# Fuzzy Systems Perspectives on Cognition, Economics and Machines in Organizations

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*Abstract – This paper unifies theories of fuzzy systems, cognition, economic man and organization behavior in order to introduce cognitive machines. It contributes by outlining the impact of fuzzy theory on these fields which have been subject of Nobel Prize in Economics. This research advocates and explains that Fuzzy Theory involves the necessary mathematical and logical foundations which materialize the representation and computation of categories of Jerome S. Bruner and Eleanor Rosch's Theory of Cognition, and also the new model of economic man of Herbert A. Simon Theory of Bounded Rationality (Nobel Prize, 1978); which have an important role in organizational behavior. Based on these premises, this research reviews the roles of cognitive machines in knowledge management and organizations; and from such a perspective, this work indicates that Fuzzy Theory represents the foremost and prior contribution to the concept, representation and computation of symbolic cognitive categories which have an important role in the new model of economic man, bounded rationality and organization behavior.*
*Keywords – Fuzzy Systems; Cognition; Bounded Rationality; Organization Behavior; Cognitive Machines.*

## I. INTRODUCTION

This research assumes that if we want to raise machines from technical to social systems, we have to design the machines with architectures that subsume cognitive processes which are inspired by human cognition. In such a view, we can elevate the machines to the levels of cognition of organizations. It is from this perspective that this research investigates cognitive machines in organizations (Nobre, Tobias and Walker, 2009b, 2010). This work premise subsumes that: If we assume that the cognitive roles in the world of organizations, as fulfilled by agents, have performance and outcomes which can be attributed to either humans or machines, without any distinction, then we are ready to consider machines as members of organizations which act in the name of them similarly to people. Proceeding further with such steps, this paper presents a class of cognitive machines with capabilities to carry out complex cognitive tasks in organizations – whereas the concepts of the organization are presented in (March and Simon, 1958).

## II. Cognition, bounded rationality and fuzzy theory

### A. *Cognitive Theory of Concepts and Categories*

The transition from behaviourism to cognitivism was paved by the school of gestalt psychology in the first half of the 20th century. Cognition is oriented to the study of high mental processes which govern human behaviour, learning and intelligence, and thus it investigates theoretical models and those concepts underlying the functioning of the human mind, like perception, attention, categorization, knowledge representation and organization, memory, language, decision-making and problem solving (Reed, 1988).

Among the theories of cognition, there is the distinguished contribution of Jerome S. Bruner (Bruner, Goodnow and Austin, 1956) on concepts and categories; whereas concepts are mental representations of our experiences that allow us to classify objects (cars, fishes, vegetables, colors, etc.) according to the characteristics they have in common. In such a proposal, Bruner expected to shift research efforts from stimulus-information-response to creation of meaning and interpretation towards a theory of construction; however, research emphasis was directed to information-processing because of the influence of the computer as metaphor of human mind (Lefrançoies, 1995). Concepts are extremely useful because they allow us to group objects into categories for improving interpretation and information processing. Concepts are mental representations of categories of physical and abstract objects with common properties like the attributes of color (red, yellow, green, etc), size (small, medium, large, etc), etc. A concept may be regarded as a percept recognized and classified into a category (Nobre, Tobias and Walker, 2009a). A few years later, after Bruner's proposals, Rosch (1973) investigated a set of experiments and concluded that most categories do not have clear boundaries, and that category borders are fuzzy; most categories have fuzzy boundaries because some of their members seem to be better examples of the category than others (Bernstein *et al*., 1997).

These developments in cognition, especially in concept formation and categorization, provide an important foundation to explain man behavior and decision in economics and organizations. Moreover, this paper suggests that a theory of fuzzy categories and concepts was first proposed by Lotfi A. Zadeh (1965, 1973) with the empowerment of definitions, mathematical properties and computational capabilities.

### B. *Bounded Rationality Theory*

The theory of bounded rationality as proposed by Herbert A. Simon (Nobel Prize in Economics 1978) represents an important framework for the analysis of human behavior, cognition and decision processes in organizations. It can also be viewed as a model of cognition and economic decision-making which considers limits of information and computational capacity of humans (Simon, 1947, 1982a, 1982b, 1997), as illustrated in Figure 1; whereas uncertainty is associated with lack of information and insufficiency of computation for general information processing and interpretation (Nobre, Tobias and Walker, 2008, 2009a).

