The Decisions of Consciousness and the Consciousness of Decisions

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ABSTRACT

For a long time the study of motor decision making has essentially been based on the mechanical neurophysiology of the connections between nervous structures. Empirical research and theoretical reflection have in this way been dominated by reflexological and cybernetic models without plausible alternatives. The tendency to separate the mental functions from the body, almost as though they were independent systems, has at times had negative consequences. Indeed, whether dealing with language or other cognitive and perceptive functions, the mind is profoundly influenced by the motor sphere, the oldest from an evolutionary point of view, which depends on the cortex, the basal ganglia and the cerebellum that contain motor, motivational and cognitive components. The ever-growing debate in the cognitive neurosciences, the philosophy of the mind and phenomenology shows that the time for a conceptual and epistemological change is growing nearer, a change which puts the idea of embodied consciousness and cognition back at the centre of the research being conducted.

1. THE MATRIX CONTROVERSIES OF THE MOTOR ACTION MODELS

In the most famous of his *Croonian Lectures*, the English neurologist John Hughlings Jackson, father of modern neurology, noted:

> That activities of the highest, least organised, nervous arrangement, during which consciousness, or most vivid consciousness arises, are determined by activities of lower, more organised, nervous arrangements, I firmly believed. As I have said, in effect, states of consciousness attend survival of the fittest states

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> of centres representing all parts of the organism as one whole. Roughly
> speaking, the highest nervous states are determined from below, and not by
> autocratic faculties acting upon the highest part of the highest centre. (Jackson
> 1884, p. 706)

Despite the many, and often incorrect, interpretations of his philosophy, Jackson can be given the undeniable credit for having moved the neurophysiological debate of the 1800's from a relational life model founded on reflection (the automatic response that causes the simultaneity of forms and movements), to another model in which motor functions descend mechanically from cortical structures, which are the biological basis of rationality, imagination, logical thought and still more. For more than two centuries, reflex had been the dominant paradigm not only for philosophers such as Descartes, but also for the majority of neuroanatomists, neurophysiologists and neuropathologists. Jackson considered identifying the site of a lesion, a functional centre and anatomic location, to be erroneous, because ontogenesis realizes but above all directs the organism, integrating at a higher level that which is integrated at a lower level. At the centre of his research are the *functional metamorphoses*, whose temporality impresses rhythm and movement, guiding the relational life of every living being. Time, in fact, does not influence only the development of forms and movements, but also assigns a functional hierarchy to them.

The Jacksonian idea, according to which the evolution of the nervous system is characterized by ascending dynamics – from the more organized lower levels towards the less organized higher centres of the *highest level* (from the most automatic to the most voluntary) – introduced a new dimension into the debate of that age on the organization of the nervous system (1884). A concept that is so conditioned by the idea of evolution joins the notion of overlap to that of hierarchy, the notion of mechanisms to that of integration. In his vision the spatial (nervous) structures are subordinate to the flow of time: in this way, that which is lower (that is, more fixed) is subordinate to that which is higher (more mobile). The natural finalism in the hierarchy of nervous functions confers upon the concept of integration logical-sequential characteristics, according to which the lower or instrumental functions controlled by the *highest level* become subordinate like words to syntax, or means to an end (Ey 1947).

In spite of its apparent mechanism, the Jacksonian idea of an autonomous ontogenesis of relational life makes the principle of hierarchy

dynamic and, therefore, functional to that same process of integration: which is then nothing other than a sensorimotor coordination, a link between the present and the past, between imagined and perceived. In this sense, that which defines the *highest level* is its contingency (its freedom), and the same concepts of "automatic" and "voluntary" represent the levels of the functional hierarchy, whose morphology and nervous structures represent the free movement of relational life (Jackson 1932). The very notion of a "centre of consciousness" – the most controversial Jacksonian theme, considered by some to be the stumbling block of his hierarchical theory of functions – remains the most important issue in the current neuroscientific debate. Consciousness, the *highest level* of the evolution of the nervous system is, for Jackson, the structural-functional basis for the unfurling of the mind's activities: its very organization (Evans 1972). The order of consciousness is, in fact, sustained by multiple horizontal levels, every one of which is in a structural and functional *continuum* with various phenomenological occurrences (Maldonato 2009). It is such characteristic that allows for the integration processes of the activities of thought and of the programming of motor activities (even when only representational). Planning an action, in fact, always requires predicting its consequences, and this type of prediction is the result of model action activity. In this sense, thought and motility are tightly linked on both a phylogenetic level as well as an ontogenetic one. This link has over time produced an enormous archive of extraordinarily fluid motor repertories. The progressive refinement of the relation between the motor and the pre-motor cortex is at the origin not only of motor behaviours (such as the ability to construct and manipulate objects), but also of the acquisition of competences from structures such as Broca's area and the basal ganglia, which control the motor aspects of language. It must be said, however, that language is not an individual and autonomous system, but rather the product of a sophisticated coordination between systems and cerebral areas that are tied to the representation of objects, to perception and to the very motility of the body.

