's possible to enhance the cognitive enterprise model by the theory of autopoietic systems. I propose a model that considers the organization as a closed system in which all cognitive activity is necessary to develop coherent operations needed to adapt the firm to environmental perturbations. The central issue of the work consists in the presentation and description of the "chain thinking-action" as a cognitive basis that builds models from which derive the actions that characterize the transformation of a business enterprise in order to maintain the viability over time. A "winning" entrepreneurial thinking is able to give a direction (objectives-strategy) always aimed at improving the organization's vital parameters. The role of entrepreneurship and management, therefore, is to create the conditions to encourage a continuous development of cognitive models in organizations, in order to maintain the conditions of survival and to lead the company in a situation of evolution and improvement.

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**Keywords:** Organizations, cognitive system, knowledge, systems of transformation, conscious behavior, autopoietic systems, thinking-action chain

## 1 – Introduction

*"Every man from the birth builds models"* (Laborit 1979: 60).

*"The knowledge that guides human behavior is made up of symbolic mental representations and cognitive activity consists in the handling of these symbols"* (Edelman 1991: 33).

This study is based on the belief that organizations, and firms, can be understood as cognitive systems which develop a learning process in order to survive in a changing environment, as it has been authoritatively demonstrated by Stafford Beer (1989). In observing enterprises I have chosen a model of cognitive system that comes from the representationalist view of cognition, typical of the cybernetics and cognitive theory (Wiener 1961; Ashby 1956; Conway and Siegelman 2005; Maturana and Varela 1980).

According to this conception, cognitive systems must create inside them a representation of the external world, by building coherent and sensible models, selecting through their sense organs, environmental cues, and transforming them into information necessary to update these representations on which they form the basis of decisions making which are trans-

lated into behaviors in order to preserve their existence.

The representationalist hypothesis is denied by Herberto Maturana and Francisco Varela who state:

... in every interaction, is the structure of the nervous system that determines which perturbations are possible and what changes they may cause in its dynamics of states. it would be wrong, therefore, define the nervous system as something that has inputs and outputs in the traditional sense (Maturana and Varela 1987: 149).

In this paper I demonstrate how it's possible to enhance the cognitive enterprise model by the theory of autopoietic systems. The model I propose considers the organization as an operationally closed system, structurally coupled to the environment, in which all cognitive activity is necessary to develop coherent operations needed to adapt the firm to environmental perturbations. According to this approach, knowledge consists of a modeling system that the organization builds and fits through a continuous structural adaptation between the firm and the environment, in a perspective of maintenance of its homeostasis (Maturana and Varela 1987).

In this work I share the enactive approach, according to which cognition derives from the construction of the world by a cognitive subject through the

mind-body interactions. Indeed, we read in Varela, Thompson and Rosch that "the fundamental intuition of the enactive approach is that you can see our activities as reflections of a structure (nervous system), without losing sight of the immediacy of our experience" (Varela, Thompson and Rosch 1992: 33).

The central issue of the work consists in the presentation and description of the model called "thinking-action chain" as a cognitive basis that builds models from which derive the actions that characterize the transformation of a business enterprise (Mella 1991) in order to maintain the viability over time (Beer 1989). The theoretical basis built in this study allowed us to reach a definition of the necessary conditions that a firm must comply in order to be considered an intelligent system.

## 2 – Firms as cognitive systems

To represent enterprises as cognitive systems should be necessary, first of all, define and highlight the characteristics of cognitive systems, in order to build up a model adaptable to firms. Following Mella (1997) A cognitive system can be described, in a concise form - by an external observer (Maturana and Varela 1980), as an autonomous system, an "individual", able to process information, to structure them in knowledge and preferences in order to develop interactive behaviors with the environment and in the environment with the purpose of survival, maintaining its identity, even in the evolution, sometimes, of its own structure.