However, Simon's theory of bounded rationality was missing alternative mathematical and computational tools which could be used to encapsulate the particularities of his model of human cognition and decision processes in a proper way. This was an important requirement for the development of the field of artificial intelligence; i.e., the need of alternative mathematical and computational approaches for the analysis and design of artificial systems (like machines which are artificial man-designed systems, and not natural systems which conception comes from nature) whose processes and behavior are metaphors for, and models of, human cognition and intelligence. Despite having important advancements since its inception in the early fifties, artificial intelligence has found limitations to progress in those areas where problems require approximate (fuzzy) rather than precise (crisp) formulation (Zadeh, 2001). These areas need alternative methodologies for the representation and manipulation of natural concepts which are characterized by fuzzy boundaries (Bernstein *et al*., 1997; Nobre *et al*., 2009a).

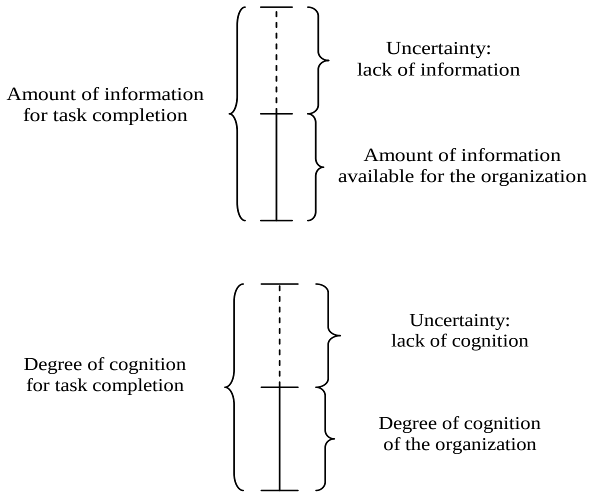


Figure 1. Uncertainty as lack of information and computational capacity

### C. *Fuzzy Theory*

The theory of fuzzy systems (Zadeh, 1965, 1973) represents an important framework with mathematical and computational background for the analysis of decision processes, complex systems, and mainly those systems which behavior is preponderantly influenced by human emotion, cognition and social networks. The more complex the system, the higher the system cognition (Nobre *et al*., 2010). The theories of computing with words and computation of perceptions (Zadeh, 1999, 2001) are derivations of fuzzy systems and they represent approaches with the necessary elements to encapsulate the particularities of the Herbert A. Simon’s model of bounded rationality. These particularities are mainly concerned with limitation of information, knowledge and insufficiency of computational capacity and interpretation; whereas knowledge primarily emerges from the information possessed and personalized in the individuals’ mind (Alavi and Leidner, 2001).

### D. *Connections between the Theories*

*Limitation of information and knowledge*. Limitation of knowledge is synonymous with lack of information and also with the kind of uncertainty which pervades most of the concepts manipulated by humans. These concepts are called natural concepts in psychology and they are characterized by fuzzy boundaries (Bernstein *et al*., 1997). Moreover, natural concepts form relations in propositions, and clusters of propositions form mental models. Natural concepts are key abstract elements in the processes of interpretation, conceptualization, categorization and knowledge organization – whereas these processes played important contributions in cognition since the 1950´s from Jerome S. Bruner’s publications (Bruner, Goodnow and Austin, 1956). In such a way, Lotfi A. Zadeh's theories provide the necessary mathematical and computational background (Zadeh, 1965, 1973) for the representation of natural concepts and mental models through complex symbols described by words and sentences of natural language.

*Limitation of Computational Capacity and Cognition*. Limitation of computational capacity and cognition is synonymous with the bounded ability of the human brain to resolve details and to solve problems characterized by constraints such as resources, time and cost. Such a limitation requires humans to search for approximate solutions and satisfactory results rather than precise and optimal outcomes. In such a way, Zadeh's theories provide appropriate mechanisms of approximate reasoning and economic decision-making which are necessary for the manipulation of natural concepts and mental models (Zadeh, 1999, 2001). Moreover, in such a context, *satisfice* as coined by Herbert A. Simon (1947, 1997) can be realistic achieved rather than optimization through Zadeh's theory and mechanisms of computation and thinking.

