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Artificial Self Awareness for Emergent Behavior

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***Abstract*-The phenomenon of consciousness involves an agent (human or software) constantly perceiving the world (experiences) with perception linked to their emotions. The main point of the research implies emotions as different ways of thinking, allowing to find functional processes and return to the phenomenon of consciousness. Based on this, the agent assesses the best set of actions leading to a goal. This paper models this reactive behavior based on analysis and design of a cognitive model that includes mental models and cognitive structure of emotions. It is intended to include the largest number of goals in order to make the system flexible.**

Keywords- Artificial Consciousness; Emerging Behavior; Cognitive Structure of Emotions; Information; Perception; Sensation; Feelings; Emergent Behavior; Motivation

I. INTRODUCTION

This paper focuses on the experience of the consciousness phenomenon and the model presented allows the simulation of a limited amount of certain aspects of consciousness. It is considered a principle with which the work can be started in order to understand it and emulate in synthetic systems.

Awareness is the ability of a human being of a first look at an event in question. This first glimpse controls the flow of mental events and builds a purpose that involves one direction and action towards a goal. Consciousness is an experience of oneself as an organizer and controller of its activities, which makes us think that the human mind is an active force that constructs a reality, selectively encrypting information and developing behaviors based on assessments. This allows prediction about future expectations. This definitely requires a structure in its own actions.

According to William James mentioned in [1] the neural substrate of consciousness is the whole brain; since the stream of consciousness is considered to be highly integrated and unified. This means that consciousness cannot be turned on and off, the above sets a space of consciousness with unclear boundaries between the phenomenon of being self-aware and not being self-aware.

The previous ideas allow us to conclude that to possess an adaptive behavior, distinguishing human intelligence from a machine; it necessarily requires a degree of consciousness, which implies that it has a kind of knowledge compilation that underlies the presence of a large amount of information [2].

On the other hand there is a phenomenon of sensation closely linked to consciousness and according to Potworowski and Ferrari, mentioned in [3] is an inner experience of coherency or accuracy, excluding the senses. It is an emotional feeling related to the evaluation of something appropriate and strong experience of unity between the object and the subject. There are at least two types of feelings (right or wrong) linked to concepts and values. The sensation emerges from a given configuration, linked to a content being inter-related with a number of references. Hence at a given time an object or event may or may not make sense. In order to distinguish the ones making sense from the ones that don't, sensation is used for the translation of content. This last feature is not limited to an individual or his mind; it is related to given cultural aspects [4]. The phenomenon of sensation is strictly personal and is linked to issues such as: 1) environmental conditions, 2) terms of the translation of content in time, 3) body of theoretical knowledge (which can be altered), 4) situatedness and embodiment, or 5) object of cognition capability (be modified). If the status of any of this changes, then the object may stop making sense; for example, in case of mental illness, such as Alzheimer's or other dementia cases [5, 6]. Emphasis is placed on that feeling being intimately linked to the perception.

Currently there are several areas of research and development that together may quickly change the relationship we have with technology and the area of cognitive systems.

There is currently an area known as macro-mapping of the brain which focuses on investigating which areas of the brain are used when people develop a specific task. This technology can be used in order to make a process of monitoring and modeling functions externally as: a) direct communication with other systems in the brain, b) precise feeding during the development of a task at critical points of brain states that may allow us to enhance the training of a particular task. On the other hand, based on the understanding of what happens at the neuronal level in conjunction with the way in which the inputs

and outputs are processed, the micro-mapping of the brain should allow specific technological developments to replace certain functions [7].

However, the internal neural interfaces should also be considered (with live neurons), which along with technological advancement and understanding of brain functions will enable more sophisticated implants, Such as chips for treating a wide range of cognitive dysfunctions.

The neuro-prostheses could mean the implantation of a chip in the brain, in order to help paraplegics, amputees or people with mobility disabilities. It is based on the use of direct electrical stimulation of the nervous system to perform a function. Examples are: a) ear (cochlear), b) the retina, c) bladder and intestines, d) movement, posture, jerking.

A frontier research example is conducted by Theodor Berger [8], at the University of Southern California in Los Angeles. The hippocampus plays a very important role, since it is responsible for the creation of memories. It will be possible to replace it when critical damage occurs. At the moment researchers are working on a model of a rat hippocampus (http://www.usc.edu). One achievement is through a chip that can perform eighteen dynamic synapses of neurons, acting as a network of real biological neurons in the hippocampus.

In the case of personalized perception, we can already find in the gyms heart monitors that interacts with the equipment in order to incite an improved training experience. Or otherwise external physical recipients can collect data in order to assist in medical analysis [9, 10]. All the technology that can be used for health is a fertile field and could be quickly, colonized with new developments and gadgets.

The text is organized in a way that it allows to follow up on the different concepts that should be considered to achieve consciousness. Section two explains the phenomenon of perception and its importance to form representations of the world and the importance of perception in order to integrate it as information for the decision-making process. Moreover, it covers the importance of integrating the collected information and its representations. Finally, it is explained how the theory of motivation helps to explain why a behavior, as emergent behavior with consciousness, implies motivations. In this case it is the vital phenomenon and the incorporation of its own location, in order to have the ability to be interpreted and develop as an emergent behavior. Section three, presents the theoretical framework that allows us to consider that the proposed model to simulate the phenomenon of consciousness, considering some aspects of it. Basically consisting of two definitions: the first one related to the perception of the world from the perspective of the device and the second related to the accuracy of the representation required according to the needs of the agent's action. The OCC theory and certain implications relating to the concepts seen above are made, and can explain why they may involve consciousness. From the theory of multi-agent systems explains what a reactive behavior and their importance in the sense of their ability to recreate the capability to be incorporated and located. This is applied in order to be able to understand what is happening around and thus to be able to perform tasks. The explanation of the chosen knowledge representation: fuzzy cognitive maps (MCD). Section four explains an example of a developed analysis and design for an emerging behavior with artificial consciousness. It meets all of the above in this case study; the latter being an agent-chimpanzee. The mechanism involves trying to clarify how the cognitive structure of emotions (CSE) integrates autonomous behavior, explaining the rise of their level of consciousness. Section five mentions different applications for health and human well-being. Finally, the conclusions section is presented.