According to autopoietic theory, a cognitive system appears to act in a "world" (environment) only to the eyes of an observer outside the system. This has no chance of "come out of himself": all that it can "know" are the changes in its cognitive basis - built by its physical structure - which it can control partly through the activity that took place through effectors (1), as theorized by von Foerster (2003) the father of second order cybernetics.

According to the model of Maturana and Varela (1987), organizations are "closed" autopoietic systems able to maintain their unity continuously producing relationships that make up their own organization. These systems operate in circular mode, in the sense that self-components of the system produce the same parts, while maintaining a stable interconnections between vital processes, in a cycle of continuous production and re-production. They are able to generate throughout their own organization, even under conditions of continuous perturbations from the environment (Maturana and Varela 1980). The system is autopoietic since it produces itself.

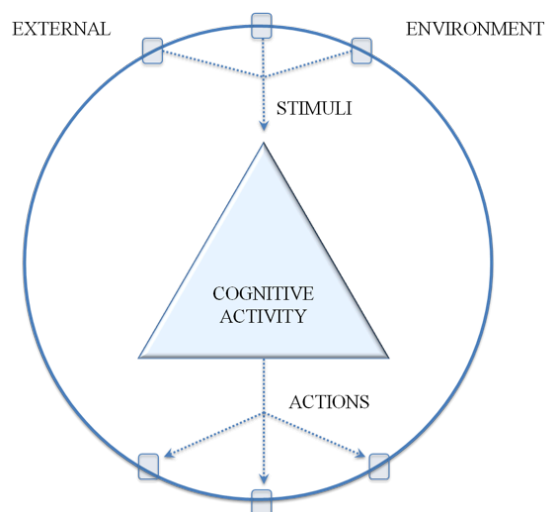
The organization, as cognitive system, through its management, consumes value for the re- production of value, in order to survive into the environment, maintaining its identity and revealing a tele-

onomic project, or objective of survival (Mella 1991). The firm maintains its identity and remains viable, if it can maintain vital parameters to levels that prevent its disintegration, showing a behavior typical of homeostatic autopoietic systems (Beer 1989). The firm, appearing as a system able to self-produce its own organization through business operation (Vicari 1991; von Krogh and Vicari 1993; von Krogh and Roos 1995) and as a system in which the internal states - organizational, economic and procedural - should assume conformations compatible with the structure itself, and with the variability of the environment that perturbs the homeostatic balance, becomes a viable system as defined by Stafford Beer in his well-known model (Beer 1989).

In this context, the environment, with its variability, is only an "activator" of the cognitive activity, which appears restricted to the field of internal cognitive processes (Vicari and Troilo 2003). The cognitive process has an organization which appears, therefore, closed and circular and this aspect is typical of all living organisms and all cognitive systems.

To an external observer, any cognitive system can be represented, in first approximation (Figure 1), as a transformation system (Mella 1991), i.e. as a black box that transforms stimulation into actions (interaction with the environment) in order to maintain its structure and maintain its identity in a changing environment. From the system itself point of view, it appears as a closed system, in which knowledge is constructed internally to react to environmental variety. The environment contains no information that the system can detect. The environment is only a source of triggers and perturbations by which the system builds its own information.

**Fig. 1 The Cognitive System**



Following the Mella's model (1997), a cognitive system, then:

- must have sensory organs, or receptors, to perceive environmental triggers from which training data are transmitted to the mind organization;
- must be provided with effectors (organs) to manipulate the environment through the use of external energy by developing actions and activities; must feed energy through the development of metabolic processes;
- must have a mind, characterized by its own organization, in which are developed cognitive processes - thinking - by basic cognitive resources.

The behavior of organizations, seen as autopoietic social systems, should be investigated in terms of interaction among individual members and in terms of how they take decisions and implement collective behavior to maintain the autopoiesis of the firm. It is therefore necessary to realize the rules sharing among the members of the organization (Gioia and Sims 1986).

