THE TEMPORAL STRUCTURE OF THE SELF

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1. Towards a synthesis

Recent studies provide a conceptual framework that changes the classical metaphor of the brain as a "symphony" to one in which brain activity is similar to "the polyrhythmic beats of a jazz drummer effortlessly combining different rhythms played on the snare drum.[1]

Current neuroscience allows us to investigate what happens in the human brain in different states of consciousness. Some recent achievements approach the task of answering the question about the type of relationship existing between corporeal and mental phenomena, which obviously are not the cause and effect. Philosophical inquiry can integrate those scientific hypotheses, which can explain better and with more breadth of perspective such a correlation.

Today, the scientific study of consciousness is not searching possible networks to sustain the required interactions. Indeed, several authors have sought the neurological seat of consciousness, in an attempt to understand how it takes place from the interactions between neurons in the cortex and thalamus.

Consciousness is seen today, as a synchronization of activity patterns: coordination, or temporary union, of oscillatory activities. Since such synchronization can disappear for a short time, or last when neuronal damage is produced, it is possible to analyse the phenomenon of self-consciousness attached

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[1] F.P. Battaglia, B.L. McNaughton, *Polyrhythms of the Brain*, «Neuron», 72 (2011), pp. 6-8.

to the body from the perspective of temporal synchronization/de-synchronization of neuronal activity patterns.

1. 1. *Activity patterns and mental representation*

Any processing of sensory information causes a specific pattern of neural activity. Among millions of possible connections between end ramifications of neurons, synapses, there are specific ones "firing on" and thus representing the object seen, the sound heard, and so on. There is a correspondence between the external world, as grasped by the senses, and the pattern of neural activity generated in the corresponding area of the brain of the individual who looks at the object, hears, touches, tastes or smells.

However, these patterns of activity are not passive, but are the result of processing. To build a "mental representation", or internal model of the world outside, the brain combines incoming information with each other and also with that in storage. It is known that mental representation of a visually perceived object requires that the various aspects of an object -like colour or movement- be processed in different areas. It is essential to an integration of information between systems operating in parallel, and that it flows in both directions at various levels of the hierarchy of cerebral control.[2] Integration requires that the cells of the visual areas that respond to different attributes of the object be excited in temporal synchrony.

The fact that perception of the world will not come due exactly to a direct projection of the environment, but through an active process of neurons,[3] does not imply that mind constructs reality, and what the mind builds is our own experience of reality. Moreover, similar representational structures exist in brains and minds of different individuals. It has been demonstrated that objects are similarly represented across different brains, allowing for reliable classification of one person's brain activity based on another's.[4]

Some stimuli that are important to the body can trigger a bodily reaction

[2] S.W. Cheadle, S. Zeki, *Masking within and across visual dimensions: Psychophysical evidence for perceptual segregation of colour and motion*, «Visual Neuroscience», 28 (5) (2011), pp. 445-451; E.H.F. Haan, A. Cowey, *On the usefulness of 'what' and 'where' pathways in vision*, «Trends in Cognitive Sciences», 15 (2011), pp. 460-466; S.P. MacEvoy, R.A. Epstein, *Constructing scenes from objects in human occipitotemporal cortex*, «Nature Neurosceince», 14 (2011), pp. 1323-1331.

[3] S. Nishimoto, A.T. Vu, T. Naselaris, Y. Benjamini, B. Yu, J.L. Gallant, *Reconstructing Visual Experiences from Brain Activity Evoked by Natural Movies*, «Current Biology», 21 (2011), pp. 1641-1646.

[4] F. Tong, *Aligning Brains and Minds*, «Neuron», 72 (2011), pp. 199-201, about article: J.V. Haxby, J.S. Guntupalli, A.C. Connolly, Y.O. Halchenko, B.R. Conroy, M.I. Gobbini, M. Hanke, P.J. Ramadge, *A common, high-dimensional model of the representational space in human ventral temporal cortex*, «Neuron», 72 (2011), pp. 404-416.

and the perception of these automatic changes is experienced as an emotion. In turn, each emotional situation causes a different pattern of changes, such as tear secretion, heart rate, posture and gestures, which are perceived as different emotions. Awareness of those emotions are feelings. With these patterns brain builds internal representations of the world.

1. 2. *Some significant aspects of neuroscientific theories of consciousness anchored to the body*

In the visual cortex it has been observed gamma frequency oscillations, which are called "40-Hz oscillations," which would mean that the neurons that process the perception of specific aspects of an object are linked together by a correlated and synchronous firing. Crick and Koch[5] proposed that synchronized firing at a rate of 40 Hz could be the neural correlate of visual consciousness. Conscience would present the results of the computations that underlie the process of putting together all the characteristics of the object, a union performed by attention.

Damasio[6] provided that the brain has a natural system, the thalamus/cortical system, to relate the external world sensory reference to the motivations and memories internally generated. Mechanisms that maintain internal equilibrium constant, ever changing body, representing the continuity of the body, and becomes the biological basis of the sense of self. For a fraction of time, the representations of the body and external objects come together in a single construct, create a new representation of second order, the self, occurring between the thalamus and cingulated cortex. "The dialogue" between thalamus and cortex is a condition for the subjectivity emergence: the information that I am the owner of that process, the holder of that body. Bearing in mind that the main sensory map belongs to the states of the body, and is configured in the form of feelings, a sense of self -in the act of knowing- emerges into the process as a special kind of feeling.

In fact, being aware means being awake, being alive in, recreating the world inside and making sense, giving meaning to it.

Edelman and Tononi[7] also involve emergency when they say that every perception is a creative act that constructs scenes in the mind, and with those maps brain makes its own maps and categorizes its own activity. Thus, Edel-

[5] F. Crick, C. Koch, *Towards a neurobiological theory of consciousness*, «Seminars in the Neurosciences», 2 (1990), pp. 263-275; F. Crick, *La búsqueda científica del alma. Una revolucionaria hipótesis para el siglo xxi*, Debate, Madrid 1994.