II. CONCEPTS RELATED TO THE PHENOMENON OF CONSCIOUSNESS

A. Perception

Why do we perceive? It would seem that the ultimate goal of perception is to act. Only then the overall question may be: How do perception systems provide an outcome that enables action?

From the point of view of neuroscience; a representation through sensorial sense and signal processing can be understood as a forward feeding process or as a constructive process in which the details of the external world, built from simple aspects of it, help create ever more complex representations [11].

As for the nature of representation, from the point of view of neurosciences, it specifies that for each unique triplet *perception-action-memory*, there must be a single status related for the brain. This status represents the information required to specify and generate these situations and events [12].

The representation in principle can take any necessary form, in order to fulfill its function consisting of choosing one of them. There are two requirements that must be met in order to achieve these: a) that the representation is paired with a unique and specific representation for the events that occur and b) that the representation has associated tasks to be developed for these events in progress [11].

The process of data processing by the brain is almost instantaneous and is aided by the senses: sight, touch, hearing, taste and smell, this may make our effort to create an artificial cognitive system quite difficult to achieve, *however we must emphasize that the brain uses a totally different paradigm from the computational one*.

Brain processing involves a flexible deployment parallelism, asynchronous, and nonlinear, as well as dynamic systems of adaptation. The levels of perception of humans and animals reach levels of development that exceed the artificial perception systems by far. In this particular case it is intended to compile this knowledge through a knowledge representation model that allows us to include: behaviors, emotions and events in a dynamic environment; from now on this representation will be called a cognitive structure of emotions (CSE), it will be explained thoroughly in section three (3.3). It has been successfully used to design different behaviors [13-17]. So, if we want to emulate the phenomenon of consciousness we must take into account its treatment of the sensory process; it refers to the reception of stimulation by the sense organs, besides referring to the haptic perception created by the whole non-visual and non-auditory sensations. This phenomenon is seen hypothetically as an emerging aspect of the phenomenon of mind embedded in the brain. As such, in principle, it can be studied and replicated within the synthetic systems [3].

Sensory processing must be considered as a part of adaptive behavior, since the latter is an emergent property of the interaction comprising: brain, body and environment.

B. How to Integrate Information

Torini studies in neuroanatomy, mentioned in [1] can derive a theory of consciousness that defines it as an ability of the system to integrate information. This definition is grounded by two phenomenological properties of consciousness: a) differentiation; referring to the ability to have a large number of conscious experiences, b) integration; as the unit that comprised all of these experiences.

For all the aforementioned reasons the cognitive structure of emotions (CSE) is classified as the information perceived from the environment, for example, experiences, since it is there the integration of the experience compiled from different behaviors resides. Moreover, it has the ability to generate an emergent behavior recreating the phenomenon of consciousness.

According to James, mentioned in [3], consciousness is a dynamic process and is constantly moving from one idea to another; from one thought to another. The structure is complex; each explicit thought is related to a strip or profile intuited content, which is known as a stream of thoughts. In this sense we could think of a CSE, where the goals are dynamic. These are activated or deactivated according to environmental events simultaneously with the individual internal status. The internal status allows the person to experience different feelings; here it is worth emphasizing that the last layer that governs the actions is where emotions are directly involved. This involves the onset of various behaviors associated with each goal, and where each behavior is linked to different emotions.

Following this line we can assume that one of the key points to model the phenomenon of consciousness can be associated with the shape of the internal representation model. On the other hand it is important to know that the muscular activity of the body should also be taken into account, since it is a key element to create descriptions, that is, feelings of being an entity in the outside world [18]. Shanahan mentioned in [19] implies that the ability to be located and incorporated in an environment is essential to be able to create experiences.

Finally consciousness is a phenomenon that breaks the reactive and autonomous process on the basis of the mechanism of attention [20].

C. The Motivation

The motivation theory helps explain the reasons behind a behavior; this is of vital importance as an emerging consciousness behavior involves motivation, in order to choose a behavior in a given time that will eventually become an action.

Basically, the motivation has two sources: internal and external. As for the external, it refers to what is casted upon our brain, that is, the mapping made from feelings from our five senses and our skin in contact with the world, such as: the weather, i.e. the concerning for a particular state of the environment as it could be a state of war. In the case of internal we have: a) emotions (biological and cognitive), b) cognition (goals, expectations, and assessment), and c) needs (physiological and psychological) [21].

The next issue to take into consideration is: How do we link motivation to consciousness? We believe that the proper way to do this is through the perception, as we know that people use their perception and motor cerebral system as a tool that allows them to complete tasks and goals that give meaning to their lives.

The motivations are goal-oriented and they are set in motion when the opportunity in the environment is combined with a target, therefore, they can be considered an opportunistic behavior. This can be seen as a set of preconditions that must be present for the chosen behavior to occur. Motivation according to [22], can be described in terms of directions and incentives (pull and push) related to the ongoing behavior.