2. THE SENSE OF MOVEMENT AND EMBODIED ACTION

On a phylogenetic level sensory and motor activities – the basis of the development of various cognitive functions – have the longest history. The

wide range of structures in the human nervous system show, on the one hand, how complex the evolution of motor control has been and, on the other hand, its impact on other functions: from language to motility and so forth (Jeannerod1994). The motor and muscular systems are high-priority systems and their activation triggers the inhibition of the perceptive, sensory, attention, and other systems. This fact is even more readily apparent if one considers that, in animals, movements are linked to the carrying out of actions essential to survival, such as escape, attack, searching for food and the selection of a sexual partner. The activation of some muscles (even when only activated potentially, such as in the case of muscle tensing) involves the activation of other muscles, the reduction of sensations, the limitation of the flow of ideas and still more. This means that motility has not only direct motor consequences but also general effects on other systems. While it is true that movements depend largely on cerebral motor areas, it is in fact the whole nervous system that presides over the control of motility (MacKay 1987). The same cortical areas that decode sensations – through which we perceive muscle tension or the position of a limb – inform us retroactively about the execution of a particular movement. Without this function the movement would be imprecise, rough or completely blocked.

As it is known, muscles are controlled by the pyramidal neurons of the motor cortex, which are connected through the spinal marrow to motor neurons situated therein in order to reach, from there, the peripheral muscular fibres. Every muscular movement – such as moving a finger, shaking hands, crying and so on – involves the activation of the nervous-muscular neuron-fibre sequence. However, motor action is extraordinarily more complicated. In fact, if it is true that the composition and harmony of movements is guaranteed by the base ganglions and by the cerebellum – it is in these structures that the memory of the sequence of muscular actions are conserved, actions that allow us, for example, to centre in on a target with an arrow, pick a small flower, or dial a number – they constitute only the infrastructures of the movement: the planning and the execution of the movement depend, instead, on other cortical and subcortical structures (Adams *et al.* 2005).

Today, the relationship between the complexity of a motor action and the number and type of nervous structures involved is clearer. It has been observed, for example, that even simple and localized movements like the flexing or the stretching of the index finger of the right hand involve the activation of the primary motor area and of the somatosensory area of the

contralateral hemisphere. These are areas that are activated when a more complex movement is in action: for example, when subjects are asked to touch the tip of their right thumb to, in the following order, the tip of their index finger, middle finger, ring finger and pinkie finger of the same hand; although it must be said that in this case even the supplementary motor cortex and the prefrontal cortex are activated, the latter being activated even when the movement is simply imagined. In the case of the imagination and execution of a complex movement, the prefrontal area and the supplementary cortex are bilaterally activated, that is to say that there is activation even in the hemisphere not involved in the execution or imagination of the motor act (Brown and Marsden, 2001). This bilateral stimulus could correspond to the activation of an abstract plan of the movement or reflect a variety of motor plans oriented towards the same goal.

There are studies that indicate that it is first the prefrontal cortex (the decision to act) that is activated, then the supplementary cortex (involved in the plan of action) and, finally, the motor cortex, which implements and modulates the action based on the proprioceptive information that reaches the somatosensory cortex (Brown and Marsden 2001). Ultimately, the sequence of movements is due to two different circuits: an internal one, which involves the supplementary area, the basal ganglia and the temporal lobe, and takes over when a motor ability becomes habitual because it is guided by an internal representation of the action; and an external one, which includes the parietal lobe, the premotor area and the cerebellum, involved in direct movements or movements guided by spatial representations.

3. THE PREDICTIVE BRAIN

The execution of remarkably complex actions, such as those of a musician at a piano, is much more articulated than what experiments on the planning and execution of simpler movements reveal, contextualized and guided as they are by the judgement of the performer. All of this was already clear to Lotze who, in the mid 1800's, wrote:

> We see in writing or piano-playing a great number of very complicated movements following quickly one upon the other, the instigative representations of which remained scarcely a second in consciousness, certainly not long enough to awaken any other volition than the general one of

> resigning one's self without reserve to the passing over of representation into action. All the acts of our daily life happen in this wise: Our standing up, walking, talking, all this never demands a distinct impulse of the will, but is adequately brought about by the pure flux of thought. (*quoted in*: James 1952, p. 791)

Beyond the musical interpretation and the talent of the single performer, all of the components of that musical ability derive from the complex interaction between motor learning, temporal processing and sequencing, in which a crucial role is played by the relations between the cortex and the basal ganglia. In reality, the line between perception and action is not well-drawn as one might believe when basing oneself on the description of the execution of a motor task (Berthoz 1993). If the cerebral structures' capacity for processing is considered, rather than their specific function in the execution of a task, not only does the crucial role played by the parietal lobe in the perception and execution of an action become clear, but also that of the basal ganglia in the sequencing of movements, language or ideation. Despite being parts of different systems, perception and action constitute integrated functions. In light of these considerations, subordinating motor functions to higher cognitive activities and classifying the body as an inferior entity to that of the mind appears implausible. The body and its movements are at the origin of the abstract behaviours of which we are proud, beginning with language which gives form to our mind. For example, the evolution of some motor behaviour, such as the ability to construct and manipulate objects, selected an order of movements based on a sequence of cause-effect links. This led the motor and premotor cortex to develop a growing ability to generate interlinking movements, inducing even *Broca's area* to produce the verbal gestures and the sequences of syllables that are at the basis of communication. In this sense, pronouncing a sequence of syllables is like sculpting bronze or sharpening a blade: this control of motility preceded language, but also contributed to structuring it as an internal motor logic (Oliverio 2009).