Firm behavior can be defined (Mella, 1997) as a set of processes by which the organization interacts with the environment, through its effectors; such behavior depends on the internal cognition processes, developed by the management through the detection processes that process the signals received by the sensory organs, and lead to the construction of models of the environment through specific instruments: accounting, budgets, plans and programs, and, in general, the performance management systems, market research, and the amplification of weak signals.

Maintaining autopoiesis, therefore, appears to be essential for the correct formation and management of knowledge; its formation represents an entrepreneurial process of improvement of the firm competitive capacity (Nonaka 1988, 1991, Leonard-Barton 1995; Nonaka and Takeuchi 1995; Vicari 1991).

### 3. Conscious behavior

Cognition, however it is defined, is a detection activity, i.e. perception of triggers and development of useful models to react to environmental changes in order to maintain viability (Beer 1989; Vicari 1991; Mella 2009, 2011). In shaping a model of cognitive system, we necessarily have to distinguish two levels: the mental - not visible by an external observer - in which the cognitive activity takes place, and behavioral - that can, instead, be observed - in which are developed the system actions into the environment.

Mental activity is characterized by the presence of cognitive resources and the implementation of cognitive processes. Cognitive resources are represented by a system of information, by a system of weights, that is, preferences, and by a computational system, in order to process information, taking into account of the weights (2). Cognitive processes can be regarded as thinking, since they lead to the for-

mation of representations, to the expression of judgment, decision-making and monitoring of their implementation.

The thought/thinking joins action, implemented by the effectors, understood as a reaction to triggers and, in advanced forms, as an execution of decisions developed by the thought, so that the cognitive system can profitably modify its "position", however defined, perceived into the environment.

Linked processes of thinking/thought and action form the system behavior that can be defined, dynamically, as a sequence of 'thinking' and 'action' acts, as a chain thinking-action, fruit of cognition. This chain allows an autopoietic system to maintain life coupling with success to the environment, produce metabolic processes that allow the regeneration of the structure and eventually the re-production. In these terms, a cognitive system that develops a behavior, can be represented as a transformation system of triggers into actions (interaction with the environment). This transformation is mediated through a knowledge basis continuously adapted (Maturana and Varela 1987).

Taking account of the external stimuli, the knowledge base and the evaluation of the weights, using the computational system, the cognitive system forms representations (models) of the environment and establishes - through decisions (thinking) (Fioretti and Visser 2004) - the efficient behavior to keep (action) - in order to survive or to improve the conditions of existence; decisions are reflected into action and new thinking. A *cognitive system* may be represented in figure 2.

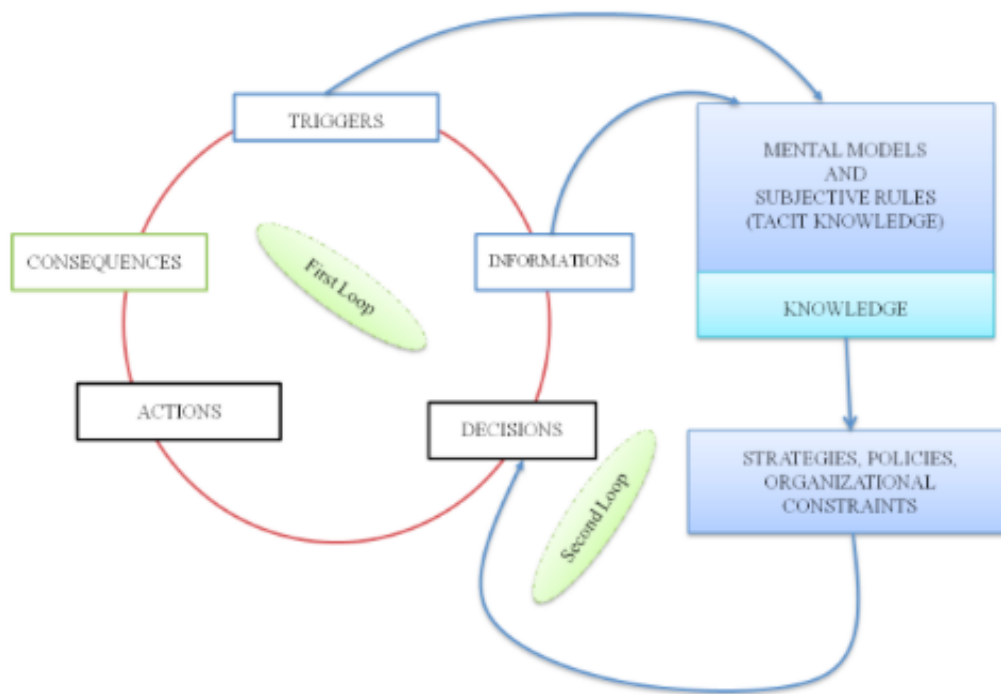
Expanding figure 2, a cognitive system can be defined as conscious when the reactions to the triggers are the result of decisions. The organizational structure of every conscious cognitive system should, then, necessarily include:

- Sensory organs of interface with whom the system is coupled to the environment in order to implement environmental information i.e. signals;
- Internal sensors organs in order to perceive vital parameters that is triggers of disequilibrium of the autopoietic network;
- Organs to select and store the triggers and transform them into meaningful information;
- Computational organs to put in a system the information and build representations of the environment which form the cognitive base;
- Organs of comparison and evaluation of information and representations (assignment of "weights" and formation of the "scale of preference");
- Effector organs in order to intervene in the environment (searching for adaptation) and in order to implement actions which make processes.

Every conscious cognitive system tries to improve its cognitive resources:

- Enhancing sensory organs in order to increase the range of perceived triggers;
- Developing the attention organs in order to improve representations of the environment;
- Improving the perception of the internal viable parameters;
- Refining the weights system, i.e. criteria evaluation of risk and trust (decision criteria);
- Reinforcing the computational system,
- Making more powerful and efficient the effectors.

**Fig. 2 - Cognitive system: adaptation from Argyris (1993).**



The above considerations can be summarized in the general model of conscious cognitive system as a transformer of data and information into sensible representations (3), from which descend behaviors, as shown in Figure 3, which is a specification of the model of Figure 1.

The model in Figure 3 perfectly describes the business organizations - such as cognitive systems in which is developed a thinking - made up of cognitive processes - and an action - consisting of the productive transformations of energetic input (factors of production) in energetic output (production of goods and services).

To an external observer organizations can be interpreted as instrumental systems that develop operational processes to achieve institutional objectives - individual, social and institutive (Masini 1964, 1979; Superti Furga 1975) - being an useful tool for the environment, according to structural coupling.

If social goals are perceived as positive, the environment will introduce favorable interactions to the organization's life, both as a single system or as a kind of systems (defined by the structure and processes). For an inner observer designed to analyze the structural processes, organizations- firms are fully cognitive systems that form representations of the external and internal environment, decide, plan, implement and control appropriate behaviors in order to counter the perceived negative perturbations and to find conditions favorable for a durable life.