[6] A.R. Damasio, *Creación cerebral de la mente,* «Investigación y Ciencia», enero 2000, pp. 66; *El error de Descartes. La emoción, la razón y el cerebro humano,* Crítica, Barcelona 2007.

[7] G. Tononi, G.M. Edelman, *Consciousness and Complexity,* «Science», 282 (1998), pp. 1846-1851.

man compares the brain to an orchestra without a conductor: each musician playing music and individually adjusting to each other and resulting in a collective creative interpretation. Edelman gives possibly the most significant step in the understanding of consciousness by providing one of the reasons for the distinction between primary consciousness, reaching to some animals, and higher order consciousness that only humans possess: the fact that man incorporates past and future to personal identity.

Certainly all the states of mind -knowledge, volition, beliefs, feelings-, are bound to the body, and therefore linked to spatio-temporal structures of the brain, but biological mental states are not space-time. Consciousness, like knowledge, is timeless.

In short, a conscious act is an only act of two dimensions, two dynamics, which refer to a single subject. The integration of activity patterns in thalamus/cortical dialogue provides the specific component, the content related to the external world, while the non-specific component would give the temporary union to the phenomenon. That is, the crucial dimension of the mind, mental processes, is time, not space. Consciousness is considered a phenomenon of mind involved in the sense of personal identity, the "I" as a being-in-the-world, or the self-embodying in the body. The self-consciousness associated with other mental phenomena – such as memory, attention, emotions and the behaviour- that are accompanied by subjective experience.

1. 3. *Approach from other states of consciousness*

Scientific research into self-consciousness is enhanced by the analysis of other forms of consciousness, having in common a de-synchronization of sensory processes. Of special interest, and very topical, are studies about the out-of-body experiences, a special state of consciousness that includes the feeling of being outside the body,[8] and observing it from a high position, and then returning to the body consciously. This is one of the experiences that are part of the near-death experience, with identical characteristics in people of all cultures and all ages.

Moreover, it is also universal that after such experiences, there is a change in the way of understanding, understanding life and relationship with others.[9] This experience of conscious events when people are unconscious, through general anaesthesia, or clinically dead from a heart attack, and remembered later, suggests that there is more awareness and memory of what can be explained only by a proper integration of neural activity.

[8] T. Metzinger, *Why are out-of-body experiences interesting for philosophers? The theoretical relevance of OBE research*, «Cortex», 45 (2009), pp. 256-258.

[9] Z. Klemenc-Ketis, *Life Changes in Patients After Out-of-Hospital Cardiac Arrest. The Effect of Near-Death Experiences,* «Int. J. Med. Behav», 20/1, (2011), pp. 7-12.

1. 4. *Working hypothesis*

In search of the times of the mind it has been an undeniable help techniques recording brain electrical fields and can be obtained via electrodes on the skull. Activation times may be measured in the various areas of the brain and its relation to the specific activity of the mind when volunteers are asked to perform the different activities of the tests. The most important result regarding these investigations is that there is a sequence in the activation/inhibition of the activity of various brain regions. There is a sequential recruitment, progressive, in different areas that process information according to the performance of different tasks or mental processes.

The perspective of this study addresses the systemic dynamics of their own reality of living closely interrelated within themselves.

We propose that the emergence of mental processes from neural processes means that the organizing principle of cortical function is not in the areas or fixed connections between circuits, but in the time code, time sequence in which these modules, activated or silenced, are recruited or de-synchronized. That is, the dynamics of the system is epigenetic.

Second, the study suggests that, although consciousness is an emergent property of neuronal activity, is the subject, released from confinement in the present, who takes over the time code. The temporal structure of personal identity requires as a precondition necessary for the brain working on a temporary code. Distinguish consciousness "online", in the present, as a simple "realize of" and self-awareness, or consciousness to "off line", showing the liberation of man from confinement in the here and now.

Third, it shows that awareness of own identity is a conscious feeling, necessarily anchored to the body under normal conditions, it is not embodying in other states, which supports that self-conscious it is not confused or identified with neuronal processes.

2. Identity and autonomy

Biology has achieved a deep understanding of life processes of the animal world, understood today as a dynamic partnership of genes and environment, resulting in the regulated expression of genetic information, immaterial and steady. This second level information, or epigenetic information, immaterial as any information, increases during the individual's constitution and development, especially of his brain, and throughout life.

Thanks to this epigenetic information life is a unitary path, dynamic and ordered, with a continuous updating of the potential corresponding to the biological identity of the species. Genetic information widens, step by step, with this new epigenetic information that comes with the life process itself,

the feedback in each process makes the outcome more than the sum of the parts and the beneficiary is always the individual. Capabilities and operations, which correspond to the biological identity as an individual of the species, are not contained in the constituent materials, but emerge of new configurations that materials acquired over time.

The different intensity of animal life depends on the development of the nervous system. The complexity of the brain depends in turn from epigenetic information permitted by the genetic identity of the species-specific, and increases with brain activity.

"Biological consciousness" places itself in the relationship of the living environment. All living beings need to act in the world from all of their dynamic existence, and in the way membership of the species dictates. Biological awareness is vital information about their possibilities and their individuality. Even the simplest living being has its own "in itself", because it is constituted from an informative material, i.e., it contains an immaterial message.

The complexity of the brain configuration allows a greater ability to adapt to the environment, greater autonomy, which is characteristic of individuals of a species. That cerebral configuration can be called "neurobiological identity", as nuclear point of biological identity. It is a second level of consciousness: is consciousness of individuality in "online", in the present.

To these two levels, each man ads integrated the consciousness of personality, characteristic of a relational being whose world is not only biological but essentially cultural. Self-consciousness, or consciousness in "off line", i.e. memory of the past and simulation of the future, is awareness of self as the subject of that autobiographical path.

The personal self, unlike the neurobiological self – enclosed in the present –, has a temporary structure. The human brain, unlike the animal brain and unlike any other body, has a development and maturation open.