It is rather probable that the logic of the body and of its movements constituted the foundation on which, over time, the operational logic of language structured itself. In terms of physical experiences many motor operations have been so important that they have progressively supplied the infrastructures for the development of symbols and metaphors used in language, translating themselves over time into classes of perceptions, behaviours and universal linguistic conventions (Lakoff and Johnson 1980).

4. EMBODIED MEMORIES, GOALS AND PLANS OF ACTION

Perception is, by its very nature, multisensory. It uses multiple reference systems adapted to the actions in progress. In fact, while receptors measure derivatives, the brain mobilizes a repertory of prototypes of forms, faces, objects, and even synergies of movements. During its progress, evolution selected simplifying laws in the geometric, kinematic and dynamic properties of natural movements. But perception is also predictive, thanks above all to memory, which uses the consequences of past actions in order to predict those of future actions (Berthoz 1998). Whether shaking hands, writing a letter or performing another action, every executive act requires a behaviour directed towards a goal, a behaviour made possible thanks to the control of a series of nervous structures and mental processes that process information.

Because of its complex relations with the other cortical areas and subcortical nuclei, the frontal cortex is at the centre of the executive functions: from the memory of work (which allows one to remember the beginning of a sentence once completed) to the behaviour directed towards a goal (which implies a continuous re-modulation of information with the passage from one plan of action to another and the continuous verification of the consequences of our actions). Such functions depend on the prefrontal cortex (in human beings it accounts for approximately half of the frontal lobe), which being linked to all of the other cortical areas and to a large part of the subcortical structures is directly or indirectly involved in all of the executive functions (Miller *et al.* 2002).

But how do we succeed in formulating plans of action corresponding to specific goals? A plan of action involves a hierarchy of relevant actions and irrelevant actions. In addition, it can be part of a vast plan consisting of immediate objectives or of sub-plans matching the principal objective. These complex functions involve the planning and the choice of an action, the monitoring of its execution, and the reinforcement tied to the reaching of the desired goal.

Since the by now classic studies of Leonardo Bianchi (1889) on the effects of bilateral ablation of the prefrontal cortex of primates, the executive functions of the motor system have been attributed to the prefrontal lobes. In order to fully grasp the subtle and complex relations of the prefrontal cortex with behaviour it is useful to understand the distinction between the lateral prefrontal cortex and the medial prefrontal cortex. The lateral prefrontal cortex

can be further subdivided into the dorsolateral prefrontal cortex (which selects the information) and the ventrolateral prefrontal cortex (which stores the information). The medial prefrontal cortex can also be subdivided into two important areas: the anterior cingulate cortex (which identifies the errors of specific behaviour) and the superior frontal gyrus which seems to be involved in the selection and the execution of a task (Rushworth *et al.* 2004). In reality, these anatomic-functional subdivisions and their implications on behaviour are not always so clear-cut. In fact, between anatomic areas and functions it is not infrequent that overlapping levels are observed, a fact that encourages researchers to be very careful when defining the role of different frontal and prefrontal areas.

This intricate neuronal geography propels us to reconsider the integration processes between frontal and prefrontal areas, whose collaboration creates that complex phenomenon called motor control, the dynamics of which are in some ways the opposite of those of perception. Indeed, if perceiving means putting the external world into an image, acting means representing to oneself the desired consequences of a movement which is being carried out while it is being carried out. In this sense, the execution of a movement has to do with a representation of the environment, beginning with the information made available by the parietal cortex and by the hippocampus which, as is known, is a structure involved in numerous aspects of spatial memory (Oliverio 2008).This information passes to the premotor cortex which, so to say, 'projects' the movement and, finally, to the motor cortex which carries out the action.

As we have seen, motor control and its execution depend on cortical and subcortical structures, among which we find the basal ganglia that play a fundamental role in the control of spatial memories, of motor actions in a specific context and of the motivational components of learning. In this schema, the cortex and the basal ganglia plan the action, the execution of the movement and the control over its state of execution, in close collaboration with the cerebellum, the red nucleus, the striated muscle and other subcortical structures. For almost a century and a half, motor functions were instead considered to be directly dependent on superordinate structures, such as cortical ones, considered to be the basis of higher cognitive activities: rationality, creativity, and thought. In reality, thought activities and motor activities (even when only representational) are always closely correlated. Whether imagining, planning or acting, it is always the same area of the brain

that is activated. The planning of an action always, in fact, requires the prediction of its consequences, and this type of prediction is the result of model action activity (Oliverio 2008).

The tendency to separate mental functions from the body has negative consequences. Whether dealing with language or other cognitive and perceptive functions, the mind is profoundly influenced by the motor sphere, which in turn depends on older structures such as the cortex, the basal ganglia and the cerebellum. The prevalence of a hierarchically superordinate vision of the mind (to the detriment of the motor sphere) has depended on true and proper philosophical misunderstandings, which are worth examining briefly. In contrast with the arguments that identify him as the greatest driving force behind modern philosophical dualism, Descartes shed light on the intimate and immediate relationship between mind and body. In the sixth of the *Meditations on First Philosophy*, the French philosopher argues that nature teaches him

> [...] through these very feelings of pain, hunger, thirst, and so forth, that I am not present in my body only as a pilot is present in a ship, but that I am very closely conjoined to it and, so to speak, fused with it, so as to form a single entity with it. For otherwise, when the body is injured, I, who am nothing other than a thinking thing, would not feel pain as a result, but would perceive the injury purely intellectually, as the pilot perceives by sight any damage occurring to his ship; and when the body lacks food or drink, I would understand this explicitly, instead of having confused feelings of hunger and thirst. (Descartes 2008, p. 57)

Descartes affirms that we are joined to our body, that the mind is mixed with the body as though it were one entity and that we are conscious of what happens in our body, although in a different way from how we are conscious of objects external to the body. In short, we do not look at our body as we look at other things. We do not have to check, for example, the position of our legs or whether we have our hands in our pockets. We know this information without having to verify it. Unlike those patients who, because of a vascular accident or another cerebral lesion, have lost the sense of the body's movement and of their own position in the space around them. As is known, in order to be aware of movement and of their own position these patients have to check the position of their own body, just as the Cartesian "pilot" looks at his own ship.