Precisely in this sense, organizations-firm should

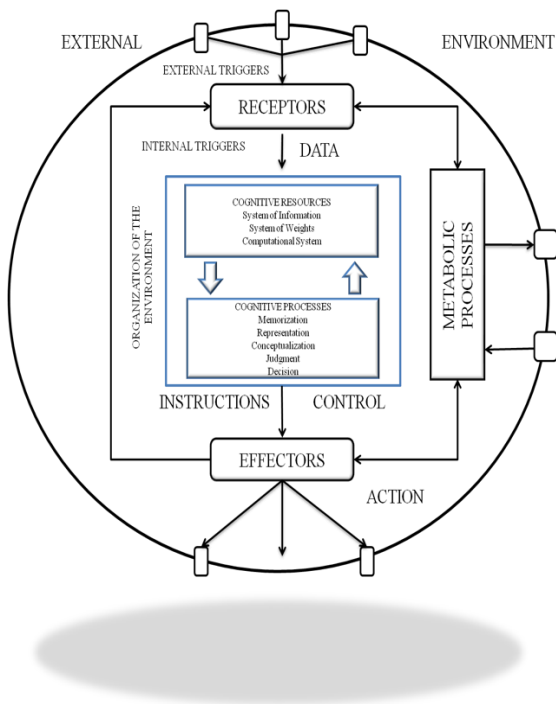
be considered as autopoietic systems, cognitive and conscious, since they develop metabolic processes that reproduce continuously the organs and the network of organizational processes, in order to maintain and evolve their structure over time, for a duration that exceeds that of the structured permanence of individuals components. The fundamental resources of the company, considered as a cognitive system, are cognitive resources, i.e. capacity of:

- Training and developing the knowledge base necessary for survival;
- Enhance the models used by the management to represents external reality,

- Collect environmental information, and order them in correct representations (external monitoring), in order to increase the cognitive base;
- Develop of appropriate weights of evaluation and size them to changing circumstances,
- Implement efficient managerial calculations,
- Enhance the computational system.

The enterprise is a system, then, able to operate on the basis of his knowledge and capable to continuously feed the knowledge of which is provided, through the cognitive behavior, as shown in Figure 4.

**Fig. 3 – The Cognitive Conscious System (source: Mella, 1997)**



Cognitive resources, ie information, weights, computational systems, themselves, are formed and modified, or by observation, ie, monitoring the environment, driven by the same cognitive processes, or by behaviors capable of finding internal and external information.

**4. The “chain thinking-action”**

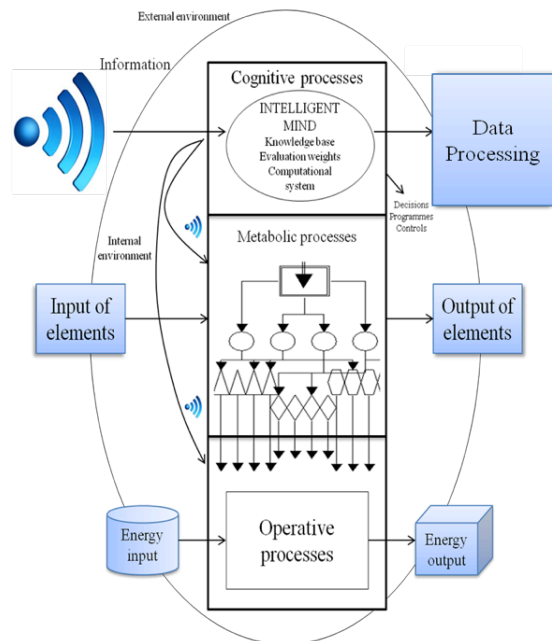
Enterprise knowledge is the result of a collective process of choices formation, that appears as a result of continuous interaction, of exchange of signals, of individual processing, of individuals expectations, of shared norms, of carried out procedures, of organizational mechanisms created within the organization. The firm, as cognitive system, is not the sum of knowledge of the individuals who make it up, but

"something more and different", being composed of several "processing nodes or networks", formed by individuals, organs, structures and procedures (Vicari and Troilo 2003).

Both thinking and action are widespread activities in the network of organizational processes. It should be observed that between thinking and action there is, necessarily, a feedback relationship: the cognitive system is a dynamic system (Sterman 2000; Reading 2004), not simply a causal system, because the actions and behavior does not depend directly by triggers but by cognitive status inside the system, i.e. by the cognitive structure which incorporates an experience, a knowledge and a culture.