2. 1. *Environmental autonomy and "neurobiological identity"*

A higher functional complexity of the brain allows for better adaptability to the environment, greater autonomy. Throughout the evolutionary process brains have appeared with one, two and three layers, with the consequent need for gradual increase in the integration of functions in each layer and between layers. And so increased autonomy from the environment.

The reptilian stage provided the brain stem and cerebellum that control basic motor skills and instincts related to survival. This basal layer has a reaction time of tenths of a second and does not allow control of the answers, so that autonomy is very limited. To this reptilian brain we men owe our automatic visceral responses.

In human beings, highly vegetative states – such as the process of feeling

thirsty and satisfying the thirst – imply an orderly activation and deactivation of "ancestral" areas of the brain on which there is no voluntary control.[10] In situations of injury or decay of the other layers of the brain, as in the anencephalic,[11] brain stem structures assume, at least in part, the development of simple stimuli and the transmission of responses to these stimuli exist.

The second layer brain, the limbic system or intermediate, with a sharp increase in the cerebral cortex, appears in mammals. It contains the thalamus, hypothalamus, hippocampus and amygdaloidal complex. Their response time is slower but its average is less than a second. The release of neurotransmitters causes the effect of slowing down or accelerating neuronal activity and thus the speed of response to the emotion aroused by a stimulus. That is, allows perfect adaptation of the organism to the environment, in which the stimulus is the occasion, not the cause, of the animal's instinctive response, according to their biological needs, provided that the stimulus is present.

To this organization we human beings owe the possibility of smelling, perceiving hormones, body and facial expression that communicate with our partners our state of mind, and so on. It basically corresponds to it the processing of emotions and memories of positive or negative emotional impact of our experiences, which pose an intuitive knowledge that advances the reasoning and leads us to accept or reject the repeated experiences.

At the stage of primate neocortex is formed. The increase in the surface of the cortex and the subdivision of it in specialized areas leads to high complexity of the brain, and makes it possible to animal combine accumulated patterns of perceptions and emotions. Some primates have primary consciousness, «a notice of" merely biological, at present, as evidenced by certain "mental states».[12] As suggested by Gallup[13] controversial interpretation of experiments, looking at their reflection in a mirror, some chimps recognize their own figure.

Furthermore, they recognize inter-subjectively members of their own species. It has been recently[14] carried out a sophisticated analysis of those ges-

[10] D. Denton, R. Shade, F. Zamarippa, G. Egan, J.B. West, M. Mckinley, J. Lancaster, P. Fox, *Neuroimaging of genesis and satiation of thirst and an interoceptor driven theory of origins of primary consciousness*, «Proc. Natl. Acad. Sci. USA», *96* (1999), pp. 5304-5309.

[11] R. Werth, *En busca de la consciencia perdida*, «Mente y cerebro», *35* (2009), pp. 36-41.

[12] J.C.B. Azzia, A. Sirigua, J.R. Duhamela, *Modulation of value representation by social context in the primate orbitofrontal cortex*, «Proc. Natl. Acad. Sci. USA», 109 (6) (2011), pp. 2126-2131.

[13] G.Jr. Gallup, *On the rise and fall of self-conception in primates,* «Annals of the New York Academy of Sciences», 818 (1997), pp. 73-84.

[14] C.J. Machado, E. Bliss-Moreau, M.L. Platt, D.G. Amaral, *Social and Non-social Content Differentially Modulates Visual Attention and Autonomic Arousal in Rhesus Macaques*, «PLoS ONE», 6 (2011), pp. e26598.

tures and vocalizations, including assessment of their emotional valence, allowing primates living in the social environment of a group. Videos with social content captured their attention more often and for longer than videos with non-social content. Moreover, the primates in this study paid more attention if signs and facial expressions of co-specifics, captured on video, were directly addressed to them.

The deployment of epigenetic information in neurons, allowing them to express different genes, marks a path capacity always parallel to the individual's age and identical for individuals of the species.[15] Always time and the operations of each stage left mark on the brain, so that the specific behaviour to the same stimulus, such as a fear provoking situation is different at different ages.

Cerebral epigenetic information, the overlap in time of activity patterns, turns into an increase of information that is more than just the sum; in this sense we speak of emergency operations.

Presumably, therefore, we may say that with the development of brain and neuronal organization that processes the relationship between the individual and his environment can be achieved "neurobiological consciousness" of individuality in present. That does imply neither reflexivity, nor self-possession, dimensions unique to the reality of man. It is merely a "biological self" locked in the automation of zoology, relationships with individuals in the group to which that animal belongs, and enclosed into the present.

2. 2. *Autonomy of self and personal identity*

Finally, the appearance of the human beings brought the development of the prefrontal lobes, above the eye sockets. George Mashour and Michael Alkire[16] have studied the evolution of consciousness across various species by means of models coming from the recovery of it after general anesthesia in animals. Using recent data from general anesthesia in humans, suggest that the arousal centers in the brainstem and diencephalon — in conjunction with even limited neocortical connectivity and recurrent processing — can result in primitive phenomenal consciousness. Early mammals and birds possessing these structures, or their equivalents, are capable of phenomenal consciousness. However, the increased complexity of networks and a functionally dominant prefrontal cortex in the humane brain likely accounts for the unique richness of the human experience.

The unique operation of the human brain, with a hierarchical system of

[15] T. Chan, K. Kyere, B.R. Davis, A. Shemyakin, P.A. Kabitzke, H.N. Shair, G.A. Barr, C.P. Wiedenmayer, *The Role of the Medial Prefrontal Cortex in Innate Fear Regulation in Infants, Juveniles, and Adolescents,* «The Journal of Neuroscience», 31 (2011), pp. 4991–4999.