Moreover, emotions have a considerable impact on the decision-making process. With two major effects on this process, the first effect implies reorganization of the hierarchy of goals and focuses attention on aspects of the environment relevant to the chosen goal [14]. The second effect to be considered implies that emotions are hedonic and are consequent with utility

value to be expected. This point out that people set goals using processes that allow them to assess the consequences of their actions in advance as positive or negative (emotions) and through this assessment select behaviors that allow the generation of the desired outputs and avoid to the maximum extent undesirable consequences.

According to Antonio Damasio (referred to in [18]), consciousness implies the will to survive associated with the ability to distinguish the internal from the external and the art to regulate our chemical system that allow homeostasis between these two worlds; homeostasis being the ability of a system to self-regulate, in other words, to stay within a tolerable internal instability between the inside and outside, provided that when stability between the two happens it means death. Thus it can be concluded that homeostasis is a phenomenon that amounts to the explicit existence of life, and this phenomenon is as valid for both bacteria or human. In this context the motivation translates to feel good and be happy, this is what it means to achieve homeostasis.

Now consciousness cannot be separated from our body because the base of it all is a map of the body towards the world. If we are aware, if we think and remember, it is because our body and its mapping of the world.

The main work of the consciousness of every living thing is to continuously create the mapping, taking into account the smaller sensations; and draw an internal model of itself; and a model of itself in the world which implies a model of the world.

This situation has the same priority to: 1) a snail, 2) a bacteria, and ultimately to a 3) human being, the complexity of which makes it different from the latter, which goes further in this phenomenon called consciousness than any other known living being.

In case of humans the result is self-recognition, and it recognizes himself as the mapping; bringing forth a new instance called the self.

From our point of view everything is intimately linked with the CSE. According to researchers in the field there are two types of information that a human being utilizes to make decisions [23, 24]. This information is integrated to generate a whole. In humans the feelings come from different sources, which are classified, into three categories:

According to the internal one:

a) Introspection: it is in charge of projecting in our brain the sensations that come from our viscera and that provides us with information about our physical condition, which becomes an interior experience either emotional or mental.

b) Proprioception: projects the muscular system mapping into the brain; it informs us about our own movements governed by our sophisticated senses of balance movements, but above all allows us to feel the action of one of our body parts.

According to the external one:

c) External Perception: projects the feelings mapping coming from the five senses into the brain, i.e. as our skin in contact with the world; it informs us about our environment and also due to mirror neurons (we have them from birth) we can perceive the same regarding to another human being through empathy.

To sum up; we have information coming from ourselves and is the introspective one, in our case study concerning emotions; the other concerns the external perception; which comes from the environment [25]. According to this assessment (emotions) the goal is fixed and certain behavior [15, 16] is triggered. The structure of emotions is related to different objectives of the various contexts that allow the achievement of partial goals. This is necessary in order to achieve a consistent behavior in that particular context that has a main objective pre-established. In the event that we wish to emulate this concept in a synthetic system the objective is to control the behavior.

Our work is based on: a) a model of reasoning that allows distributed and parallel analysis of the two types of information that humans analyzed to make a decision; one of them is related to the information that comes from ourselves (introspection) and in the study case refers only to the emotions; the other is external and comes from the environment (external perception), and b) in the theory of emotions proposed by the authors Ortony, Clore and Collins [26], also known as the OCC theory (and related with motivation theory). Last within the theoretical framework allows us to model the phenomenon of consciousness proposed by [27].

In the next section the theoretical framework proposed by [27] is presented, which allows us to model consciousness.

III. THEORETICAL FRAMEWORK AND A MODEL OF PHENOMENON OF CONSCIOUSNESS

A. Description and Phenomenology (the Experience of the Phenomenon)

The central hypothesis of [19] on which the theoretical framework of this proposal is based is framed by two definitions containing the implications of the phenomenon of consciousness in a synthetic scheme (S).

Definition 1 (Def. 1): in order to perceive the phenomenon of consciousness in a synthetic scheme (S), An S system must contain a mechanism that represents its meaning or significance: the world and the S system from the viewpoint of S system.

This definition refers to the ability of human beings to have a performance-description (RD) of their environment. This representation authors is known as depiction (the word mapping can also be used). The latter must be fully supported by the body movement.

Definition 2 (Def. 2): A RD is a state in the S system, which is as accurate as required for the purposes of S, the state of the world; from a virtual viewpoint within S.

Claim 1: The RD at which Def. 2 refers, is the required mechanism to ensure that the synthetic system S, is able to perceive the phenomenon of consciousness according to Def. 1, mechanism.

Statement 2: If S has the capability of mobility and has mechanisms for mobile perception. An RD as the Def. 2 can only be conceived if within the S system can be encoded information collected (interior and exterior). This refers to being able to answer the question. In which part of S, the elements of the world need to be indexed by the parameters of the body of the system S? For example in vision: eye movement clearly needs compensation mechanisms in order to achieve RD.

Claim 3: When referring to the phrase with the accuracy that is required in the Def. 2, it implies that effectors (which will take action in the world) must have all necessary information to be able to deploy an action in a dynamic world.

Statement 4: The phrase with the accuracy that is required in the Def. 2. Also sets an upper limit regarding the granularity of detail that must be reached in accordance with the requirements of the RD of S system.

Statement 5: While the Def. 2, does not require a topological representation. Then RD does not require the call to different areas of knowledge in order to achieve a performance as explained in the statement 2. For example in animal vision it is known already that the meaning of different visual attributes are located in different parts of brain, like color and motion of a point, in other words, which mechanisms does the brain use to gather the dispersed and present it as a whole [20]?

Our work takes into consideration all these aspects in order to propose an artificial model that simulates them.