As a cognitive autopoietic system, the firm bases its existence on the ability to self-create and maintain its network of knowledge. This constant process of creation of cognition through a continuous interaction between thinking, which determines action, and action, which produces triggers that modify the knowledge base, can be identified in the "chain of thinking-action", which is the process that - thanks the computational devices and evaluation - develop rational calculation from which flows the decisions that are implemented in organizational actions. The "chain thinking-action" can be represented with a cyclical model made up of six phases, shown in Figure 5.

**Fig. 4 – The firm as a Cognitive System**



The experience accumulates by detecting information about the successes and failures (errors) resulting from the execution of actions, through the activity of objectives control (Mella 1991, 2011). Any firm behavior depends on the experience, therefore, accu-

mulated in representations and models, and, depending on the relationship between experience and behavior, we can distinguish four types of behavior:

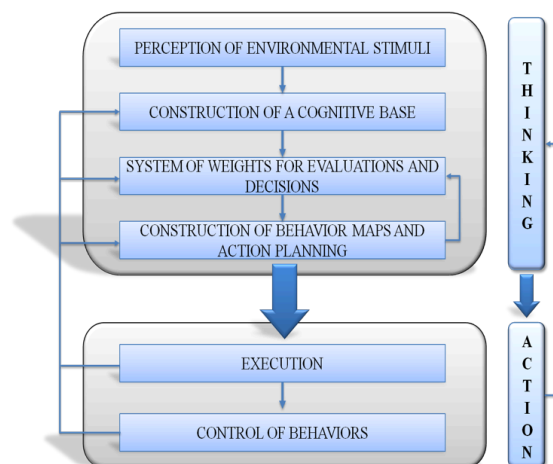
1. *Automatic Behavior*: the behavior is reactive, and originates from automatic feedback that activate control systems which act outside of the thought, in order to react quickly to triggers or to remove the causes of interference. This behavior does not depend on the experience stored by the system, but comes from contingent facts that require an immediate reaction.

2. *Adaptive behavior*: the organization is aware of the triggers and perturbations and, using the experience gained through cognitive processes, reacts according to action models considered effective. The success of such behavior reinforces and consolidates these models, for the use in future decisions.

3. *Exploratory behavior*: it is a typical behavior in which management, seeks new challenges and new knowledge in order to predict and prevent errors and avoid them or to find new positive triggers to strengthen its survival.

4. *Innovative or creative behavior*: try to overcome the experience stored, creating new incentives that can bring benefits to overcome stored models and form new representations, through processes of creation and invention, which incorporate elements of the knowledge base.

**Fig. 5 – The “Chain Thinking-Action”**



## 5. The successful entrepreneurial thinking: intelligent firms

We define *intelligent* a cognitive system if it can translate its experience into models, expanding its cognitive basis by carrying formal descriptions of experience, transmittable through a linguistic behavior,

so that linguistic behavior makes possible enabling new structural couplings.

A necessary and sufficient condition for an intelligent cognitive system is that it is able, with its own cognitive processes, to build representations of the world, i.e. descriptions, concepts, uniformity and laws, and to develop a formal communicative behavior through which it extends the range of structural couplings that favors its existence.

The cognitive activity of firms (Figures 3 and 4), considered intelligent cognitive systems, can be specified in entrepreneurial and managerial “thinking” (Mella 2009; Beer 1989). These forms of “thinking” are distinguished by the manner in which it is developed the “chain” presented above:

1. the *ENTREPRENEURIAL THINKING* (or innovation), whose output is represented by the policies, strategies and plans that put the company's management in performing productive, economic and financial behavior, directs the system i.e.:

a) evaluates the competitive position of the firm in the environment in terms of strategic vector: [products (quality service) / market (customers, price) / channel] / [processes (productivity, cost) / technology / organization],

b) develops innovative thinking and then creative in order to change the competitive position of the firm,

c) establishes the desired position in terms of strategic vector,

d) sets the goals as points of arrival to the desired position,

e) determines the set of actions necessary to achieve the objectives, i.e. the company's strategy to change the competitive position,

f) acts feedforward; the thinking is strategic: to move from the present to the future strategic situation; to modify the efficiency matrix:

g) enacts a typical exploratory behavior (trying several solutions) and innovative (new solutions).