### E. *Unification*

The previous reviews suggest and demonstrate that Jerome Bruner (1956) and Eleanor Rosch (1973) contributed with theories of concepts and categories in cognition; Herbert A. Simon (1947) contributed to a theory of New Economic Man with the conceptual premises of Bounded Rationality (Nobel Prize, 1978); Lotfi A. Zadeh contributed with the Fuzzy Theory which involves the necessary mathematical and logical foundations which materialize the representation and computation of categories of Bruner and Rosch's Theory of Cognition, and also the new model of economic man of Herbert A. Simon Theory of Bounded Rationality; which have an important role in organizational behavior. In such an unification, concepts and categories form the base of a new model of economic man and organization behavior; and fuzzy theory supports the cognitive theory of fuzzy concepts and categories with definitions and mathematical background, and therefore, fuzzy theory forms a basis to represent the new model of economic man and his/her impact in organizational behavior.

### F. *Core Rationale for Cognitive Machines*

From this unification of theories, this paper proposes that cognitive machines are necessary when we need to extend the human boundaries of computational capacity, cognition along with knowledge and uncertainty management to more advanced models of cognition and information processing.

## III. PRINCIPLES OF COGNITIVE MACHINES

Initial lines of contribution on the perspectives of cognitive machines in organizations were first touched in (Nobre, 2005; Nobre *et al*., 2008, 2009a, 2009b). Cognitive machines are information processing and knowledge management (interpretation) systems which unify computational and cognitive strengths of humans and computers. They are necessary when we need to extend the reasoning or mental capacity of humans, groups and organizations to more advanced models of cognition. Cognitive machines are agents whose processes of functioning are mainly inspired by human cognition. Therefore, they have great possibilities to present intelligent behavior. When participating in organizations, cognitive machines are agents of organizational cognition and they contribute to improve the degree of cognition, intelligence, autonomy, learning and knowledge management of the organization (Nobre *et al*., 2010). The design of cognitive machines involves theories of cognition and information-processing, and also the mathematical and theoretical background of Fuzzy Systems (FS), Computing with Words (CW) and Computation Theory of Perceptions (CTP) (Nobre, 2005; Nobre *et al.*, 2009a). Cognitive machines are deliberately designed to participate in organizations by carrying out complex cognitive tasks; and in particular the task of decision-making which involves representation and organization of knowledge via concept identification and categorization along with the manipulation of percepts, natural concepts and mental models. The ability of these machines to manipulate a percept provides them with higher levels of information-processing than other symbolic-processing machines; and according to the theory of levels of processing in cognition (Reed, 1988), these machines can mimic (even through simple models) cognitive processes of humans. Percepts and thus concepts (along with mental models) are described by words, propositions and sentences of natural language (Zadeh, 2001).

## IV. DESIGN OF THE COGNITIVE MACHINE

### *A.* ***Strategy***

This paper assumes that intelligence depends on cognition and emotion. Therefore, we should firstly be concerned with the design of cognitive processes in order to provide machines with some intelligent behavior (Nobre, 2005). The strategy of design of the cognitive machines of this paper is based on such a premise, and it is illustrated in Figure 2.

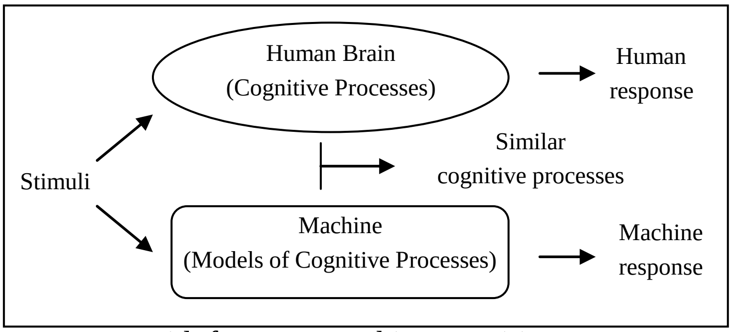


Figure 2. Design strategy with focus on machine cognition

### *B.* ***Information-Processing Structure***

An outline of the cognitive machine structure is sketched in the Figure 3. This structure is adapted from the information-processing system approach presented in (Bernstein, 1997; Newell and Simon, 1972). In summary, cognitive machines operate like:

(1) Stimuli from the environment are modified and transformed by the sensory system into neural activity signals. These signals are called sensations; (2) The perceptual system maps sensations into new structures and representations of perceptual amodal-symbols (Barsalou, 1999). Viewed as a process, perception organizes sensations into patterns, and furthermore, it uses knowledge stored in memory to recognize those patterns. It gives meaning to sensations through perceptions of depth, distance, motion, light, etc.; (3) The processor receives and manipulates perceptual amodal-symbols. It consists of a process of reasoning which uses the knowledge stored in memory to make decisions. Its output decisions are represented by the same structure of amodal-symbols given by the perception block; (4) The memory stores knowledge in the form of mental models described by concepts, categories and clusters of propositions; (5) The response

block transforms amodal-symbols to a new structure compatible with the environment requirements. This block can also include task execution and actuation on the environment; (6) The process of attention acts on the perception, decision-making and response processes. Attention provides perception with the selection of specific parts of stimuli and sensations when recognizing patterns and storing them into memory for further manipulation in decision-making and response.

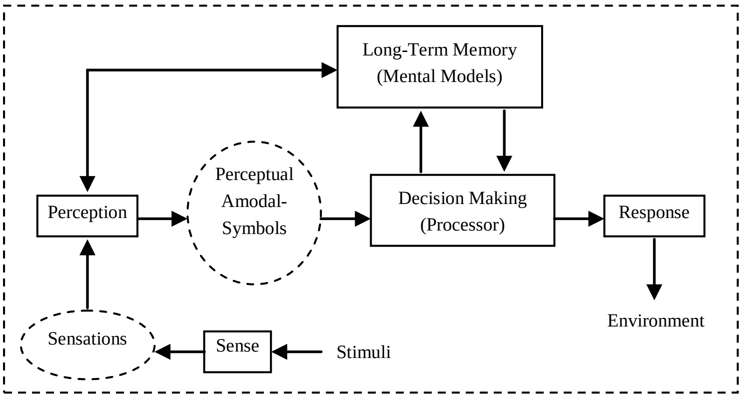


Figure 3. Structure of the Cognitive Machine

### *C.* ***Cognitive Machine Framework***

The framework of the cognitive machines is represented in the Figure 4.