B. Theory and Representation of a Cognitive Structure of Emotions (CSE)

1) OCC Theory

OCC [26] proposed a general structure in which it is stated that there are three main kinds of emotions, the result of focusing on each of the three highlights of the world:

- Events and their consequences.
- Agents and their actions.
- Pure and simple objects.

For this a set of criteria is created:

- Goals to assess events.
- Standards to evaluate the action of the agents.
- Attitudes to evaluate objects.

The three major classes of emotions are:

- Event-based emotions: to produce desirable effects or undesirable events against targets.
- Attribution emotions: attribute responsibility to the agents about their actions according to standards.
- Emotions Attraction: based on attitudes towards objects.

Local and global variables that modify the intensity of emotions are established. As a result, the emotions that will be taken into consideration in accordance with this hierarchy of intensity are presented. OCC proposes a hierarchical structure composed of: 1) an upper (general) goals, and 2) sub-goals called (more specific) instrumental goals. In these structures the compiled knowledge representations to simulate the phenomenon of perception is implicit. On the other hand, these structures construct a reality, selectively coding information from the environment (through global and local variables) and developing behaviors based on assessments to predict what could be expected to happen.

These goals relate to each other with links defined as: necessary, sufficient, facilitators or inhibitors. Goals are of different types: active persecution (MA) that you want to have done; they are actively pursuing goals, interest (MI) you want to happen and filler (MR) which are cyclical, which explains why even if they are not immediately met, they are not abandoned either. Fig. 1 summarizes the OCC Theory [13, 21].

The goals involve motivation; each entails tasks to be developed (or lower-level goals). An important aspect of the representation of a CSE is its constant changing as the old goals are met or are abandoned implying that new scenarios are generated with different goals; in some cases you can generate a totally different configuration of the initial CSE [26]. CSE is

composed of a set of goals that imply a hierarchy. Each goal involves a development plan so this representation covers the part where through perception and cerebral system (tools) people complete tasks and goals that give meaning to their lives.

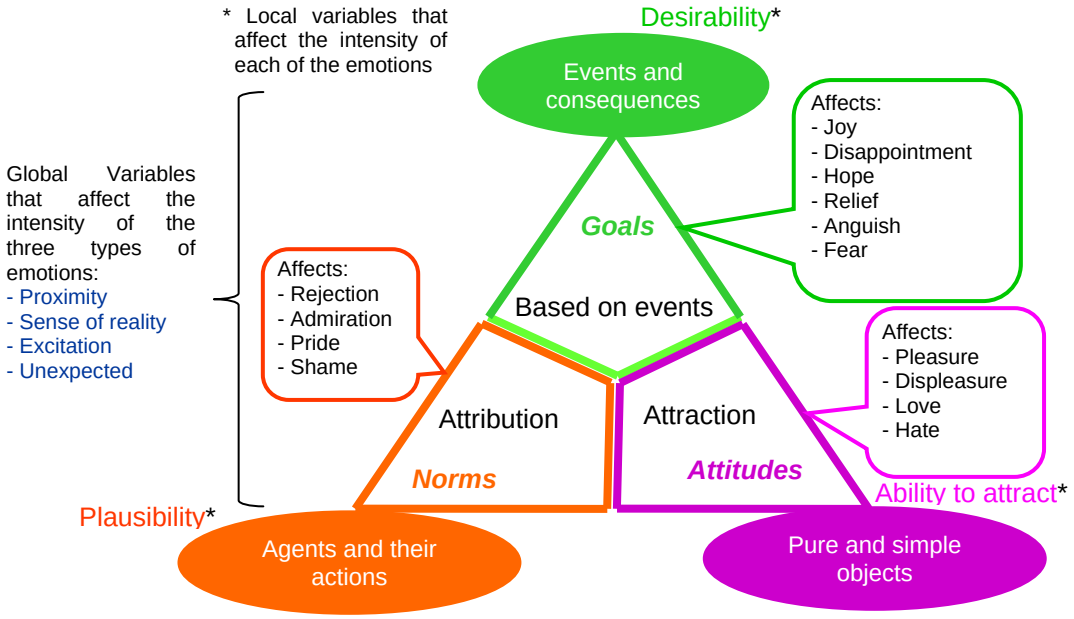

Fig. 1 OCC theory

2) Mental Models

In order to achieve a CSE, the mental model (MM) of the behavior in design should be established. In some cognitive areas it is possible to formulate theories of competence; specifying what has to be calculated, when, and why; then, based on these theories they developed an algorithm to represent it. This area of study is known as the theory of competency and is based on mental models.

To achieve this, a conceptual representation enabling the mechanism with recursive review, and the use of connecting operators are required (conjunctions and disjunctions) for determining the existence of an element concluding the existence of need based relationships to which these elements belong. The use of the disjunctions should be applied provided that the basic conditions are true, to avoid the combinatorial explosions.

Johnson-Laird [28] proposes five restrictions on possible representations of the MMs:

1. The principle of computability: the MMs and mechanisms for its construction and interpretation should be computable.
2. The principle of infinity: an MM must be finite in size and cannot directly represent an infinite domain.
3. The principle of constructivism: an MM is built based on a set of elements having an array in a structure, and represent a state of affairs.
4. The principle of economy models: a single mental model represents the description of one state of affairs, even if the description is incomplete or indeterminate.
5. MMs can represent not deterministic situations, if and only if its use is not computationally intractable; as exponential growth of combinations.

The pseudo code to represent the algorithms is a mechanism through which the construction and conceptual interpretation of the MM is allowed, they have been used successfully to model different behaviors as the guardian of an intelligent tutoring system behavior module and pedagogical agents virtual and physical phenomena [13-17, 25, 29, 30].