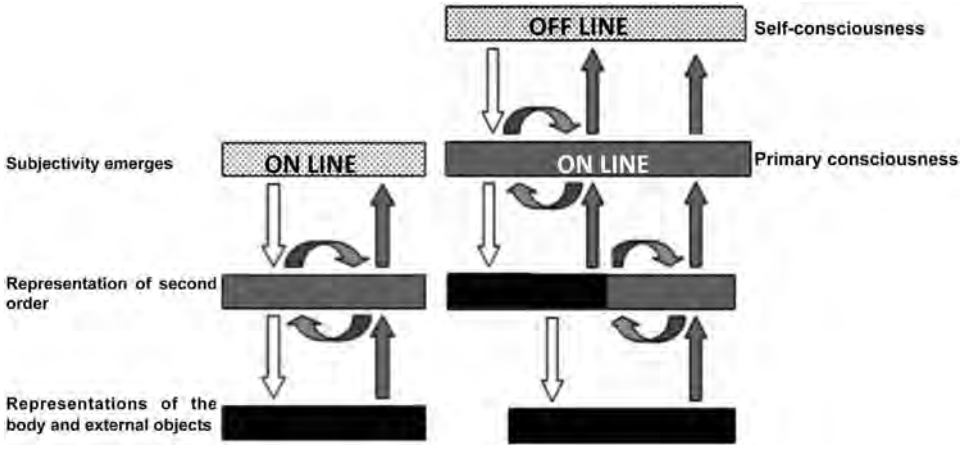
[16] G.A. Mashour, M.T. Alkire, *Evolution of consciousness: Phylogeny, ontogeny, and emergence from general anesthesia*, «Proc Natl Acad Sci USA», 110 (2013), pp. 10357–10364.

control neurons located in areas of the prefrontal cortex is the budget for autonomy from the medium is in him self-autonomy.

Specifically human capacities rest on the hierarchical control exerted by this area. The human brain is rational for the integration of cognitive-emotional, and has in each person as biological budget the ability to curb the excitement automatically. The braking of the excitation of neuronal circuits breaks automatic responses.[17] The release of closure in the here and now is manifested, among other features genuinely human, abstracted in the ability to simultaneously capture the general and particular, the delay in time to the satisfaction of desires and not have to respond immediately to stimuli it receives. Man is capable to plan actions, foresee future consequences and anticipate them. We also understand that there are other minds and take the place of others.

In humans, the genetic and epigenetic information in the brain are intrinsically relational information added to within him and to others, which power to another level information flows. Mental states that arise from the activity of a brain shaped by biography do not determine behaviour. The ability to stop the excitement and think, value and travel to past experiences and preexperience the future, lets you make decisions.

Ss shown in scheme, the flow of information from different information levels is always caused in more directions than just mechanistic level from the bottom up. It may be caused from above, from a higher level, to coordinate the flow of information from a lower level and can grow the information structure on the same level as feedback information content.



The lower level is the representation of stimuli in activity patterns of neurons. The mental states emerge from them, from bottom up, by the meeting

[17] N. López Moratalla, *Una lectura de la neurobiología actual desde la antropología trascendental de Leonardo Polo*, «Studia Poliana», 11 (2009), pp. 21-46; Idem, *Dotación ética universal del cerebro*, «Acta Philosophica», 19 (2010), pp. 297-310.

in time unit of activity patterns. The sequential control of the synchronization/de-synchronization of neuronal processes are a mental process that is not identified with neural activation patterns.

This coordinating function modifies the mode of action proper to the lower level to change both the activity patterns themselves, as a trace in the expression of genes of involved neurons.[18] The modification of the causal relationships of the lower level generates brain plasticity.

Efficiency is in the process itself, a stimulus is not introduced to modify the integration of representations of stimuli, but uses patterns that are generated in the process. The animal consciousness, consciousness only "online", emerges with an external stimulus, causing it up automatically from the individual and allowing certain autonomy from the environment.

Human self-consciousness, consciousness in "off", emerges in the presence or absence of external and internal stimuli, without the automatic enclosure of the neural processes, as each man has a higher control by self-braking of neuronal excitation and de-automation functions. And that reveals autonomy of himself, freedom from confinement in the present, in every human being.

Self-awareness is another level of primary consciousness, consciousness in off, out of the present.

In humans, the genetic and epigenetic information is attached to relational information within themselves and to others. It allows a new level of hierarchical control by controlling the time of neuronal activity and its synchronization/de-synchronization.

Neither the conscience "online", or self-consciousness, consciousness in "off line", are identified with neural processes. The brain processes are systemic, i.e. an epigenetic dynamic in which information flow flows bottom-up and increase with the process itself with top-down control.

3. The subjective perception of time

A large number of competing models exist for how the brain creates a representation of time.[19] Several research has shown how strongly intertwined emotions and feeling states of the body are with the processing of duration and how climbing neural activity may be its basis for the representation of duration: a ramp-like increase (or decrease) of neural activity that peaks at the end of a timed interval.

To consciously perceive time, and evaluate the time elapsed between two events we have two different mechanisms depending on the time elapsed. An

[18] V.M. Ho, J.A. Lee, K.C. Martin, *The Cell Biology of Synaptic Plasticity,* «Science», 334 (2011), pp. 623-628.

[19] M. Wittmann, *The inner sense of time: how the brain creates a representation of duration*, «Nature Reviews Neuroscience», 14 (2013), pp. 217-223.

internal clock measures the duration of a short event, or the interval between two recent developments. But, they require "travel to past and future" to measure the time out of this, the times when "off line".

3. 1. *Time "online" and the internal clock*

The internal clock is the yardstick brain activity in areas of the cortical and subcortical layers. All download brain processing involves neural impulses at a constant average frequency; these pulses are accumulated and stored in a memory[20] network and the amount of cumulative neuronal firing that measures time. Therefore it functions as a stopwatch, which to evaluate the duration, it counts the number of pulses.

Subjective time is strongly embodied.[21] The ongoing afferent stream of neural signals originating from within the body may function as an internal reference for subjective time when judging the duration of external events. Integration of ascending body signals may underlie human time perception. Through a posterior-to-anterior progression of representations, the human insular cortex integrates sequential body states with cognitive and motivational conditions. This progression reaches the anterior insula and leads to the conscious awareness at one moment — the 'emotional moment' — and subjective experience of duration is provided through a series of these moments

For some activities with automated and fast control, such as rhythmic movements, motor control, perception of the word, music time, it is imperative the right side of the cerebellum. This type of processing is done on the supplementary motor area, left sensormotor cortex, lateral cortex promoter, basal ganglia, and thalamus.