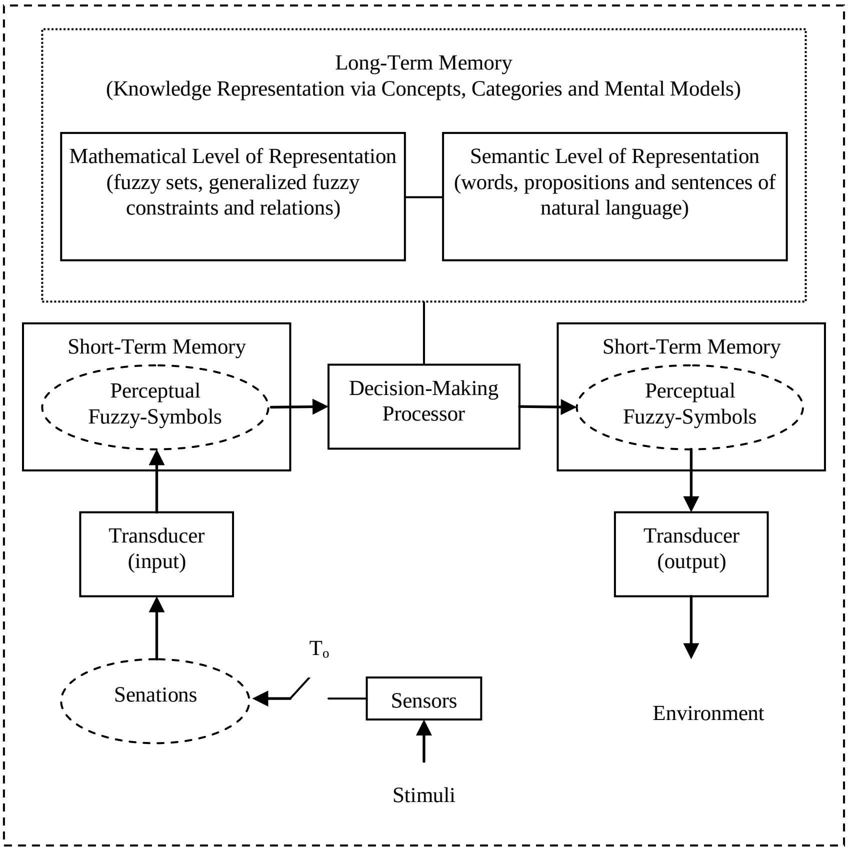


Figure 4. Framework of the Cognitive Machine

It is tailored from the general structure of the information-processing system illustrated in the Figure 3. This framework manipulates percepts and concepts in the form of complex symbols described by words, propositions and sentences of natural language. Most importantly, such a framework is equipped with the mechanisms of fuzzy logic, computing with words and computational theory of perceptions (Zadeh, 1999, 2001) in order to manipulate percept and concepts, clusters of propositions, and thus representations of mental models. The cognitive machine framework subsumes the processes sensory processing and attention (or selection), transduction (from sensations to symbols), concept identification and categorization, short-term memory and long-term memory, decision-making, transduction (from symbols to task environment signals). These processes and their associations to the functional blocks of the cognitive machine are proposed and described in (Nobre *et al*., 2009a, 2009b).

### D. *Levels of Symbolic Processing*

The levels of information-processing of the cognitive machine represent layers of a simplified model of the human mind. From a bottom up perspective, the cognitive machine maps information from the levels of stimuli and sensations (neural activity signals) to the levels of percepts and thus concepts stored in memory in the form of words, propositions and sentences of natural language. At its higher level of processing, the machine manipulates percepts and concepts in the form of clusters of propositions which represent people's understanding on how things work. Such clusters are called metal models (Bernstein, 1997). In such a way, fuzzy sets and fuzzy logic along with computing with words and computation of perceptions provide appropriate tools to represent descriptions of mental models; and secondly, they also offer the necessary mechanisms to manipulate mental representations similarly to the ability of humans to think with fuzzy concepts and to perform approximate reasoning (Gupta and Sanchez, 1982; Nobre *et al*., 2009a; Sanchez and Zadeh, 1987). Table 1 summarizes levels of information and processing along with their representations and technologies.

TABLE 1. LEVELS OF SYMBOLIC-INFORMATION-PROCESSING

| **Information level** | **Processing level** | **Representation** | **Technology** |
|---|---|---|---|
| Stimuli and sensations | Sensory and neural circuit systems | Signals (electrical, optical, digital, etc.) | Sensors |
| Sensations and percepts | Transducer and decision-making processor | Fuzzy-perceptual symbols (linguistic variables) | Fuzzy sets and fuzzy granulation |
| Concepts, categories and mental models | Memory and decision-making processor | Words, propositions and clusters (natural language) | Fuzzy constraints and modeling |

## V. ANALYSES OF COGNITIVE MACHINES

### A. *Abilities of the Cognitive Machine*

Bounded rationality and economic decision-making are characteristic processes of the human mind (Simon, 1997). Therefore, they are discussed in this subsection in order to understand some capability boundaries of cognitive machines.

*Bounded Rationality and Economic Decision-Making*. The fundamental premises about bounded rationality are (March, 1994) i) scarcity of information (limitation of knowledge);

ii) and limitation of computational capacity (or limit of cognition). In order to deal effectively with such limitations, humans search for approximate and satisfactory solutions rather than optimal outcomes in their daily life (March and Simon, 1958); where the term satisfactory is synonymous with *satisficing* (Simon, 1947, 1997). The process of decision used by humans that lead them to satisfactory outcomes is called economic decision-making (Nobre, 2005; Nobre *et al*., 2009a), which is synonymous with approximate reasoning (Sanchez and Zadeh, 1987). Therefore, economic decision-making can be associated with economy in the processes of decision rather than with processes of choice that pursue optimal outcomes such as in neo-classical economics (Simon, 1997). Economic decision-making plays an important part in those environments where information is scarce and fuzzy, and where the costs of search and computation of information is high. Theories of choice that do not assume these premises seem to be unrealistic and they cannot provide models of human cognition (Simon, 1997).