Beyond the necessary rereading of Cartesian philosophy, in evolutionary terms the human nervous system developed mainly in order to coordinate

perception and body movements and to increase efficiency in activities essential for survival such as hunting, coupling and raising offspring. As paradoxical as it may seem, evolution has favoured the development of knowledge for efficient action, not so much for reflection. James asks himself whether the simple idea of the effects of a movement is a sufficient motor stimulus or whether there is an additional mental antecedent, such as a decision or some other analogous phenomenon, in order to which there may be movement (James 1952). He advances the idea that a movement is always associated with a representation of its consequences and that every representation of a movement reawakens with the maximum level of intensity the real movement, every time it is not impeded by an antagonistic idea simultaneously present in the mind (James 1952). Following along the lines of Lotze, who believed that the imagination of a movement activated the same structures involved in its execution, James suggests that consciousness is always the consciousness of an action.

5.   DECISIONS OF CONSCIOUSNESS

During its different evolutionary stages biological life on our planet produced two main adaptations: to begin with it imprinted elements into the genetic code that would facilitate the periodic variability to environmental changes such as light, temperature, precipitation and still others; and secondly it equipped the animal nervous system with structures that would guarantee the sensory and motor activities developed through time (Maldonato and Dell'Orco 2010). Compared with higher animals human beings also have an internal representation of time, and this originates in the birth of conscious experience. It is through the conscious perception of time that, over the course of evolution, human beings have been able to achieve enormous adaptive and reproductive advantages.

As a neurobiological phenomenon distinct from awareness, consciousness originates in the cortical-subcortical space, even if it is only in the cerebral cortex that the experience of time is realized, that is, the unmistakable individual impression of continuous past experiences that is bound together with future expectations. And it is always in the cortex that the unification of time takes place, realized through the combination between nervous circuits and our conscious experience, to which we can add through introspection and

accounts in the 'third person'. Although it is an essential characteristic of consciousness, we know little about time. These notions revolve around the categories of succession and duration (Fraisse 1987). Succession implies the eminently cognitive distinction between the simultaneity and the sequence of a number of events – although not in an absolute sense, because when temporal scales of tens of milliseconds are used the reliability of our judgement becomes more uncertain. Duration instead implies the ability to understand sequential perceptive events as though they were simultaneous, that is to 'feel' the interval of time without discontinuity. In *Time and Free Will: An Essay on the Immediate Data of Consciousness* (1910), Bergson problematizes the spatialized vision of duration of the positive sciences by identifying two dimensions of conscious life: a superficial I, which is built on cognitive issues; and a fundamental I, which is built through the synthesis of consciousness. Before Bergson, it was the Eleatic philosophers and later Saint Augustine (*The Confessions*) who shed light on the problematic nature of the concept of the Present and who questioned time as the succession of present moments. How short can a moment be, that changing interval that flows from the past to the future and vice versa? According to James (1952) our consciousness of time originates in different speeds, which depend on the number of events or changes that we experience in a certain interval (neuroscientists would speak of a minimum necessary time for the emergence of neural events correlated to a cognitive event). This immaterial structure has been interpreted as the phenomenon of surfaces of a neural integration at wide range, tied to a diffuse synchrony: this being an interpretation that could clarify, through a dynamic reconstruction, both the invariant nature of events and the synchronization process of tangible experience (Petitot *et al.* 1999).

In reality, there is no agreement on the nature of the processes at the basis of succession and duration. In general, the most accredited hypothesis is that the perception of time takes place around the following orders of magnitude: below one hundred milliseconds it is possible to distinguish the beginning and the end of an event, its instantaneity; past five seconds the perception of the duration seems to be cut in half by memory (Fraisse 1987). The 'moments' of this *deceptive present* are believed to oscillate between 100 milliseconds and 5 seconds. Other hypotheses indicate that at the foundation of consciousness is a mechanism of temporal unification of neuronal activities that synchronizes impulses in medium oscillations of 40 Hz (Crick 1994). These oscillations are not believed to codify additional information, but they are thought to unify part

of the existing information in a coherent perception. Our consciousness, therefore, would not be generated by the action of a specific zone of the brain, but by the concomitant activation of a series of neurons distributed in the brain. Such oscillations are a necessary but insufficient condition for the production of conscious experience.