A study performed in rhesus monkeys[22] has allowed us to study the functional properties of medial premotor cortex neurons during the execution of a rhythmic task. They have observed that two different cell populations of the promoter cortex are involved; a group encodes the time remaining for the next action and the other group encodes the time since the last movement. The complex rhythmic behaviours, such as playing music, may depend upon the cyclical interaction between different neural timers.

However, when the task is not automatic but requires cognitive control, the left cerebellum, the prefrontal cortex and right parietal cortex are activated.

[20] V. Pouthas, *Bases neuronales de la percepción del tiempo*, «Mente y Cerebro», 51 (2011), pp. 68-75; S. Droit-Volet, *Las ilusiones temporales*, «Mente y Cerebro», 51 (2011), pp. 58-63.

[21] M. Wittmann, *The inner sense of time: how the brain creates a representation of duration*, «Nature Reviews Neuroscience», 14 (2013), pp. 217-223.

[22] H. Merchant, W. Zarco, O. Pérez, L. Prado, R. Bartola, *Measuring time with different neural chronometers during a synchronization-continuation task*, «Proc. Natl. Acad. Sci. USA», 108 (49) (2011), pp. 19784-19789.

The assessment and perception of interval durations longer than one second and up to one hour, the consciousness of time requires the right prefrontal areas, motor and the striatum. The striatum, a sort of orchestra conductor which with his baton, determines the beginning and end of significant duration to evaluate.

Moreover, the perception of time depends on the physiological conditions, drugs and certain medications, psychological state and especially of the emotions. Precisely the release of neurotransmitters involved in emotional processing, dopamine, among others, play an active role of the basal ganglia involved in the accumulation of impulses the basis of evaluation time.

The fact that the internal clock changes allows us voluntarily to adjust ourselves to the time of others and so connect with them. For example, the clock speeds up to an interpersonal situation that requires our cooperation, and to a sad person, while it slows down when we feel sad.

Animals are governed by biological rhythms, as that of 24-hour, or circadian, automatically. They are able to learn, always to be achieved conditioning them, conditions to compute either a time interval. Animals only predict the consequences of events that have had experience before with a "then-yes." Many animals learn to associate pleasures and pain with prior events – for example, the smell of a predator -, which enables them to move towards pleasure or away from the pain before they are experiencing it, but only if the sensory stimuli that they had experienced is present.

3. 2. *The time to "off line", out of present*

To evaluate longer durations -weeks, years- does not serve the internal clock, but is necessary memory and attention in order to keep the evaluation of time spent and pay attention to what is happening. Men are capable of retrospection, re-experiencing the past, and for prospecting, pre-experiencing the future simulations in mind. In this, frontal cortex plays a fundamental role. In fact, patients with damage to the prefrontal cortex are tied to the stimulus in the immediate present and similar to young children, who have not matured yet this brain area.

In several experiments it has been possible to measure, with the «imaginary time travel»,[23] the awareness of subjective time. And it has been possible to show overlapping neuronal firing patterns of autobiographical remembrances with imagination patterns simulating the future, and do so in the inferior frontal cortex, fusiform gyrus, cingulate/pecuneus posterior and lower parietal cortex.

[23] L. Nyberg, A.S. Kim, R. Habib, B. Levine, E. Tulving, *Consciousness of subjective time in the brain*, «Proc. Natl. Acad. Sci. USA», 107 (51) (2011), pp. 22356-22359; D.T. Gilbert, T.D. Wilson, *Prospection: Experiencing the Future*, «Science», 317 (2007), pp. 1351-1354.

This memory is episodic, autobiographical, and requires activation of the prefrontal cortex, parietal and left temporal. When memory is not autobiographical, semantic memory is required mainly, usually associated with activity in the hippocampus and in relation to the message itself, the content of experience, and not to time-consciousness of its duration. The subjective perception of time requires differential activation in the left parietal lobe as time is short or long.

Imagining and planning the future – the basis of progressive technology – only humans achieve, since the manufacture of a simple stone tool would be inconceivable without the imagination of the future. To achieve that we evoke the past, combining new bits of memory and storing the result.

And since the imagination of a scene often triggers feelings, emotions play a major role in developing the future. Often we imagine the future just to see how we feel. That is, felt in advance, a faculty we take the advantage of seeing how we feel in front of a new situation. Moreover, it has been reported that it has been predicted with an accuracy of a few hundred milliseconds before initiating a voluntary act.[24] In other words, volition emerges internally generated once the change in firing rate of neurons goes beyond a threshold.

While episodic memory is an explicit memory, conscious, however, prospecting exploration and simulation is carried out unconsciously and are factors influencing decisions. Indeed, in developing evocations we store what we have imagined, and thus we may retrieve it later. At the same time, the past is reconfigured into episodic memory, with the risk of messing up memories based on real experiences. That is, as the context of what happens influences predictions of future experience, experience in the present is influenced by simulation of the future.

The ability to associate each time new patterns to previous memory acts as a mode of "self-projection" that predicts and also allows our mind to travel to the mind of others.

In conclusion, the time perspective arises from cognitive processes that divide human experience into past, present, and future. Every man takes hold of the past memory, present and evaluates options to imagine and simulate the future. So the content of memory is a component of consciousness.

4. Attention and awareness

The attention is a special state of consciousness. Attention anticipates the awareness and overlaps in time with both declarative memories, semantic memory stored knowledge, and episodic memory, the core which is personal

[24] I. Fried, R. Mukamel, G. Kreiman, *Internally Generated Pre-activation of Single Neurons in Human Medial Frontal Cortex Predicts Volition,* «Neuron», 69 (2011), pp. 548–562.

experience. Autobiographical memory, personal memory – which in turn is recalled for the simulation of the future –, is the foundation of self-consciousness.