*Extending the Boundaries of Human Cognition with Machines*. With the advent of digital computers, along with the disciplines of operational research, management science, and artificial intelligence, new technologies sought to extend the limits of rationality established by the cognitive boundaries of individuals and organizations (March and Simon, 1958; Simon, 1982b). A powerful combination of massive knowledge storage with high capability of symbolic-processing, and more specifically numerical and analytical computation, gave computers and general information technologies special places in organizations (Simon, 1977). However, despite providing organizations with tangible and intangible benefits (Brynjolfsson and Hitt, 2000), computers and general information technologies have found serious limitations of applicability in those areas where problems involve fuzzy or natural concepts, and decisions require approximate rather than precise formulations. Such areas involve managerial roles and thus the management of decisions at higher layers in the organization hierarchy.

On the one hand, people have a distinct ability to reason with fuzzy concepts and to solve problems through approximate and satisfactory solutions. Types of such problems involve tasks of interviewing and hiring employees, driving in city traffic, playing football, and most of the managerial and strategic decisions at upper-levels in the organization hierarchy. Moreover, people have a large long-term memory, but a very limited short-term memory. They also have limitations to reason with numerical and analytical representations of symbols. On the other hand, computers are still poor at solving problems which require the formulation and manipulation of natural concepts along with the execution of approximate reasoning. They have a large memory and no distinction is needed between short and long-term memories. Hence, they overcome the limits of human's short-term memory. Computers also overcome the inability of humans at solving arithmetic and analytical problems (Simon, 1982b). Figure 5 brings together the strengths of human cognition and computers in order to illustrate the abilities of a cognitive machine.

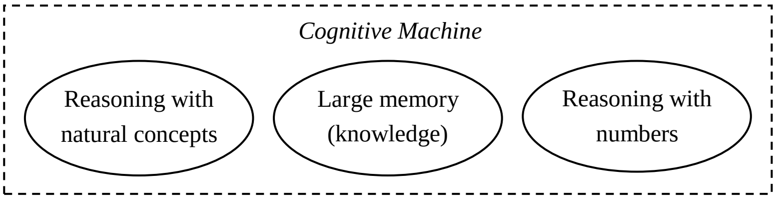


Figure 5. Abilities of the Cognitive Machine

### *B.* ***Design Boundaries of Cognitive Machines***

The design of the class of cognitive machines as proposed in (Nobre, 2005; Nobre *et al.*, 2009a, 2009b) assumes similar conditions to bounded rationality and human decision-making processes (March and Simon, 1958; Simon, 1997):

1) Alternatives of choice are not simply given but they must be generated through a process of search; 2) the probability distributions of outcomes are unknown and may be only estimated through high computational costs; 3) humans manipulate natural concepts (Bernstein, 1997). Therefore, most of the uncertainty that pervades the alternatives and their consequences are classified into fuzziness (Zadeh, 1965, 1973) rather than probabilistic uncertainty (IEEE, 1994); and 4) satisfactory outcomes are preferable to maximization or optimization.

Therefore, in order to satisfy such conditions, the design of the cognitive machines assumes that:

i) Alternatives (conditional statements or rules) which form the knowledge base of the machine are searched and generated by human experts or with the support of computational tools of adaptive and learning capabilities (Wang, 1994). The process of search and generation of conditional statements is better described by a combination of the logic of appropriateness and the logic of consequences (March, 1994; Simon, 1982b). Therefore, it involves a combination of experience, intuition, expertise along with calculation.

ii) The higher the number of alternatives, the higher is the number of rules; the higher the number of rules, the higher is the completeness of the knowledge base (Nobre, 2005).

iii) Fuzziness is the type of uncertainty that pervades the alternatives (antecedents) and their consequences (conclusions). The knowledge base of the cognitive machine comprises antecedents and conclusions which describe relations between natural concepts. Such concepts have fuzzy boundaries. Therefore, fuzzy sets theory (Zadeh, 1973) is a necessary tool for the representation of such concepts.

iv) A satisfactory strategy for decision-making is implemented through principles of fuzzy logic, computing with words and computation of perceptions (Sanchez and Zadeh, 1987; Zadeh, 1999).