The phenomena of general neuronal activity as seen by EEG originate in the activation, parallel inhibition and synchronization of multiple neuronal circuits. This is a dynamic balance, in which every event, lasting from 100 to 200 milliseconds, reflects the activation of a distributed and parallel neural network that is translated into the contents of consciousness, such as an abstract thought or a visual image (Le Van Quyen *et al.* 1997). In certain conditions, there are areas in which neuronal oscillations play a crucial role. In addition, certain states of consciousness (alertness, falling asleep, waking, etc.) and pathologies such as depression, epilepsy, and Parkinson's disease cause different registrations of thalamic-cortical rhythms (Charney *et al.* 1996), whose duration varies with the variation of clinical populations. For example, in paranoid schizophrenics they are shorter (Torrey *et al.* 1994), whereas in manic patients the rhythms show continuous changes (Goodwin and Jamison 1990) and so on. It is not implausible to maintain that these neuronal harmonies and discords give way to the emerging phenomena that make subjective experience possible. A thus-constructed model would allow us to do without metaphysical entities such as the *central theatre* of Baars (1997), the *homunculus* of Dennett (2005) or any other metaphysical entity, letting the I of neuronal organization emerge and, therefore, the subjectivity of the physical brain. Careful reflection on the concept of temporality encourages the reconsideration of some aspects of consciousness that seem obvious. The first aspect to be reconsidered is the unity of conscious experience, which disappears as soon as it is considered on the basis of time scales of milliseconds (Roeckelein 2000); the second is immediacy, a phenomenon sometimes too quickly attributed to consciousness. We have already seen previously how continuous visual information is connected to different processes that require certain intervals of time. Furthermore, the milliseconds relating to the duration of these processes are irrelevant (Richelle *et al.* 1985) and no piece of information can reach consciousness until at least half a second has passed after its arrival in the cerebral cortex.

In reality, experimental research has yet to propose convincing solutions for the problem of the experience of time. This is perhaps because this

disconcerting enigma is different from the one relating to the cerebral areas and structures that are at the origin of phenomena and experiences, which can be studied today through *brain imaging* methods (Posner and Raichle 1994, Zeman 2001). As the origin and structure of consciousness, temporality joins together the different levels of neurophysiological and phenomenological reflection. An efficient research method is composed of cerebral activation studies (PET, fMRI, MEG, event-related potentials) which allow for the exploration of the central nervous system before and after an adequate stimulus: the presentation of ambiguous visual stimuli, the transition from general anaesthesia to reawakening, the passage from a vegetative state to a minimally conscious one and still others. For example, the rekindling of the activity of the re-entering thalamic-cortical circuits, in a patient who was first 'vegetative' and then 'minimally conscious', shows the importance of the role of the connections between the intralaminar nuclei of the thalamus and the frontal and parietal associative cortices in the maintaining of consciousness. Here, a fundamental task is performed by the *Ascending Reticular Activating System* (ARAS) – a system composed of the reticular formation, the thalamus and the thalamic-cortical projection system – which presides over the diffuse activation of the cerebral cortex in states of wakefulness and alertness, states necessary for the formulation of the contents of consciousness (Moruzzi and Magoun 1949). This is a distributed system, not circumscribable to the reticular nuclei of the encephalic trunk (Plum and Posner 2000) that projects itself in a descending direction towards the spinal cord and, in an ascending direction, towards the cerebral hemispheres. Each one of its constituent nuclei has particular anatomic, physiological and biochemical characteristics: those that modulate the functioning of the cortex reside in the upper two thirds of the pontine tegmentum, others in the lower third of the pons and in the bulb – that is why, in stroke patients, isolated lesions of the pons can cause a coma even in the absence of mesencephalic damages (Wilkinson and Lennox 2007). It is not without significance, moreover, that some nuclei of the cerebral trunk surpass the thalamus in order to connect directly with the frontal-basal cortex, from which the bilateral projections diffused to the cerebral cortex originate; or that other nuclei go beyond both the thalamus and the frontal-basal cortex to reach wide areas of the cerebral cortex; or that, finally, other nuclei are connected with the reticular nucleus of the thalamus and not with the intralaminar nuclei.

    This unique neuronal geography allows us to consider the functions of the ARAS as being much more wide-ranging and complex than those linked to the

simple 'desynchronization' of the cerebral cortex (Mancia 1994), also essential to the state of wakefulness and attention. Then there are the non-specific thalamic-cortical projections, such as the activation of the thalamic-cortical circuit at a high oscillatory frequency, projections fundamental to the essential functions of consciousness. Studies on cerebral activation (Laureys *et al.* 2004) have demonstrated that, in patients in a vegetative state (a state of wakefulness without content), the connectivity between cerebral areas that are normally connected is lost: in particular, between the primary cortical areas and the associative multimodal ones (the prefrontal, premotor, and parietal-temporal areas, the cortex of the posterior and precuneous gyrus cingulate) or between these cortical areas and the thalami. This leads one to wonder whether the exclusive role of ARAS in determining consciousness should not be reconsidered, rethinking consciousness as the effect of the interaction of an enormous variety of *qualia* and of distinct perceptions implied in the distributed and dynamic activity of the thalamic-cortical nucleus.

In general, consciousness is a stable and at the same time variable temporal event generated by an interaction of different levels – neural infrastructures, qualitative-subjective experiences and functional units – that are logically interrelated. This is a structure-function that is radically different from the other phenomena of the natural world (Maldonato 2007), one that emerges through an order in which the schema produced by the system's elements cannot be explained by the individual action of the system's single constituents, but rather by the synergy between its elements: this being a phenomenon that can be found both in elementary environments and in extremely complex ones.