Numerous studies support the conclusion that vision is aware of that to pay attention. For a brief time a representation of the whole figure, which is not conscious to the observer, but is however the raw material for attention. Phenomenological consciousness is a memory that remains available for living stimuli. Attention then selects what it really becomes conscious, so the person can tell about it.[25] It is consciousness directed to focus, because only those perceptions we become aware of that attention remains present. The prefrontal region is responsible for selective attention to keep certain information only for a short period of time. When you hold the attention focused on something a group of neurons, located across and along the cerebral cortex and thalamus, synchronize a shot and we may stay conscious.

Attention induces subjective bias to perception[26] by modulating the first sensory signals, exerting their influence in the thalamus, before modulating the signals in the cortex. In turn, attention is modulated by subcortical structures -the thalamus returns information to the cortex –,[27] and reward systems. It permits, without disconnecting the interior,[28] filter sensory information to pay attention to what is most relevant.

Animal's attention is drawn depending on the biological significance of the stimulus and in terms of survival. A recent study[29] analyses the mechanisms by which a rapid modulation of cortical circuits in two different processes: change of state to generate an alert in rodents, and the effect of attention in the visual system of primates. The classical view of global cortical states, as synchronized or de-synchronized simultaneously in all cortical areas, leads to the idea that the change from one state to another, or selective attention, affects the local cortical de-synchronization. In both cases the representation of the stimulus increases and suppresses the activity patterns generated in the interior, which suggests that attention does not select between competing sensory stimuli, but between the inner and outer world.

Indeed the synchronized state is a "power save' mode. Synaptic activity uses

[25] V.A.F. Lamme, *Why visual attention and awareness are different*, «*TRENDS in Cognitive Sciences*», 7 (2003), pp. 12-17.

[26] F. Baluch, L. Itti, *Mechanisms of top-down attention*, «Trends in Neurosciences», 34 (2011), pp. 210-224.

[27] D. Rahnev, B. Maniscalco, T. Graves, E. Huang, F.P. de Lange, H. Lau, *Attention induces conservative subjective biases in visual perception,* «Nature Neuroscience», 14 (2011), pp. 1513-1515.

[28] Y.B. Saalmann, S. Kastner, *Cognitive and Perceptual Functions of the Visual Thalamus,* «Neuron», 71 (2011), pp. 209-223.

[29] K.D. Harris, A. Thiele, *Cortical state and attention*, «Nature Reviews Neuroscience», 12 (2011), pp. 509-522.

a lot of energy and fluctuating activity means that a part is active for less time. When de-synchronizing the response to attended stimulus increases and decreases the response to those unattended. Thus the point stimulus is capable of generating a great response in all states, while extending the time is not accurately represented in the cortex during de-synchronized state. This regulation is fixed from the inside; therefore, a large value of animal adaptation to changing environmental circumstances, as is characteristic of the animals to analyse the perception of the immediate horizon as a single operation.

In human beings attention, besides being attracted, may be fixed from within, since they choose any information relevant to them. It has been shown[30] that attention is not fixed before hand, seeing how memory maintains a real-time visual task in the presence or absence of distractions. There is in man a mechanism of cognitive control, hierarchical, top-down, which promotes and enhances the proper maintenance of the relevant information in memory in the present, when there are stimuli that involve distractions. Cortical processing reflects the interaction of synaptic excitation and synaptic inhibition. The inhibition has a crucial role in cortical activity and getting to know better inhibitory circuits in cortical function.[31]

Brain activity has been investigated in people with experience of meditation and compared with controls that did not have that experience.[32] This mental state of meditation requires maintaining the focus of attention on an object, avoiding the wandering of the mind, and redirect attention to this object when it deviates. The mind centred on the instant is correlated with the activation of areas associated with self-referential processing. Medial prefrontal regions and posterior cingulate cortex are involved. In addition, it was observed a stronger coupling between the posterior cingulate cortex, dorsal anterior cingulate and dorsolateral prefrontal cortex, regions involved in attention and cognitive control, both initially and during meditation, both in those with meditating experience and in controls.

5. Integration of brain polyrhythms and work memory

The transmission systems use electromagnetic oscillations of different frequencies. Waves act as efficient channels that combine several messages with-

[30] E. Feredoesa, K. Heinena, N. Weiskopf, C. Ruffb, J. Drivera, *Causal evidence for frontal involvement in memory target maintenance by posterior brain areas during distracter interference of visual working memory*, «Proc. Natl. Acad. Sci. USA», 108 (42) (2011), pp. 17510-17515.

[31] J.S Isaacson, M. Scanziani, *How Inhibition Shapes Cortical Activity*, «Neuron», 72 (2011), pp. 231-243.

[32] J.A. Brewer, P.D. Worhunsky, J.R. Gray, Y.-Y. Tang, J. Weber, H. Kober, *Meditation experience is associated with differences in default mode network activity and connectivity*, «Proc. Natl. Acad. Sci. USA», 108 (50) (2011), pp. 20254-20259.

out interference. Similarly, the brain uses oscillations as a way of processing in various fields. Oscillations of the activity permit temporary communication across different brain structures to keep them on phase constantly, moment to moment.

Hippocampus and prefrontal cortex are intercom knot structures. Both are capable of orchestrating the activity of many cortical and subcortical areas underlying cognitive functions, acquisition and consolidation of memory, and decision-making. These structures receive inputs from sensory association areas.

The task of holding at the time only the information selected by attention from the present or the past, is performed by a working memory, memory "in real time" or "in the present", the task that requires hierarchical control of the prefrontal region. According to Carruthers,[33] other primates have working memory systems in many respects homologous with our own. However, humans are unique in some of the uses that they make of memory on time specifically of inner speech. Mammals same to have retention abilities, and probably capacity for prospection and future planning, using working memory. Moreover, it seems likely that humans excel in their abilities to withstand interference and to deploy attention and rehearsal in flexible ways to maintain and manipulate representations in working memory. In addition, humans may be unique in making frequent task-independent use of their working memory abilities.