### *C.* ***Conflicts in Decision Making Processes***

*Constructive and Dysfunctional Conflicts*. Conflicts shape and affect the behavior of individuals, groups and organizations (Daft and Noe, 2001). They can be classified into constructive and dysfunctional conflicts. On the one hand, constructive conflicts are classes of conflicts which contribute to improve the behavior and performance of individuals, groups and organizations. On the other hand, dysfunctional conflicts are synonymous with obstacles which limit the action and performance of individuals, groups and organizations. This paper deals with dysfunctional conflicts which arise from decision-making processes in organizations. They are classified into intra-individual and group conflicts.

*Intra-Individual Conflict*. Processes of decision-making involve trade-offs among alternatives which are characterized by uncertainty, incomparability and unacceptability and hence they can lead organization’s participants to intra-individual conflict (March and Simon, 1958). Such a kind of conflict arises in an individual mind and it also can emerge from the influence of others.

Premises 1:

1.1. The Problem of Uncertainty: When considering models of rational choice and calculation which follow a logic of consequences, uncertainty means that the probability distributions of outcomes are unknown (March, 1994; Simon, 1982b). This work assumes either: that such probabilities cannot be estimated or they can be calculated only with unrealistic costs of computation.

1.2. The Problem of Incomparability: It means that the individual that participates in the organization cannot recognize a most preferred alternative. It can happen, for instance, when the individual has to decide between two alternatives with the same label such as good.

1.3. The Problem of Unacceptability: It means that the most preferred alternative which has been identified by the individual does not satisfy standard criteria.

*Group Conflict*. In addition to the factors that lead participants to intra-individual conflicts, members of groups in organizations can differ in their perceptions, values and culture, needs and goals (Daft and Noe, 2001). Hence, they can disagree in their decisions causing group conflict (March and Simon, 1958). This kind of conflict arises from differences between the choices made by distinct participants within the organization.

*Relations between Conflicts and Bounded Rationality*. The intra-individual and group conflicts which arise in organizations are mainly influenced by lack of information as well as by uncertainties, and most importantly, by cognitive limitations. In such a way, these conflicts cannot be solved by incentive and reward systems. Such cognitive and information constraints are synonymous with bounded rationality (March, 1994; March and Simon, 1958; Simon, 1947, 1997). However, this paper asserts that cognitive machines can be used to reduce or to solve such conflicts.

### D. *The Role of Cognitive Machine in Conflict Resolution*

This subsection proposes principles to support the assertion that cognitive machines can contribute to improve processes of choice in the organization by reducing intra-individual and group conflicts.

*Resolution of Intra-Individual Conflict*. The reduction of the frictions in intra-individual conflicts can be achieved by providing the organization with means to cope with uncertainty, incomparability and unacceptability factors.

Premises 2:

2.1. Solution to Uncertainty: According to the theory of natural concepts proposed in the literature of cognition (Bernstein *et al.*, 1997), most of the concepts which humans manipulate have fuzzy boundaries. Hence, fuzziness is the principal kind of uncertainty that the cognitive machine must deal with and manage during task execution and decision-making. Fuzzy concepts can be represented through complex symbols whose structure is properly defined via fuzzy sets; and their manipulation can be done through principles of fuzzy logic, computing with words and computation of perceptions (Zadeh, 1999, 2001).

2..2 Solution to Incomparability: Instead of identifying a most preferred conditional rule (or alternative) the cognitive machine fires (or selects) a set of rules according to a criterion; for example, the rules whose value is greater than 0; and then it unifies (or aggregates) the fired set of rules through the application of one of the operators in fuzzy logic. Such operators comprise s-norm and union (Dubois and Prade, 1985). Therefore, aggregation of preferences and unification of rules is applied rather than the selection of only one alternative.

2.3. Solution to Unacceptability: This is avoided by using criteria of design during the specification of the cognitive machine's knowledge base. For such a purpose, the criteria of completeness can be applied in order to guarantee that for each state there is an associated output (Bobre, 2005; Nobre *et al*., 2009a).