There now seems to be a general consensus that at the basis of consciousness there is synchronization between different cerebral regions, and that this form of temporalization constitutes a deciding factor in the integration processes of neuronal information. However, the question remains open as to the nature of the passage from the neuronal level to that of perception and, finally, consciousness. It is not enough, in fact, to postulate an explanatory principle (chronological time or any other synchronizing function) without taking the mechanisms for accomplishment into account. Varela (1996) has long insisted on the necessity of considering consciousness as an emerging phenomenon, in which local events can give rise to properties or global objects in a reciprocal causal co-involvement. These are structural invariants incompatible with the continuous representation of linear time inherited from

classical physics (Prigogine 1986, 1997). More recent theories on consciousness hypothesize a minimum necessary amount of time for the emergence of neural events that connect themselves to a cognitive event (Dennett and Kinsbourne 1992). This temporality can plausibly be attributed to long-range cerebral integration linked to diffuse synchrony: an event that would shed light on phenomenological invariants, restoring tangible experiential content to the synchronization process.

For a long time scholars focused on the concept of the unitarity and the permanence of consciousness in time. Today, instead, numerous studies show that consciousness is a plural process that encompasses different contents in itself simultaneously, each element of which has its own intentionality (Zeki 2003, O'Brien and Opie 2000).

But what are the biophysical mechanisms of the unified experience of consciousness? And how does this internal plurality unify the different contents? There seem to be two possible models. The first model hypothesizes that consciousness is generated by a central neural system, in which duly integrated information is first represented and then brought to consciousness. In this schema consciousness appears to be the result of the work of the central neural system that generates different contents and representations, a phenomenon taking place exclusively in the brain. In the second model the simultaneous co-activation of the contents generated by distributed structures in the brain are believed to give rise, ultimately, to the phenomenon of consciousness. Consciousness would in this way be generated by distributed cerebral mechanisms – both cortical and subcortical – the contents of which, each element being independent one from the other, are exposed to intrasensory and intersensory (environmental) influences. The contents of the distributed cerebral mechanisms and the intrasensory and intersensory influences affect each other reciprocally and thus co-determine conscious experience. It is in this fine line that the distinction between a unitary model and a plural model of consciousness lies.

Ramachandran (2004) has a number of times discussed the plausibility of a model that integrates visual, auditory, tactile and proprioceptive experiences as well as other experiences. These individual spheres, in a relatively independent way, can be altered or neutralized without influencing the other spheres. Experimental evidence relating to the consequences of lesions and ablation of cerebral areas show that if, on the one hand, it is possible to lose the capacity to visually grasp movement, conserving however the other aspects of visual

experience (Zeki and Bartels 1998), on the other hand, it is possible to lose the sensation of colour, without losing visual experience and the experience of movement. Studies on the deficits caused by lesions on the level and kind of functional specialization and cerebral localization have shown that the brain works on a large scale, between procedures and domains that are reflected in specific anatomical districts (primary visual processing in the occipital cortex, auditory processing in the temporal cortex, planning and memory processing in the frontal cortex), while specific functions are realized in well-demarcated anatomical districts and locations (for example, the visual motor function takes place in area V5 and that of colour in V4). The zones of the brain that program particular informational content are those in which the contents come into consciousness. For example, different events from a visual scene, presented simultaneously, are not perceived with the same duration. This multiple asynchrony seems to prove that consciousness is the integrated result of countless micro events more than a unitary faculty (Zeki 2003).

But how can these multiple neural events restore to us the impression of a unitary subjectivity? And which paths lead to the composition of the Self and of consciousness? Concepts such as 'unitary subjectivity' and the 'Self' remain problematic. Here, we will limit ourselves to affirming that the Self emerges when the individual events produced by the brain are sufficiently representational, coherent and close-knit. In the absence of neurological and psychiatric disorders, we experience a structured world of distinct objects ordered in space, organized according to regularities and contents within meaningful spatial-temporal schemas: extramodal contents (colours, forms, etc.) and intramodal contents (proprioceptive, auditory and visual). In reality representational cohesion is not an invariant characteristic of conscious experience, but the result of a selection through which the brain searches for the path of its own integration. Ultimately, the Self has to do with a regulatory activity of consciousness that processes and maintains such plurality in an interweaving of local contents in contact with each other. In such a model, consciousness appears not as a hierarchical entity, but as a multiple horizontal entity, whose representational cohesion is carried out by thalamic-cortical and cortico-cortical distributed circuits. All conscious experiences, beginning with those that are qualitative (*qualia*), become unified within the field of consciousness. In this sense, unity is implicit in qualitative subjectivity. But if our consciousness is determined by the play between these innumerable dynamics, then there are not only different conscious states unified in

subjectivity, but also aggregate underlying fields of consciousness. In other words, the unitarity of consciousness follows subjectivity and quality because there is no way to have subjectivity and quality without unity.