3) A Reactive Behavior

An agent who follows another or reacts to movements is perceived as an object, which is driven, by internal intentions and objectives. Based on the above idea, we define an agent as a computer system situated in some environment and capable of flexible autonomous action in this environment in order to achieve the objectives for which it was designed [31].

There are three questions related to the design of agents:

1. How can an agent determine the direction of its goals?

The answer is the cognitive model that allows for a MM of the task view as a whole, and associated to a set of sub-tasks that comprise it [13, 20]. Each of them is linked to the various goals and sub-goals of the CSE [15, 21].

2. How can an agent plan for a series of actions in order to achieve these directions and objectives?

Planning is articulated in the design of behavior. And with as many possibilities as permitted by the protocol of a mental model [30, 32] that will always allow for alternate behaviors. This is achieved by providing dynamism to behaviors based on the stimuli that occur in a dynamic environment.

3. How can an agent interact with humans and other software agents in order to meet its goals.

In the theory of multi-agent architectures there is a subarea that refers to the various forms of communication that can be used in order to be able to perform a certain task. One way is through the changes that occur in the environment, this involves a set design per activity [33]. Each agent has its motivations and objectives; each has different levels of competence [34]. When presented in the dynamic environment stimuli environment they make a match with the competencies of each agent; the first ones triggering a group of actions associated with different competencies [35].

4) Fuzzy Cognitive Maps (FCM's)

The fuzzy cognitive maps (FCMs) were introduced by Bart Kosko [36] to describe the behavior of a system in terms of concepts and causal relationships between these concepts. These digraphs called FCM are used to represent causal reasoning in which the nodes are concepts that describe the main features of the system, and the edges between nodes establish causal relationships (positive or negative) between the concepts. The diffuse part allows degrees of causality in relationships. FCMs are used as a representation technique, due to its ability to handle inherent uncertainty in the complex decision making processes. Also due to it possessing a parallel and distributed reasoning characteristic [37].

The qualitative approach of the relationship matrix allows us to observe the behavior of the system. However, you must have a quantification and interpretation with respect to causation of FCM. This quantification allows for the next state of each node, by adding effects to all nodes on the particular node [38-42].

Causality relationships refer to the effect that a concept has on the rest of the concepts involved in the description of an environment. The effect is to increase or decrease the possibility of another concept occurring. Therefore there are two types of relationships: negative and positive.

- *Negative:* the negative relationship is one in which the increase in the possibility of occurrence of an element causes the proportional decrease in the possibility of occurrence of another element. And the decrease in one causes the proportional increase of other. Is expressed numerically by taking a value within the range [-1, 0).
- *Positive:* the positive relationship is one in which an increase in the possibility of occurrence of an element causes proportional increase in the possibility of occurrence of another element and a decrease in the possibility of one causes the proportional decrease in the possibility of occurrence of other. For example, increasing errors originates increased likelihood of occurrence of frustration. Is expressed numerically by taking values in the range (0, 1].
- If there is *no effect or it is neutral*, the relationship is expressed as 0 (zero).

C. Cognitive Structure of Emotions (CSE)

The CSE is a structure that allows us to have a point of view of what happens in an environment from three separated perspectives: agents, objects and events. Researchers Ortony, Clore and Collins developed this theory in 1988 [26]. Its main objective was to create a methodology of analysis and design with the objective to emulate the process of emotions in a synthetic system [17]. Considering that emotions according to [43] are a different way of thinking, where the latter allows the involvement of motivations according to a specific emotional state. This theoretical framework is considered within a reactive behavior. This allows us to emulate the phenomenon of artificial consciousness, within a specific context.

As emphasized previously, a CSE may justify the different elements involved in the phenomenon of consciousness.

The following sections provide a justification from the perspective of the elements of the OCC theory. Subsequently a CSE is introduced, upon which it is explained how the phenomenon of consciousness is achieved.

IV. AN EMERGING BEHAVIOR WITH A CONSCIENCE: CHIMPANZEE BEHAVIOR

The artificial intelligence technique that we use to represent the emergent behavior is an FCM. In this model a reactive mechanism is defined to choose a behavior from the set, including emotions [15].

The study case concerns the behavior of the welfare of a chimpanzee [44], the MMs of which [30] are found in section 4.1, the goals and sub-goals of behavior are embedded in the MMs and CSE in Fig. 2.

A. Mental Models of the Chimpanzee Behavior

Mental Model 1 (Principal)
Welfare
Dead=0
REPEAT
Assess_Environment (1);
WHILE (Danger=0)
Associate (2);
END_WHILE
UNTIL (Danger=3)
END_Welfare

Mental Model 2
Assess_Environment (1);
Perceive_Danger (6);
(Danger):
1: Submit (7) (Lose); (Dead=0)
2: Flee (8) (Predator); (Dead=0)
3: Die (9) (default, It means that the chimpanzee did not flee nor was submitted, Dead=1)
END_CASE
END_Assess_Environment

Mental Model 3
Associate (2)
Explore in groups (3)
IF (Danger=0) THEN
CASE (1. Hunger or 2. Need to raise hierarchy):
1: Gather / Hunt (4): (Hunger);
2: Fight (5): (Challenged or Challenger);
END_CASE
END_IF
END_Associate (Alive=1; Dead=0)

Mental Model 4
Gather or Hunt (4);
IF (Feed (10)) THEN
Survive (13) AND Welfare (15);
END_IF
END_Gather or Hunt

Mental Model 5
Fight (5);
CASE (1. Win, or 2. Lose)
1: Win (11): (Raise or Maintain Hierarchy) AND (Welfare)
2: Lose (12): (Perceive Danger)
END_CASE
END_Fight