*Resolution of Group Conflict*. The absence of intra-individual conflict reduces group conflict, but it does not extinguish the problem since it is not a sufficient condition. By assuming the absence of intra-individual conflict, this subsection discusses the additional agents of group conflict and it proposes solutions to solve it. Group conflict also arises from divergences of opinions of the participants in a group which can be a consequence of the differences in their needs, goals, values, culture and perceptions. On one hand, such a type of conflict could be reduced by equalizing the participants' perceptions, opinions and knowledge. On the other hand, it could be solved through a methodology which supports the integration and combination of the participants' perceptions, opinion and knowledge. Both strategies are important, but the latter is the selected approach used in this research to justify the use of cognitive machines in group conflicts resolution. This strategy consists of the integration and storage of the participants' perceptions, opinion and knowledge in a common knowledge base (memory).

The design of the cognitive machines introduced in (Nobre, 2005; Nobre et al., 2009a, 2009b) comprises the specification of a knowledge base through commonsensical expertise; i.e., different experts express their perceptions, opinions and knowledge in the form of words and sentences of natural language which take the form of linguistic rules or conditional statements (Zadeh, 1973). Such rules may also be generated automatically, modified and improved through the principles of adaptive and learning systems (Wang, 1994). During the functioning of the cognitive machine, the activation of rules and their aggregation represent a common sense and integrated process which takes into account the perceptions, opinion and knowledge of different experts together. Therefore, decision-making processes are automated through the rules of inference of fuzzy logic (zadeh, 1999, 2001). Moreover, intra-individual and group mental models are represented through a set of fuzzy propositions and fuzzy conditional statements (rules), which can be mathematically defined through fuzzy generalized constraints (Zadeh, 1999).

### *E. Cognitive Machine, Designer and the Organization*

*On Designers of Cognitive Machines.*

Definition 1: The designer of a cognitive machine is the person (or third part organization) responsible for the cognitive abilities and the behavior of the machine. Such a kind of designers can have independent legal identity which enables them to make contracts and to seek court enforcement of those contracts if necessary.

Definition 2: Designers can use technologies for automatic design and engineering of cognitive machines. Such technologies are classified as artificial designers and they cannot ask for, nor answer, a formal contract. Therefore, their first designer (a person or third part organization) is the agent who is able to make it.

*On Responsibility: The Designer, the Machine and the Organization*.

Definition 3: The work relationship between the machine designer and the organization can be regularized by a contract which makes explicit: - the cognitive abilities of the machine; - the tasks that the machine can perform within the organization; - the roles that the machine fulfils in the organization; - and also the designer and the organization attestation (or signatures).

Definition 4: The organization is responsible for the assignment of roles to the cognitive machine, and the machine is responsible for the roles it fulfils in the organization. However, the machine designer and the organization are the main parts responsible for the machine results and performance. If the machine exhibits deviant behavior during task execution, or performance below specified criteria, then the contract between the organization and the machine designer is the object of analysis and judgment.

## VI. CONCLUSIONS

This research contributed by unifying theories of Cognition of Jerome S. Bruner and Eleanor Rosch, and Bounded Rationality and Administrative Behavior of Herbert A. Simon, with theories of Fuzzy Systems of Lotfi A. Zadeh. These unifications contributed to indicate that cognitive machines can extend limitations of human cognition, that involve limitations of computational capacity along with uncertainty management, towards more advanced models of information processing and interpretation. From such connections, this paper proposed the conception of a class of cognitive machines in organizations.

It proposed and explained that Fuzzy Theory involves the necessary mathematical and logical foundations which materialize the representation and computation of categories of Jerome S. Bruner and Eleanor Rosch's Theory of Cognition, and also the new model of economic man of Herbert A. Simon Theory of Bounded Rationality (Nobel Prize, 1978); which have an important role in organizational behavior. From such premises, this research reviewed the roles of cognitive machines in knowledge management and organizations.

From such a perspective, this work indicated that Fuzzy Theory represented the foremost and prior contribution to the concept, representation and computation of symbolic cognitive categories which have an important role in the new model of economic man, bounded rationality and organization behavior.


## VII. ACKNOWLEDGEMENTS

This paper is scientifically dedicated to Lotfi A. Zadeh due to his brilliant contributions of Fuzzy Theory to cognition, artificial intelligence, systems theory, decision analysis, economics, organization behavior, control, and other areas. In conclusion, this paper scientifically suggests that Lotfi A. Zadeh also deserves the Nobel Prize in Economics.


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