The issue of conscious subjectivity goes beyond the search for its neuronal correlates and even beyond the conceptual contraposition between consciousness and the unconscious. For example, in the phenomenon of vision the methodologically relevant question certainly concerns the neural coordinates of consciousness, but above all it regards the way in which visual experiences enter and become part of the conscious sphere. If the infrastructure behind the field of consciousness is the thalamic-cortical system – which reprocesses the information originating from the different districts in various sensory forms (visual, tactile, auditory and so on) – from its operational neural levels one could remount to the structure of visual consciousness, of *qualia*, of temporal experience and still more. Nevertheless, the brain cannot generate conscious experience on its own: it is, in fact, only a necessary condition so that countless neuronal micro events may generate conscious perceptions of the world's objects (Varela *et al.* 1992). In this sense, an in-depth study of consciousness requires multi-level explanatory criteria: a *quantitative-categorial* criterion (attention, alertness, sleep, and coma); a *qualitative-dimensional* criterion (subjective experiences such as sensations, thoughts, and emotions); and a final criterion for the analysis of the different synchronic (the field of consciousness) and diachronic (the I and personality) types and levels of consciousness. At the present day, almost no one among scholars maintains that consciousness is characterized by a strict alternation between states of wakefulness and sleep. The constant variability of consciousness is demonstrated by numerous situations: from the clear and ready alertness of an airplane pilot to the attention levels of a student immersed in speculation; from the concentration of a monk in contemplation to the labile alertness of a drowsy or distracted individual. Something analogous can be said of sleep, which through the study of EEG correlates can be analyzed according to different qualitative and quantitative criteria (Mancia 1994). It must be noted, furthermore, that levels of consciousness are conditioned not only by physiological variations of the sleep-wakefulness rhythm, but also by the ingestion of anaesthetic drugs (which reduce the level of consciousness) or psychoactive substances (which increase attention levels).

Studies conducted on experimental animal models have shown that among the cerebral structures involved in the modulation of alertness are the *locus*

coeruleus (with adrenergic projection), the posterior portion of the hypothalamus (with histaminergic projection), other brainstem nuclei (with serotonergic and dopaminergic projection) and, above all, the intralaminar nuclei of the thalamus. The latter, in particular, play the essential role of synaptic relay for the diffuse cortical paths that regulate the synchronization of the cortical electrical activity registered by EEG. A lesion of these centres can cause a coma and vegetative states measurable using criteria such as those of the *Glasgow Coma Scale* (Teasdale and Jennett 1974). Expressions such as a loss of consciousness, a reduction of the level of consciousness, regaining consciousness, and others refer to this meaning of the term, essentially overlapping with the concept of *awareness*.

6.   CONCLUSIONS

In this essay, it has been shown how numerous aspects of motor planning and of the intentional perception of an agent do not appear on the conscious level. The integration between these levels has a concrete meaning, which has effects on those conceptions of the mind that have been at the centre of the philosophical debates on the philosophy of action. Varela (1996) highlighted the role played by the body on the dynamics of perception; however, his reflection is still "disembodied", that is without empirical support. According to Berthoz (1998), the body is not only a thing, a potential scientific object of study, but also the necessary condition of experience. It constitutes the perceptive opening to the world: the primacy of perception is a primacy of experience, when perception reassumes an active and constitutive role and can be at the basis of action.

In the embryonic, fetal and infancy stages, action precedes sensation and not the opposite: first reflex movements are carried out and after they are perceived. We are normally led to emphasize sensations and perception, and particularly to retain that movement is essentially dependent on them. On the contrary, we could represent this sequence inversely through a schema in which one begins with movement in order to then consider the consequences that this has on the surrounding environment, namely the perception of the consequences and the modifications that this has on subsequent movements.

REFERENCES

Adams, R. D., Victor, M., & Ropper, A. H. (2005). *Principles of Neurology.* New York: Mc Graw-Hill.

Baars, B. J. (1997). *In the Theater of Consciousness: The Workspace of the Mind.* New York: Oxford University Press.

Bergson, H. (1910). *Time and Free Will: An Essay on the Immediate Data of Consciousness.* London: George Allen and Unwin.

Berthoz, A. (1993). *Multisensory Control of Movement.* Oxford: Oxford University Press.

Berthoz, A. (1998). *Il senso del movimento.* Milano: McGraw-Hill Companies.

Bianchi, L. (1889). Semiotica delle malattie del Sistema Nervoso. Milano: Vallardi.

Brown, P., & Marsden, J. F. (2001). Cortical network resonance and motor activity in humans. *Neuroscientist, 7*(6), 518-527.

Charney, D. S., Woods, S. W., Krystal, H. H., & Heninger, G. R. (1996). Neurobiological mechanism of human anxiety. In B. S. Fogel, R. B. Shiffer & S. M. Rao (Eds), *Neuropsychiatry*, (pp. 257-286). Baltimore: Williams & Wilkins.

Crick, F. (1994). *The Astonishing Hypothesis: The Scientific Search for the Soul.* New York: Scribner.

Dennett, D. (2005). *Sweet Dreams. Philosophical Obstacles to a Science of Consciousness.* Cambridge, MA: MIT Press.

Dennett, D., & Kinsbourne, M. (1992). Time and the observer: The where and the when of the consciousness in the brain. *Behavioral and Brain Sciences, 15*, 183-247.

Descartes, R. (2008). *Meditations on First Philosophy with Selections from the Objections and Replies.* New York: Oxford University Press.

Evans, P. (1972). Henry Ey's concepts of the organization of consciousness and its disorganization. An extension of Jacksonian theory. *Brain, 95*(2), 413-440.

Ey, H. (1947). Système Nerveux et Troubles Nerveux. *Evol. Psych., XII*(1), 71-104.

Fraisse, P. (1987). Temporal structuration of cognitive processes: Discussion. In M. Olivetti Belardinelli (Ed.), *Comunicazioni scientifiche di psicologia generale, 15*, (pp. 26-33). Roma: Bulzoni.