Mental Model 6
Explore in groups (3);
Assess environment (1)
END_Explore in groups

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Mental Model 7
Perceive Danger (6);
        Danger=0
         IF (Predator) THEN
                  Danger=1
                  IF (Weak) THEN
                           Danger =3
                  END_IF
          ELSE IF (Lose) THEN
                   Danger=2
                   IF (Rebel) THEN
                      Danger=3
                  END_IF
                END_IF
        END_IF
END_Perceive_Danger
```

The development of the cognitive structure of emotions (CSE) in Fig. 2, takes into consideration two aspects of OCC theory: a) emotions based on events: events and their consequences, entailing a goal-based evaluation; and b) attribution emotions: agents (agent-chimpanzee) and their actions, entailing the responsibility attributed to other agents according to the standards. In case a) this structure has emotions associated with different goals. This implies that the agent-chimp feels an emotion according to the events that occur in the environment. CSE is configured in a way that allows to distinguish which secondary goals (or tasks) needed to achieve higher-level goals are. This is related to having a representation and related activities in order to exhibit behavior. Thus motivation is active and is expressed as a goal of the highest level, which in this case is the *welfare* of the agent. The *desirability is associated local variable*.

In case b) in the same Fig. 2, the behaviors needed (sub-goals) are shown in order to develop a limit powers of the *agent-chimpanzee* and creates an appropriate behavior to live in a society of chimpanzees. In case of implementation, the following primary activities are necessary for development of the above behaviors: walking, seeing, hearing, collecting items and eating.

The inference engine is to be built, giving life to the consciousness of the Chimpanzee, consists of a CSE with the following affects: joy-anger, satisfaction-frustration, courage-fear, pride-shame, relief-anguish; linked to behaviors in Table 1.

TABLE 1 BEHAVIOR OF CHIMPANZEE AGENT

Behavior	Affects/Motivations	Local/Global Variable
1. Assess environment	Relief-anguish	Proximity
2. Associate	Courage-fear, Relief-anguish	Proximity
3. Explore in Groups	Courage-fear, Relief-anguish	Proximity
4. Gather / Hunt	Satisfaction-frustration, Courage-fear, Relief-anguish	Proximity
5. Fight	Satisfaction-frustration, Courage-fear	Proximity
6. Perceive Danger	Satisfaction-frustration, Courage-fear	Desirability
7. Submit	Satisfaction-frustration	Desirability
8. Flee	Courage-fear	Desirability
9. Die	-	Desirability
10. Feed	Satisfaction-frustration, Relief-anguish	Desirability
11. Win	Joy-anger, Satisfaction-frustration, Pride-shame, Relief-anguish	Desirability
12. Lose	Joy-anger, Satisfaction-frustration, Pride-shame, Relief-anguish	Desirability
13. Survive	Joy-anger, Relief-anguish	Desirability
14. Raise or Maintain Hierarchy	Joy-anger, Pride-shame	Desirability
15. Welfare	Joy-anger	Desirability

Behaviors 8, 10, 11, 13 and 14; are *positive terminal states* and behaviors 7, 9 and 12 (Fig. 2), are *negative terminal states consequence of an action*. *Welfare* behavior is the goal of the *highest level* and governing all others. *Explore* behavior is necessary because it allows the perception cycle involved in *assess environment*.

Affects are considered motivations of behavior, which are associated to an assessment level. Depending on the magnitude of this intensity it will affect the motivation, which may or may not influence the behavior [45]. In other words, according to the level of activation in tune with environmental events the behavior either appears or not [23, 46, 47]. A causal matrix relates all these elements so their causality implies that this activation was designed.

The causal matrix representing the global behavior consists of the elements of Table 1. The behavior ranging from 1 to 6 are the *actions of active goals* belonging to the main behavior of MMs.

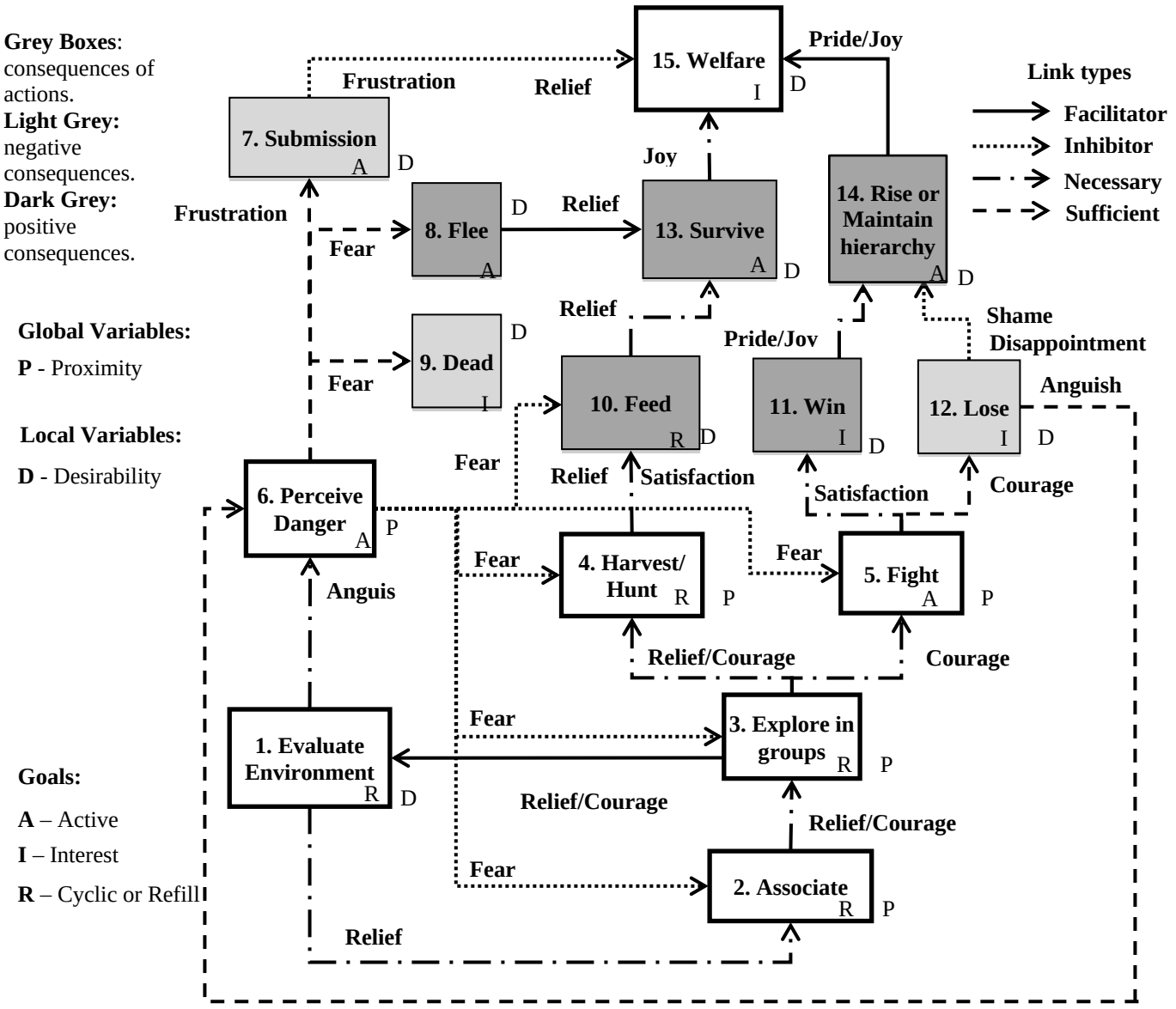

Fig. 2 Cognitive Structure of Emotions (CSE) of the wellbeing of a chimpanzee

Table 2 shows the causal matrix representing the autonomous behavior of *agent chimpanzee*. This matrix is composed of series of behaviors through causalities determining an action at a particular time. The matrix is supplied by external environmental conditions; internal conditions are motivations, in this case, emotions that come from an interpretation of the environment through the CSE. In other words, energy is added to each behavior depending on the environment (physical stimuli) and motivations (interpretation of emotions through an environment interpretation based on the CSE designed specifically for that autonomous behavior).