The work of Fujisawa and Buzsaki,[34] which starts with the vision of oscillatory brain activity as coherence or temporary union of oscillatory activities allows us an insight into real-time memory, as yet unknown.

Researchers trained rats to choose from a field in "T" between going to the right or the left and reach food, and associating targeting to a particular odour at the point of departure. Subsequently measured potentials generated in specific areas of the brain, while the animals retained the information in memory. In this case spatial orientation conditioned to reward, the brain areas involved and to be integrated are the prefrontal cortex entorhinal/hippocampal system that keeps the memory map, and the reward system (ventral tegmental area). These areas process at very different rates: the prefrontal cortex remains with potential oscillations of 4 and 8 Hz. The 8 Hz are in phase with the hippocampus of 8 Hz, while those of 4 Hz are in phase with each of the second peak of 8 Hz VTA ventral tegmental area.

Furthermore, between the prefrontal cortex and ventral tegmental area gamma oscillations are observed (30-80 Hz). These high frequencies are gen-

[33] P. Carruthers, *Evolution of working memory*, «Proc Natl Acad Sci USA», 110 (2013), pp. 10371–10378.

[34] S. Fujisawa, G. Buzsaki, *A 4 Hz Oscillation Adaptively Synchronizes Prefrontal, VTA, and Hippocampal Activities*, «Neuron», 72 (2011), pp. 153–165.

erated by complex neuronal interactions within each area. In fact, cortical activity is modulated by neurotransmitters, and by fast action such of glutamate and GABA inhibitor. Also, in the ventral tegmental area are generating neurons producing dopamine and the inhibitory neurotransmitter GABA.

Well, 4 Hz interactions between prefrontal cortex and ventral tegmental area can modulate these local neuronal relationships, gamma oscillations arise, and lay in phase with those of 8 and 4 Hz. There is, therefore, a triple timing control between the three areas. By converging three independent rates (4 Hz, 8 Hz, and gamma) transiently form temporary joint-oscillatory activities and are allowed to perform the specific action: maintain information in memory at present.

In conclusion, the brain uses oscillations, as a way of gathering consistently what is being processed in different areas. Oscillations remain in phase, moment by moment, waves of different frequency allowing the communication of information from past and present.

Similarly, mechanisms of memory and planning have evolved from mechanisms of navigation in the physical world and the neuronal algorithms underlying navigation in real and mental space are fundamentally the same. Specific firing patterns and oscillatory dynamics in the entorhinal cortex and hippocampus can support both navigation and memory.[35]

6. Awareness independent of sensory input and des-embodied

6. 1. *Contemplation and ecstasy*

Mental state of intense contemplation and state of ecstasy, are achieved in two ways that are complementary. Good for focusing attention on something, religious or not, while overriding discursive thought; or, on the resignation of thoughts, distractions and pleasures. This brakes automation regarding the environment by turning off the processes that organize, limit, select and interpret perceptual stimuli coming from outside.

Consciousness is perceived usually embodied, anchored to the body, and distinct from the environment, thanks to the right parietal lobe activity responsible for the orientation in space. Moving on the environment requires a body map, which makes the target area of the left parietal and another map environment, the right parietal provides spatial coordinates for the body to navigate. Both sides constantly receive information and cooperate in the perception of self-anchored to the body and distinct from the environment.

In strenuous activities with much focused attention such as contemplation, both areas are disconnected. The sense of self gradually disappearing, bound-

[35] G. Buzsáki, E. Moser, *Memory, navigation and theta rhythm in the hippocampal-entorhinal system*, «Nature Neuroscience», 16 (2013), pp. 130-138.

aries erased, and the brain interprets that there is no distinction between the self and the world around him, a feeling of oneness characteristic of this experience. At the same time increases the activity of prefrontal areas able to focus attention.

In the experience of ecstasy, the right hippocampus and amygdaloidal complex – within the temporal lobe -, which are associated with the sense of self in relation to time and space, are hyper-stimulated. They act on the parasympathetic regions of the hypothalamus leading to a cycle that feeds back excitation. An intense emotional state is changing the way we perceive and may even distort sensory input. In fact, the hippocampus via the thalamus can block the sensory inputs to the cerebral cortex.

The active-intellectual style that combines reality to external stimuli, is replaced by a passive receive mode, in which there is a de-differentiation and fusion of the sensory modalities. It thus gains in intensity and overall sensory wealth at the expense of abstract categorization and sensory differentiation. Thus, these experiences of contemplation take advantage of memory –hippocampus – now subject to another type of self-awareness, global, holistic, intense sense of one's self. Interestingly, these changes exhibit a notable similarity with those found in Carmelite nuns during another form of spiritual meditation.[36]

As stated by Rubia,[37] these experiences mean that the religious sense is innate, our sense of spirituality is linked to the brain. That is, structures existing in the brain that make that possible. The existence of the structures responsible does not say anything in favor or against the belief in supernatural beings. For the believer it makes possible to understand some conditions necessary to communicate with God. For the unbeliever such experiences would be only projections of our own brains to the outside world.

6. 2. *Disembodiment of self: "out-of-body" experiences*

It has been extensively analysed the "out-of-body experiences" in people who have survived a cardiac arrest a few minutes. Patients in apparent coma, have a clear increase of consciousness, memory clearly recalls later, maintain their self-identity, knowledge and emotions. This type of extra-body experience requires the dissolution of the sense of unity in the brain between the two body representations and a weakening of the connection between such representations and immediate space environment.

[36] M. Beauregard, V. Paquette, *Neural correlates of a mystical experience in Carmelite nuns,* «Neurosci Lett», 405 (2006), pp. 186–90; M. Beauregard, V. Paquette, *EEG activity in Carmelite nuns during a mystical experience*, «Neurosci Lett», 444 (2008), pp. 1–4.

[37] F.J. Rubia, *La conexión divina*, Crítica, Barcelona 2004².