Goodwin, F. K., & Jamison, K. R. (1990). *Maniac Depressive Disorder.* Oxford: Oxford University Press.

Jackson, J. H. (1884). The Croonian lectures on evolution and dissolution of the nervous system. *The British Medical Journal, 1*(1214), 660-663.

Jackson, J. H. (1932). *Selected Writings*, 2 Vols. London: Hodder Stoughton.

James, W. (1952). *The Principles of Psychology.* Chicago: Encyclopedia Britannica Inc.

Jeannerod, M. (1994). The representing brains: Neural correlates of motor intention and imagery. *Behavioural Brain Sciences, 17*, 187-202.

Lakoff, G., & Johnson, M. (1980). *Metaphors We Live By.* Chicago: University of Chicago Press.

Laureys, S., Owen A. M., & Schiff N. D. (2004). Brain function in coma, vegetative state, and related disorders. *Lancet Neurology, 3*(9), 537-546.

Le Van Quyen, M., Adam, C., Lachaux, J. P., Martinerie, J., Baulac, M., Renault, B., & Varela, F. J. (1997). Temporal patterns in human epileptic activity are modulated by perceptual discriminations. *NeuroReport, 8*(7), 1703-1710.

MacKay, D. G. (1987). *The Organition of Perception and Action*. New York: Springer Verlag.

Maldonato, M. (2007). La coscienza prismatica. Un mosaico di forme incostanti. In M. Maldonato (Ed.), *La coscienza. Come la biologia inventa la cultura*, (pp. 13-60). Napoli: Guida.

Maldonato, M. (2009). Il meraviglioso algoritmo. Sulla struttura immateriale della coscienza. In M. Maldonato & R. Pietrobon (Eds.), *Pensare la scienza*, (pp. 41-68). Milano: Bruno Mondadori.

Maldonato, M., & Dell'Orco, S. (2010). *Psicologia della decisione.* Milano: Bruno Mondadori.

Mancia, M. (1994). *Neurofisiologia.* Milano: Cortina.

Miller, E. K., Freedman, D. J., & Wallis, J. D. (2002). The prefrontal cortex: Categories, concepts and cognition. *Philos. Trans. R. Soc. Lond., B, Biol. Sci., 357*(1424), 1123-1136.

Moruzzi, G., & Magoun, H. W. (1949). Brain stem reticular formation and activation of the EEG. *Electroencephalogr. Clin. Neuro., 1,* 455-473.

O'Brien, G., & Opie, J. (2000). Disunity defended: A reply to Bayne. *Australasian Journal of Philosophy, 78*(2), 255-263.

Oliverio, A. (2008). *Geografia della mente.* Milano: Raffaele Cortina.

Oliverio, A. (2009). *La vita nascosta del cervello.* Milano: Giunti Editore.

Petitot, J., Varela, F., Pachoud, B., & Roy, J.-M. (Eds.) (1999). *Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science.* Standford, CA: Stanford University Press.

Plum, F., & Posner, J. B., (2000). *Stupor e coma.* Roma: SEU.

Posner, M. I., & Raichle, M. E. (1994). *Images of Mind.* New York: Scientific American Library.

Prigogine, I. (1986). *Dall'essere al divenire: tempo e complessità nelle scienze fisiche.* Torino: Einaudi.

Prigogine, I. (1997). *La fine delle certezze: il tempo, il caos e le leggi di natura.* Torino: Boringhieri.

Ramachandran, V. (2004). *The Emerging Mind.* London: Profile Books.

Richelle, H., Lejeune, J. J., Perikel, & Fery, P. (1985). From biotemporality to nootemporality: Toward an integrative and comparative view of time in behavior. In J. A. Michon & J. L. Jackson (Eds.), *Time, Mind and Behavior,* (pp. 75-99). Berlin: Springer-Verlag.

Roeckelein, J. E. (2000). *The Concept of Time in Psychology.* Westport: Greenwood Press.

Rushworth, M. F. S., Walton, M. E., Kennerley, S. W., & Bannerman, D. M. (2004). Action sets and decisions in the medial frontal cortex. *Trends in Cognitive Sciences, 8*(9), 410-417.

Teasdale, G., & Jennett, B. (1974). Assessment of coma and impaired consciousness. A practical scale. *Lancet, 2*(7872), 81-84.

Fuller Torrey, E., Bowler, A. E., Taylor, E.H., Gottesman, I. I. (1994). *Schizophrenia and Manic-Depressive Disorder: The Biological Roots of Mental Illness as Revealed by the Landmark Study of Identical Twins.* New York: Basic Books.

Varela, F. J. (1996). Neurophenomenology: A methodological remedy for the hard problem. *Journal of Consciousness Studies, 3*(4), 330-350.

Varela, F., Thompson, E., & Rosch, E. (1992). *La via di mezzo della conoscenza. Le scienze cognitive alla prova dell'esperienza.* Milano: Feltrinelli.

Wilkinson, I., & Lennox, G. (2007). *Manuale di neurologia.* Torino: Minerva Medica.

Zeki, S. (2003). *La visione dall'interno. Arte e cervello.* Torino: Bollati Boringhieri.

Zeki, S., & Bartels, A. (1998). Toward a theory of visuale consciousness. *Consciousness and Cognition, 8*(2), 225-259.

Zeman, A. (2001). Consciousness. *Brain, 124,* 1263-1289.