The links of the causal matrix of Table 2 represent a behavior model, under which an *agent-chimpanzee* must act in a society, trying act properly and according to the standards that govern the behavior of an *agent-chimpanzee* within the society. It is emphasized that the matrix does not have all the behaviors represented in Table 1. Last because in the case of *associate* is a default behavior for gather / hunt and fight. A*ssess environment* is a constant behavior that involves perception.

TABLE 2 CAUSAL MATRIX OF CHIMPANZEE WELFARE BEHAVIOR

	Welfare	Submit	Flee	Survive	Raise hierarchy	Perceive Danger	Feed	Win	Fight	Joy	Satisfaction	Courage	Pride	Relief
Welfare	0	-1	-1	1	1	-1	1	1	0	1	1	0	1	0
Submit	-1	0	-1	0	-1	-1	-1	-1	1	-1	-1	0	-1	0
Flee	-1	-1	0	1	0	1	-1	0	-1	-1	-1	0	0	0
Survive	0	-1	1	0	0	1	1	0	0	0	0	0	0	0
Raise hierarchy	1	-1	0	0	0	0	0	1	1	1	1	1	1	0
Perceive danger	-1	-1	1	1	0	-1	-1	-1	-1	-1	0	1	0	0
Feed	0	-1	-1	1	0	-1	-1	0	0	0	1	0	0	1
Win	1	-1	0	0	1	-1	0	0	1	1	1	0	1	1
Fight	0	0.5	0	0	0.5	0	0	0.5	0	0	0	1	0	0
Joy	1	-1	-1	0	1	-1	0	1	0	0	1	1	1	0
Satisfaction	1	-1	-1	0	1	-1	1	1	0	0	0	1	1	1
Courage	1	-1	0	0	0	0	0	1	1	0	1	0	1	0
Pride	1	-1	0	0	1	0	0	1	1	1	1	0	0	0
Relief	1	-1	-1	0	1	-1	1	1	0	0	1	0	0	0

B. Results: Possible Scenarios and Their Link with Consciousness (Each Possible Scenario with Section 3.1)

Scenario 1: *(perceive_danger, feed)*

Output scenario:

No welfare, submits, flees, may or may not survive, not raise hierarchy, and perceive danger, not feed, lost, is sad, dissatisfied, cowering with shame and anguish.

Justification:

We have a mental model that implies that Perceive Danger may be due to three different causes: BEHAVIOR 2.

Assess Environment (1);

Perceive Danger (6);

CASE (Danger):

1: Submit (7) (Lose); (Dead=0)

2: Flee (8) (Predator); (Dead=0)

3: Die (9) (default, It means that the chimpanzee did not flee nor has submitted, Dead=1)

END_CASE

END_Assess_Environment

Under this perspective, the output scenario contains the events *submit* and *flee*. The interpretation will be justified by environmental events where *submit* is an event during which the chimpanzee fought and lost and *flee* is an event during which a *predator* was found.

On the other hand, the behavior *Perceive_Danger* remains alert after having been perceived.

Scenario 1.a: *(perceive_danger)*

Output Scenario:

No welfare, submit, flee, may or may not survive, not raise hierarchy, perceive danger, not feed, not win, not fight, not joy, dissatisfied, not has courage, not pride and anguish.

Same justification that scenario 1.

Scenario 1.b: *(feed)*

Output Scenario:

There is welfare, is not subject, not flee, raise hierarchy, and not perceive danger, feed, win, fight, joy, satisfaction, courage, pride and relief.

Justification: in this case the scenario implies that feed, allows him to be in optimum condition that makes him want to fight; with the possibility of raise hierarchy; on the other hand, *feed*, means no perceive danger.

Scenario 2: *(win)*

Output Scenario:

Welfare, is not subject, not flee, raise hierarchy, and not perceives danger, feed, win, fight, joy, satisfaction, courage, pride and relief.

Justification: In this case, the state *win* feeds the desire to *fight* to *win* again. After winning he feels *satisfaction* that inhibits *perceive danger*.

Scenario 3: *(lose)*

Output Scenario:

No welfare, submit, flee, not raise hierarchy, perceive danger, not feed, not win, not fight, not joy, dissatisfied, not has courage, shame and anguish.

Justification: In this case, *lose* implies *not raise hierarchy* and has two choices: *submit* or *flee*. This implies *perceive danger* because, otherwise, could die. Therefore this result not feed, not fight, not win, not joy, dissatisfied, not has courage, shame and anguish.

V. APPLICATIONS IN THE FIELD OF HEALTH AND WELLBEING OF HUMANS

In this section we provide some examples of future applications as a result of and advanced understanding of the brainwork and technological advances.

Currently we use technology in order to repair flaws in humans, as for example: a) glasses; to help improve eyesight, b) a pacemaker that helps bring the rate of the heartbeat to normal frequencies, c) a pocket calculator; that helps quicken simple mathematical operations, d) an electronic gadget; helps you to remember your appointments and follow up on your to-do list.

The change that can be expected will provide us with a greater sense of intimacy. Since the information will be used in a deeper fashion, the use of technology will be closer to us [8].