The neural correlates[38] of a type of hallucinations have been analysed in a type of brain damage that generates disconnection of temporo-parietal regions and of some of the regions of the temporo-occipital cortex. Patients see a second own body in extra-personal space body and identify themselves as located on one or the other. The location and identification of itself into the illusory body are complete on out-of-body experiences that thousands of people report having been in a near-death situation. The disconnection is associated with right temporo-parietal cortex impaired. Stimulation of the posterior superior temporal gyrus on the right reproduces this experience,[39] during this state the patients' brains show increased activity in the pecuneus and posterior thalamus up to superior to the vermis, suggesting that activation of these regions is the neural correlate of disembodiment, part of the out-of-body experiences.

Several mechanisms have been identified that perform the disconnection of areas that are perceived as disembodiment of the self, from lack of oxygen, which would destroy interneurons that inhibit the cortical activity, triggering the activity of many others, release of endorphins or other neurotransmitters.[40] Every state of mind corresponds to a situation of the brain.

This experience cannot be reduced, according to Lommel,[41] to imagination, fear of death, hallucinations, psychosis, drug or oxygen deficiency in the brain, but it means a continuity of consciousness in times. For others it is a hallucination, but it is not easy to explain.[42] The subjective nature and lack of a framework for this ineffable experience makes the vocabulary used to describe it, to depend on the individual, culture and religion.

So, what these experiences reveal is that consciousness can be experienced in another dimension, other than our conventional space/time, in which all past, present and future can be observed simultaneously and instantaneously. Identifying brain and consciousness is too restrictive to explain the significance of these phenomena.

[38] O. Blanke, S. Ortigue, T. Landis, M. Seeck, *Stimulating illusory own-body perceptions,* «Nature», 419 (2002), pp. 269–270; O. Blanke, T. Metzinger, *Full-body illusions and minimal phenomenal selfhood*, «Trends Cogn. Sci.», 13 (2008), pp. 7–13.

[39] D. De Ridder, K. Van Laere, P. Dupont, T. Menovsky, P. Van de Heyning, *Visualizing out-of-body experience in the brain,* «N. Engl. J. Med.», 357 (2007), pp. 1829–1933.

[40] T. Lempert, *Syncope and near-death experience*, «Lancet», 344 (1994), pp. 829-830; J.C. Saavedra-Aguilar, J.S. Gómez-Jeria, *Aneurobiological model for near-death experiences*, «J Near-Death Studies», 7 (1989), pp. 205-222.

[41] P. van Lommel, R. VanWees, V. Meyers, I. Elfferich, *Near-death experience in survivors of cardiac arrest: a prospective study in the Netherlands*, «Lancet», 358 (2001), pp. 2039–2045. P. van Lommel, *Near-death experiences: the experience of the self as real and not as an illusion*, «Annals of the New York Academy of Sciences», 1234 (2011), pp. 19–28; P. van Lommel, *About the continuity of our consciousness,* «Adv. Exp. Med. Biol.», 550 (2004), pp. 115–132.

[42] T. Metzinger, E. Thompson, P. van Lommel, *To be or not to be: The self as illusion*, «Annals of the New York Academy of Sciences», 1234 (2011), pp. 5-18.

7. The temporal structure of the self

This conscience of oneself shows an extra-cosmic dimension of man, becoming timeless. The extra-cosmic dimension of the human being allows the possibility to introduce rationality in time. Not being locked in the immediate present or instinct, thanks to his intelligence, you can set your mind before performing your action; you may organize it according to ends and direct it.

"Stop and think!" is the way of introducing rationality in time. The life of each one is a moral enterprise performed a long time and organized as biography. You can live without giving time to the immediacy or discontinuities, enslaving discontinuities, imposed from outside. The release from this enclosure is what allows us to grow. And growing is to gain time to biological time, at that level of freedom from the limits of the laws of biology. It is precisely there where our personal being is.[43]

Each time a man thinks, wants, remembers, he creates a "within", which feeds and reconfigures and opens to the future. He retains and grows over time. Time does not simply go away. Time does not just pass. Setting goals is putting in time what is timeless: operations not tied to the present. It is the inner time which is open to the future. Therefore, the internal organization of time is a task entrusted to his own freedom.

In conclusion, only man, released from confinement in the present, the here and now, the automation of processes in the brain, has a consciousness in "off line", a higher consciousness. The self-evident extra-cosmic dimension of man: mentally covering every possible space and every possible time. Neuroscience, by itself, has nothing to say about the ultimate origin of the ability of every man to free from the here and now. However, interdisciplinary dialogue opening human biology to time should be present for the rational explanation of genuinely human mental and universal phenomena.

Abstract: *Recent research in neuroscience supports the hypothesis that, although consciousness is an emergent property of neuronal activity, is the subject, released from confinement in the present, who takes over the time code. It gives a sequential recruitment to different areas that process information according to the performance of different tasks or mental processes. The ability to change the temporal rhythm brings to the present the past, and simulates the future – time travelling – it has the necessary condition, regulatory efforts, braking of neuronal excitation, which can coordinate different rhythms in time units. Synchronization of oscillations in temporary unions of various brain structures provides self-consciousness, anchored in the body. Self-consciousness relates to the experiences of events and personal identity recognized by the succession of past experiences, present, and a harbinger of the future, indicating that the self has an embodied temporary structure. Synchronization of oscillations in tem-*

[43] L. Polo, *Presente y futuro del hombre*, Rialp, Madrid 1993.

porary unions is perceived as "I'm sorry, I think, I remember, I decide. Knowledge of de-synchronization in the brain that occurs in phenomena, such as what happens in the experiences of meditation and ecstasy, without normal sensorial perception, should be incorporated into scientific and philosophical theories of mind-brain relation. Precisely, the self is manifested in the release of every human being from the automatism of the "here and now", as an extracosmic dimension which makes him able to cover not only all space but all time.

KEYWORDS: *consciousness, mind-brain relation, neuroscience, personal identity, temporary structure.*