2. the *MANAGERIAL THINKING* (or conservation) whose output is represented by a system of controls on production, economic and financial behaviors, in order to ensure that these will be realized according to the strategic decisions and management policies; the organizational transformation controls, i.e. configures the most efficient paths to get to the points of arrival (Mella, 2014):

a) considers strategies such as objectives,

b) sets out plans for implementing the organization behavior,



c) controls the execution trying to minimize the deviations between the implemented and scheduled execution,

d) develops, therefore, a conservative thinking, then adaptive;

e) acts developing controls; the thinking is programming how to develop the efficiency matrix: put goals and determine courses of action for self-maintenance of the structure,

f) enacts a typical automatic behavior (procedures) and adaptive (planning and control for exceptions).

As an *intelligent cognitive system*, using an innovative entrepreneurial thinking, the firm is able to construct actively the reality in which it operates (Weick 1979, Daft and Weick 1984; Smirchich and Stubbart 1985; Vicari and Troilo 1998), and to check its path in it, through managerial thinking. Particularly importance is seen in the ability of developing entrepreneurial thinking since it is the basis of innovation and organizational change strategies (Amabile 1988, 1997), but, above all, because it stimulates the differentiation of product and process which represents a crucial determinant of competitive advantage (Andrews and Smith 1996; Im and Workman 2004). The cognitive and intelligent firm does not fit, therefore, the scope in which it operates, but it creates a different context from the others in relation to its own patterns of knowledge and activates its specific environment, in a typical autopoietic view of structural coupling (Maturana and Varela 1987).

The environment does not provide, thus, any "objective" input to the firm. By coupling to it (putting itself in relation to it) and "activating it" the company, through the looping of the "chain thinking - action", generates a pattern of cognitive representation of its position, i.e., a map, which takes the form of a "network of causal sequences" (Hebb 1949; Hayek 1952; Weick 1979), which provides guidelines on the future production, economic and financial path (Mella 2011; Senge 1990).

The environment "activated" is, therefore, that section of space to which the company attributed a sense, that portion of the environment in which it is immersed, and which identifies as close to its own action and needs (Vicari and Troilo 1998).

## 6. Conclusions

To build a model of autopoietic cognitive and intelligent, I wanted to emphasize cognitive activities developed by industrial organizations. I tried to show how the process described by the cognitive model called "thinking-action chain" - that fuels the entrepreneurial and managerial thinking - both features companies that want to maintain high levels of viability

(Beer 1989), performance (Sobek, Liker and Ward 1998) and to develop their ability to evolve from environmental perturbations.

The perturbations, which the organization is constantly subjected during its economic life, are the conditions that allow it to build, improve and expand its cognitive processes and models and entrepreneurial (innovation and implementation) and managerial (monitoring and adaptation) behavior, organizing itself, finding new ideas, new solutions, new products, new market approaches, new ways to "invent the future" (Fink et al. 1971; Hedberg et al. 1976; Ford 1985; Ford and Baucus 1987; Mone et al. 1998), in order not to lose its independence and unity, in a perspective of homeostasis maintenance (Maturana and Varela 1980, 1987).

A "winning" entrepreneurial thinking is able to give a direction (objectives-strategy) always aimed at improving the organization's vital parameters. The entrepreneurial thinking develops knowledge models that derive less from direct experience, since it programs innovative and exploratory behaviors and the parallel managerial thinking, oriented to control programming, translates in efficient behavior.

The role of entrepreneurial and managerial thinking is to create the conditions to encourage a continuous development of cognitive models in organizations, in order to maintain the conditions of survival, leading the company in a situation of creative tension (Senge 1990) to generate new ability to evolve.

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