Consciousness and fear for a car. It is well known that the human being is not capable of evolving with regard to the safe driving of automobiles, especially in the following conditions: a) high speed, b) heavy traffic, c) lack of visibility on roads d) city streets congestion, e) irresponsible drivers (drunk or lacking consciousness). Hence it is not uncommon to have traffic accidents. The devices measuring safe distance between vehicles can be created, taking into account all the aforementioned aspects. Daimler Chrysler [8] is working on a device that allows the exchange of information between vehicles; this would allow cars to accelerate or brake according to the safe distance concept and thus would avoid reaching a dangerous situation. Imagine a road accident if the cars communicated with each other, they would be able to develop an emerging behavior focused on security that could allow them to study and determine alternate paths and hence prevent a colliding event between each other. Now imagine a car that does not turn given the lack of awareness of their drivers and make an emergency call.

Even the most experienced drivers have few opportunities to learn how to control a vehicle in extreme conditions. Artificial systems have advantages over human drivers; they can learn and tune the control algorithms on millions of hours of simulated and real driving. It is only a matter of time before society develops a preference for automatic control instead of human one. Examination of responsibility and capacity would have to be rethought. How can management be examined in a vehicle that is much more competent than you in many circumstances? In any case, insurance will insist on reducing the scope of human control under many conditions.

VI. CONCLUSIONS

It was found that the definitions and statements of phenomenon of consciousness are considered in the CSE:

Regarding Def. 1. One of the highlights of the OCC theory and the CSE, is that they embody the feeling of a person from its particular point of view. This phenomenon is the primary job of every living thing and is known as mapping. This requires the generation of an internal model that pertains: a) oneself b) oneself in the world, and therefore c) of the world; taking into account all the sensations perceived, from the smallest to the largest ones.

As in case of fingerprints, each person has a unique map of non-transferable emotions, in which different aspects are embodied: 1) culture 2) education, and 3) the genetic aspect; as an agent might be born with more physical abilities. In the CSE the knowledge of an expert is articulated, and emphasizes that there are factors that are handled randomly; as changing

thresholds of a specific agent-chimpanzee and make it grumpier. Also the fact of being born in different levels of the hierarchy or born the fittest in a physical level can be considered as random attributions. This random assignation allows for a completely different point of view and different reactions to the same events.

Regarding the Def. 2. When one thinks differently, we must also consider that emotions are only different ways of thinking. Then, during the decision-making process, the relevant aspects of the environment are different. An agent-chimpanzee will fight depending on different aspects that he observes, if an association can be made to collect food or hunting, or not.

Affirmation (1..5), are closely linked to the performance. In the model we propose, the perception and representation develops when the design and analysis of the various goals and behaviors develop, those will be encapsulated in autonomous agents with the subsequent modules [29]. It is noted that there is a behavior that is constantly monitoring and assessing the environment, it is called environment evaluation, as survival depends on it, it is an always on behavior. One of the premises of any agent is to know its own location and incorporates all the environment information for which it has to have a constant awareness of the environment in a way that doesn't allow itself to be unaware of it. And it also must have a motivation that allows him to manipulate the environment in order to assign partial objectives to other agents, in other words, to use all additional resources or behavior that relate to lower-level goals within the CSE. According to [12], all human beings without exception keep looking for an own welfare, which we managed to get through the three basic instincts of life: to survive, expand the territory and reproduce.

As part of our future work we are planning to integrate this FCM on a multi-agent simulation.

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